한국물리학회
The Korean Physical Society

한국물리학회 초록집

2017 가을 학술논문발표회 및 임시총회

2017.10.25(수)-27(금)
경주 화백컨벤션센터

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Oral session abstracts

Non-accelerator-based particle physics experiments(D)/0813 A1.01

Status of the AMoRE experiment

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Abstract :

AMoRE (Advanced Mo-based Rare process Experiment) aims to search for the neutrinoless double beta decay of ^{100}Mo using low-temperature detectors consisting of Mo-based scintillating crystals read out via metallic magnetic calorimeters. Simultaneous measurements of heat and scintillation light signals are performed at mK temperatures that are reached using a dilution refrigerator. The AMoRE-Pilot experiment, the first stage of the AMoRE project, has been running in the 700-m-deep Yangyang underground Laboratory using six ^{100}Mo-enriched, ^{48}Ca-depleted $^{40}Ca^{100}MoO_4$ crystals, with a total mass of about 1.89 kg. The current status of the AMoRE-Pilot experiment, as well as the most recent analysis results, will be presented. Plans for AMoRE-I, which is the next experimental phase of the project, will also be presented.

Non-accelerator-based particle physics experiments(D)/0895 A1.02

Analysis methods and detector performance for AMoRE-Pilot

KIM Inwook[1,2,3], Seon Ho Choi[1], Yong Hamb Kim[*2]

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Abstract :

AMoRE (Advanced Mo-based Rare process Experiment) is an international collaboration searching for neutrinoless double beta decay (0νββ) of 100Mo in 40Ca100MoO4 (CMO) scintillating crystals with the use of metallic magnetic calorimeters (MMCs) at millikelvin temperatures. AMoRE utilizes phonon-photon simultaneous measurement technique to achieve an excellent α background rejection power. The pilot phase of the experiment has been running in the Yangyang underground laboratory, with about 1.8 kg of CMO crystals at 20mK. We present the techniques used for the data processing and analysis of the AMoRE-Pilot experiment and the performance of the detector.

Non-accelerator-based particle physics experiments(D)/0385 A1.03

AMoRE-Pilot Background Simulation

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Abstract :

The AMoRE(Advanced Mo-based Rare process Experiment) is a very rare events experiment to search neutrino-less double-beta decay from Mo-100. Since the Amore requires a very low background level, a simulation study to understand the background levels of the Amore experiment has been performed. At first, ^{232}Th and ^{238}U decays at 12 major AMoRE detector components ($CaMoO_4$ crystal, crystal hold frame, Vikuiti reflector, radiation shield parts, cryogenic chambers, etc…) and rock layers are simulated. Simulation results show that the background in the ROI (Region of Interest) is 11.021 x 10^{-3} ckky (counts/keV/kg/year). Secondly, a surface simulation was done to understand the 5.3 MeV signals from the measurement data. According to the simulation result, surface peaks occur from $CaMoO_4$ and Vikuiti, and the sum of the two peaks is 5.3 MeV. Details of this study will be presented in this talk. and Vikuiti, and the sum of the two peaks is 5.3 MeV. Details of this study will be presented in this talk.

Non-accelerator-based particle physics experiments(D)/0575 A1.04

Measurment of Internal Contamination of $^{40}Ca^{100}MoO_4$ Crystals for the AMoRE-I Experiment

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Abstract :

Neutrino-less double beta decay is one the most promising processes to find the absolute masses of neutrinos. A scintillation crystal, $^{40}Ca^{100}MoO_4$ (CMO), with ^{48}Ca depleted and ^{100}Mo enriched has been developed by the AMoRE (Advanced Molybdenum based Rare process Experiment) to search the decay from ^{100}Mo. We have measured internal radioactivities of the CMO crystals to confirm wether they are acceptable or not in the AMoRE-I which would be running at the YangYang underground laboratory(Y2L) with a rather low cosmic muon background environment. But there are still backgrounds from the internal contaminations of the crystals, especially daughter isotopes in Uranium and Thorium decay chains. In order to understand the contaminations, we have measured Polonium decays sequences which have relatively short half-lives using a delayed-coincidence analysis. We will report the radioactivity measurements results of nine CMO crystals with a total mass of ~ 3.4 kg.

Non-accelerator-based particle physics experiments(D)/0426 A1.05

Status of the COSINE-100 experiment

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Abstract :

The COSINE is a dark matter experiment to confirm or refute the observation of dark matter signal by the DAMA using the same type NaI(Tl) crystals. A total of 106 kg NaI(Tl) crystals was installed in several layers of shielding materials together with plastic scintillator muon counters covering the outmost structure at the Yangyang underground laboratory. The first phase experiment, COSINE-100, has started in September 2016 and has been running very stable. In this talk, the status of the experiment will be presented.

Non-accelerator-based particle physics experiments(D)/0534 A1.06

R&D projects for the COSINE experiment

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Abstract :

The first phase of the COSINE experiment has been stably collecting physics data since September of 2016. However, it is still necessary to develop extremely low background NaI(Tl) crystals with background levels below 1 count/day/keV/kg for the next phase of the experiment. To develop such crystals, it is essential to understand the purification of powders, clean crystal growing facility, crystal cutting and polishing techniques along with its encapsulation. In addition to this, it is equally important to continuously monitor the level of environmental neutron background in the experiment hall. For this purpose, we are developing a neutron monitoring detector using liquid scintillator. Here, we will present status of the R&D projects of the COSINE experiment and prospects for future experiments.

Non-accelerator-based particle physics experiments(D)/0557 A1.07

A measurement of surface background from Pb-210 for NaI(Tl) dark matter searches

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Abstract :

Low background is the most important factor in a rare event search such as COSINE-100 dark matter experiment. The COSINE-100 uses NaI(Tl) crystals as a target scintillator and deposition of Pb-210 from radon progeny on the crystal surfaces has been identified as a dominant source of low energy background. The most serious surface background is Pb-206 recoils. It is generally found at a few keV energy range and generates a fast signal which can be misidentified as a WIMP candidate signal. We measured Pb-210 decays on the NaI(Tl) crystal surfaces and demonstrated that Pb-206 recoils can be rejected by a pulse shape discrimination analysis. In this talk, a study on surface events from Pb-210 will be presented.

Non-accelerator-based particle physics experiments(D)/0392 A1.08

Low-temperature anisotropic properties of $ZnWO_4$ crystals for directional dark matter detection

Jeon Jin-A[1], Kim Hyelim[1], Kim Inwook[1], Kim Sora[1], Kim Younghamb[*1,2], Lee Hyejin[1], Lee Sunghoon[1], Oh Seungyoon[1], Hiroyuki Sekiya[3]

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Abstract :

Present direct detection weakly-interacting-massive-particle (WIMP) search experiments have intrinsic limit from inevitable backgrounds due to coherent neutrino-nucleus scattering. Directionality approaches are one of the ways to solve the problem from the neutrino scatterings. A few experiments have been proposed using directional dependance of their signals such as nuclear emulsion plates, low-pressure gaseous time projection chambers (TPCs), and anisotropic crystal detectors.

We studied $ZnWO_4$ crystals as a target candidate for WIMP detection with directional information. $ZnWO_4$ is a scintillating crystal with high anisotropy in its crystal structure. Simultaneous phonon and scintillation measurements were made in a compact detector setup at low temperatures below 40 mK. Phonon and scintillation signals are measured simultaneously in two different directions of alpha and gamma radiations respect to the crystal axes. In this presentation, we show the first R&D result using a cubic $ZnWO_4$ crystal and discuss about the directional dependence of the signals.

Non-accelerator-based particle physics experiments(D)/0984 A1.09

An improved understanding of the Ar-gas ionization chamber for alpha particle detection at Yangyang.

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Abstract :

An alpha particle counting using an ionization chamber is a well-known method for an estimation of material's radioactivity. Typically, the counter measures ionization electrons produced when a charged particle passes through the gas. Since the alpha counter, UltraLo-1800, was installed at Yangyang underground laboratory in June, 2015, it has been continuously collecting data for various samples. The main purpose of this counter is to measure alpha particles produced from the surface of a sample, especially from ^{210}Po decays. This instrument records characteristic signals from the ionization electrons produced by the sample material's alpha particles in the Ar-gas filled chamber. Its distinct rise time from the signal allows us to select alpha particles that originate from the specimen on the tray and veto those from other sources. We present our efforts to understand the sensitivity of the detector better using various measurements and R&Ds which include a sample test with ^{210}Pb/^{210}Po removed from the surface and a ^{222}Rn reduction in the Ar-gas using a cold trap.

Complex systems(D)/0062 A2.01

Standing question of body-mass index

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Abstract :

Body-mass index, abbreviated as BMI and given by M/H2 with the mass M and the height H, has been widely used as a useful proxy to measure a general health status of a human individual. We generalise BMI in the form of M/Hp and pursue to answer the question of the value of p for populations of animal species including human. We compare values of p for several different datasets for human populations with the ones obtained for other animal populations of fish, whales, and land mammals. All animal populations but humans analyzed in our work are shown to have p≈3 unanimously. In contrast, human populations are different: As young infants grow to become toddlers and keep growing, the sudden change of p is observed at about one year after birth. Infants younger than one year old exhibit significantly larger value of p than two, while children between one and five years old show p≈2, sharply different from other animal species. The observation implies the importance of the upright posture of human individuals. We also propose a simple mechanical model for a human body and suggest that standing and walking upright should put a clear division between bipedal human (p≈2) and other animals (p≈3)

Complex systems(D)/0111 A2.02

The bursty-get-burstier model for correlated bursty dynamics

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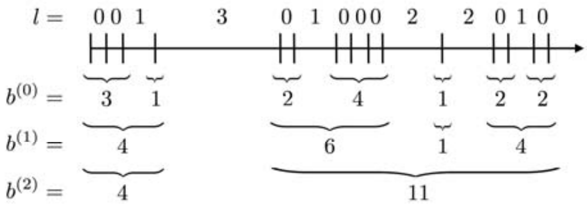
Abstract :



Temporal correlations of time series or event sequences in natural and social phenomena have been characterized by power-law decaying autocorrelation functions with decaying exponent γ. Such temporal correlations can be understood in terms of power-law distributed interevent times with exponent α, and/or correlations between interevent times. The latter, often called correlated bursts, has recently been studied by measuring power-law distributed bursty trains with exponent β. A scaling relation between α and γ has been established for the uncorrelated interevent times, while little is known about the effects of correlated interevent times on temporal correlations. In order to study these effects, we devise the bursty-get-burstier model for correlated bursts, by which one can tune the degree of correlations between interevent times, while keeping the same interevent time distribution. We numerically find that sufficiently strong correlations between interevent times could violate the scaling relation between α and γ for the uncorrelated case. A non-trivial dependence of γ on β is also found for some range of α. The implication of our results is discussed in terms of the hierarchical organization of bursty trains at various timescales.

Complex systems(D)/0209 A2.03

Algebric Growth of Infected Cluster in Heterogenous Network

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Abstract :

We study a spreading pattern of epidemics over a complex network. In susceptible-infected (SI) model, it has been well known that the intial growth of infected nodes follows the exponential form as a function of time t with a time scale described by degree statistics, and that so does the final growth with an infection rate as a time scale. We put focus on the dynamics in the intermediate range except for both the early- and late- time regime and examine on the complex networks governed by degree distribution $P_d(k) \sim k^{-\gamma}$. It is observed that, for $2 < \gamma < 3$, infected nodes increase with a power law such as $t^{1/(3-\gamma)}$ whereas a growth of infected nodes maintains the exponential form in the homogeneous network for $\gamma > 3$.

Complex systems(D)/1152 A2.04

Perception biases in social networks with homophily

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Abstract :

Human perception is influenced by a limited information coming from the social structural of ego-network, and thus it can be easily biased. Filter bubble – connecting to other like-minded people– and majority illusion – over-represntation of certain groups in social networks– are two examples in which people's perception can become distorted. In particular, the perception bias for a specific underrepresented group, such as minorities, can be a root of many social conflicts.

In this paper, we study the perception bias in six empirical datasets that exhibit various level of homophily and group sizes. Furthermore, we analyze the perception bias on a generative network model with adjustable homophily and a group sizes. Our results show that perception bias can emerge in networks that exhibit high homophily or heterophily and disproportionate group sizes.

Also, we show that our model can reproduce the perception bias in real world networks and asymmetric homophily among groups play a crucial role in determining the perception biases. Finally, we investigate ways in which the perception bias can be improved by aggregating ego's perception with her neighborhood perception. Our findings can shed lights on understanding the root of many social biases and offering quantitative approach to address these issues in society.

Complex systems(D)/1151 A2.05

Efficiency of urban street network affected by street density distribution

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Abstract :

Street networks aim to facilitate efficient transportation of goods and people. While the efficiency of transportation networks has been studied for decades, route factor which is the ratio between travel distance and geodesic distance (crow-flies distance) (also called the detour index, detour factor, circuit, directness and so on) has been one of the well used and simple ways to measure the efficiency. The statistics of route factors provided in the studies share several commonalities. Broadly, the average detour factor of street networks are within the range of 1.0-2.0, and it decreases with the increase of the geodesic distance between the origin and destination pairs.

The detour factor is influenced by the connectivity or density of its embedded street network and the physical boundaries, and the density and connectivity do not show a uniform pattern across the city. One can expect the connectivity of the city center to other regions would be better than the periphery.

In the present study, we discover how the efficiency is affected by the street pattern in different parts of a city. We measure the detour factors of routes systemically selected by radii and angles for 20 global cities and find the relationship with density distribution of street networks. We also suggest the detour factor model explain the empirical finding with unique street patterns.

Complex systems(D)/1133 A2.06

Motifs dynamics on a network model of evolving open system

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Abstract :

Complex networks, such as ecosystems, nervous systems, WWW (World Wide Web), and social communities, fluctuate over time. We analyze which mechanism makes these networks grow, using an evolving open network model that is a temporal network with signed, weighted, and directed links [1]. Depending on the number of interactions per node, this network continues to grow or disappears. By measuring the Zscore, we compare the number of motifs in this network with the number of motifs in a random network with the same number of nodes and links. We find that the number of specific motifs in this network is five times more than the number of the motifs in the random network. We confirm the universal property of the motifs dynamics in the complex network model.

[1] T. Shimada, Sci. Rep. 4, 4082 (2014).

Complex systems(D)/1065 A2.07

Ranking influential spreaders is an ill-defined problem

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Abstract :

Finding influential spreaders of information and disease in networks is an important theoretical problem, and one of considerable recent interest. It has been almost exclusively formulated as a node-ranking problem —methods for identifying influential spreaders output a ranking of the nodes. In this work, we show that such a greedy heuristic does not necessarily work: the set of most influential nodes depends on the number of nodes in the set. Therefore, the set of n most important nodes to vaccinate does not need to have any node in common with the set of n + 1 most important nodes. We propose a method for quantifying the extent and impact of this phenomenon. By this method, we show that it is a common phenomenon in both empirical and model networks.

Complex systems(D)/0969 A2.08

Expended supply-demand theory in a distribution network

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Abstract :

We use the structure of a real distribution network of agricultural product in Korea and investigate how the change in the supply may affect the price changes in agents across the distribution network. In particular, we focus on the real network structure of cabbage distribution composed of various types of agents, from farms to consumers, and apply a dynamic model to describe how each participant reacts upon the change of input and output flow of products through the adjustment of price. Our main result implies that the effect of fluctuation of production quantity in the supplying participant can be nontrivial and the consumer price responds to such changes. We believe that our results can be useful to predict what will happen if the agricultural production changes much in the future due to the climate changes.

Field and string theory(B)/1156 A3.01

Full Einstein from Entanglement First Law and Entaglement Entropy as Flux

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Abstract :

Recently it was observed that Entanglement Entropy first law (EEFL) leads to the linearized Einstein equation.
In this talk, we show that EEFL leads to full Einstein equation using Holland-Ward off-shell identity. We also explicitly construct a vector field whose flux is the entanglement entropy such that the flux of the vector field is independent of the surface.

Field and string theory(B)/1024 A3.02

Magnetic and electric properties of stongly interactinc ferromagnetic material from holography

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Abstract :

We construct gravity dual of the strongly interacting system without time-reversal-symmetry from gauge/gravity point of veiw. The key feature of the background geometry is it shows ferromagetic behavior at the boundary theory. We calculate magetotransport of the system for non-ferromagnetic case and find the results are similar to the experimental data of the surface state of the topological insulator. In this work, we study backgournd geometry which corresponds to the finite magnetization. We calculate the magnetization and discuss on the hysterisis behavior of the system. We also calculate several magneto-transport coefficients and compare to experimental data.

Field and string theory(B)/1009 A3.03

What is the Mott gap in Holography?

Geunho Song[1], Yunseok Seo[1], Yonghui Qi[1], Sang-Jin Sin[*1]

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Abstract :

We analyze the two-point fermion correlators by using a semi-holographic description, where a dynamical boundary field is coupled to a strongly coupled conformal sector having a gravity dual. Semi-holographic method is useful since they can explain the low energy properties, which are most likely to be relevant to the realistic system. Furthermore, it allows more flexible model-building such as explicit spin-orbit coupling or a spatial lattice. With this semi-holographic description, we find that the Mott gap can be generated by the bulk fermion mass which corresponds to conformal dimensions. This imples that we don't need any kind of bulk interaction for generating mass gap.

Field and string theory(B)/0496 A3.04

Domain walls of massive K"{a}hler sigma models on Sp(N)/U(N) in three dimensions

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Abstract :

We construct domain walls of mass-deformed Kähler nonlinear sigma models on Sp(N)/U(N) in three dimensions by using moduli matrices. We discuss the operators generating walls and the roots.

Field and string theory(B)/0331 A3.05

Asymptotic M5-brane entropy from S-duality

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Abstract :

We study M5-branes compactified on S1 from the D0-D4 Witten index in the Coulomb phase. We first show that the prepotential of this index is S-dual, up to a simple anomalous part. This is an extension of the well-known S-duality of the 4d N = 4 theory to the 6d (2, 0) theory on finite T^2. Using this anomalous S-duality, we find that the asymptotic free energy scales like N^3 when various temperature-like parameters are large. This shows that the number of 5d Kaluza-Klein fields for light D0-brane bound states is proportional to N^3. We also compute some part of the asymptotic free energy from 6d chiral anomalies, which precisely agrees with our D0-D4 calculus.

Field and string theory(B)/0032 A3.06

String Field Theory and Polyakov String Path Integral

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Abstract :

I will discuss the correspondence relationship between the string field theory and the Polyakov string path integral, which represents the first quantized string theory. I will show how to fix the reparametrization invariance of the Polyakov string path integral to obtain the Fock space representations of the multi-string vertices of the second quantized theory.

Hadron physics(C)/1145 A4.01

Omega_cs

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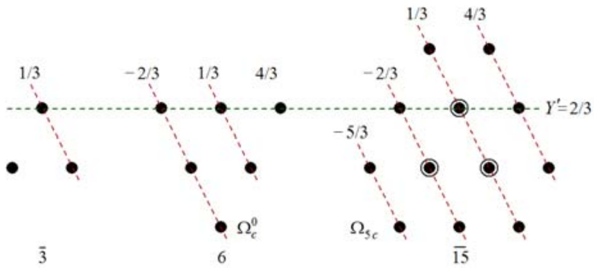
Abstract :

In the present talk, we discuss Omega_cs found by the LHCb Collaboration in a meson mean-field approach. We identify two out of five narrow Ω0c statesas the exotic pentaquarks and three of them as excited sextet members. This interpretation can be easily verified experimentally, since exotic Ω0c states—contrary to the regular excitations—form isospin triplets rather than singlets.



Hadron physics(C)/1087 A4.02

Vector mesons in tensor representation

정기상[*1], 오용석[2], 이수형[3]

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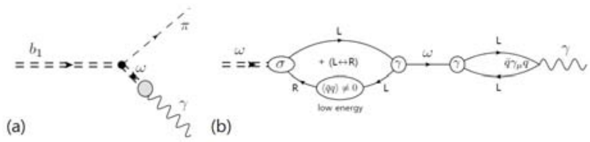
Abstract :



Vector mesons represented as Dirac tensor bilinear are studied in frame work of operator product expansion (OPE). Especially, $b_1(1235)[1^+(1^{+-})]$ meson decay mode is analyzed in OPE at soft pion limit. According to current-field identity, charged spin-1 meson can be strongly overlapped with photon in low energy regime, which leads vector meson dominance hypothesis (VMD). However, for the parity-even mode $b_1(1235)$ decay, the observed width for final photon could not be explained via VMD hypothesis in consistent arguments. The tensor representation of $b_1(1235)$ provides omega(?)$[0^-(1^{--})]$ state as consequence of chiral symmetry breaking, which can be overlapped with omega(782)$[0^-(1^{--})]$ state well described in chiral representation in low energy regime. The tensor current can have overlap with electromagnetic current. So the channel for the final photon state can be originated from both of the representations. The prediction depends on QCD theta vacuua and the four-quark condensates in the vacuua. Detailed analysis for OPE, subsequent spectral sum rules, and the topologies of QCD vacuum which look like the main reason of this puzzle will be presented.

Hadron physics(C)/0987 A4.03

Instanton effects on the heavy-quarkonium states

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Abstract :

We investigate the instanton effects on the heavy-quark potential, including its spin-dependent part, based on the instanton liquid model. Starting with the central potential derived from the instanton vacuum, we obtain the spin-dependent part of the heavy-quark potential. We discuss the results of the heavy-quark potential from the instanton vacuum. We finally solve the nonrelativistic two-body problem, associating with the heavy-quark potential from the instanton vacuum. We discuss the instanton effects on the masses of charmonia and hyperfine mass splittings.

Hadron physics(C)/0903 A4.04

Pc(4380) in a constituent quark model

Woosung Park[1], Su Houng Lee[*2]

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Abstract :

The constituent quark model with color-spin hyperfine potential is used to investigate the property of a compact pentaquark configuration with Jp=3/2− and isospin=1/2, which is the most likely quantum number of one of the recently observed exotic baryon states at LHCb. Starting from the characterization of the isospin, color, and spin states for the pentaquark configuration, we construct the total wave function composed of the spatial wave function, which we take to be symmetric and in S-wave, and the four orthogonal isospin ⊗ color ⊗ spin states that satisfy the Pauli principle. We then use the variational method to find a compact stable configuration. While there are compact configurations where the hyperfine potential is more attractive than the sum of p and J/ psi hyperfine potentials, we find that the ground state is the isolated p and J/psi state. Furthermore, the mass of the excited state lies far above the observed pentaquark state leading us to conclude that the observed states can not be a compact multiquark configuration with Jp=3/2−.

Hadron physics(C)/0177 A4.05

$DD\sigma$ and $D^*D^*\sigma$ coupling constants

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Abstract :

In this talk, we present a recent investigation on the coupling constants for the $DD\sigma$ and $D^*D^*\sigma$ vertices. We first compute the $D\bar{D} \to \pi\pi$ and $D^*\bar{D}^* \to \pi\pi$ amplitudes in the pseudophysical region in a meson-exchange picture. Combining these amplitudes with the $\pi\pi$ transition amplitudes constructed within the same framework, solving the rescattering equation, we derive the 2π-correlated amplitudes for the $D\bar{D} \to \pi\pi$ and $D^*\bar{D}^* \to \pi\pi$ processes. Constructing the $D\bar{D}$ and $D^*\bar{D}^*$ amplitudes by two-body unitarity and using the dispersion re- lation, we arrive at the DD amplitude with correlated 2π exchange. Employing the zero-width approximation, we obtain the $DD\sigma$ and $D^*D^*\sigma$ coupling constants. We discuss uncertainties arising from the values of the cut-off masses and possible applications.

Hadron physics(C)/0176 A4.06

Photo- and electroproduction of Lambda(1405) via gamma* p --> K^+ pi^+ $Sigma^-$

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Abstract :

In this talk, we perform a textit{toy-model} analysis for the unpolarized photo- and electroproduction of Lambda(1405) = Lambda* via Lambda(1405) via gamma* p --> K^+ pi^+ $Sigma^-$ by employing the effective Lagrangian approach at the tree level only. We consider that Lambda* consists of the high-mass (H) and low-mass (L) poles as suggested by the chiral unitary model (ChUM). We determine all the model parameters including coupling constants and cutoff parameters for the phenomenological strong form factors by using the theoretical information from ChUM and available experimental data. The electromagnetic (EM) form factors for the two poles are parameterized appropriately being similar to that for the neutron by employing the ChUM estimates for the EM root-mean-squared (rms) radii for the two poles. We observe from the numerical calculations that, for the photoproduction of Lambda*, the interference between the two poles turns out to be destructive, resulting in the single-peak line at M_{pi^+ $Sigma^-$} ~ 1405 MeV in the invariant-mass distribution. On the contrary, there appear two peaks in the distribution for the electroproduction as observed in the CLAS/Jlab electroproduction data, due to the constructive interference, which is mainly caused by the Dirac form factors for the two poles. From this observation, we conclude that, in order to explain the photo- and electroproduction data simultaneously, i.e., *single* and *double* peaks, respectively, in the invariant-mass distribution, the interference patterns for the two poles should follow those suggested by ChUM. In turn, it is a strong theoretical and experimental supports for the two-pole structure scenario for Lambda*.

Hadron physics(C)/0064 A4.07

Masses of singly and doubly heavy baryons within the self-consistent SU(3) chiral quark-soliton model

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Abstract :

We study the masses of lowest-lying singly and doubly heavy baryons, based on the self-consistent chiral quark-soliton model. We discuss the effects of flavor SU(3) symmetry breaking on the mass splittings of heavy baryons. The anomalous chromomagnetic moments, which is responsible for the splitting between the spin 1/2 and 3/2 sextet representations, is determined by the experimental data. We find that the values of the strange current quark mass tend to decrease as the heavy quark mass increases. Having fixed the sum of the clasical soliton mass phenomenologically, we predict all the masses of the lowest-lying singly and doubly heavy baryons.

Hadron physics(C)/0063 A4.08

Mass spectra of excited baryons in a mean-field approach

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Abstract :

A baryon can be viewed as a bound state of the Nc valence quarks in meson mean fields with hedgehog symmetry as first suggested by Witten. The Nc valence quarks are also self-consistently influenced by the meson mean fields. When it comes to an excited baryon, one valence quark is excited to a higher level characterized the grand spin defined as the sum of the spin and isospin operators. Assuming that the soliton rotates slowly, we can make a zero-mode quantization of the soliton and derive the collective Hamiltonian for the excited baryons. The splitting between the excited baryon octet and decuplet is explained by the moments of inertia, which indicates the effects of the meson mean field. The splitting within a representation is described by flavor SU(3) symmetry breaking to leaner order. We discuss the problem of the mass orderings in the spectrum of the excite nucleons. We present the results of the mass spectra of excited baryons up to 2 GeV.

Focus: Current research trends in Attosecond Science and Technology/1093 A5.01

Strong field excitation using a few cycle pulse

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Abstract :

An excitation of an atom is one of the most fundamental process that occur when the strong light field interacts with a matter. In the strong laser field, an electron can be tunnel-ionized. When the laser pulse is turned off, the electron may recombine to the Rydberg states of the atom. This strong field excitation is a process known as a frustrated tunneling ionization. In this work, we demonstrate that the excitation process is coherent, and hence the resulting atomic line emission is coherent. The intensity of the emission strongly depends on the carrier envelope phase of the driving laser pulses, showing the coherent property of the excitation process. The coherent control of the excitation process would provide a useful coherent EUV light source for applications, and also opens up a new possibility in studying ultrafast spectroscopy.

Focus: Current research trends in Attosecond Science and Technology/0324 A5.02

High harmonic generation in crystalline solids and its applications

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Abstract :

Coherent EUV and even X-ray radiation can be produced from various gaseous atoms when their electrons are driven into the continuum by quantum tunneling. In recent years, efforts have been made to exploit solids as HHG materials ever since the first report of HHG success with a ZnO bulk crystal. Subsequent investigations were made with various solid materials in the form of thin films, bulk crystals, solid phase atoms, or nanostructures. In contrast to the use of gaseous atoms, the HHG mechanisms that occur in crystalline solids can be explained in terms of the interband and intraband transitions of the electrons inside the band structure as they interact with the incident laser field. In this reports, we will introduce the high harmonic generation from crystalline Sapphire. The experimental data also shows that the generated high harmonics displays the least dependence on the crystallographic orientation on the material; its yields are strongly confined in either the Γ–K or Γ–M direction in the Brillouin zone.

The experimental verification for the spatiotemporal coherence of the generated harmonics was studied. The measured visibility from the two slits interference can be assumed to represent the modulus of the complex coherence factor, which can straightforwardly be interpreted as the spatiotemporal coherence of the generated harmonics. The measured data shows that both the H7 and H9 harmonics exhibit high degrees of visibility of 0.83 and 0.76, respectively. This quantitative result is comparable to that for the case of gaseous atoms and proves that bulk sapphire is able to produce HHG signals of high spatiotemporal coherence.

Unlike gaseous atoms, sapphire crystal is a dense periodic bulk solid that contains many electrons that can act as not only HHG emitters but also strong EUV absorbers. This implies that the EUV radiation produced by HHG is subsequently subject to strong reabsorption by the specimen material itself. This observation implies that the output EUV radiation can be steered simply by using a sloped surface without extra grazing reflective mirrors. Furthermore, if the specimen is patterned to have an appropriately curved shape, the EUV propagation may be brought possibly to a focal spot in free space without using reflective or diffractive optics.

Focus: Current research trends in Attosecond Science and Technology/0918 A5.03

Subfemtosecond dynamics of correlated electrons

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Abstract :

Electron correlation is essential to understand a broad class of many-body phenomena. In particular, subfemtosecond dynamics of correlated electrons open up a new perspective of fundamental electronic processes. By explicitly solving the time-dependent Schroedinger equation, we investigate the real-time dynamics of two correlated electrons in the solid environment with a periodic array of atomic potentials. Effects of the electron correlation on the sunfemtosecond time span will be discussed.

Focus: Current research trends in Attosecond Science and Technology/0609 A5.04

Plasmonic field-enhanced high-order harmonic generation in solids

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Abstract :

High-order harmonics generation (HHG) from an atomic gas has been studied for decades. In recent years, however, solids have attracted much attention as high-density targets. Also, by introducing plasmonic enhancement by nanostructures, HHG can be possible in solids with relatively low intensity lasers. We review the theory of HHG in solids, and investigate the localization of HHG in solids under spatially inhomogeneous fields produced by plasmonic field enhancement.

Focus: Perovskite optoelectronic materials/1211 A6.01

Next-Generation Emitters: Metal Halide Perovskites

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Abstract :

Metal halide perovskites are emerging high color-purity emitters with low material cost. However, low electroluminescence (EL) efficiency at room temperature is a challenge that should be overcome. Here, we present efficient perovskite light-emitting diodes (PeLEDs) using various strategies to overcome the EL efficiency limitations where the perovskite layers are in forms of (1) 3D crystal structures, (2) quasi-2D crystal structures and (3) nanoparticles (NPs). First, to improve EL efficiency of PeLEDs based on 3D crystal structures, we introduced a self-organized buffer hole injection layer to reduce the hole injection barrier and block the exciton quenching at the interface. The high-efficiency methylammonium lead bromide ($MAPbBr_3$) and $CsPbBr_3$ PeLEDs were realized based on the buffer hole injection layers and the temperature dependence of EL in the $CsPbBr_3$ PeLEDs was systematically investigated and related with ion migration, EL quenching pathways and electron-phonon coupling. Furthermore, we found that the formation of metallic lead atoms causes strong exciton quenching, and it was prevented by finely increasing the molar proportion of MABr in $MAPbBr_3$ solution. Also, we suggest that the efficiency in PeLEDs can be increased by decreasing $MAPbBr_3$ grain sizes and consequently improving uniformity and coverage of $MAPbBr_3$ layers. Using these strategies, a high-efficiency PeLEDs was realized (current efficiency = 42.9 cd/A). High-efficiency flexible $MAPbBr_3$ PeLEDs based on graphene anode were also developed for the first time. Chemically inert graphene avoids quenching of excitons by diffused metal atom species from indium tin oxide. Second, quasi-2D perovskites were studied because of the advantages of quasi-2D perovskites such as the enhancement of film quality, exciton confinement and reduced trap density, and quasi-2D PeLEDs with high efficiency and brightness were demonstrated. Finally, perovskite NPs were studied because they can show high luminescence efficiency and high color-purity in both solution states and film states, and high efficiency PeLEDs based on $MAPbBr_3$ and formaminidium lead bromide ($FAPbBr_3$) NPs were also fabricated.

Focus: Perovskite optoelectronic materials/0590 A6.02

Peroptronic Devices: Perovskite-Based Light-Emitting Solar Cells

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Abstract :

Solution processed perovskite semiconductors have developed rapidly over the past decade to yield excellent performance in both solar cell and light emitting diode devices. Both of these device types are prepared using similar materials and architectures, raising the possibility of perovskite based light emitting solar cells. Recent reports have indicated that some low band gap perovskite solar cells are able to emit infrared light efficiently, however, intermediate band gap perovskite solar cells which emit visible light have not, to the best of our knowledge been deliberately designed or extensively characterized. In this work, we have investigated the use of different electron transport layers in order to minimize energetic barriers to electron injection and extraction in methylammonium lead bromide ($MAPbBr_3$) films. We demonstrate that through appropriate band structure engineering, $MAPbBr_3$ can be used to make such “peroptronic” light-emitting solar cells, which simultaneously exhibit efficient solar cell power conversion efficiencies over 1% and 0.43 lm/W green light emission.

Focus: Perovskite optoelectronic materials/0543 A6.03

Improvement of Device Performances in Organic–Inorganic Perovskites in Light-Emitting Diodes

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Abstract :

Perovskite-based optoelectronic devices have been rapidly developing in the past 5 years. Since the first report the external quantum efficiency (EQE) of perovskite light-emitting diodes (PeLEDs) has increased rapidly through the control of morphology and structure from 0.1% to more than 11%.
Here, we report the use of various conjugated polyelectrolytes (CPEs) as the hole injection layer in PeLEDs. In particular, we find that poly[2,6-(4,4-bis-potassium butanylsulfonate)-4H-cyclopenta-[2,1-b;3,4-b']-dithiophene)] (PCPDT-K) transfers holes effectively, blocks electron transport from the perovskite to the underlying ITO layer and reduces luminescence quenching at the perovskite/PCPDT-K interface. Our optimized PeLEDs with PCPDT-K show enhanced EQE by a factors of approximately 2 compared to control PeLEDs with PEDOT:PSS, reaching EQE values of 1.5%, and exhibit improved device stability. Moreover, we demonstate the loss mechanism in PeLEDs via electrical, optical and surface analysis.

Focus: Perovskite optoelectronic materials/0137 A6.04

Halide perovskites: Towards an age of hybrid nonlinear optical materials

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Abstract :

Although emerged from the field of photovoltaics, organic-inorganic hybrid halide perovskites have also shown their great promise for other optoelectronic applications such as radiation detectors, lasing, thermoelectricity, light-emitting diodes, nonlinear optics, etc. In this focus section, I will talk about these materials with a special emphasis on their nonlinear optical properties as probed by wavelength-dependent Z-scan nonlinear spectroscopy. Specifically, I will present recent key results on 1) enhancement of second harmonic generation in noncentrosymmetric Ge-based perovskites by hybridization, 2) tunability of multiphoton absorption in Pb-based perovskites, and 3) selective enhancement of third-order nonlinearity in two-dimensional Ruddlesden-Popper series perovskites. Considering that traditional nonlinear optical materials have been typically available from either solely organic or solely inorganic perspective, the hybrid nonlinear optical perovskites can provide unique opportunities since the combination of their organic-inorganic properties can be further exploited.

Pioneer: Oxides for energy application/1183 A7.01

Band Structure Engineering and Defect Control of Oxides for Energy Applications

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Abstract :

Transition metal oxides play an essential role in modern optoelectronic devices because they have many unique physical properties such as structure diversity, superb stability in solution, good catalytic activity, and simultaneous high electron conductivity and optical transmission. Therefore, they are widely used in energy related optoelectronic applications such as photovoltaics and photoelectrochemical (PEC) fuel generation. In this talk, using first-principles band structure calculations, I will discuss the electronic, optical, and doping properties of oxides and address some fundamental questions related to their unique materials properties such as (i) why most of the transparent conducting oxides (TCOs) are n-type and how to engineer band structure of a transparent oxide so it can be doped both p- and n-type? (ii) Is oxygen vacancy an efficient intrinsic n-type dopant in metal oxides? (iii) To achieve optimal n-type conductivity through extrinsic doping, what type of dopants one should use? (iv) Why amorphous TCO can have good electrical conductivity even without passivation? (v) How to engineer the band structure of oxides through defect control for PEC water splitting and battery applications?

Pioneer: Oxides for energy application/1184 A7.02

Oxides for improving the performance of Li-battery cathodes

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Abstract :

Developing efficient and stable cathode materials becomes significantly important in improving Li-battery performance for large scale applications. This talk is to discuss two examples of work related to cathode materials, one on the coating of nickel-rich NCM cathodes and the another one on the catalyst design for Li-O_2 battery. It has been well known that surface coating (such as metal oxides, metal fluorides, metal phosphates etc.) in Ni-rich NCM materials is the key to prevent surface side-reactions of electrolyte decomposition and transition metal ions dissolution. We found that some Li-ion conductor materials satisfying certain criteria can not only exhibit a high Li-ion conductivity by minimizing interfacial resistant but also effectively alleviate surface side-reactions. On the Li-O_2 battery with extreme high capacity, two catalytic models, surface acidity (electron transfer capacity) and interfacial bonding energy, are quantified to reveal the catalytic mechanism and to screen effective cathode catalysts for reducing charge potential of Li-O_2 battery. The relatively quantitative models predict some highly active catalysts such as Co_3O_4 and FeO, confirmed later by experiments in reducing overpotential and improving cyclic performance.

Pioneer: Oxides for energy application/0539 A7.03

Computational Materials Design for Developing High Performance Solid Oxide Fuel Cell Electrodes

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Abstract :

Solid oxide fuel cell (SOFC) operated at high temperature have received considerable attention as a prospective device due to its high efficiency and fuel flexibility. For enhancing the SOFC performance, however, there are some critical issues to be resolved. First, oxygen reduction kinetics and its transport are drastically suppressed at reduced temperature. Second, severe degradation observed in electrode deteriorates long-term stability. To tackle these problems, it is essential to rationally develop the materials of SOFC components. Unfortunately, it is not easy to completely achieve it by depending only on conventional experimental methods. In this talk, we therefore introduce computational approaches to design SOFC electrode materials. Specifically, enhanced electrochemical performance through both the strain-driven chemical stabilization and the metallic nanoparticle exsolution of perovskite electrode surfaces will be discussed. We believe that our computational study will play an important role in improving SOFC performance by guiding or complementing the relevant experiments.

Pioneer: Oxides for energy application/1206 A7.04

Perovskite materials for energy applications

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Abstract :

Perovskites are materials with a ABO_3 type structure where cations A/B occupy the corner and center of the cell, respectively, and oxygen is located at the faces of the unit cell. Proper choice of A/B site cations with different oxidation states, ionic radii, and coordination numbers can bring rich and novel physical properties such as ferroelectric, magnetic, catalytic properties and electrical, ionic conductivities. Here, in this talk, from a computational point of view, I will briefly introduce desired materials properties necessary for energy-related applications, and new findings related to the perovskite materials and their energy-related applications will be presented and discussed along with recent experimental reports.

Focus: Magnetic van der Waals materials/0421 A8.01

Magnetic van der Waals materials: opportunities and challenges

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Abstract :

There has been a huge increase of interests in two-dimensional van der Waals materials over the past ten years or so. Despite the impressive list of new materials and the novel physics it has come to offer, there is the conspicuous absence of one particular class of materials: magnetic van der Waals systems. It is certainly a sorry status of materials science given the huge impact the magnetic materials have had on both the fundamental understanding and the diverse applications. In this talk, I will identify and illustrate how we might be able to benefit from exploring these so-far neglected materials.

Focus: Magnetic van der Waals materials/0200 A8.02

Raman spectroscopic studies on ordering in atomically thin antiferromagnets

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Abstract :

Magnetism in atomically thin 2-dimensional materials is attracting much interest [1-4] due to its fundamental physics as well as the possibility for application in flexible electronics, etc. Since it is extremely difficult, if not impossible, to measure magnetic susceptibility of atomically thin materials directly, a number of measurement techniques are used. For ferromagnetic materials, high-precision magneto-optical Kerr effect measurements have been successful [3,4]. For antiferromagnets, no direct measurement is possible, and Raman spectroscopy has emerged as the most reliable experimental technique [1,2]. In this talk, I will review our recent Raman spectroscopic work on 2-dimensional antiferromagnets. In particular, I will first review the observation of antiferromagnetic ordering in $FePS_3$, which is an Ising-type antiferromagnet. I will then report more recent data on $NiPS_3$, which is an XXZ-type antiferromagnetic material.

[1] X. Wang, et al., 2D Materials 3, 31009 (2016).

[2] J.-U. Lee, et al., Nano Letters 16, 7433 (2016).

[3] C. Gong, et al., Nature 546, 265 (2017).

[4] B. Huang, et al., Nature 546, 270 (2017).

Focus: Magnetic van der Waals materials/0857 A8.03

Anisotropy-controlled long-range order in ultrathin ferromagnetic van der Waals metals

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Abstract :

We report that an Ising-type ferromagnetic (FM) van der Waals (vdW) material Fe_3GeTe_2 hosts the large anomalous Hall current and the long-range itinerant ferromagnetism in nano-meter-thick crystals. The stability of the FM long-range order in ultrathin crystals, measured by the Curie temperature T_c, is found to be highly sensitive to the uniaxial magnetic anisotropy energy, which is dominantly controlled by the surface anisotropy, revealing their two dimensional (2D) nature of ferromagnetism. Thickness tuning of the key parameters for spintronic applications, including conductivity, coercive field, magnetic anisotropy and T_c highlights that ultrathin Fe_3GeTe_2 crystals are a promising spin-source material for 2D spintronics.

Focus: Magnetic van der Waals materials/0501 A8.04

Carrier density and strain tunable magnetism in 2D transition metal chalcogenides

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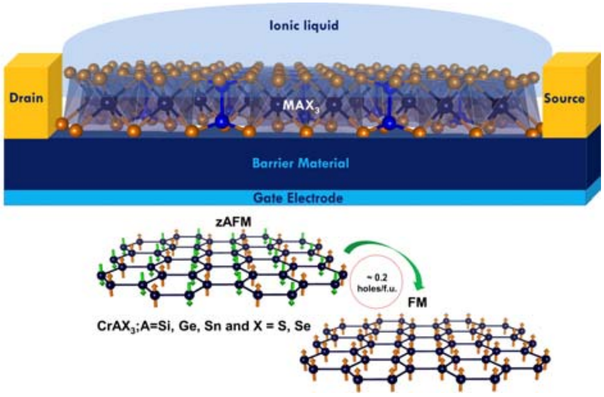
Abstract :



Magnetic order in two dimensional (2D) materials are attractive because they can offer unprecedented electrical and mechanical control of magnetic configurations through gate tunable carrier density and strains. In this presentation I will provide a theoretical survey on the electronic and magnetic properties of 2D MAX_3 (M = transition metal, A = P, Si, Ge, Sn and X = S, Se, Te) chalcogenides to examine their potential role as single-layer van der Waals materials that possess magnetic order. Our *ab initio* calculations predict that magnetism and electronic structure in these materials exist in a variety of forms of interest for potential spintronics device applications. The phase transition boundary from antiferromagnetic to ferromagnetic phases can be substantially influenced by gating or by strain engineering. The sensitive interdependence we find between magnetic, structural, and electronic properties establishes the potential of this 2D materials class for applications in spintronics, suggesting pathways for controlling the magnetic configurations and their critical temperatures by tuning system parameters such as the carrier density and strains.

Focus: Magnetic van der Waals materials/1131 A8.05

Charge-spin correlation in van der Waals antiferromagnet NiPS3

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Abstract :

Strong charge-spin coupling is found in a layered transition-metal trichalcogenide NiPS3, a van derWaals antiferromagnet, from our study of the electronic structure using several experimental and theoretical tools: spectroscopic ellipsometry, x-ray absorption and photoemission spectroscopy, and density-functional calculations. NiPS3 displays an anomalous shift in the optical spectral weight at the magnetic ordering temperature, re ecting a strong coupling between the electronic and magnetic structures. X-ray absorption, photoemission and optical spectra support a self-doped ground state in NiPS3. Our work demonstrates that layered transition-metal trichalcogenide magnets are a useful candidate for the study of correlated-electron physics in two-dimensional magnetic material.

Focus: Superconductivity in low-dimensional materials and systems/0486 A9.01

Macroscopic Quantum Tunneling in Superconducting Junctions of beta-Ag_2Se Topological Insulator Nanowire

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Abstract :

We report on the fabrication and electrical transport properties of strongly coupled nanohybrid superconducting junctions made of beta-Ag_2Se topological insulator (TI) nanowires [1]. The maximum supercurrent density is about 1.2×10^5 A/cm^2, which is similar to a superconducting junction made of PbS semiconductor nanowire [2]. Temperature dependence of the critical current indicates that the superconducting junction belongs to a short and diffusive junction regime. The critical current decreases monotonously with increasing magnetic field, which is a characteristic feature of the narrow junction. The strong superconducting coupling strength enables us to observe the macroscopic quantum tunneling behavior of the switching current distribution below T = 0.8 K [3]. These results indicate that TI nanoribbon-based superconducting junctions would be a promising building block for the development of nanohybrid superconducting quantum information devices.

[1] J. Kim et al., ACS Nano **10**, 3936 (2016); [2] B.-K. Kim et al., ACS Nano **11**, 221 (2017); [3] J. Kim et al., arXiv:1708.06041 (2017).

Focus: Superconductivity in low-dimensional materials and systems/0435 A9.02

Superconductivity in Te-deficient polymorphic $MoTe_{2-x}$ and its derivatives: Rich structural and electronic phase transitions

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Abstract :

Two-dimensional (2D) transition metal dichalcogenides (TMDs) have received great attentions because of diverse quantum electronic states such as topological insulating (TI), Weyl semimetallic (WSM) and superconducting states. Recently, the superconducting states emerged in pressurized semimetallic TMDs such as $MoTe_2$ and WTe_2 have become one of the central issues due to their predicted WSM states. However, the difficulty in synthetic control of chalcogen vacancies and the ambiguous magneto transport properties have hindered the rigorous study on superconducting and WSM states. In this talk, our recent report on the emergence of superconductivity at 2.1 K in Te-deficient orthorhombic T_d-$MoTe_{2-x}$ with an intrinsic electron-doping will be introduced. Further, we synthesized Te-deficient polycrystals of semimetallic $MoTe_{2-x}$ and its derivatives ($Mo_{1-x}TM_xTe_{2-y}Ch_y$ where TMs are Nb, Mn or V, Ch is P), and investigated the structural and electronic phase transitions. It was found that all Te-deficient semimetallic phases (orthorhombic T_d, hexagonal 2H and rhombohedral 3R) exhibited the superconducting transition, in which hexagonal 2H and rhombohedral 3R structures were evolved in heavily Nb-substituted $Mo_{1-x}Nb_xTe_{2-y}$ (X=0.4 for 2H, 0.6 for 3R). The details of superconducting phase diagram along with structural phase diagram will be discussed.

Pressure and chemical tuning of charge density wave and superconductivity competition in multiband superconductors 2*H*-Pd_xTaSe_2

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Abstract :

We have investigated the hydrostatic pressure dependence of in-plane resistivity in the 2*H*-Pd_xTaSe_2 single crystals (intercalation ratios x = 0.03 and 0.05) up to 8 GPa with a hybrid piston cylinder cell and a cubic anvil cell. of x = 0.03 exhibits signatures of an incommensurate charge density wave (ICDW) order at 117 K and a commensurate charge density wave (CCDW) order at 91 K, and superconductivity at T_c =~2.14 K whereas for x = 0.05 [1], only shows a superconducting transition at T_c =~3.23 K. For the x = 0.03 crystal, pressure weakly suppresses the ICDW order by a rate of 2.2 K/GPa while the CCDW state is suppressed more rapidly by a rate of 7.6 K/GPa. Moreover, superconductivity is found to increase linearly from 2.14 K at 0 GPa to 2.74 K at 1.82 GPa (dT_c/dP = 0.33 K/GPa), clearly pointing out competition between the CCDW and superconductivity. In case of x = 0.05, T_c is found to increase linearly from 3.02 K at 0 GPa up to 5.01 K at 8 GPa (dT_c/dP = 0.25 K/GPa). These steep and almost linearly increasing superconducting transitions with pressure suggest that increased interlayer coupling should be effective in stabilizing superconductivity and simultaneously weakening the CCDW order in 2*H*-Pd_xTaSe_2. We also provide systematic experimental data from thermal conductivity, upper critical fields, and penetration depth that support the superconductivity in 2*H*-Pd_xTaSe_2 has the multiband character. [2]

[1] D. Bhoi, S. Khim, W. Nam, B. S. Lee, Chanhee Kim, B.-G. Jeon, B. H. Min, S. Park, Kee Hoon Kim, Scientific reports 6 (2016) 24068.

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Focus: Nano/mesoscopic system, graphene and topological materials/1076 A10.01

Dirac-Fermion Optics in Ballistic Graphene

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Abstract :

Ever since discovered, graphene has brought in high-energy relativistic quantum mechanics to low-energy condensed matter system. Exploiting its unique relativistic characters and electrostatic tunability, ballistic graphene has a great potential leading us to novel electronic optical quantum devices. When electrons tunnel *p*-*n* barriers, which is termed by Klein tunneling, they exhibit negative refraction in order to conserve their pseudo-spins. With this phenomenon, Veselago's lens was demonstrated by using two sharp *p*-*n* barriers in series. We also demonstrated a quantum switch based on Dirac-fermion optics, where the angle dependence of Klein tunneling is utilized to realize optical analogies of collimators and mirrors. Through systematic measurements, we isolate the net optical contribution and extract a full set of transmission coefficient, demonstrating clear evidences of Dirac fermions' optical characteristics. We observed an on/off ratio of ~ 6 due to the absence of energy gaps, however at the same time we have demonstrated its notable robustness against temperature and bias fluctuations. The reported work offers a new platform for graphene based electron-optical device, leading us toward advanced researches involving additional numbers of optical components, such as Dirac-fermion interferometers.

Focus: Nano/mesoscopic system, graphene and topological materials/0127 A10.02

Valley magnetoelectricity in MoS_2 through tuning the crystal symmetry

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Abstract :

In two dimensional honeycomb lattices with broken inversion symmetry (BIS), a quantum degree of freedom of electrons, called valley, emerges. The valley degree of freedom in these lattices is binary which is indexed as K and K' points in momentum space. By introducing different electron distribution about K and K' points, valley orbital magnetization can be generated. The unique control of valley magnetization by external fields is not only fundamentally interesting, but may also find applications in valley-based electronic and logic devices. In this talk, we discuss methods to generate valley magnetization in MoS_2, a prototype of honeycomb lattices with BIS. First, we describe the valley magnetization generated at the channel edges in monolayer MoS_2 through the valley Hall effect. We use Kerr rotation microscopy to directly image valley magnetization. Second, we apply strain to monolayer MoS_2 to break the crystal's 3-fold rotational symmetry which leads to the generation of valley magnetization on the entire channel. The observed magnetization switches the sign when the in-plane bias direction flips and the magnitude scales with the amount of channel current. We discuss the dependence of the observed magnetization on bias, gate, strain direction, and external magnetic fields.

Focus: Nano/mesoscopic system, graphene and topological materials/1180 A10.03

Spatial-Temporal Imaging of Pure Spin-Valley Current in Transition Metal Dichalcogenides Heterostructures

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Abstract :

Transition metal dichalcogenide (TMDC) materials are promising for spintronic and valleytronic applications. Similar to charge current in electronics, pure spin and valley current can play a central role in device applications. Here we demonstrate efficient generation of pure and locked spin-valley current in TMDC heterostructures without any driving electric field. We further directly image the dynamic propagation of valley current in real time and real space by means of space-and-time-resolved pump-probe spectroscopy. The valley current in the heterostructures can propagate over 20 um, and its generation efficiency is orders of magnitude higher than that obtained through the valley Hall effect. In addition, the valley carrier lifetime and valley current diffusion length can be controlled through electrostatic gating. The high efficiency and electric-field-free generation of locked spin-valley current in TMDC heterostructures holds promise for new types of spin and valley devices.

Nuclear fusion(C)/0362 A11.01

The High Performance KSTAR Experiments and Heating and Current Drive

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Abstract :

An auxiliary heating and current drive (HnCD) in tokamak is an indispensable to high pressure long pulse plasma operation. Various high performance plasmas such as ITB, high betaP, and fully steady-state in long pulse KSTAR discharges have been achieved through the elaborated control of NBI and EC HnCD. Besides the growing understanding of the tokamak plasma physics and the tokamak engineering, matured technology in high power HnCD has enabled the high performance plasma discharges. Encouraged on these successful experiences, additional heating powers are being prepared focusing on the HnCD profile control and instability control. The controllability will increase accessibility to advanced tokamak regime such as high-li, low-q, and reverse shear plasma through q-/pressure profile control, and suppressing instabilities limiting the sustainment of the advanced discharges. For the further enhancement of net driving current and q-profile control, advanced current drive schemes are being developed. A passive-active-multi-junction LHCD antenna which would be compatible with high density plasma will be tested in KSTAR targeting ultimately 4 MW power. The HFS or top launch LHCD is also being studied to be tested in KSTAR to deal with the requirements at further higher density plasma. The helicon CD (HCD) is another subject which is being studied for efficient CD at the mid-radius of high density plasma. Preceding experiments and analysis show that the helicon wave coupling at KSTAR plasma is highly viable.

Nuclear fusion(C)/0301 A11.02

Status of ITER Project and Activities of KO Procurements

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Abstract :

ITER project is the international multi-billion dollars project to build the world-largest Tokamak fusion experimental device in the south of France, which is aiming to prove that fusion could solve our energy needs by generating electricity from water with no carbon dioxide emissions. This presentation introduces overall status of ITER project including various construction activities. As a contributing member country, Korean domestic agency (KO-DA) is responsible for procurement of key components such as TF conductors, vacuum vessels and its ports, blanket shield blocks, thermal shields, assembly tools, coil power supplies, tritium storage and delivery system, diagnostic systems. The status and recent activities of KO procurements will be presented.

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*This research was supported by the National R&D Program through the National Research Foundation of Korea funded by the Ministry of Science and ICT & Ministry of Knowledge Economy.

Nuclear fusion(C)/1025 A11.03

Exploration of Hybrid Scenarios in KSTAR

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Abstract :

Here, we report the status of hybrid scenario development in KSTAR [1]. The hybrid scenario in KSTAR is defined as discharges exhibiting higher performance than standard H-mode, H_{89} > 1.9, β_N > 2.2 sustained more than 5*τ_E at q_{95} < 6.5 without or with mild sawtooth where the sawtooth activity is inherently present. The four experimental approaches to access this regime are introduced and their characteristics are classified according to the MHD activities such as fishbones and neoclassical tearing modes. The origin of the confinement enhancement is studied in terms of the plasma rotation, fluctuation characteristics, and edge pedestal. The role of the plasma rotation is found to be small in experiments where electron cyclotron heating or non-resonant magnetic perturbation is applied to reduce the toroidal rotation. The turbulence property is investigated by using fluctuaton measurements and the gyrokinetic simulations by comparing the high and the low performance phase. The pedestal structure is evaluated and its enhancement is found to be the main reason for the confinement improvement in KSTAR hybrid scenarios.

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Nuclear fusion(C)/0789 A11.04

디버터 냉각성능 향상을 위한 전산유체역학 기반 형상최적화 및 3D 프린팅 활용 연구

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Abstract :

핵융합로 디버터의 안정적인 냉각을 위해서는 10-20 MW/m2 수준의 고열부하 냉각 기술이 필요하다. ITER 디버터의 경우 단면으로 입사하는 고열부하의 냉각을 위해 twisted tape 이 삽입된 냉각유로를 채택하고 있으나 과도한 압력손실이 발생한다는 단점을 가진다. 본 연구는 현재 디버터 설계의 단점을 보완하고 냉각성능을 향상시키기 위하여 전산유체역학 기반의 형상최적화 기법을 활용하여 최적의 3 차원 유로형상을 설계하고, 3D 프린팅을 이용하여 모형을 제작한 뒤 실험적으로 냉각성능을 검증하는 것을 목표로 한다.

형상최적화를 이용한 3 차원 냉각유로 설계는 단면 가열에 의해 발생하는 냉각유로의 열유속 집중 현상 완화를 위한 냉각유로 단면 형상과 임계열유속 향상 및 압력손실 감소를 위한 내부 유동구조물 형상으로 세분화하여 수행하였다. 첫째, 기존 디버터에서 채택한 원형 냉각유로에서 발생하는 열유속 집중 현상을 완화하기 위해 형상최적화 기법을 활용하여 타원형으로 변형된 냉각유로 형상을 도출하였으며, 그 결과 50% 가량의 열유속 집중 완화 효과를 얻었다. 둘째, 기존 twisted tape 의 중심에 자유유동이 가능한 빈 공간을 배치하고 열전달 벽면 근처에서는 회전유동에 의한 임계열유속 향상 원리가 유지되도록 하는 rail-type twisted tape 개념을 제안하였다. 제안된 설계 개념에 대해 형상최적화 기법을 적용하여 압력손실과 열전달 측면에서 최적인 구조를 결정하였다.

설계 결과의 성능을 검증하기 위해 rail-type twisted tape 이 삽입된 냉각유로 모형을 금속 3D 프린팅으로 제작하여 열전달 및 압력강하를 측정하는 실험을 수행 중이며, 핵융합 디버터 적용 시 냉각성능 검증을 위해 모노블록 형태의 모형을 제작하여 단면가열 고열부하 시험을 수행할 계획이다.

“ 이 논문은 2017 년도 정부(미래창조과학부)의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구 사업임(No. 2015M1A7A1A01002426).”

Focus: Organic materials and devices/0118 A12.01

Multi-Functional Organic Field Effect Transistors: Control of Ferroelectricity of P(VDF-TrFE) Copolymer via Photocrosslinking

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Abstract :

The recent technological development demands new concepts of organic electronic devices including light emitting diodes, photovoltaic cells, sensors, field effect transistors and non-volatile memory devices. [1-5] Due to solution processability of organic materials such as spin-coating and various printing techniques, use of organic materials granted the prominent advantages including low cost, high throughput production, vertical stackability and facile fabrication at low temperature on diverse substrates. [6-7] According to the demand of the new concepts of organic electronic devices, organic field-effect transistors (OFETs) have been considered as a basic platform for multifunctional electronic applications such as detection, data storage or light illumination. There has been negligible reports on use of intrinsic switching function from the multi-functional OFETs.

Here, we report new type of the multi-functional OFETs by modulating ferroelectric property of the dielectric layer of the OFETs. The ferroelectric properties of P(VDF-TrFE) were systematically controlled by the photocrosslinker contents and gate bias of the device. They exhibited not only a stable operation as the switching transistors with negligible hysteresis, but also a non-volatile memory function with clockwise hysteresis by applying high writing/erasing voltages. PMOS depletion load inverters were demonstrated with a series connection of two multi-functional OFETs. In addition, we will discuss the first demonstration of wearable intelligent device based on a free-standing ferroelectric organic neuromorphic transistors (FONTs) platform.

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Focus: Organic materials and devices/0081 A12.02

Optoelectronics using quantum-dots for transparent electronics

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Abstract :

This talk will focus to introduce a new type of optoelectronics based on nanomaterials, such as quantum-dots and metal nanoparticles. These kinds of optoelectronics are considered as an emerging science and technology due to the potential applications including transparent and soft interactive devices. During the presentation, the interfacial physics of quantum-dots light emitting diodes(QLEDs) will be considered as well as the fabrication process of red, green, and blue QLEDs. In addition, a method to fabricated transparent photosensors, which can be perfectly turned on and off by a visible light, based on quantum-dots and metal nanoparticles will be discussed in detail. The measurements and analysis of interfacial electronic structure of the device will be introduced in detail as well.

Focus: Organic materials and devices/0033 A12.03

Solution-Processed Tantalum Pentoxide for Low-Power Electronic Devices

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Abstract :

The progress of solution-processed field effect transistors (FETs) based on organic and inorganic materials over the last two decades has demonstrated the significant development in these technologies. However, solution-processed FETs generally require absurdly high voltages to switch on and off, which precludes their application in low-cost, hand-held devices and confounds their integration with standard logic circuitry. In this manuscript, we demonstrate a universal and environmentally friendly solution-processing method for the preparation of tantalum pentoxide (Ta_2O_5) amorphous dielectric thin films and extend the method to hafnium dioxide (HfO_2) and zirconium dioxide (ZrO_2) thin films as well. High mobility CdS FETs were fabricated on such high-κ dielectric substrates entirely via solution-processing. The highest mobility, 2.97 $cm^2\ V^{-1}\ s^{-1}$ was achieved in the device utilizing Ta_2O_5 as a dielectric with a low threshold voltage of 1.00 V, which was higher than the mobility of the reference CdS FET with SiO_2 dielectric with an order of magnitude decrease in threshold voltage as well. Because these FETs can be operated at less than 5 V, they may potentially be integrated with existing logic and display circuitry without significant signal amplification. This report marks the first demonstration of high-mobility FETs using solution-processed Ta_2O_5 dielectrics with drastically reduced power consumption; ~95% reduction compared to that of the device with conventional SiO_2 gate dielectric.

Organic electronics and photonics(E)/0445 A12.04

Interfacial tunneling barrier modulation governed by molecular tilt configuration and van der Waals interaction in graphene/oligophneylene thiol/Au junction

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Abstract :

In the field of molecular electronics, understanding the charge transport of a molecular junction that significantly depends on electrode-molecule interface and molecular conformations is one of the primary challenges.[1-4] Here, we fabricated a molecular junction consisting of an Au-tip/oligophenylene thiols (OPT)/graphene structure stacked on an Au/SiO_2/Si substrate using a conductive atomic force microscopy (CAFM) technique, and investigated the electrical tunneling properties depending on the interfacial barrier height that can be modulated by a controlled loading force (F_L) of Au tip and van der Waals interaction between molecules. In order to estimate the interfacial barrier height defining as the difference between a nearest molecular orbital level and the Fermi level of electrodes, we employed the transition voltage spectroscopy (TVS) method and experimentally found each transition voltage (V_T) in both voltage polarities when different F_L was applied. A noteworthy phenomenon of V_T behaviors is that they have two-distinct features according to the dependence of applied F_L (i.e. F_L-dependent and F_L-independent V_T regime) regardless of the voltage polarities. We believe that this result is originated from the correlated effects between the molecular-tilt configuration and van der Waals interaction that can significantly affect the interfacial barrier height.

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Organic electronics and photonics(E)/0735 A12.05

Effect of counterions on interfacial dipoles in nonconjugated polyelectrolytes

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Abstract :

In this work, we have devised a new material that can be used as an interfacial layer to improve the energy efficiency of organic solar cells. We will proceed with the study of the physical properties, finally, combine them with the application elements and try to know the possibility of its utilization. In order to simplify the production method of organic solar cells, a solution process method is introduced, We have selected a polymer electrolyte capable of producing an electronic device having a multilayer structure through the regulation of the polarity of the organic/inorganic solvent. In addition, we introduced a simple synthesis method, developed a new material with various counterions of the nonconjugated polyelectrolyte (NPE), and performed a basic physical property analysis. Moreover, we confirmed the possibility of using it by combining with electronic devices. The results of this study show that the energy conversion efficiency of solar cells increases with the use of a new nonconjugated polyelectrolyte.

Organic electronics and photonics(E)/0407 A12.06

Improved Performance in N-Type Organic Field-Effect Transistors via Polyelectrolyte Mediated Interfacial Doping

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Abstract :

To enhance electron injection in n-type organic field-effect transistors (OFETs), non-conjugated polyelectrolyte (NPE) layers are interposed between a [6,6]-phenyl-C_{61}-butyric acid methyl ester (PCBM) layer and Au electrodes. A series of NPEs based on an ethoxylated polyethylenimine (PEIE) backbone with various counterions including Cl^-, Br^- and I^- improve electron mobilities up to ~10^{-2} $cm^2V^{-1}s^{-1}$ and yield on-off ratios (I_{on}/I_{off}) of 10^5 in PCBM OFETs. Ultraviolet photoelectron spectroscopy (UPS) reveals that all of the NPEs lead to reduced electron injection barriers (ϕ_e) at the NPE/metal interface; this reduction in ϕ_e is consistent with dipole formation or n-type doping at the electrode interface. Absorption measurements of PCBM films treated with NPEs are consistent with n-doping of the PCBM. Regardless of the type of anion, thick NPE layers led to high conductivity in the films independent of gate bias, whereas thin NPE layers led to dramatically improved electron injection and performance. These results demonstrate that thin polyelectrolyte layers can be used to achieve controlled interfacial doping in organic semiconductors. Furthermore, this study provides valuable information about the function of NPEs, which may be exploited to improve device performance and to design new materials for future use in optoelectronic devices.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0044 A13.01

Exploring interplay between electron-electron and spin-orbit interactions with x-ray resonant scattering and spectroscopy

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Abstract :

Strong electron correlations in 3d metal oxides and spin-orbit interactions in 5d metal oxides can give rise to exotic electronic and magnetic properties. Here, emerging phenomena at the interface between $SrIrO_3$ (SIO) and $La_{2/3}Sr_{1/3}MnO_3$ (LSMO) are investigated. Structural compatibility of the SIO and LSMO perovskite structures allows well-controlled interlayer octahedral coupling between the dissimilar 3d and 5d oxide layers. Nominally, SIO with strong spin-orbit interaction is metallic and nonmagnetic on the verge of a metal-insulator transition, whereas LSMO is metallic and ferromagnetic with itinerant character and high spin polarization. In LSMO/SIO superlattice structure, we observe ferromagnetic Mn moments with an insulating behavior, accompanied by antiferromagnetic ordering in SIO. Element-resolved x-ray magnetic circular dichroism measurements prove that there is a weak net ferromagnetic Ir moment aligned antiparallel to the Mn counterpart. The branching ratio shows the molecular-orbital forming between the Mn and Ir layers without charge transfer modifies the 5d electronic configuration from J_{eff} = 1/2. In addition, Ir magnetic moment directions appear to be pointing mostly [100] direction with high magnetic anisotropy. The result demonstrates a pathway to manipulate the 5d oxide by digitally doping with 3d oxide layers novel phases.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0049 A13.02

Soft X-ray Applications for Exploring Quantum materials

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Abstract :

One of the most challenging extant issues in materials science is the search for post-silicon based electronics. In this context, exotic phenomena on quantum materials offer hopes that new classes of functionality can be developed out of these intriguing phenomena via the strongly correlated interactions between their degrees of freedom such as spin, orbital, charge and lattice. Concurrently, the underlying understandings of such exotic phenomena could provide key information that is at the core for overcoming such challenging. In this sense, I would like to introduce a few examples on quantum materials in this talk, which were explored by soft X-ray applications (scattering and spectroscopy) at both synchrotron and free electron laser (FEL). Meantime, with the examples I will also introduce why the soft x-ray demonstration is not only powerful, but also necessary for the fundamental understanding of quantum materials.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0043 A13.03

Magnetic/electronic transitions probed with polarization dependent x-ray spectroscopy

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Abstract :

The linear and circular polarization dependence in x-ray absorption spectroscopy enables studies of electronic and magnetic transitions in an element- and orbital-sensitive way. In this talk I will present studies of materials with magnetic/electronic transitions using x-ray magnetic circular dichroism and linear dichroism. In combination with structural characterization using x-ray resonant scattering, the polarization dependent x-ray spectroscopy provides a valuable tool to study the interplay between structural, magnetic, and electronic responses at phase transitions.

A combination of x-ray scattering and magnetic circular dichroism allowed studying the magneto-structural transition in thin films with unprecedented detail. The temperature evolution of structure and magnetism were measured simultaneously, providing a unique view of the interplay between structure and magnetism across the phase transition. Hetero-structured thin films provide a fertile ground to study emergent interfacial behaviors as structurally compatible materials with different properties are forced to coexist in a well-defined two dimensional structure. In transition-metal-oxide thin films, x-ray linear dichroism provided valuable insight into the link between structural distortion and electronic response.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/1138 A13.04

In-situ observation of switchable low energy geometric ferroelectric domains

OH Yoon Seok[*1,2,3], HU Rongwei[2,3], JEON Young Hoon[4], HUANG Fei-Ting[2,3], CHEONG Sang-Wook[2,3,4]

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Abstract :

Geometric ferroelectrics are called as improper ferroelectrics where geometric structural constraints, rather than typical cation-anion pairing, induce proper ferroelectric polarization. Among the geometric structural distortion, trimerization of MnO_5 bipyramids in hexagonal manganites induces intriguing multiferroicity such as topological vortex-antivortex, angle dependent conducting domain walls, enhanced magnetoelectric coupling at domain walls, etc. The ferroelectric transition induced by incorporation of trimerization and ferroelectricity occurs at very high temperature 1120 – 1435 C in hexagonal RMnO$_3$ (R=Ho, Er, Yb, Lu, Y). Because of the high transition temperature, it has been unavailable to study thermodynamic behavior of trimerization and polarization. Here, we introduce a switchable low energy geometric ferroelectric compound and present in-situ x-ray diffraction in structural and polarization evolution near the transition temperature of the improper ferroelectric in order to clearly understand the fundamental thermodynamics of improper ferroelectric correlated with trimerization and polarization.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/1137 A13.05

Time-resolved x-ray diffraction study for measuring photo-induced lattice movements in picosecond to microsecond time scale.

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Abstract :

Light absorption in optically opaque materials such as semiconductors leads to rapid generation and propagation of free carriers and heat from surface to bulk. The process occurs via various pathways, such as electron-electron scattering, electron-phonon scattering, radiation and non-radiation recombination processes until the lattice returns to its equilibrium state. Previously, such light-matter interaction has been mostly studied with optical probe that is primarily sensitive to the surface properties of the materials. And thus, rich dynamics taking place in bulk or at interfaces still remain mostly unknown. In this work, we demonstrate how time-resolved x-ray diffraction methods can be used to directly probe these transient phenomena that take place at surface, bulk and as well as at various heterogeneous interfaces. In particular, we show that femtometer spatial resolution and picosecond resolution can be utilized to correctly measure important material properties such as carrier and thermal diffusion, which deviate from previously expected values.

Focus: Introduction to mathematical biology/0335 A14.01

Mathematical modeling in the immune systems

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Abstract :

In the talk, we discuss how chemotaxis affects the immune system by proposing a minimal mathematical model, a reaction-diffusion-advection system, describing a cross-talk between antigens and immune cells via chemokines. We analyze the stability and instability arising in the chemotaxis model, find their conditions for different chemotactic strengths and numerical simulations are also performed to the model. From the analytical and numerical results for our model, we explain not only the effective attraction of immune cells toward the site of infection, but also hypersensitivity when chemotactic strength is greater than some threshold.

Focus: Introduction to mathematical biology/0189 A14.02

수학이 생물학을 만나면 ?

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Abstract :

21 세기는 생명과학의 시대이다. 생명과학에서의 두 가지 화두는 인간이 건강하게 오래 사는 것과 교란에도 불구하고 지구의 생태계가 지속적으로 안정된 상태를 유지하는 것이다.

본 강연에서는 생물학에 수학이 어떻게 접목되는지를 실제의 사례들을 가지고 살펴보고자 한다. 그래서 수학이 생물학과 만나면 보다 합리적이고 유용한 정보들을 도출할 수 있고, 수학의 타 학문분야로의 적용 가능성이 무한하다는 것을 이해시키고자 한다.

이를 위하여 먼저 주요 전문용어들을 소개하고, 수학이 생물학에 적용되는 여러 사례를 수학모델을 중심으로 제시하고자 한다. 특별히 20 세기 초반에 시작된 이런 연구를 수행하는 학문을 통합하여 수리생물학으로 분류되었고, 현재 많은 학자들이 참여하여 이론과 그 응용의 폭과 깊이를 넓혀가고 있다.

마지막으로 생물학에서 사용되는 수학모델에서의 몇 가지 고찰할 점들을 살펴보고자 한다.

Focus: Introduction to mathematical biology/0530 A14.03

Quantum effects in photosynthetic pigment-protein complexes

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Abstract :

In plants and photosynthetic bacteria, light absorption by pigments creates molecular electronic excitations (excitons), which are transferred through pigment-networks to reaction centres where electron transfer occurs. These initial steps of photosynthetic energy transport ultimately result in the conversion of light energy to chemical energy. Recent advances in experimental techniques have revealed the energy transfer pathways and timescales of photosynthetic pigment-networks and demonstrated the presence of quantum-coherent effects in transport dynamics, which provide sufficient information to develop detailed theoretical modelling [1]. In this talk, I will introduce the concept of open quantum systems [2], which allows one to describe the interaction between electronic states of pigments and their vibrational environments using the language of quantum mechanics. Then, I will present an experimental-theoretical study [3] where experimental observations can be quantitatively explained by a model [4], while alternative models [5] can be excluded based on detailed theoretical analysis. Finally, I will present a recent work on organic solar cells [6] where the theory originally proposed to describe biological systems [3,4] explains the origin of ultrafast charge separation in artificial systems. References: [1] S. F. Huelga and M. B. Plenio, Contemporary Physics 54, 181 (2013). [2] H.-P. Breuer and F. Petruccione, The Theory of Open Quantum Systems (Oxford University Press, 2002). [3] J. Lim et al, Nature Communications 6, 7755 (2015). [4] A. W. Chin et al, Nature Physics 9, 113 (2013). [5] H. Lee et al, Science 316, 1462 (2007). [6] A. De Sio et al, Nature Communications 7, 13742 (2016).

Non-accelerator-based particle physics experiments(D)/0371 B1.01

Production rates of 8Li/9He at RENO

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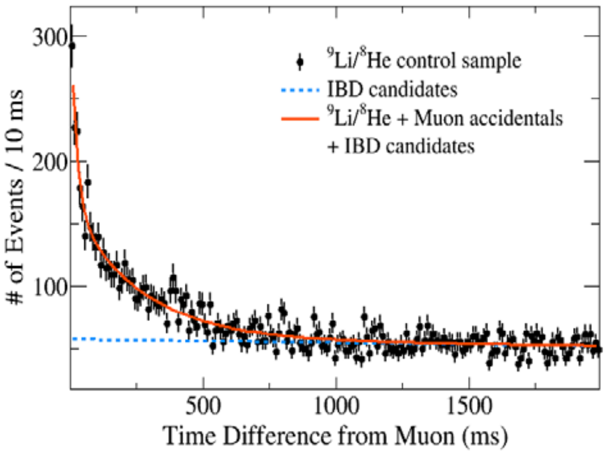
Abstract :



High energy cosmic muons produce unstable isotopes of 9Li/8He that mimic reactor neutrino candidate events in the RENO detector.They are one of the most serious background component in the reactor neutrino oscillation measurement. The background shape is measured using a control sample that is obtained from close time association between a reactor neutrino candidate and its a preceding energetic muon. The 9Li/8He production rate is estimated by extrapolating from the background dominant region (8 ~ 12 MeV) by a fit to an observed reactor candidate spectrum using the measured 9Li/8He backgrounf spectral shape.In this talk, we present the method of reducing the background and the measured production rate of 9Li/8He in the RENO detector.

Non-accelerator-based particle physics experiments(D)/0286 B1.02

Theta13 measurement of using neutron captures on hydrogen at RENO

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Abstract :

RENO has been taking data since August, 2011 and successfully measured the smallest neutrino mixing angle, theta13. The measurement results were published based on the observed reactor neutrino events with neutron captures on gadolinium (n-Gd) in the target detector region. In addition, RENO has successfully measured the mixing angle from an independent sample with neutron captures on hydrogen (n-H). Due to a large accidental background in the n-H data sample, the analysis requires additional reduction of backgrounds. This independent measurement provides a valuable systematic cross-check of the theta13 measurement using the n-Gd sample. In this talk, the results from the n-H analysis using the 1400 days of data sample will be presented.

Non-accelerator-based particle physics experiments(D)/0545 B1.03

Precise measurement of theta13 and dm^2 at RENO

김우영 [1], Serguey[1], 박명렬 [2], 최준호 [2], 장한일 [3], 권은향 [4], 김상용 [4], 김수봉[*4], 서선희 [4], 서현관 [4], 양정열 [4], 이동하 [4], 이용창 [4], 이현기 [4], 김종건 [5], 김종현 [5], 유인태 [5], 전상훈 [5], 정다은 [5], Carsten Rott[5], 김재률 [6], 문동호 [6], 박경환 [6], 박영서 [6], 신창동 [6], 임인택 [6], 주경광 [6], 장지승 [6,7], 유종희 [7,8]

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Abstract :

The RENO experiment has measured the neutrino mixing angle θ_13 and dm^2_ee, using reactor antineutrinos from the reactors at Hanbit Nuclear Power Plant since Aug. 2011. In 2016, RENO published results on sin^2(2θ_13) and dm^2_ee using the energy dependent oscillation of reactor antineutrinos in the 500days of data. RENO has accumulated roughly 2000 days of data with reduced backgrounds and thus decreased systematic uncertainties. Due to the improved statistics and systematic uncertainties we measured sin^2(2θ_13) and dm^2_ee more precisely. In this talk we will present new results from the 2000 day data.

Non-accelerator-based particle physics experiments(D)/0394 B1.04

Status of T2HKK/KNO Project

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Abstract :

Hyper-Kamiokande is a future large (260 kton) water Cherenkov detector
to be built in Japan. It is a multi-purpose detector from particle physics using J-PARC neutrino beam
to astroparticle physics such as solar, supernova burst and relic neutrino physics.

The J-PARC neutrino beam also arrives to Korea for free and this gives an wonderful opportunity
for Korea to build a 2nd detector (T2HKK) in a much longer baseline, which will improve physics sensitivities
on neutrino mass ordering, CP violation and non-standard neutrino interactions.
Thanks to large overburden in the Korean candidate sites the astroparticle physics sensitivities
in the Korean Neutrino Observatory (KNO) are also expected to be very good.

In this talk I will give a talk on recent progresses made in T2HKK/KNO.

Accelerator-based particle physics experiments (C)/0923 B1.05

Physics Prospect of Deep Underground Neutrino Experiment (DUNE)

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Abstract :

DUNE is designed to conclude the massive neutrino parameters; mass ordering, CP violating phase and mixing angles. The long-baseline neutrino facility for DUNE consists of far detectors, near detectors, and proton accelerator. Each element of the facility will be installed using the most advanced techniques to maximize the physics potential of the intensity frontier effort. Besides understanding of the three-neutrino masses and mixing parts, proton decays and SN observation at far detector and deep search of neutrino interaction at near detector also are under study in parallel to the detector R&D and construction.

Non-accelerator-based particle physics experiments(D)/0958 B1.06

Progress in Deep Underground Neutrino Experiment (DUNE)

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Abstract :

The R&D and construction of DUNE are making remarkable progress in 2017, which is the third year. Single-phase and dual-phase ProtoDUNE detectors are under assembly at CERN, groundbreaking took place at Sanford Underground Research Facility (SURF), and initial consortia for far detector construction is at work. We will reach a consensus on conceptual design of near detector in this year. The contents of progress and short-term plan will be reported in this talk.

Non-accelerator-based particle physics experiments(D)/0909 B1.07

Direct detection of WIMP wind using Nuclear emulsion

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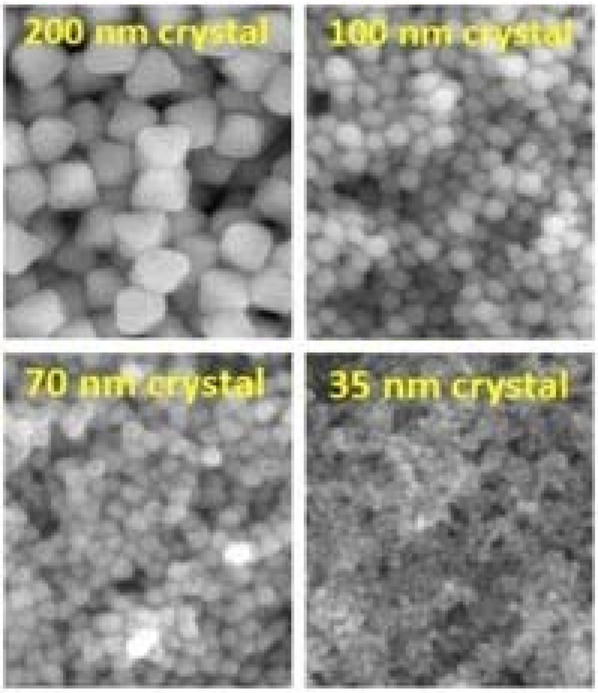
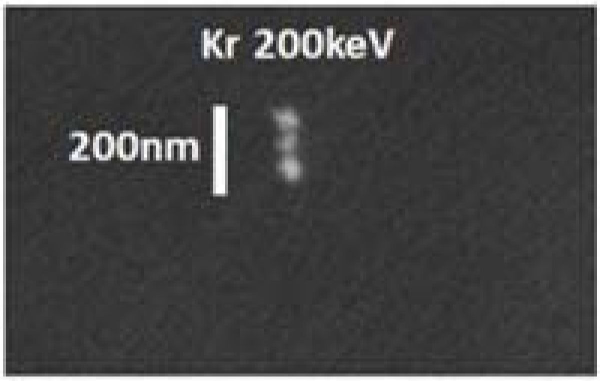
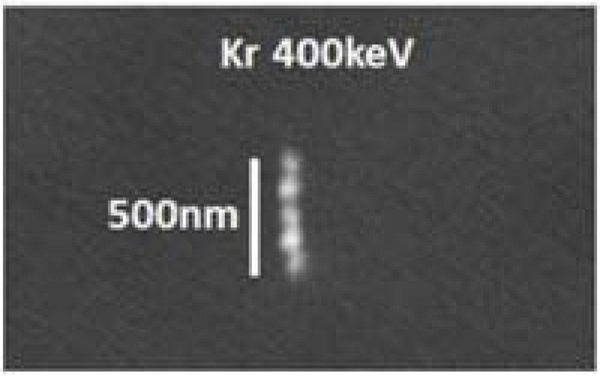
Abstract :

The NEWS-dm (Nuclear Emulsions for WIMP Search-directional measurement) experiment was proposed at Gran Sasso underground laboratory (LNGS) aiming for direct detection of the WIMP wind. Since our solar system moves in the galaxy, the WIMP flux is not isotropic at earth. Therefore directional measurement of the WIMP wind is as a strong signature and unambiguous proof of the galactic DM origin. For this challenge, a new generation nuclear emulsions with nanometric grains, called NIT (Nano Imaging Tracker), have been developed. By using the NIT, we can identify order of 100 nanometer track that is a candidate of WIMP-induced nuclear recoil. Most of the current directional experiments are based on gaseous detector. But this technology is hardly scalable to very large detector masses needed to reach a good sensitivity. The use of a solid target like NIT would overcome the mass limitation thus allowing to reach a high sensitivity in the low cross section region. This kind of newly developed detector capable of measuring the directionality of nuclear recoils would provide an unambiguous identification of WIMP as candidate for the galactic dark matter and could overcome the limit imposed by coherent neutrino scattering. In this talk, R&D of this special emulsion tracker and the current status of NEWS-dm experiment will be introduced.







Particle physics theory(A)/0620 B1.08

Search for Inelastic Boosted Dark Matter

박종철*[1], 김두진 [2], 신서동 [3]

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Abstract :

We propose a new dark matter detection strategy for non-minimal dark sector models. The strategy is to look for relativistic and inelastic scattering signatures of dark matter. An incoming relativistic dark matter particle scatters off to an excited state (if kinematically allowed) which subsequently decays back into dark matter along with lighter states including visible Standard Model particles. The energetic recoil signal of the target particle associated with the secondary decay signature is a very unique feature of this strategy.

Particle physics theory(A)/0204 B1.09

Gauged U(1) Clockwork Theory

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Abstract :

We consider the gauged U(1) clockwork theory with a product of multiple gauge groups and discuss the continuum limit of the theory to a massless gauged U(1) with linear dilaton background in five dimensions. The localization of the lightest state of gauge fields on a site in the theory space naturally leads to exponentially small effective couplings of external matter fields localized away from the site. We discuss the implications of our general discussion with some examples, such as mediators of dark matter interactions, flavor-changing B-meson decays as well as D-term SUSY breaking.

Focus: Frontiers in machine learning and phase transitions/0652 B2.01

Critical data clustering of deep learning

조정효*[1]

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Abstract :

Deep learning shows wide applications for pattern classification and generation. However, it is still poorly understood how it works so well. The usual architecture of deep neural networks has multiple layers of which sizes shrink as layers become deeper from input layer. Thus some patterns in shallower layers propagate into the same pattern in deeper layers. Therefore, one may interpret the coarse graining process of deep learning as data clustering. Using information theory, we found that deep learning made critical data clustering that effectively extracted relevant features from data. Then the critical data clustering most faithfully generated patterns in data. In this talk, I will introduce how information theory contributes to understand the underlying process of deep learning.

Focus: Frontiers in machine learning and phase transitions/0560 B2.02

Study on Phases of Supercritical Fluid using Machine Learning Techniques

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Abstract :

Machine learning technique (MLT) is used to directly classify liquid-like and gas-like particles in SCF. The number fraction of gas-like particles (π_gas) shows a robust sigmoidal dependence on the bulk fluid density, even in the deeply supercritical condition. Moreover, the locus found by MLT agrees with and extends the conventional Widom line, which is well-defined only in the vicinity of the critical point. The new Widom line is clearly distinguished from the Frenkel line, and we partition the supercritical phase diagram into three sub-regions: gas-like, soft-liquid-like and rigid-liquid-like. This result suggests a novel solution to the problem of distinguishing liquid and gas in supercritical phase diagram, and can be widely applied to explain the anomalous nature of inhomogeneous systems.

Focus: Frontiers in machine learning and phase transitions/1186 B2.03

Two local states of ambient water via machine learning classification

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Abstract :

The signature anomaly of water density has long been mystery. It has strongly suggested that the ambient water may be a supercritical fluid phase of liquid-liquid critical point, and local high density water (HDW) and low density water (LDW) may form local micro domains though they are not macroscopically phase separated. In this work, we identify the formation of local micro-domain formations of water attributing its softness by using machine learning order parameters. The microstructures are very fluctuating but clearly contrasts physical properties. Interestingly, water is more affected by the composition of these local structures than thermodynamic relaxations which may be related with the origin of water anomaly.

Focus: Frontiers in machine learning and phase transitions/0852 B2.04

Learning a discontinuous phase transition in the Hubbard model

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Abstract :

Phase transition is a key concept in understanding emergent phenomena occurring in various domains of physical systems. While a numerical approach to phase transitions conventionally depends on how precisely and efficiently treating a system hamiltonian in a given statistical ensemble, recent development of the machine learning has been suggesting a new direction in this problem. We briefly review the recent progresses in the machine-learning-based methodologies as a new tool to study the phase transitions, and we present our own approach on detecting a discontinuous phase transition in a quantum system of the repulsive Hubbard model undergoing the Mott metal-insulator transition. The performances of a support vector machine and a multilayer perceptron are compared, and we find that the multilayer perceptron reconstructs the phase diagram with reasonable accuracy based on the learning sets of the dynamical mean-field theory calculations.

Focus: Current research trends in Attosecond Science and Technology/0203 B5.01

Coherent electronic and non-equilibrium vibrational motions in natural photosynthesis and organic photovoltaics

Lim Jaemin*[1], Huelga Susana F.[1], Plenio Martin B.[1]

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Abstract :

Recent advances in nonlinear spectroscopy have revealed the presence of long-lived quantum coherences in molecular systems. Coherent features observed in two-dimensional electronic spectra of light-harvesting systems, such as photosynthetic complexes and organic solar cells, have demonstrated the possibility that exciton transport and charge separation in these systems are governed by quantum mechanics in a wave-like manner even at room temperature. In this talk, I will introduce the concept of coherent vibronic mechanism that makes coherent electronic motions to be maintained under decohering environments [1]. Then, I will present joint experimental-theoretical studies on macromolecular J-aggregates [2] and conjugated polymers [3] where long-lasting coherences are induced by coherent vibronic mechanism. It will be shown that alternative models can be quantitatively excluded based on experimental data and detailed theoretical analysis, which further clarifies the underlying mechanism behind experimental observations. Finally, I will present a recent work on quantum control where pulse shaping reduces the complexity of nonlinear optical responses of molecular systems significantly [4], which opens up the possibility that coherent light-harvesting process is investigated in a more controlled manner with suppressed vibrational and disorder effects. References: [1] A. W. Chin et al, Nature Physics 9, 113 (2013). [2] J. Lim et al, Nature Communications 6, 7755 (2015). [3] A. De Sio et al, Nature Communications 7, 13742 (2016). [4] J. Lim et al, in preparation (2017).

Cold atoms and molecules(D)/0675 B5.02

Realization of Polarization-synthesized Two-dimensional Optical Lattice of Neutral Atoms

Moon Geol[*1], Stefan Brakhane[1], Gautam Ramola[1], Carsten Robens[1], Wolfgang Alt[1], Dieter Meschede[1], Andrea Alberti[1]

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Abstract :

We report on the experimental realization of a polarization-synthesized two-dimensional square spin-dependent optical lattice as quantum simulator. We demonstrate high-resolution images of single atoms through an objective lens with very high numerical aperture (NA~0.92), which installed inside the home-built ultra-low-birefringence dodecagonal vacuum glass cell [1]. Here we focus on how to develop the system in detail. Our system provides an ideal platform to study the topological features of 2D quantum walk as the simulator of topological phases [2, 3]. Furthermore, controlling the phase accumulated when atoms move from site to site on the 2D lattice permits to realize artificial gauge fields [4].

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Photoionization and photodissociation(B)/1036 B5.03

Carrier-envelope phase dependence of low energy structures in above-threshold ionized electron spectra

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Abstract :

Since the laser field oscillates only a few times in few-cycle laser pulses, the strong field processes such as above threshold ionization (ATI) and high harmonic generation greatly depends on the carrier-envelope phase of the laser pulse. In this work, we focus on the carrier-envelope phase dependence of the low energy structures in the ATI electron spectra obtained from xenon atoms using few-cycle linearly polarized laser pulses. We present that low energy structures in the ATI electron spectra observed in the experiment show the strong dependence on the carrier envelope phase. The numerical results show that the carrier-envelope phase dependence of low energy structures results from an interference between a tunneling-ionized electron and a resonantly ionized electron from Rydberg states.

Quantum optics and quantum information(C)/1049 B5.04

도플러 선폭확대가 있는 원자계에서 생성한 광자쌍을 이용한 이-광자 간섭현상

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Abstract :

본 연구에서는 도플러 선폭확대가 있는 ^{87}Rb 원자계에서 $5S_{1/2}$-$5P_{3/2}$-$5D_{5/2}$ 전이선을 이용하여 780, 776 nm 파장의 시간 상관관계를 가진 광자 쌍을 생성하고 생성된 광자 쌍의 간섭현상을 편광기반 마이켈슨 간섭계를 통하여 확인하였다. 간섭계내에서 광자 쌍이 서로 다른 경로로 진행하는 진동수-얽힘과 서로 같은 경로로 진행하는 경로-얽힘상태, 두가지의 이-광자 상태가 같은 확률로 존재한다. 위상 랜덤화를 통해 위상에 민감한 경로-얽힘 상태를 상쇄시킨뒤 Hong-Ou-Madel(HOM) 간섭을 일으키는 진동수-얽힘 상태의 간섭무늬와, 위상 랜덤화 없이 두가지의 이-광자 상태가 모두 존재할때의 간섭무늬를 측정하였다. 진동수-얽힘에 의한 HOM 간섭의 경우 광자쌍의 4 nm 파장차이에 의해 142 um 의 맥놀이 주기로 간섭무늬가 나타남을 확인하였다. 진동수-얽힘과 경로-얽힘 상태가 모두 간섭에 기여할 경우 경로-얽힘 상태에 의한 진동수합 성분으로 파장의 절반인 390 nm 의 간섭무늬(super resolved fringe)를 측정 하였다. 또한 진동수 필터링을 통해 광검출기로 들어오는 광자를 선택적으로 측정함으로 단일-광자 간섭무늬가 이-광자 간섭무늬에 미치는 영향을 알아 보았다.

Quantum optics and quantum information(C)/0662 B5.05

Doppler-free coherent-control spectroscopy of atomic rubidium fine structures with a colliding pair of shaped ultrafast pulses

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Abstract :

We demonstrate the ultrafast spatial coherent-control method to resolve the fine-structure two-photon transitions of atomic rubidium. The counter-propagating femtosecond pulses with programmed spectral phase and amplitude induced the Doppler-free two-photon transitions through $5S_{1/2}$ - $5P_{1/2}$ - 5D and $5S_{1/2}$ - $5P_{3/2}$ - 5D pathways, forming a specific excitation pattern with constituent transition pathways resolvable in space. Three different spectral phase programming solutions are suggested, corresponding to our strategy for enhancing the spatial excitation probability by counter-propagating pulses, while suppressing the single-side excitation contribution. All three phase solutions are experimentally verified in a good greement with the theory.

Quantum optics and quantum information(C)/0565 B5.06

Site-specific loading and detection of single atom in a 1D optical lattice

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Abstract :

We report on loading a single lithium atom to a specific site of a 1D optical lattice and also on detecting the atom with single-atom precision. Spacing between the nearest sites is 530 nm. For the site-specific minipulation, we apply magnetic field gradient along the lattice to induce site-dependent Zeeman shift for a ground hyperfine transition. We use "magic polarization" to overcome inhomogeneous broadening, which prevented previous efforts from obtaining the nearest-site resolution in loading and detection. We also succeeded in detecting a lattice-bound lithium atom with single atom precision by using only doppler cooling beams All of the previous detection schemes on lithium atoms involved side-band Raman cooling or other complicated cooling, because of the tendency of a light atom such as lithium to boil out of the lattice easily. We will also report coherent manipulation of the lithium qubits toward a quantum information processing.

Quantum optics and quantum information(C)/0535 B5.07

Fabry-Perot Interferometer with a Bilayer Lattices of Low-Temperature Atoms

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Abstract :

Ready access to nanometer-size systems of homogeneously broadened atomic vapors is possible in most recent experiments, which enables one to simulate numerically light-matter interactions at fundamental and microscopic level. We present large-scale simulations of light propagation through a pair of monolayer and identical square lattices with dense atomic populations for a linearly polarized and normally incident driving radiation. We suggest that our bilayer samples might be used for experimentally implementing a Fabry-Perot interferometer. We simulate numerically optical spectra and radiated powers of the bilayer systems with neutral atoms from semiclassical analysis and compare such results to the ones from an isotropic and infinite lattice model, leading to validation of our numerical schemes.

Focus: Quantum ring (growth/characterization/theory)/0346 B6.02

단일 양자링 반도체에서 입자들의 동역학과 비선형 특성

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Abstract :

분화구(volcano) 모양의 단일 양자링 구조에서 전하들의 에너지 준위와 외부 자기장에 대한 주기적인 운동을 기술하여 그에 대한 광학적인 현상들을 연구하였다. 먼저 분화구 모양의 양자링 구조에 대한 전하들의 위치 에너지, V(z(r,Φ))를 계산하고 parabolic potential 근사로 양자링의 에너지 구조를 계산하였다. [1, 2] 광학적으로 생성된 전하들은 쿨롱상호작용으로 인하여 준입자들(엑시톤과 쌍엑시톤)은 다양한 각운동량을 갖는 에너지 준위를 갖게 된다. 준입자의 경우 전하와 홀의 magnetic flux 의 차이로 인하여 Aharonov-Bohm 현상이 관측된다. [3] 이와 같이 외부에서 자기장의 변화를 통해 준입자들은 각운동량의 변화를 갖는 주기적인 현상에 대한 광학적인 특성을 TI-FWM 과 SR-FWM 신호들을 계산함으로써, Aharonov-Bohm 현상으로 인한 양자링의 광학적인 비선형성을 소개하였다.

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Focus: Quantum ring (growth/characterization/theory)/0326 B6.03

Droplet epitaxy for the fabrication of InAs type-II quantum rings on GaSb (100) surface

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Abstract :

In this presentation, we would like to introduce the progress of droplet epitaxy (DE) for the fabrication of InAs quantum ring (QR) structures on lattice matched GaSb (100). The InAs QRs embedded in GaSb matrix have type-II band alignment. During the DE process, the surface reconstructions were discussed by the reflection high-energy electron diffraction (RHEED) results. The structural properties were discussed with the atomic force microscopy (AFM) and scanning electron microscopy (SEM) results. From the results the formation mechanism of surface nanostructures will be discussed. In addition, the InAs/GaSb hetero-interface effects were investigated by photoreflectance (PR) spectroscopy.

Low dimensional nano-materials(F)/0037 B6.04

Optical Aharonov-Bohm Effect in a Single Quantum Ring

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Abstract :

As long as quantum coherence is preserved around a ring structure, the rotating charge was known to give rise to novel physics, the so-called Aharonov-Bohm (AB) effect, which can be manifested in terms of persistent current in a metal ring or conductance oscillation for increasing an external magnetic field in a mesoscopic device based on a quantum point contact. While these electric measurements require extreme low temperature of a few mK, optical version of the AB effect in a semiconductor quantum ring (QR) can be observable near 10 K. Type-II hetero-structure is often used for the optical AB effect as either electron or hole is rotating in the shell with respect to the other in the core structure. However, optical AB effect of a neutral exciton in a single QR still is in debate and analysis is limited to an idealized ring ignoring the asymmetry and anisotropy.

We have clarified the optical AB effect of a neutral exciton in a single quantum ring systematically. We propose failure of the optical AB effects, which were often claimed, is associated with the height anisotropy, which determines either delocalized or localized states along the rim. The presence of the localized states was observed, and explained by the adiabatic potential energy. Under the delocalized condition, clear optical AB oscillations were observed. The period was reproduced theoretically, where the Coulomb interaction, Zeeman effect, and diamagnetic effects are all included.

Pioneer: Oxides for energy application/1182 B7.01

Potential and opportunities in complex oxides for advanced energy technologies

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Abstract :

Complex oxides are known to possess a fascinating collection of properties that includes magnetism, colossal magneto-resistance, superconductivity, ferroelectricity, multiferroicity, ionic conductivity, and more. This wide breadth of remarkable properties is the consequence of strong coupling among charge, spin, orbital, and lattice degrees of freedom. Spurred by recent advances in the synthesis of such artificial materials at the atomic scale, the physics of oxide heterostructures containing atomically smooth layers of such correlated electron materials with abrupt interfaces is a rapidly growing area. Oxide materials are of fundamental interest for the novel phases that could only occur at the interface of bulk materials due to the coupling of energy quanta across the interface. In fact, interactions between energy quanta, such as electron, spin, phonon, photon, and others, are rather complex in correlated oxide materials due to their strong interactions and various competing states in close proximity of the interface. Therefore, the interface between two dissimilar materials provides a rich environment to yield new materials by epitaxially stabilizing materials layer-by-layer. In this talk, I will present the potential, challenges, and opportunities in epitaxial multivalent transition metal oxides for addressing the grand challenges to control material processes at the level of electrons, to design revolutionary new forms of matter with tailored properties, to understand and control complex correlations in complex oxides, and to mater the flow of energy quanta to create new technologies.

The work was supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, Materials Sciences and Engineering Division.

Pioneer: Oxides for energy application/0548 B7.02

Double enhancement of thermoelectric power factor in oxide two-dimensional electron system via precise dimensionality control

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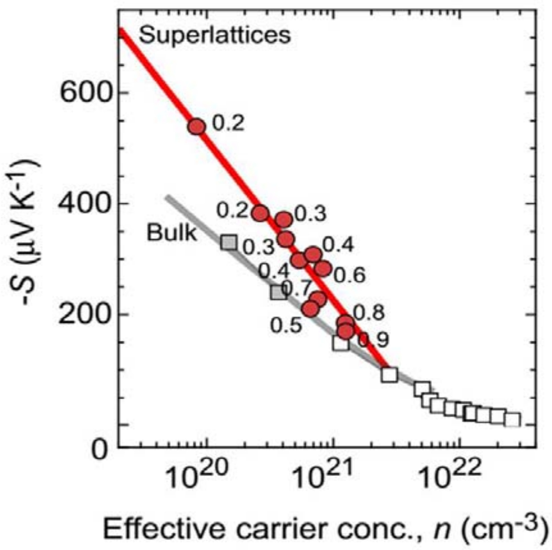
Abstract :



Two-dimensional electron system (2DES) is known as one of efficient ways to acheive an enhanced thermoelectric power factor ($S^2 \cdot \sigma$) because it exhibits an enhanced thermopower (S) without reducing electrical conductivity (σ).[1] Since the degree of S enhancement strongly depends on both carrier concentration and the two-dimensionallity of the 2DES,[2,3] a systematic investigation is demanded to optimize *PF*. Here we report thermoelectric properties of an oxide 2DES, [N uc $SrTi_{1-x}Nb_xO_3$|11 uc $SrTiO_3$]$_{10}$ superlattices ($1 \le N \le 12$, x=0.2−0.8). The slope of $-S$ vs. log n relationship for the N=1 superlattices is –300 K μV K^{-1}, ~1.5 times larger than that for bulk (–198 K μV K^{-1}), indicating 2DES formation (see Figure). As a result of precise dimensionality control, *PF* of the superlattice (N=1, x=0.6) exceeded ~5 mW m^{-1} K^{-2}, which is double of the optimized bulk $SrTi_{1-x}Nb_xO_3$ (*PF* ~2.5 mW m^{-1} K^{-2})[4]. The present results might be fruitful to design efficient thermoelectric materials with 2DES.

[1] H. Ohta *et al.*, *Nature Mater.* **6**, 129 (2007). [2] H. Ohta *et al.*, *Nature Commun.* **1**, 118 (2010). [3] H. Ohta *et al.*, *Adv. Mater.* **24**, 740 (2012). [4] Y. Zhang, H. Ohta *et al.*, *J. Appl. Phys.* **121**, 185102 (2017).

Pioneer: Oxides for energy application/1205 B7.03

High-Performance Nanogenerators with Multifunctional Triboelectric Nanomaterials

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Abstract :

Low output current represents a critical challenge that has interrupted the use of triboelectric nanogenerators (TENGs) in a wide range of applications as sustainable power sources. Many approaches (e.g., operation at high frequency, parallel stacks of individual devices, and hybridization with other energy harvesters) remain limited in solving the challenge of low output current from TENGs. As the fist issue, I will present a nanocomposite material system having a superior surface charge density as a triboelectric active material. The nanocomposite material consists of a high dielectric ceramic material, BTO, showing great charge-trapping capability, together with a ferroelectric copolymer matrix, P(VDF-TrFE), with electrically-manipulated polarization with strong triboelectric charge transfer characteristics. We successfully acheived boosting power-generating performance for 1,130 V of output voltage and 1.5 mA of output current with this ferroelectric composite-based TENG, under 6 kgf of pushing force at 5 Hz. As the second topic, I will introduce a new strategy of adding electrolytes with asymmetric ion pairing to polymer friction layers of TENGs in order to enhance their triboelectric property. Indeed, KPFM measurements show that an addition of H_3PO_4, an electrolyte with more cations than anions, to PVA can make it one of the most negative triboelectric material; whereas, an addition of $CaCl_2$, an electrolyte with more anions than cations, to PVA can make it one of the most positive triboelectric material. Furthermore, the TENGs based on such solid polymer electrolytes (SPEs) produce significantly higher power output than typical metal-polymer TENGs. Due to these unique features, SPEs are a promising triboelectric material for realizing high performance TENGs for self-powered small electronics. The recent research and design efforts for enhancing power generation performance of nanogenerators to realize self powering of portable and wearable sensors and electronics will also be discussed in this talk

Pioneer: Oxides for energy application/0325 B7.04

Epitaxial complex oxides for energy and environmental applications

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Abstract :

Mixed ionic and electronic conducting behaviors in transition metal oxides (TMO) have attracted lots of attentions for many energy devices such as solid oxide fuel cells and electrochemical sensor applications, where redox reactions and catalytic activity at the interfaces of gas-solid play critical roles for the performance of such devices. In this talk, redox reactions in epitaxial complex oxides will be presented. The first example is reversible redox reaction in epitaxial oxygen sponges, $SrFe_{1-x}Co_xO_y$ (x = 0.2 and 0.5 and $2.5 \le y \le 3.0$). For probing low temperature reversible redox reactions, synchrotron-based real-time x-ray diffraction experiments were done. The result indicates low temperature reversible redox reactions at ambient pressure can be realized. Second example will be about our recent attempt on possible redox-driven phase reversal in 4*d* binary oxide, MoO_x ($2 \le x \le 3$). In this example, we will present epitaxial phase transformation from metallic rutile to transparent insulating layered structures as as low as 200^{o}C. These redox reactions in expitaxial complex oxides provide useful route for designing fuel cells, sensors, and smart windows.

Focus: Magnetic van der Waals materials/0438 B8.01

New 2-dimensional magnetic materials in electrides and others

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Abstract :

In this talk, new 2-dimensional (2D) magnetic materials will be introduced. The new materials are created based on the engineering of crystal structure and real space in lattices, showing unprecedented physical properties. The first material is “electride”, which is regarded as a new electronic material, is ionic crystal in which interstitial electrons serve as anions. The physical properties of electrides are determined by the topology of cavities or channels which confine anionic electrons. The confining sites have been restricted to cavities or weakly linked channels of organic systems. It will be highlighted that the two dimensionally (2D) confined electron systems can show diverse magnetic properties as electrons are localized or delocalized. The second material is 2D polymorphic layered material based on Zintl phases. These systems can be exotic 2D materials for “beyond graphene” or “beyond state-of-the-art 2D materials” that allow unlimited extent of 2D science in terms of the diversity of materials and their magnetic properties.

Focus: Magnetic van der Waals materials/0834 B8.02

Magnetism in two dimensional Mn di-halides through hydrogen functionalization

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Abstract :

We explored the electronic and magnetic properties of two-dimensional manganese di-halide (MnY_2, Y=I, Br, Cl) and hydrogenated systems ($MnHY_2$). The pristine MnY_2 monolayers had a very weak magnetic exchange interaction and we found degenerated magnetic states between ferromagnetic and antiferromagnetic states although the Mn had a high magnetic moment of 5 μ_B with a finite band gap. However, we found that the electronic band structure and magnetic properties could be significantly altered by functionalization with hydrogen atom because the degeneracy in the pristine MnY_2 structure was broken and the FM ground state was obtained in all $MnHY_2$ systems. We obtained a negative spin polarization in the H atom and the magnetic moment of Mn atom decreased from 5 μ_B to 4 μ_B. However, this negative polarization played a pivotal role to induce a FM ground state in $MnHY_2$ systems. Furthermore, the asymmetric spin dependent bang gap in $MnHY_2$ was also greatly enhanced due to this hydrogenation as compared with that in the pristine MnY_2 systems. This finding suggests that the hydrogenated $MnHY_2$ can be used as a potential ferromagnetic semiconductor for spintronics.

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and Future Planning (2016R1A2B4006406).

Focus: Magnetic van der Waals materials/0906 B8.03

Enhancement of magnetic moments by bi-axial strain in 2D Fe3GeTe2 monolayer

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Abstract :

Two-dimensional (2D) materials have been in the spotlight these days, because of their technological advantages, such as highly tunable flexibility. Especially 2D ferromagnetic materials could have huge potential as a data storage device. Fe3GeTe2 is one of the ferromagnetic material candidates. It can also be stable as mono layer because each constituent layer can be easily cleaved due to the weak van der Waals bond as confirmed by previous experimental researches [1]. In this work, we used first-principles DFT calculation to predict changes of magnetic properties of 2D Fe3GeTe2 induced by bi-axial strain. In addition, we calculated phonon dispersion of each strained Fe3GeTe2 structure to verify that it is dynamically stable. Our results expect that there some significant enhancement of magnetization as strain increased. We will discuss possible atomic-scale origin of that.

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Focus: Magnetic van der Waals materials/0833 B8.04

Magnetism in two-dimensional feroxyhyte (δ-FeOOH): A first principles study

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Abstract :

Few years ago, it was claimed that the two-dimensional (2D) feroxyhyte (δ-FeOOH) layer could possess a net magnetic moment and it could be applied for potential spintronics application because it showed a band gap. However, the exact crystal structure is still unknown. Hereby, we investigate the crystal structure, electronic band structure, magnetic and optical properties of 2D δ-FeOOH using density functional calculations. Based on the experimental observation and dynamical stability calculations, we propose that the 2D δ-FeOOH originates from a bulk $Fe(OH)_2$ via oxidation. An antiferromagnetic ground state was observed in monolayer structure with an indirect band gap of 2.36 eV with no net magnetization. On the other hand, the bilayer structure displayed a direct band gap of 0.87 eV and we obtained a ferrimagnetic state. The net magnetic moment in bilayer was 1.4 μ_B per cell. To compare with the experimental band gap of 2.2 eV obtained from UV visible optical spectrum measurement, we also calculated the absorption spectra and the onset of the absorption peak in bilayer ferrimagnetic state was found at 2.8 eV. Overall, considering the magnetic state and optical absorption, our bilayer structure seems to be closer to the experimental structure.

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and Future Planning (2016R1A2B4006406).

Surface/Interface/Nanomaterials(F)/0351 B8.05

STM study of the monolayer VSe_2 on graphene

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Abstract :

Layered transition metal dichalcogenides (TMDCs) have attracted much attention due to their unique physical and chemical properties. Each layer of TMDCs is coupled by weak van der Waals force which allows easy mechanical exfoliation to prepare monolayer or a few layers thickness films. Recently, some theoretical studies predicted that monolayer 1T-VSe_2 shows ferromagnetic property which has attracted significant interest.[1] It has been also reported that bulk 1T–VSe_2 exhibits a commensurate 4 × 4 charge density wave (CDW) with transition temperature T_c = 110 K.[2] Regarding these issues, however, few experimental researches have been reported on monolayer 1T–VSe_2 films. In this presentation, we investigate atomic and electronic structures of monolayer VSe_2 on graphene via home-built scanning tunneling microscopy and spectroscopy (STM/S) at 80 K. We observed (*3* ×*7*) and (*3* ×*2*) modulation structures in STM topographic images which are very different from 4 × 4 (CDW) structure of bulk 1T –VSe_2. Dual-bias imaging and dI/dV mapping experiments were conducted to explain the physical properties of observed modulations.

References

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Surface/Interface/Nanomaterials(F)/0756 B8.06

Thickness Dependent Band alignment at the Au-MoS_2 interface

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Abstract :

Transition-metal dichalcogenides (TMDCs) materials have band structure which is dependent on their thickness. For TMDCs to be used in device application, band alignment study for the metal-semiconductor junction is important. However, there are still few studies on thickness-dependent band alignment studies of the metal-TMDCs interface.

In this study, we investigated band alignment in Au/MoS_2 interface by using photoelectron spectroscopy technique. To obtain MoS_2 films, pre-deposited Mo films were sulfurized with the H_2S gas. The thickness of MoS_2 was controlled by pre-deposited Mo film thickness. MoS_2 thicknesses were estimated by Raman spectroscopy. Using x-ray photoelectron spectroscopy, the Mo 3d core level shift between bare MoS_2 and Au/MoS_2 interface was measured. The valence band of Au-MoS_2 interface is also measured. From the core level shift and valence band data, we result in the thinner MoS_2 has a larger Schottky barrier at the Au-MoS_2 junction.

[Acknowledgements: NRF-2016M2B2A4912288, NRF-2015R1D1A1A01060381]

Surface/Interface/Nanomaterials(F)/1150 B8.07

Built-in graphite Joule heater on monolayer MoS_2 field-effect transistor for local annealing

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Abstract :

To improve performance degradation of two-dimensional system coming contact resistance and surface impurities such as water molecules, thermal annealing has been generally employed. However, previous thermal annealing system has low efficiency in the point of complicated equipment setup and large power consumption. Herein, for the locally precise and convenient thermal treatment with low cost, we placed graphite Joule heater on MoS_2 field-effect transistor. With the built-in Joule heater, electrical performance of MoS_2 device such as contact resistance, surface trapped charges, mobility, and n-doping effect is much more improved than conventional thermal annealing treatment using the hotplate in the vacuum chamber. Additionally, our local Joule heater can be used as an oxygen gas sensor. Noise and thermal image analysis are demonstrated for oxygen response with repeated gas inlet and pumping experiments.

Condensed matter physics(D)/0411 B8.08

Classification of accidental band crossings and emergent semimetals in two-dimensional noncentrosymmetric systems

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Abstract :

We classify all possible gap-closing procedures which can be achieved in two-dimensional time-reversal invariant noncentrosymmetric systems. For exhaustive classification, we examine the space group symmetries of all 49 layer groups lacking inversion taking into account spin-orbit coupling. Although a direct transition between two insulators is generally predicted to occur when a band crossing happens at a general point in the Brillouin zone, we find that a variety of stable semimetal phases with point or line nodes can also arise due to the band crossing in the presence of additional crystalline symmetries. Through our theoretical study, we provide, for the first time, the complete list of nodal semimetals created by a band inversion in two-dimensional noncentrosymmetric systems with time-reversal invariance. The transition from an insulator to a nodal semimetal can be grouped into three classes depending on the crystalline symmetry. Firstly, in systems with a two-fold rotation about the z-axis (normal to the system), a band inversion at a generic point generates a two-dimensional Weyl semimetal with point nodes. Secondly, when the band crossing happens on the line invariant under a two-fold rotation (mirror) symmetry with the rotation (normal) axis lying in the two-dimensional plane, a Weyl semimetal with point nodes can also be obtained. Finally, when the system has a mirror symmetry about the plane embracing the whole system, a semimetal with nodal lines can be created. Applying our theoretical framework, we identify various two-dimensional materials as candidate systems in which stable nodal semimetal phases can be induced via doping, applying electric field, or strain-engineering, etc.

Focus: Superconductivity in low-dimensional materials and systems/0016 B9.01

Observation of novel magnetic field induced phases in a quasi-2D superconductor FeSe

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Abstract :

Superconductivity is conventionally described as a spin-singlet state with zero net momentum arising from pairing of electrons with opposite spins and momentums. When spin population is imbalanced, however, a novel magnetic field induced phase may occur, coexisting with a superconducting order, e.g. the Fulde-Ferrel-Larkin-Ovchinnikov (FFLO) state. Particularly in multiband superconductors, different degrees of spin inbalance and superconducting strength in multiple Fermi surfaces leads to rich phases at high magnetic fields, which is yet to be observed in real systems. Here, we report the observation of multiple field-induced phases in a quasi two dimensional FeSe, below its upper critical field, which was thermodynamically evidenced by anomalies in torque magnetometry and magnetocaloric effect. The field-induced anomalies exhibit negligible temperature and angle dependences, constrasting to a clear upturn of the upper critical field at low temperatures and near the in-plane magnetic field, but are sensitive to impurity concentration. Possible candidates for the field-induced phases will be discussed.

Focus: Superconductivity in low-dimensional materials and systems/0561 B9.02

Robust magnetism without orbital order in surface electron doped $BaFe_2As_2$

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Abstract :

The nematic phase, the electronic phase with lowered C2 rotational symmetry from C4 symmetry, became a major playground of iron-based superconductor research by its exotic nature as well as its possible connection to the superconductivity. However, microscopic mechanism has not been made and even the driving force of the nematic phase is unclear whether it is coming from spin or orbital degree of freedom.

In this talk, I will present the observation of very new phase that, spin ordered phase without orbital ordering induced near the surface of $BaFe_2As_2$ through the surface-electron-doping. It is clearly contrast to the previous bulk study results as spin ordering without orbital ordering has never been observed before. This new class of phase may provide the new insight on the origin of the nematic phase in the iron-based superconductor.

Focus: Superconductivity in low-dimensional materials and systems/1132 B9.03

Spin-polarized STM/STS studies on iron-based superconductor Sr_2VO_3FeAs, cuprate superconductor La-Bi2201, and strongly correlated delafossite $PdCrO_2$.

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Abstract :

Interfacial phonons between iron-based superconductors (FeSCs) and perovskite substrates have received considerable attention due to their potential capability of enhancing preexisting Fe-based superconductivity [1]. Using scanning tunneling spectroscopy, we studied the correlation between superconductivity and electron-phonon (e-ph) interaction in an iron-based superconductor Sr_2VO_3FeAs (T_c 33 K) made of alternating FeAs layers and oxide layers [2]. Our high-resolution quasiparticle interference measurement clearly showed replica bands in the filled and the empty states around an electron band - the signature of the renormalization of the electron band by e-ph interaction with forward-scattering symmetrically breathing optical phonons with energy ~13 meV. Furthermore, the positive local correlation of the band renormalization and the superconducting gap is in agreement with quasiparticle interference simulation based on self-consistent Eliashberg calculations and the electron-phonon coupling strength locally modulated by O vacancies in VO_2 layer. These observations together provide a unique real-space evidence of the forward-scattering interfacial-phonon contribution to the total superconducting pairing in FeAs/oxide heterostructure. I will also show spin-polarized scanning tunneling microscopy (SP-STM) [3] studies on (1) the frustration induced switching of magnetism and superconductivity in Sr_2VO_3FeAs by spin-polarized current injection [4], (2) extremely under-doped cuprates which shows signature of fluctuating spin glass states, and (3) signature of highly coherent 2D metallic behavior in strongly correlated delafossite $PdCrO_2$.

Nano and mesoscopic physics(E)/1038 B10.01

Magnetic sensor based on 2D TMD system for ultrasensitive Hall sensitivity

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Abstract :

A Hall effect magnetic sensor transduce magnetic flux into electrical voltage difference. The magnetic sensitivity of conventional semiconductor based Hall sensor is generally affected by its high carrier mobility and channel thickness. Previously, a graphene is suggested as a well optimized channel for those conditions and in addition, tunable carrier concentration. The graphene Hall elements have been demonstrated with higher current-normalized magnetic sensitivity (SI) than Si-Based Hall sensors. However, the feasibility of Hall sensor based on 2D transition metal dichalcogenide (TMD) system has not been studied thus far, although the system would largely suppress 2D carrier density. In this work, we show the feasibility of ultra-sensitive Hall sensor based on TMD material. A monolayer molybdenum disulfide Hall element (MHE) on a hexagonal boron nitride (*h*-BN) film was fabricated and the appropriate bias conditions were found by the analytical model simulation from transconductance data without magnetic field. The maximum SI was found to be ~3000 V/AT.

Nano and mesoscopic physics(E)/0914 B10.02

Quantum capacitance of surface states in Bi_2Se_3 nanowire

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Abstract :

We construct a nanomechanical resonator with a Bi_2Se_3 nanowire and study the correlation between the mechanical motion and the surface modes of topological insulator. The suspended nanowire is capacitively actuated by a nearby bottom gate and its flexural motion is transduced into a RF current which we monitor in the experiments. Here, the resonance frequency of mechanical oscillator is determined by the total capacitance, which is a combination of the geometric and quantum capacitance in the system. We observe a periodic resonance frequency shift depending on the chemical potential and axial magnetic flux, and the observed periodicity in the frequency shift can be explained by the oscillation in quantum capacitance of surface modes in Bi_2Se_3 nanowire. Our results provide useful information of quantum capacitance in one-dimensional sub-bands in the Bi_2Se_3 nanowire and demonstrate a novel measurement technique for the quantum capacitance of one-dimensional electronic system.

Nano and mesoscopic physics(E)/0908 B10.03

The Josephson inductance of a InAs proximity junction embedded in a superconducting coplanar microwave resonator

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Abstract :

The inductance of a Josephson junction, or Josephson inductance, arises due the nonlinear relation between the current and voltage across the junction. This nonlinear inductance is an essential element in superconducting qubits and other quantum device applications. We investigate the Josephson inductance of semiconductor proximity juntions which recently demonstrated their potential for superconducting quantum devices. We fabricate a hybrid system with a superconducting coplanar microwave resonator and a InAs Josephson junction, and study the Josephson inductance by measuring microwave resonances at millikelvin temperatures. We discuss our experimental results and compare them to a RCSJ junction model to estimate the kinetic inductance of our InAs proximity junction and its microwave loss.

Nano and mesoscopic physics(E)/0651 B10.04

Infrared spectroscopy of gated twisted bilayer graphene

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Abstract :

In twisted bilayer graphene (tBG), the twisted angle makes unique features in band structure such as gap opening and van Hove singularities (vHs) which lead to a series of strong angle-dependent optical properties. In this study, we measure optical absorption of Ion-gel gated tBG. We observe that (1) Interband Pauli-blocked transition splits into two components with different Fermi energies, (2) α peak, vHs transitions, shows energy shift and gate bias dependent strength, and (3) In a high doped region, a new peak emerges (β peak). We analyze the correlation between the Fermi energies and the α peak energy. From the relation, we characterize the band structure of gated tBG. The band structure can be obtained solely by FTIR; This technique can be used to research band for other materials.

Nano and mesoscopic physics(E)/0621 B10.05

Topological semimetals induced by magnetic control of the Luttinger q-term in pyrochlore iridates

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Abstract :

Pyrochlore iridate antiferromagnet is the first material in which Weyl fermions are predicted to exist in condensed matters. Although several promising experimental results, which may be originated from Weyl fermions, have been reported, an unambiguous proof for the presence of the Weyl semimetal in this system has not been achieved yet. The accumulated theoretical and experimental knowledge consistently shows that the Weyl semimetal can, in principle, be realized in this system but only within a very narrow window in the parameter space, which makes it difficullt to access the relevant state in experiment. In this work, we theoretically propose that applying magnetic field is a promising way to realize the Weyl semimetal phase in pyrochlore iridates since magnetic field not only can expand the range in which the Weyl semimetal phase exists but also can create new topological semimetal phases across additional band inversion. Here the central role is played by the presence of a quadratic band crossing with four-fold degeneracy in the paramagnetic band structure that exists before the time-reversal symmetry is broken. Due to the large degeneracy at the crossing point and the strong spin-orbit coupling, the degenerate states at the crossing point can show the anisotropic Zeeman effect, which has been known as the q-term in the Luttinger Hamiltonian, as well as the conventional isotropic Zeeman effect. Moreover, the relative magnitude of these two different Zeeman terms can be controlled by varying the orientation of the four spins within the unitcell, which, in turn, manipulates the topological property of the iridium band structure. Such an intriguing behavior occurs due to the fact that the unit cell is composed of a cluster of four spins in a tetrahedron whose magnetic mulipole moments can be continuously tuned by varying the spin orientation within the unit cell. We propose the most general topological band structure under magnetic field, which would facilitate the experimental discovery of novel topological semimetal states in pyrochlore iridates.

Nano and mesoscopic physics(E)/0405 B10.06

Linking characterizes Z2 monopole charge in nodal line semimetal

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Abstract :

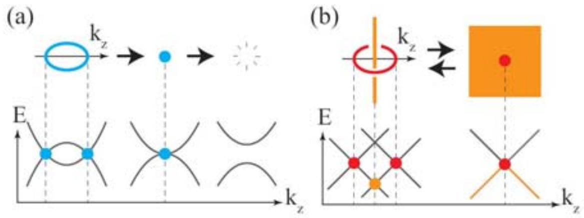

FIG. 1: Band structure and stability of trivial (blue) and linked (red) nodal lines. The line of valence band degeneracy is colored orange. (a): Line node described by a two-level Hamiltonian. The line can open a band gap after shrunk into a point. (b): Line node linked to the line of band touching between valence bands. It is stable against shrinking: when shrunken into a point, the line becomes a Dirac point which is protected from opening a band gap, and further deformation generates a line node again.

We study the nodal line semimetal protected by the combination of inversion and time-reversal symmetry in the absence of spin-orbit coupling. When the number of valence bands exceeds two in the semimetal, nodal lines can have an additional topological invariant, Z2 monopole charge, besides the pi Berry phase. Here we show that the Z2 monopole line is always linked with another line which is defined by the points of touching between valence bands. We found that the linking number is identical to the monopole charge mod 2. Because the monopole charge is protected by symmetry, the monopole line can be considered the first construction of a symmetry-protected linked line. In addition, we show that a pair of Z2 monopoles emerge through the process we call double band inversion. When the system is inversion symmetric, the process changes the inversion eigenvalues of two valence bands. Through the investigation of band structure and inversion eigenvalues, we propose candidate materials which may host Z2 monopole lines.

Graphene on hexagonal Boron Nitride: emergence of tertiary Dirac points and magnetic breakdown

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Abstract :

Hexagonal BN (hBN) 위에 그래핀을 적층한 구조에서, 높은 에너지 영역에 12 중의 축퇴도를 갖는 세번째 디락점의 존재를 보이고, 또 magnetic breakdown 에 의해 새로운 전자궤도의 양자화가 일어남을 보인다 [1-3]. 그래핀을 hBN 위에 적층하면, 두 격자주기의 차이에 의해 그래핀 본연의 격자주기보다 훨씬 더 긴 주기를 갖는 초격자구조가 나타난다. 이전 연구에서 우리는, 이 초격자에 의해 그래핀의 디락점보다 높은 에너지에 두번째 디락점이 나타나고, 또 전자에너지가 자기장의 세기 변화에 따라 프랙탈하게 변하는 호프스태터의 나비로 발전하는 것을 보인 바 있다 [4-6]. 이번 연구에서는 스핀과 밸리의 축퇴도를 포함하여 총 12 중의 축퇴도를 갖는 란다우 준위의 존재로부터, 보다 높은 에너지 영역에 세번째 디락점이 존재할 가능성을 보일 것이다. 또한, 대칭성에 의해 초격자포텐셜이 비교적 약하게 작용하는 전자밴드에서, 에너지 영역이 겹쳐진 두 밴드 사이의 magnetic breakdown 에 의해 새로운 전자궤도의 양자화가 일어남을 보일 것이다.

[1] G. Chen et al., Nano Lett. 17, 3576 (2017). [2] L. Wang et al. (in preparation). [3] Y. Kim et al. (in preparation). [4] C. Dean et al., Nature 497, 598 (2013). [5] B. Hunt et al., Science 340, 1427 (2013). [6] P. Moon and M. Koshino, Phys. Rev. B 90, 155406 (2014).

Nano and mesoscopic physics(E)/0266 B10.08

Quantum torque of nanoresonator coupled to molecular nanomagnets

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Abstract :

A new mechanism is proposed for the torque dynamics of nanoresonator with tunneling macrospins in the presence of an ac field. Applying a static magnetic field with a gradient, we present quantum oscillations with a beat structure which depend on four parameters related to the frequency of ac field, Rabi frequency, the moment of inertia of the resonator, and the coupling strength. Analytic equations describing the dynamics have been derived and investigated numerically. The range of parameters required for observing quantum torque has been proposed.

Nano and mesoscopic physics(E)/0103 B10.09

Exploring the Angstrom Excursion Dynamics of Au Nanoparticles Excited Away from a Metal Surface by an Impulsive Acoustic Pulses

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Abstract :

The time-resolved femtosecond laser spectroscopy has been extensively used as a powerful source to investigate the dynamics of confined metallic structures based on the Localized surface plasmon resonance (LSPR). Picosecond acoustic pulses generated by femtosecond pump laser pulses, as new excitation source of the surface plasmons, present the advantages of GPa mechanical pressures without carrying thermal energy. Therefore, it is very useful for directly transferring the translational momentum to neighbouring objects resulting in altering the inter-object's distance between them. Here, we report about the Angstrom excursion dynamics of Au nanoparticles (NP) excited away from Ni film by acoustic pulses showing up the large dynamic shifting of LSPR.

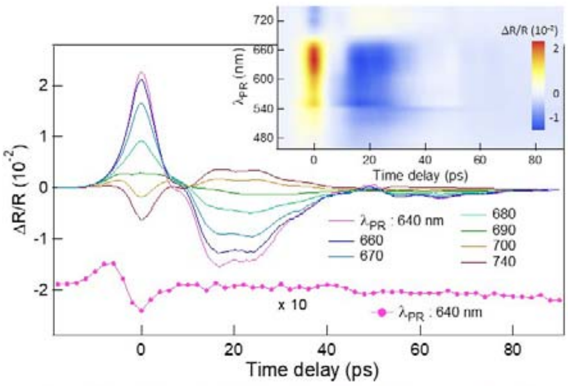

Figure1. Dynamical reflectivity $\Delta R(t,\lambda_{PR})/R$ of Au:NPs induced by acoustic pulses measured with various probe wavelengths (λ_{PR}) near LSPR showing the two distinct oscillations. The two dimensional mapping of $\Delta R(t)/R$ for the whole continuum range is shown in the inset.

Using time-dependent calculation of the transient reflectivity based on Hamaker-type Lennard-Jones anharmonic potential between Au NP and Ni, we prove that Au NP oscillates within 1 Angstrom length scale. Because of the extreme measurement sensitivity to the distance due to the strong interaction of the near-field interaction, the Angstrom motion of the particle efficiently changes the LSPR spectral and temporal characteristics.

Focus: Symposium for the basic fusion research & development program/0579 B11.01

A Brief Introduction to Research Activities on Divertor/SOL, Plasma-Surface Interaction in KSTAR

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Abstract :

This paper deals with a brief introduction to research activities on divertor/scrape-off layer (SOL), plasma-surface interaction in KSTAR. The research starts with particle and heat flux from core plasma through SOL towards inner wall, so called plasma-facing components (PFCs) such as limiter and divertor. Plasma particles reaching PFCs interact with surface of PFCs, so called plasma-surface interaction which results in erosion/redeposition of PFCs, fuel retention, and creation of in-vessel dust. This is a broad area of research, because plasma parameters from the pedestal inside the SOL, all the way down to the surface of the PFCs have to be known first, then plasma-surface interaction part comes later. From the basic concept of the research, as well as both experimental and theoretical approaches to understand divertor/SOL physics will be introduced.

Nuclear fusion(C)/0450 B11.02

플라즈마-텅스텐 상호작용 해석을 위한 수소 흡착 모델 개발

진영길[*1], 김남균 [1], 송재민 [1], 노기백 [1], 김곤호 [1]

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Abstract :

핵융합로와 같은 장주기 플라즈마 시스템에서 방출속 (ouflux) 및 유입속 (influx)의 변동성을 야기하는 방전 연료가스의 입자균형 이해를 위해서는 시간변수를 갖는 대면재와 플라즈마 방전가스 간의 상호 작용의 결과인 벽면 재료내 방전가스의 흡착 및 재방출 기전에 대한 이해가 필수다. 핵융합로 운전의 관점에서 방전가스이자 연료가스인 수소 흡착을 이해할 수 있는 모델은 고방사성 삼중수소의 토카막 내 안전 규제 제한치 (Safety Limit) 대비 벽면 흡착량 예측과 벽면에서 재방출되는 중성가스속에 의한 플라즈마의 안정성 침해 방지의 측면에서 활용될 수 있다. 본 연구에서는 플라즈마 공간반응과 재료 표면반응만이 고려되었던 기존연구들의 관점을 확장하여, 운전중 플라즈마-대면재 간 상호작용의 결과로 나타나는 재료 공간내에서의 장주기 흡착 기전들까지 포함하는 수소 흡착 모델을 구성하였다. 해당 모델은 흡착반응의 종류와 수소흡착량 정보를 바탕으로 흡착된 수소의 재방출 특성 시간에 대한 예측이 가능해 운전중 시스템의 입자균형 변동을 시간적으로 예측하는데 활용가능하다. 해당 모델 구축의 전제조건은 수소 흡착 기전의 규명이므로, 본 연구에서는 가장 핵심적인 장주기 공간 수소 흡착 반응 종류인 수소과포화에 따른 기공형 결함의 수소 흡착, 반응성이 큰 불순물 침투에 따른 화학적 불순물-수소간 흡착, 자가이온 등의 침투에 따라 발생한 군집결함에 의한 고에너지 흡착 기전, 핵융합 유사조건 (Ar, He 혼입)에서의 변동성을 규명하고 이를 플라즈마-대면재간 상호작용의 결과로서 수소흡착모델에 반영하였다. 해당 기전 해석의 결과이자 수소 흡착량 및 재방출 특성시간 함수의 지배 인자인 수소 재방출특성화 에너지는 본 연구에서 개발되고 정립된 열탈착 분광계 (Thermal Desorption Spectroscopy, TDS)를 통해 획득되었고, 국제원자력기구에서 주관한 열탈착분광계 표준화 회의 참가를 통해 신뢰도를 검증받았다. 따라서 개발된 수소 흡착 모델은 수소 플라즈마와 텅스텐 재료간 수소 주입, 흡착, 재방출의 일련의 과정에 대한 이해를 제고함으로써 핵융합로 운전 안정성 향상 및 벽면 세정방전 시나리오 도출에도 활용 가능할 것으로 기대한다.

Focus: Symposium for the basic fusion research & development program/1204 B11.03

Plasma diagnostics using laser-plasma-produced THz waves

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Abstract :

Several diagnostic methods are available for fusion plasmas, but they have their own limitations and better plasma diagnostic methods need to be developed. In our research, we are developing a new plasma diagnostic tool using laser-plasma-based THz waves, where a rather intense laser pulse with an energy of ~mJ/pulse and a pulse duration of 40 fs is focused in gas and a strong THz (Tera-Hertz) wave pulse is generated by the interaction between the laser pulse and the laser-produced plasma. The THz wave pulse has a rather broadband in spectrum, so it can be used for a wide range of plasma densities if it is used for density measurement. For this purpose, we developed a small ICP (Inducttively-Coupled-Plasma) source that is powered by a 13.56 MHz RF source. In this talk, we will show the results for the developed plasma diagnostic method.

Nuclear fusion(C)/0363 B11.04

Measurement of hydrogen-isotope permeation and retention in fusion materials

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Abstract :

The permeation and retention behaviors of hydrogen isotopes in fusion materials were experimentally investigated. The permeability values of hydrogen (or deuterium) in an ELBRODUR G CuCrZr alloy and a 316L stainless steel coated with a thin aluminum oxide layer were determined by using the time-dependent gas-phase technique, and the deuterium retention and desorption behavior in an advanced reduced-activation alloy was measured by using the thermal desorption technique. Detailed results are presented, and our results are also compared with those previously reported by other authors.

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* "This work was supported by the National Research Foundation of Korea (Project No. 2015M1A7A1A01002234)."

Organic electronics and photonics(E)/0034 B12.01

Probing Charge Transport in Highly Doped Conjugated Polymers by Solid-State Diffusion

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Abstract :

Since the demonstration of a high conductivity in doped pi-conjugated polymer by chemical doping, various different doping methods have been employed to achieve a metallic level of the conductivity. However, the charge transport properties have been limited by structural and energetic disorder created by dopants upon doping. We have recently demonstrated an efficient solid state doping method for conjugated polymers to achieve a coherent charge transport in poly(2,5-bis(3-hexadecylthiophen-2-yl)thieno[3,2-b]thiophene) (PBTTT) doped with 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F_4-TCNQ) with one of the highest Hall mobilities for conducting polymer[1]. This enabled observation of a nearly-ideal Hall effect in addition to a low-dimensional quantum mechanical phenomenon that is in agreement with free-electron like magnetic susceptibility. The coherent charge transport in the doped PBTTT can be attributed to a preserved lamellar microstructural order upon doping- the dopant molecules were found to intercalate in the sidechain regions and not disturb the π-stacking of the polymer backbones. Comparison with the transport with other polymers with disordered microstructure further reveals a strong correlation between the degree of structural order and resulting charge transport properties. The demonstrated doping method was also found to be effective for other thiophene-based and donor-acceptor polymers which potentially can be extended further to a wide range of organic systems.

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Focus: Organic materials and devices/0215 B12.02

Poly (metal 1,1,2,2-ethenetetrathiolate)s for solution processed organic thermoelectric generator

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Abstract :

Recent progress in conducting polymer-based organic thermoelectric generators (OTEGs) has resulted in high performance due to high Seebeck coefficients (S), high conductivity (σ), and low thermal conductivity (κ) obtained by chemically controlling the material's redox level. However, the scarcity of good candidates for soluble organic *n*-type materials limits the use of π-leg module structures consisting of complementary elements of *p*- and *n*-type materials because of unbalanced transport coefficients that lead to power losses. In particular, the extremely low electrical conductivity of *n*-type materials compared with those of *p*-type materials is a serious challenge.

These days, OTEGs using poly (metal 1,1,2,2-ethenetetrathiolate)s (P(Mett)s) are focused to great attention recently. P(Mett)s are 1D-linear conducting polymers with metal-ligand (d-π) conjugation and form so-called metal-organic-frameworks (MOFs). These material systems show great thermoelectric properties and relatively good stability in air. However, P(Mett)s suffer from solubility issues like carbon nanotube and graphene groups, making the realization of all-solution-processed OTEGs difficult. This insolubility, which interferes with the fabrication of smooth thin films, also complicates the analysis of physical and optical properties and electronic states, thus inhibiting further exploration of their derivatives.

In this study, we trying to overcome this issues, the P(Mett)s thin films are tested as a semiconductors in solution-processed OTEGs. The electronic structures thin films as a function of carrier concentration were further explored based on changes in absorption spectra and ultraviolet photoelectron spectroscopy, and the chemical states were investigated by X-ray photoelectron spectroscopy.

Focus: Organic materials and devices/0139 B12.03

Unveiling the Electronic Structure of ZnO-C_{60} Core-Shell Quantum Dots: The Origin of Efficient Electron Transport

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Abstract :

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The energy level alignment inside core-shell structure quantum dot (QDs) is a critical factor from the view of carrier transport mechanism in optoelectronic applications using QDs. Recently, we reported UV photovoltaic (PV) cells using a ZnO QD absorber based on wide band gap of ZnO (3.4-3.5 eV) [1]. To improve efficiency of the UV PV cells, the ZnO core-C_{60} shell structure (ZnO-C_{60}) QDs are introduced and they showed great photoluminescence quenching under UV illumination compared to pristine ZnO QDs. Herein, we studied the electronic structure of ZnO-C_{60} QDs to understand those photophysical phenomenon with in-situ ultraviolet and x-ray photoelectron spectroscopies. The valence density of states for ZnO-C_{60} and pristine ZnO QDs films are measured and their interface formation was reproduced as a planar model by stepwise deposition of ZnO QDs on C_{60} film using vacuum electrospray. As a result, it is found that the interaction between ZnO QDs and C_{60} induce a negligible energy barrier for electron transport and this result led to enhance the performance of UV PV cells using ZnO-C_{60} QDs.

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Focus: Organic materials and devices/0823 B12.04

Fabrication of microbial battery with carbon nanomaterials for high efficient organic semiconductor devices

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Abstract :

In this study, we are developing a new type self-sustainable, large areal and flexible organic semiconductor device by combining bio, material, and electronics technologies. It is capable of extracting a highly efficient microbial energy using carbon nanotube and graphene materials. To do that, we prepare graphene layer and carbon nanotube integrated hydrogel cell patch for harvesting bio-based photocurrent energy. Electronics formed on the cell surface in the hydrogel were effectively transferred to the electrode through the carbon nanotube. Using the carbon nanomaterial, we analyze the electron transport for the development of highly efficient microbial energy device for organic semiconductor devices.

Organic electronics and photonics(E)/0026 B12.05

Controllable charge transport in molecular junctions engineered by chemical p-doping of graphene electrodes

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Abstract :

In the molecular-scale electronic junctions, the interface of molecule-electrode is important in determining the overall charge transport at a quantum-scale system where charge carriers can travel. Therefore, it is important to adopt unique conductive materials as the electrode of molecular electronic junctions for interfacial engineering in order to achieve ultimately-controllable charge transport behaviors. As a promising candidate, we adopted a chemical p-type doping method of graphene film using trifluormoethanesulfonic acid (CF_3SO_3H, denoted as TFMS).[1] Specifically, we fabricated high-yield vertical molecular junctions consisting of self-assembled monolayers of benzenedithiol between multi-layer graphene and Au films as top and bottom electrodes. Pristine graphene and TFMS-doped graphene films were prepared and compared. From the statistical analysis of electrical characterization results, the TFMS p-doped graphene-electrode molecular junctions showed enhanced charge transport properties, exhibiting higher current density and lower charge injection barrier height than those for pristine graphene-electrode molecular junctions. The validity of these results was proven by the theoretical analysis based on the coherent transport model with considering asymmetric couplings at the molecule-electrode interfaces.

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Organic electronics and photonics(E)/0774 B12.07

Surface Electrical Properties of Organic−Inorganic Lead-Free Halide Mesoporous Perovskite Solar Cells

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Abstract :

Lead-free photovoltaic devices based on methylammonium tin iodide ($CH_3NH_3SnI_3$) perovskite material is designed as a less toxic alternative to $CH_3NH_3PbI_3$. $CH_3NH_3SnI_3$ has a broader absorption to 950 nm and can be easily tuned by adjusting the perovskite composition. Specifically, Bromine (Br) incorporation has been shown to affect the controlling band gap of perovskite absorber layer, leading to cover the visible range of optical spectra. Power conversion efficiency (PCE) ~ 2.3% of $CH_3NH_3SnI_{3-x}Br_x$ (x=1.2) while PCE ~ 0.5% of $CH_3NH_3SnI_3$ due to the efficient charge transport. In this study, we investigated the local electrical and optical properties of $CH_3NH_3SnI_{3-x}Br_x$ ($0<x<3$) thin-films by using scanning probe microscopy and Raman scattering spectroscopy. Based on that, we can describe the electron-hole carrier transport with various I/Br compositional ratio. Consequently, we can suggest the correlation of the local composition and electrical properties in perovskite layer depending on the Br concentration. Thus, we can anticipate the origin of the high efficiency perovskite solar cells with optimal Br concentration.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0042 B13.01

Current-driven creation, translation, and annihilation of ferrimagnetic skyrmions observed by scanning transmission X-ray microscopy

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Abstract :

Magnetic skyrmions are topologically-protected spin textures in material systems with strong Dzyloshinzskii-Moriya interaction (DMI).[1-4] Due to their small size and fast current driven dynamics, they have potential as magnetic information units in high-density and ultra-fast spin memory devices. However, the skyrmion Hall effect, intrinsic to ferromagnetic skyrmions, hinders efficient current-driven motion.[5,6] Recent theoretical studies predict that the skyrmion Hall effect can be eliminated in antiferromagnetically coupled skyrmions.[7,8]

In this work, we study the current driven dynamics of the magnetic domains of Pt/GdFeCo/MgO multilayer stacks by scanning transmission X-ray microscopy (STXM). First, we find that the magnetic domain images acquired at the Fe-and Gd- absorption energy show opposite magnetic contrast, implying that their magnetic moment is antiferromagnetically-coupled, i.e. the GdFeCo is ferrimagnetic. The stripe-like domains of Pt/GdFeCo/MgO multilayers at zero field change into skyrmions at a certain magnetic field. When the current pulse driven translational motion of these skyrmions along a magnetic wire is measured, we find that the skyrmion Hall effect is significantly reduced in this ferrimagnetic GdFeCo system: the skyrmion Hall angle (angle between skyrmion displacement along and transvere to the current pulse) is significantly reduced to $\theta_{SkHE} < 10°$, which is much smaller than the skyrmion Hall angle of ferromagnetic skyrmions ($\theta_{SkHE} \sim 30°$).[5,6] We also show the deterministic creation and annihilation of isolated skyrmions by nanosecond bipolar electrical current pulses observed by time resolved STXM measurements. From micromagnetic simulations, the microscopic mechanism of the topological fluctuation during the skyrmion generation and annihilation process is revealed. A unique current-pulse profile for efficient skyrmion creation/annihilation is suggested.

Our findings show that skyrmions can be created and annihilated (read and write) and translated by current pulses, which are important requirements for the realization of all-electric skyrmionic memory devices.

[Acknowledgements]

This work was supported by the KIST Institutional Program, the Samsung Research Funding Center of

Samsung Electronics, and the National Research Foundation of Korea (NRF) funded by the MSIP (2016K1A3A7A09005418).

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Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0827 B13.02

Exploring Quantum Emergent Properties using Resonant Inelastic X-ray Scattering

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Abstract :

Correlated electron systems have attracted great attention due to the scientific interest. Recently, some researchers suggested an innovative way to explore the emergent properties via controlling ‘spin-orbit coupling’ rather than the conventional physical picture. In this talk, we introduce a new experimental approach based on resonant inelastic x-ray scattering (RIXS). Specifically, we investigate new quantum emergent properties (j_{eff} system) of lacunar spinel ($GaTa_4Se_8$), which was recenlty theoretically predicted. Our hard X-ray RIXS studies can offer a new method to elucidate j_{eff} = 3/2 system. RIXS is a powerful tool to unveil the detailed mechanisms and to detect elementary excitations related to spin-orbit coupling. Furthermore, we will present *in situ* RIXS combined with high pressure and electric field, which can generate new phases and quantum emergent physical properties.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0052 B13.03

Symmetry breaking in 3D flux-closure domain structure

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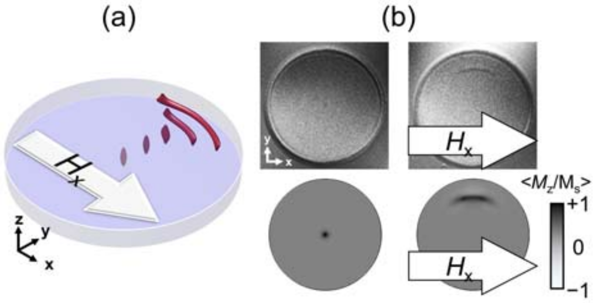
Abstract :



In a nanometer or sub-micrometer scaled ferromagnetic disk, a flux-closure domain structure appears along the edge of the disk to reduce demagnetization energy [1]. A Landau domain structure in a square disk and a magnetic vortex structure in a circular disk are representative flux-closure domain structures. Such magnetic configuration has been studied in a two-dimensional (2D) structure. However, as increasing the thickness of the sample, i.e. three-dimensional (3D) system, the disk does not show the simple 2D flux-closure domain structure but it shows a complex 3D structure [2, 3]. For example, in a rectangular disk, asymmetric Bloch wall (ABW) with Néel cap is positioned between two shifted vortex cores to reduce demagnetization energy along the thickness of the sample. In a 3D system, a rotating sense of an ABW is an additional degree of freedom [2]. In this study, we show that 3D flux-closure domain structure can be formed even in a disk sample with rotational symmetry under an external magnetic field by utilizing magnetic transmission soft X-ray microscopy (MTXM) as shown in Fig. 1. Furthermore, the rotation sense of ABW depends on the direction of the external magnetic field. Which reveals that the generation of the energy states of ABW with rotating sense which are degenerated in the rectangular-shaped sample [2, 3].

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Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0387 B13.04

Synchrotron x-ray study of hydrogen-induced phase transition in VO_2 epitaxial thin films

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Abstract :

Phase transition by band filling control is one of the core concepts in correlated electronic systems. Unlike the substitutional dopants, hydrogen, the smallest and the lightest atom, plays a key role in effectively filling significant amount of carriers in the empty narrow *d* band by reversibly adding it into interstitial sites and supplying carriers. Vanadium dioxide (VO_2), typical correlated oxide with $3d^1$ electronic configuration, can also reversibly incorporate hydrogen atoms into its interstitial sites and simultaneously occurs phase transition by its 3*d* band filling.

Here, we demonstrate that as many as two hydrogen atoms can be incorporated into each VO_2 unit cell, and that hydrogen is reversibly absorbed into, and released from, VO_2 without destroying its lattice framework due to the low temperature annealing process. This hydrogenation process demonstrates two-step insulator (VO_2) – metal (H_xVO_2) – insulator (HVO_2) phase modulation during inter-integer *d*-band filling. Moreover, HVO_2 can be thermodynamically stabilized regardless of facet direction of VO_2 epi-layer, but remarkable discrepancy in kinetics of phase modulation was clearly visualized depending on the crystal facet. Based on *in situ* XRD, XPS and NEXAFS in synchrotron, the unprecedented insulating HVO_2 with $3d^2$ configuration is attributed to highly doped electrons via hydrogenation process in conjunction with huge lattice expansion. Our finding suggests the possibility of reversible and dynamic control of topotactic phase modulation in VO_2 and opens up the potential application in proton-based Mottronics and novel hydrogen storage.

Focus: Synchrotron x-ray studies for spintronic and advanced functional materials/0667 B13.05

Study of the Magnetic Proximity Effect in Pd/Co/Pd and Pt/Co/Pt trilayer systems using X-ray Resonant Magnetic Scattering

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Abstract :

In nonmagnetic / ferromagnetic thin film systems, the ferromagnetic material can induce magnetic moments in the adjacent nonmagnetic material, which is called the magnetic proximity effect. Since the induced magnetic moment significantly influences spin transport properties, understanding the magnetic proximity effect is very important for the study of spintronic devices. Magnetic proximity effect in Pd/Co/Pd and Pt/Co/Pt trilayer systems are studied by element specific X-ray magnetic circular dichroism (XMCD) and interface sensitive and depth resolved X-ray resonant magnetic scattering (XRMS). In the case of Pd/Co/Pd trilayer system, Pd induced magnetic moment at bottom Pd/Co interface is larger than Pd induced magnetic moment at top Co/Pd interface, although the top Co/Pd interface and bottom Pd/Co interface are almost identical structurally. In contrast, in the epitaxial Pt/Co/Pt trilayer system, the Pt induced magnetic moment in the top Co/Pt interface is nearly identical with the Pt induced magnetic moment in the bottom Pt/Co interface.

Pioneer: Dark matter and a new physics/1190 C1.01

Bose-Einstein Condensation of Dark Matter Axions

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Abstract :

It has long been known that axions produced by vacuum realignment during the QCD phase transition in the early universe form a cold degenerate Bose gas and are a candidate for the dark matter. More recently it was found that dark matter axions thermalize through their gravitational self-interactions and form a Bose-Einstein condensate (BEC).

On time scales long compared to their rethermalization time scale, almost all the axions go to the lowest energy state available to them. In this behaviour they differ from the other dark matter candidates. Axions accreting onto a galactic halo fall in with net overall rotation because almost all go to their lowest energy available state for given total angular momentum. In contrast, the other proposed forms of dark matter accrete onto galactic halos with an irrotational velocity field.

The inner caustics are different in the two cases. I'll argue that the dark matter is axions, at least in part, because there is observational evidence for the type of inner caustic produced by an axion BEC.

Pioneer: Dark matter and a new physics/1209 C1.02

Hunting for answers for the Dark matter and matter-antimatter questions

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Abstract :

The center for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS) is launching axion dark matter experiments capable of answering the question of whether they are composing a significant component of the local dark matter density. The main thrust of our effort is based on the development of superconducting magnets made beyond the common NbTi low Tc cables, which have a hard B-field limit of 10T. The new cables, either low Tc Nb3Sn or the high Tc ones, offer a unique opportunity of reaching much higher fields, greatly enhancing the axion detection sensitivity. We currently have under development a 12T with 32cm inner bore diameter Nb3Sn magnet from Oxford and a 25T, 10cm inner bore diameter high Tc magnet from Brookhaven National Laboratory. Another magnet of 18T with 7cm inner bore diameter made with high Tc cable by SuNAM, a Korean company, has already been delivered to CAPP and demonstrated to performed better than the specs. Overall within the next two to three years we expect to be covering the frequency range 1-10GHz and beyond with hadronic axion sensitivity.

In parallel to this effort we are launching a comprehensive study to finalize the design of the proton and deuteron electric dipole moment (EDM) experiments at CERN. We need to finish a conceptual design report by the end of 2018 and present it at the European Strategy meeting in Venice in 2019. CERN has made significant resources available aiming at a successful result of those studies. Korea (IBS/CAPP) is developing high-tech critical components for the proton EDM experiment and is playing a leadership role in the experiment.

Pioneer: Dark matter and a new physics/1063 C1.03

Light axino dark matter from freeze-in production

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Abstract :

We consider light axino dark matter decaying into photons. If the mass of axino is 7 keV, its decay can be a source of 3.5 keV X-ray excess. The axino dark matter is produced mainly by freeze-in processes, and it can reduce the tension with constraints from Lyman-alpha forest data. The decay of its scalar partner, saxion, produces a certain amount of entropy, so the tension can be completely avoided. The freeze-in axino meets the observed dark matter density.

Overview of the Electromagnetic Calorimeter Trigger System at the Belle II Experiment

김성현 [1], 이인수 [1], 김철훈 [1], 조한얼 [1], Y. Unno[1], 천병구[*1], 김영준 [2], 최원지 [2], 안정근 [2]

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Abstract :

The new SuperKEKB factory at KEK in Japan is an upgrade version of the KEKB electron-positron asymmetric collider, with a target instantaneous luminosity of 8 x 10^{35} cm^{-2}s^{-1}, about 40 times higher than the KEKB. The Belle II experiment is in the final stage of construction as well toward the luminosity run for physics data collection in early of 2018. In this report we present an overview of the Belle II electromagnetic calorimeter(ECL) trigger system that has been already started to provide an ECL trigger signal to take a global cosmic run with Belle II DAQ system before the luminosity run.

Accelerator-based particle physics experiments (C)/0458 C2.02

Search for CP violation using T-odd correlations in D0 → K+K-π+π- decay

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Abstract :

We search for CP violation using T-odd correlation in the singly Cabbibo suppressed D0 → K+K-π+π- decay at the KEKB asymmetric e+e- collider. Based on the 976 fb-1 Belle detector Monte-Carlo sample the D*+- particles are reconstructed to tag the D0 particles and a triple product using the momentum of the D0's daughter particles is calculated. Cuts and vetos are applied to the reconstructed sample. A two dimensional simultaneous fit using four sub-samples depending on the triple product and D0 flavor while using the invariant mass of D0 and the invariant mass difference between D*+ and D0 particles as the two dimensions is performed. The T-odd correlation and systematics are calculated.

Accelerator-based particle physics experiments (C)/0413 C2.03

Prospects for the CKM angle phi3 at Belle II

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Abstract :

The CKM angle phi3 (also known as gamma) is currently the least constrained of the Unitary Triangle angles, but it is unique in being able to be determined to sub-degree precision in B->DK decays with almost no theoretical uncertainty. The Belle II experiment on the SuperKEKB e+e- collider is planning to collect several inverse ab of BBbar data, which will allow for these precision measurements to be achieved. We review the current status of phi3 and present results using Belle II simulation showing the prospects of these future measurements.

Accelerator-based particle physics experiments (C)/0844 C2.04

KOTO 실험 KL0->pi0pi0pi0 을 재구성을 이용한 표본형 열량계의 성능 평가

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Abstract :

일본 J-PARC 에서 2013 년부터 KL0->pi0 nu nubar 희소 붕괴를 탐색하는 KOTO 실험이 본격적으로 진행 중이다. 표준 모형에서 예측하는 이 붕괴 현상의 갈래비는 2.8 +/- 0.4 * 10^-11 으로 매우 작기 때문에 배경 사상의 제거가 중요하다. 배경 사상의 제거에 중요한 원통형 표본형 열량계(Barrel Veto) 의 광자와의 반응을 이해하기 위하여 CsI 열량계 검출기와 Barrel Veto 를 이용하여 KL0->pi0pi0pi0 을 재구성하였다. KL0->pi0pi0pi0 재구성의 결과로 광자에 대한 Barrel Veto 의 성능 평가를 수행하였다. 또한 기존의 우주선 데이터를 사용하는 방법보다 KL0->pi0pi0pi0 반응을 이용한 교정으로 더 향상된 검출기의 에너지 및 시간 정보를 얻을 수 있었다.

Accelerator-based particle physics experiments (C)/0192 C2.05

Time-Of-Flight detector of the GBAR experiment

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Abstract :

The GBAR(Gravitational Behavior of Antihydrogen at Rest) experiment is one of the first endeavors to observe gravitational properties of antimatter. It aims at measuring the free-fall acceleration of antihydrogen in the terrestrial gravitational field. The Time-Of-Flight(TOF) detector will be situated in the last step and detect signals of secondary particles from antihydrogen annihilation. From that, we can know when/where the antihydrogen annihilation occurred and after all a gravitational constant of antihydrogen. After prototype test and simulation studies, a part of TOF has been built and installed at CERN. During this summer, we could obtain cosmic rays data and signals from AD/ELENA injection, which will be important background sources. Through analysis of them, we have checked TOF's performance and improved its readout/data acquisition system.

Accelerator-based particle physics experiments (C)/0881 C2.06

Current Status of the SHiP Experiment

김성현 [1], 박병도 [1], 손종윤 [1], 윤천실[*1], 이강영 [1], 박성근 [2], 이경세 [2], 김영균 [3], 최기영 [4], 고재우 [5], 우종관 [5]

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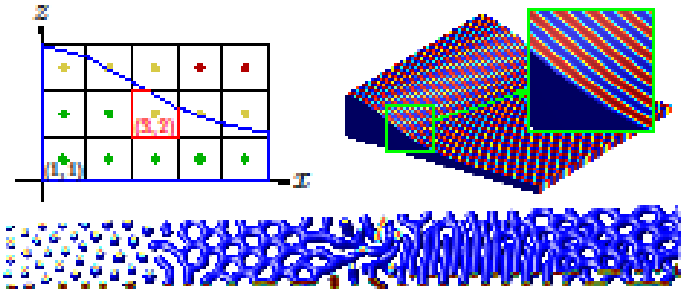
Abstract :



The SHiP (Search for Hidden particles) is a multi-purpose experiment whose aim is to explore the domain of hidden particles and make measurements with Tau neutrinos. The hidden particles are predicted by a large number of recently elaborated models of hidden sectors beyond the standard model. The SHiP is a fixed-target experiment at CERN SPS that will use decays of charm and beauty mesons and search for light long-lived exotic particles whose mass ranges are from sub-GeV up to *O*(10) GeV/c^2 with superweak coupling down to 10^{-10}. We expect about 3500 tau neutrino events and the first observation of anti-tau neutrino in this experiment. One of the major concerns for the design of the SHiP experiment is the lack of a precise knowledge of the muon flux. In order to measure the expected muon flux, a test experiment was proposed by installing a replica of the SHiP target in a 400 GeV/c proton beam at SPS H4. A muon tagger will be built using RPCs which will be contributed by our group, and the drift tubes constructed for OPERA will be used for this test experiment in early 2018. After the measurement of the muon flux, this setup can also be used to measure the charm cross section (including the cascade production) with Nuclear emulsion target. The current status of the experiment and our contributions will be introduced.

Direct detection of light dark matter at SHiP

최기영 [1], 김성현 [2], 김영균 [3], 고재우 [4], 이강영 [*2], 이경세 [5], 박병도 [2], 박성근 [5], 손종윤 [2], 우종관 [4], 윤천실 [2]

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Abstract :

SHiP (Search for Hidden Particles)은 1 GeV 이하부터 수 GeV 에 이르는 질량을 가지는 숨겨진 입자를 탐색하기 위해서 새로 제안된 실험으로써, 유럽입자물리학연구소 CERN 의 SPS 가속기를 이용하는 고정 표적 실험이다. SHiP 은 기본적으로는 매우 약하게 상호작용을 해서 수명이 긴, 무거운 중성 렙톤 (HNL), 새로운 스칼라나 벡터 보존, 페르미온과 같은 입자들이 표준모형 입자들로 붕괴하는 신호를 찾도록 설계되었다. 하지만 이러한 입자 외에 가벼운 암흑물질이 생성된다면 암흑물질이 SHiP 검출기의 중성미자 검출기나 전자기 열량계 검출기의 물질과 상호작용할 때의 신호를 포착할 가능성도 있다. 본 연구는 이러한 가능성에 대해서 살펴본다.

Focus: Gravitational wave astronomy/1189 C3.01

Gravitational Wave Astrophysics

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Abstract :

The advanced LIGO detected three black hole binary mergers and one candidate during until early this year. We are still in very early stage of gravitational wave astronomy, but we already learned many new things in astrophysics. The existence of the binary black hole was never established observationally until the LIGO made detections of binary black hole mergers. The masses of the black holes in the binaries before the merger are systematically higher than the typical masses of the black hole candidates in X-ray binaries in the Galaxy. Most of the black holes were not spinning rapidly before the merger. These results pause many fundamental questions regarding the evolution of massive stars, the epoch of formation of the black holes and origin of the compact black hole binaries. We need many more detections with high signal to noise ratios in order to answer these questions. In this talk, I will focus on the astrophysical significances of the detected gravitational waves so far and discuss future prospects of gravitational astrophysics with current and future generation of gravitational wave detectors.

Focus: Gravitational wave astronomy/0248 C3.02

Properties of light propagating through gravitational waves

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Abstract :

Well-known effects induced on a light beam propagating in a gravitational field include deflections and frequency shifts. Detection experiments such as LIGO, Virgo and KAGRA use the phase difference of light beams in two interferometer arms caused by a passage of gravitational waves, and have turned out to be able to measure an extremely weak signal, resulting in the first direct detection of gravitational waves. This talk considers the interaction of a light with gravitational waves in a wider context. We first review the interference process at both a transverse-traceless coordinate system (e.g., a laboratory frame) and a proper reference frame of the beam splitter (e.g., a locally Lorenz frame). Finally, the possibility of phase and polarization shifts in two differently polarized light beams due to gravitational waves has briefly been discussed theoretically.

Focus: Gravitational wave astronomy/0321 C3.03

KAGRA Status and Parameter Estimation

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Abstract :

최근의 LIGO 와 Virgo 협력 연구단의 레이저 중력파 검출기에서 블랙홀 쌍성계의 병합(merge)에서 발생하는 중력파를 직접 검출하였다. 이를 통하여 블랙홀의 존재와 중력파의 실체가 파악 되었다고
할 수 있으며 검출을 좀더 확증적으로 보여주기 위해서는 독립적인 중력파의 검출이나, 중력파에 이은
전자기파의 발생을 기존의 전통적인 천문학적 방법으로 검출하는 것이 필요하다. 그 것 중의 하나가 거의
건설이 완성단계에 와있는 일본의 레이저 중력파 검출기인 KAGRA 의 역할은 매우 중요하다고 할 수 있다.
KAGRA 는 초기건설 단계부터 한국 연구자들이 적극적으로 참여하여 중요한 역할을 하고 있다.
독립적인 검증과 아울러 중력파원의 물리적 변수들에 대한 좀 더 정확한 관측적 결정이 중요해 졌다. 좀 더 정밀한 변수들의 결정을 통하여 일반 상대론 및 강한 중력장에서의 물리현상에 대한 많은 새로운 사실들을 관측으로 알 수 있게 될 것이 기대되고 이와 관련한 매개변수 결정 방법에 대해서 논의할 것이다.

Nuclear engineering and nuclear power study(G)/0357 C4.01

The Comparative Analysis of Rectangular- and Helical-type DC Electromagnetic Pump for ADHRS in PGSFR

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Abstract :

A DC electromagnetic pump with rectangular- and helical-type was optimally analyzed for the active heat decay removal system (ADHRS) in prototype GenIV sodium fast reactor (PGSFR). The direct current (DC) electromagnetic pump was used to circulate liquid metal using Lorentz force which was vector product of current from electrode stub and magnetic flux density from permanent magnet. The two-types of DC electromagnetic was analyzed in the respect geometrical sizes, needed current, magnetic flux density, developed pressure while optimize each electromagnetic pump at pressure drop of 2 kPa and flow rate of 0.02 m^3/s in liquid sodium temperature condition of 226 ℃. The FEM method using ANSYS code simulation and analytical method were used to determine specification of DC electromagnetic pump.

Nuclear experimental method and instrumentation(F)/1039 C4.02

Test of a Prototype Neutron Detector Array for high-LAMPS at RCNP

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Abstract :

Neutron array detector is a part of LAMPS(Large Acceptance Multipurpose Spectrometer) that will be installed at the rare-isotope beam facility, RAON. Neutron detector array will measure high-energy neutrons in the final states of nuclear reaction. we performed neutron beam test with the energy of 392MeV, 65 MeV at RCNP. With this experiment, we checked basic detector performances. specially studied events that hit more than one detector.

Nuclear experimental method and instrumentation(F)/0532 C4.03

Development Status of Target and Ion Source System for RISP

Hong Sung Gwang*[1], Park Sung Jong[1], Hwang Wonjoo[1], Jeong Jae Won[1], Joung Mi Joung[1], Kim Jang Youl[1], Ishiyama Hironobu[1], Lee Jin Ho[1], Kang Byoung Hwi[1], Jeong Sun Chan[1]

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Abstract :

The target and ion source (TIS) system is the heart of the isotope separation on-line (ISOL) facility. The ISOL off-line test facility has been established to develop the ISOL TIS system at the Rare Isotop Science Project (RISP). We performed ionization efficiency measurement to evaluate the ion sources: the surface ion source and the laser ion source. As preliminary results, the surface ionization efficiencies for Rb and Cs have been measured to be about 75% from the prototype of the RISP surface ion source. In this talk, the current status of the development of the TIS system including the laser system for laser ion source will be presented.

Nuclear experimental method and instrumentation(F)/0516 C4.04

한국의 가스전자증배기 생산 현황

박인규[*1], 정영군[1], 장세덕[1], 송동현[1], 박덕환[1], 최민규[1], 이상훈[1], 양운기[2], 윤인석[2], 오성빈[2], 이한얼[2], 최수용[3], 최영일[4], 유인태[4], 이용훈[4], 이세욱[5], 문동호[6], 김현수[7], 김태정[8], 정태성[9], 김근호[9], 유연수[9], 김태준[9]

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Abstract :

GEM 호일 국내 생산 시설 구축 현황과 현재까지 진행된 다양한 GEM 호일 개발 경험을 소개한다.

Nuclear experimental method and instrumentation(F)/0507 C4.05

Pulse-shape Analysis of the Prototype Neutron Detectors for LAMPS at RAON

MULILO Benard[1], LEE Jong-Won[1], SHIM Hyunah[1], HONG Byungsik[*1], AHN Jung Keun[1]

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Abstract :

The Neutron Detector Array for LAMPS (Large-Acceptance Multi-Purpose Spectrometer) at RAON consists of 2-m long plastic scintillator bars read out at both ends by the photomultiplier tubes (PMTs). The output signals from PMTs are sent to the flash ADC (Analog-to-Digital Converter) for the time-dependent deposited energy as well as the arrival time of the particles impinging on the scintillator bars. Since the accuracy of the reconstructed energy and the particle identification capability of the time-of-flight (ToF) system strongly depend on the time resolution, we have systematically analyzed the various pulse characteristics such as the reflection and pileup, the width and amplitude, the rise and decay times, the position dependent response, and the attenuation length with a hope to improve the detector resolutions.

Nuclear experimental method and instrumentation(F)/0464 C4.06

Development of $Tl_2Gd_{(1-x)}Ce_xCl_5$ (x= 0, 1, 5, 10 mole%) scintillator for X- and γ-ray detection

Arshad Khan[1], Gul Rooh[2], H. J. Kim[*1], Hwanbae Park[1], Sunghwan Kim[3]

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Abstract :

In the quest for new heavy inorganic single crystals with excellent scintillation properties, such as high effective atomic number, density, light yield, energy resolution, fast decay time and proportionality of response, we are presenting on the discovery and development of $Tl_2Gd_{(1-x)}Ce_xCl_5$ (x= 0, 1, 5, 10 mole%) scintillator. High radiation detection efficiency for X-and γ-rays are expected using this material due to its high effective atomic number (71) and density (5.10 g/cm^3). Two zone vertical Bridgman technique is employed for the single crystal growth of this material. Pure Tl_2GdCl_5 crystal exhibits broad band emission in the range of 350-600 nm peaking at 400 nm under X-ray excitation due to Tl^+ emission. X-ray induced emission spectra of 1, 5 and 10 mole% Ce^{3+} doped Tl_2GdCl_5 samples shows Ce^{3+} emission in the range of 350-500 nm peaking at 389 nm. Among all the samples, 5 mol% Ce^{3+} Tl_2GdCl_5 crystals shows highest light output of 53,000±5,300 ph/MeV and energy resolution of 5% (FWHM) under 662 keV γ-rays excitation at room temperature. Three decay time components are obtained under γ-rays excitation for all the samples having major decay time <40 ns. Good energy resolution, high light yield, fast decay time response and high effective atomic number suggest $Tl_2GdCl_5:Ce^{3+}$ a potential γ-ray detector for applications in the field of medical imaging.

Nuclear experimental method and instrumentation(F)/0457 C4.07

PPAC development and beam test for the KOBRA spectrometer

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Abstract :

Several prototype position sensitive parallel plate avalanche counters (PPACs) have been fabricated for the Rare Isotope Science Project (RISP). Our detectors have active areas of 20x20 cm^2 and utilize a stripped electrode structure, together with a delay line readout, to extract position information. The detector performance was tested with ^{12}C and ^{16}O 3 MeV/u beams and they were observed to work stably up to an intensity of 2x10^6 pps. A position resolution of 0.8 mm, and a time resolution of 0.9 ns, full width at half maximum (FWHM) were measured with beam intensities up to 2x10^5 pps. The detection efficiency at this intensity was measured to be $>$99%. A new production technique, using photolithography, for the fabrication of PPAC electrodes of areas up to 40x20 cm^2 is also presented.

Nuclear experimental method and instrumentation(F)/0455 C4.08

RAON: Isotope Separation On-Line 시설 개발 현황 및 진행 계획

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Abstract :

중이온가속기건설구축사업단(RISP)에서는 최대 70 KW 급의 온라인 분리방식인(ISOL) 희귀동위원소 발생시설을 개발 중에 있다. 사업기간 내에 목표로 한 10 kW 급 ISOL 표적/이온원 개발 및 구축을 목표로 다양한 장치가 시제품 개발 및 성능평가가 수행 중이다. 전체적인 ISOL 시설의 장치 개발 현황과 앞으로의 계획을 소개하고 개발 현안을 논의하고자 한다.

Nuclear experimental method and instrumentation(F)/0454 C4.09

Present design status of KoBRA (KOrea Broad acceptance Recoil spectrometer and Apparatus) for Rare Isotope Science Project (RISP)

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Abstract :

KoBRA (KOrea Broad acceptance Recoil spectrometer and Apparatus) as a multi-purpose experimental instrument using both stable and rare isotope ion beams for studies of various topics in low energy nuclear physics is being designed for RAON facility. The present design status of KoBRA is reported with a brief introduction to ROAN facility.

Quantum optics and quantum information(C)/0292 C5.01

자기쌍극자 상호작용으로 결합된 다이아몬드 내 다중 큐빗 생성

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Abstract :

다이아몬드 안의 점결함 발광 센터인 NV center 는 양자 연산 소자를 실현할 수 있는 여러 양자 큐빗 후보들 중에 하나이다[1]. 양자 연산 소자는 다수의 큐빗들로 구성된 양자노드와 이를 이용한 양자역학적 논리 게이트들로 구성된다. 이를 위해서는 강한 상호작용으로 결합된 큐빗들로 이루어진 양자계의 스핀 중첩 상태나 얽힘 상태가 필요하다. 고체 스핀 큐빗의 경우 전자 스핀들 사이 자기 쌍극자 상호작용 혹은 전자 스핀과 핵 스핀 사이 미세 상호작용으로 결합된 스핀 큐빗들을 이용하여 이러한 양자 중첩상태들을 생성할 수 있다. 그리고 이 스핀 상태들을 광학적 방법과 자기공명을 결합하여 제어, 측정함으로써 양자 연산들을 수행할 수 있다. 최근에 다이아몬드 내에서 4 개의 스핀 큐빗을 이용한 논리 게이트 구현이[2] 발표되었으나 그보다 많은 갯수의 고체 큐빗 시스템으로 확장 시키기 위해서는 몇가지 장애물들을 극복해야 한다. 첫번째는 큐빗들 간의 강한 상호작용을 유발하기 위해 수십 nm 영역에서의 큐빗 생성 위치의 정밀 제어가 필요하며, 두번째, 상호작용하는 스핀 큐빗 들의 coherent control 과 측정이 가능해야 한다. 세번째, 양자 노드 내 스핀-스핀 상호작용의 토폴로지를 정확히 이해하는 것이 필요하다. 마지막으로 양자 노드 안의 스핀 노이즈를 줄여서 스핀 큐빗들의 충분히 긴 결맞음 시간도 보장되어야 한다.

이 연구에서는 집적된 큐빗 시스템의 구현을 위한 기초연구로서 다이아몬드 내의 NV center 와 강하게 상호작용하는 인근의 질소 스핀들로 구성된 NV–N 스핀 페어들을 제작하고 pulsed ODMR (optically detected magnetic resonance) spectroscopy 를 이용하여 이들 스핀 큐빗 페어들을 확인하고 스핀 페어의 스핀들 간의 상호작용을 탐구하고자 한다.

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Implementation of Gate Set Tomography on Superconducting Transmon Qubit for Characterization and Optimization of Single Qubit Gates

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Abstract :

Characterizing the fidelities of quantum gates and improving them are essential requirements to build a scalable quantum computation platform. Two typical methods for such purpose, i.e., randomized benchmarking and quantum process tomography, contain drawbacks that cannot be compensated without the aid of the other, which demands the development of a new stand-alone protocol. Gate set tomography (GST) is one of such protocols developed to obtain detailed information of qubit gates that are free from the state preparation and measurement (SPAM) errors. We have implemented GST on single transmon qubit embedded in a three dimensional cavity. As a result, GST analysis not only estimated the process matrices of target gates but also suggested the direction for further calibration to achieve more accurate gate operations.

Quantum optics and quantum information(C)/0553 C5.03

Quantum Compiler and Quantum Virtual Machine

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Abstract :

We introduce our quantum compiler based on the ScaffCC program with modification. This can compile well-known important quantum algorithms and analyze the resources required in executing quantum algorithms in quantum computer. On the other hand, quantum virtual machine is a crucial issue. We can verify the correctness for quantum algorithms and can predict the execution of a quantum algorithm in advance using a quantum virtual machine. Therefore, we have made our own virtual machine. Finally, we show the compiled results of simple quantum algorithms and simulated results by our quantum virtual machine.

Quantum optics and quantum information(C)/0654 C5.04

양자 컴퓨팅 성능 평가

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Abstract :

본 발표에서는 양자 컴퓨팅의 성능에 대해서 살펴보고자 한다. 특히, 알고리즘부터 물리 큐빗의 조작까지 모든 요소들을 추적하여 기존에 발표되었던 양자 컴퓨팅 성능 평가체계보다 정교한 성능 평가를 수행한다. 기존의 양자 컴퓨팅 성능 평가 [1, 2] 는 대부분 알고리즘 기반으로 큐빗과 게이트의 수를 추정하거나 또는 여러가지 가정하에서 양자 컴퓨팅의 성능을 추측했었다.

반면, 우리는 알고리즘을 프로그래밍하고 컴파일하여 양자 어셈블리 코드 (QASM) 를 확보하고, 양자 오류 정정 부호를 이용해 논리 큐빗 (logical qubit) 을 만들어 알고리즘 수행에 필요한 만큼 1D 또는 2D 구조로 배치를 한다. 적정하게 배치된 논리 큐빗들 위에 양자 어셈블리 코드를 매핑하여 양자 알고리즘을 구동하는데 필요한 모든 경우를 추적한다. 이렇게 "알고리즘 컴파일, 논리큐빗생성->시스템 매핑" 과정을 거쳐서 양자 컴퓨터의 예상 성능, 즉, 알고리즘 구동 시간, 알고리즘 구동 정확도를 비롯하여 여러가지 양자 컴퓨팅 성능 통계 수치등을 산출한다.

본 발표에서는 대표적인 양자 컴퓨팅 알고리즘인 Shor 의 소인수 분해 알고리즘 [4] 과 Ground State Estimation 알고리즘 [2] 의 구동 예상 성능을 분석한다. 특히, 논리 큐빗을 만들기 위해서 대표적인 양자 오류정정 부호인 [[7, 1, 3]] Steane code [5], [[9,1,3]] Bacon-Shor code [6] 그리고 Surface code [7] 를 이용하고, 물리 시스템은 양자점 (Quantum Dot) [8], 초전도체 (Superconductor) [9] 그리고 이온 (Trapped ION) [10] 을 바탕으로 한다.

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Demonstration of Two-Qubit Algorithms in Superconducting Qubit System

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Abstract :

Quantum computing platforms are expected to outperform their classical counterparts in solving certain technical problems such as factorization and searching process. With remarkable progresses in the field, a lot of efforts and attentions are being made to experimentally demonstrate such supremacy of quantum computation. As a primitive attempt, we have implemented simple and well-known two-qubit algorithms in our superconducting qubit system. Our system consists of two transmon qubits, one of which is a frequency-tunable qubit, embedded in a single copper cavity forming a circuit QED system. The entangling gate that is essential for implementing quantum algorithms has been realized by utilizing MAP (microwave-activated phase) gate. We evaluate the performance of two-qubit processor by estimating the fidelity of the entangling gate with two-qubit quantum process tomography (QPT). Then we demonstrate the implementation of two-qubit algorithms such as Deutsch-Josza algorithm and Grover search.

양자 컴퓨팅 성능에 대한 큐빗 레이아웃 (Layout) 의 영향

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Abstract :

전세계적으로 양자 컴퓨터 연구 개발이 한창이다. IBM 에서는 5-qubit, 16-qubit 양자 컴퓨팅 클라우드 서비스를 제공하고 있고 [1], Google 은 49-qubit 양자 컴퓨터를 통해서 Quantum Supremacy 를 보이기 위한 준비가 한창이다 [2]. 양자 컴퓨터의 성능에 영향을 미치는 요소는 매우 다양한다. 가장 상위 단계인 알고리즘, 컴파일부터 가장 하위 단계인 물리 큐빗 부분까지 모든 요소들이 직간접적으로 양자 컴퓨터의 성능에 영향을 준다 [3]. 본 발표에서는 큐빗의 레이아웃이 양자 컴퓨팅 성능에 미치는 영향에 대해서 살펴보고자 한다.

큐빗의 레이아웃은 큐빗들을 배치하여 상호간 직접 연결하는 방식을 말한다 [4]. 다시 말하면, 1D nearest neighbor 레이아웃 상에서는 큐빗들이 일렬로 배치되어 좌우 두 개의 큐빗들과만 직접 연결할 수 있다. 2D nearest neighbor 레이아웃에서는 큐빗들을 2D 사각형 위에 배치하여 큐빗들이 상하좌우 4 개의 큐빗들과 직접 연결을 할 수 있다. 그동안 양자 컴퓨터 구현을 위해서 주로 1D 와 2D 구조가 많이 논의되어 왔다. 3D 구조의 경우 큐빗들간 더 많은 연결성을 가지고 있지만, 큐빗을 제어하기 위해 필요한 외부장치와 연결이 어려워 아직 본격적으로 논의되지 않고 있다.

큐빗의 레이아웃에 의해서 영향을 받는 주요한 대상은 멀티 큐빗 게이트이다. 범용 양자 컴퓨팅을 위해서는 two-qubit gate 인 CNOT 게이트가 필수적이다 [3]. 현재까지 멀티큐빗 게이트를 구현할 수 있는 가능한 방안은 게이트의 대상이 되는 큐빗들이 local, 즉 서로 인접해 있어야 한다. 만약 큐빗들이 서로 인접해 있지 않으면, 해당 CNOT 게이트를 인가하기에 앞서 SWAP 게이트 등을 이용해서 큐빗들이 인접하여 위치하도록 해주어야 한다. 이때, 큐빗의 레이아웃에 따라서 큐빗의 이동량이 달라진다. 특히, SWAP 게이트의 경우 3 개의 CNOT 게이트로 구성되어 있기 때문에 SWAP 게이트의 양이 늘어날 수록 양자 컴퓨팅 성능에 악영향을 끼치게 된다. 우리는 본 발표에서 복수의 양자 알고리즘을 1D, 2D 큐빗 레이아웃상에 매핑한 후 양자 컴퓨팅의 예상 성능을 확인하도록 한다.

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Quantum optics and quantum information(C)/0818 C5.07

Squeezing microwave photon using a Josephson parametric amplifier

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Abstract :

The squeezed state is important to detect a weak signal with a low noise level and apply to the quantum entanglement. Josephson parametric amplifier (JPA) is a representative nonlinear resonator that can be used to generate the squeezed state in microwave frequencies. We fabricated the JPA consisting of LC resonator terminated with SQUID. The squeezed state is produced when the JPA operates in the degenerate mode, in which the pump frequency is twice the signal frequency. Here, we used the homodyne detection technique to characterize the generated squeezed state. Finally, we performed the tomographical reconstruction of the squeezed state by using the Wigner function.

3 큐빗 양자 오류 정정부호의 유효성 및 논리적 큐빗의 연산 가능시간에 대한 전산 모사 분석

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Abstract :

논리적 큐빗은 높은 정확도를 갖는 양자 컴퓨터를 구현하기 위한 필수 요소로 평가되고있다. 물리적 큐빗의 확장성이 점차 좋아짐에 따라 논리적 큐빗의 구현이 가까워지고 있어, 이를 위한 물리적 큐빗의 요건이 KQ 모델[1]에 비하여 더 명확해 질 필요가 있다. 이에 큐빗의 연산에 요구되는 최대시간 및 최소 신뢰도 등의 분석[2]이 진행되고있다. 본 연구에서는 현재 보고된 큐빗의 정보를 바탕으로 3 큐빗 오류 정정 부호를 구현하였을 때를 전산모사하여 그 유효성과 연산가능시간에 대하여 분석하고자한다.

3 큐빗 오류 정정 부호는 가장 간단한 형태의 오류 정정 부호로 논리적 큐빗의 구현이 용이하다. 양자상태에 대한 전산 모사는 밀도 행렬을 이용하여 연속적인 큐빗의 상태변화를 기술하였으며, 물리적 큐빗의 결맞음 시간을 직접적으로 반영하는 에러모델을 사용하였다[3]. 이에 따라 본 연구에서는, 물리적 큐빗의 연산가능 시간과 논리적 큐빗의 연산 가능 시간을 비교평가하여본다. 또한, 동일한 연산 정확도를 가질 때, 논리적 큐빗의 연산 가능 시간이 얼마나 나아지는 지에 대하여 평가하고자 한다.

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Acknowledgement

본 연구는 한국전자통신연구원 연구운영비지원사업의 일환으로 수행되었음. [17ZH1200, 양자컴퓨팅 플랫폼 및 비용효율성 향상에 대한 연구 개발]

Pioneer: Energy harvesting technologies/1168 C6.01

Optoelectronic and transport properties of organic-inorganic methylammonium lead halide crystals and thin-films

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Abstract :

Organic-inorganic lead halide perovskite, $CH_3NH_3Pb(Br,I)_3$ is taking the spotlight with outstanding performance for photovoltaic, light-emitting, and memristic devices. Most studies of all, examination on single crystals are demanded to comprehend the intrinsic physical characteristics. Grain growth in perovskite is not fully interpreted with regards to compositions, textures, and even believed as a trapping source of ionic migration. We confirm the structural systems and phase purity by using transmission electron microscopy and Raman scattering spectroscopy. We verify the details of the crystal structure in terms of configuration of the methyl-ammonium ligands. Thus, we evaluate the exposed surface of the perovskite crystals in terms of surface potential with Kelvin probe force microscopy. Calculated work function exhibits distribution around 4.6 eV, which is a similar value with thin film perovskite thin film. We also measured its photoluminescence and temperature dependent resistivity in order to estimate electronic structure and transport behaviors of the crystals.There are the deformations of the perovskite materials to the methyl-ammonium halide and lead halide on the surface partially by the deconvolution of the surface potential and it imply the alternative electrical characteristics depending on the surface doping. Synthetically, we obtained a stereographic schematic picture for the electronic band structures, which reveal the possible semiconducting nature of the materials by consolidating the information of the band gap and work function. One of the issues is hysteresis phenomenon with ionic migration. Current-voltage curves tend to differ depending on the sweep rate and direction. Several mechanisms have been proposed including difference in trapping efficiency, ion migration, imbalance between electron and hole fluxes into an electron transfer layer and a hole transfer layer, and ferroelectricity of the perovskites. We report our observations on the piezoelectricity in the perovskite thin-films grown on TiO_2 mesoscopic and planar bottom electrodes by measuring piezoelectric responses and ferroelectric property using piezoelectric force microscopy which is one of atomic force microscopy techniques. In addition, we investigated for the distribution of the surface electric potential and current transport by Kelvin probe force microscopy and conductive atomic force microscopy, respectively. We propose a device model to enhance charge transfer with in the perovskite solar cells when we have a preferred polarization in the materials through examination for the nature of the hysteresis properties.

Pioneer: Energy harvesting technologies/0682 C6.02

Flexible voltage generator based on movement of electrolyte droplet on carbon nanotube thin film

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Abstract :

Energy harvesting from environment energy sources is emerging technology for driving sensor devices for IoT. Recently, the voltage generation of a few millivolts from the movement of electrolyte solution have been demonstrated by using graphene [1, 2] and carbon nanotubes (CNTs) [3]. However, the generated voltage and power were quite low, and the improvement is needed for driving sensor devices. We developed the flexible generator with single-walled CNT thin film on a plastic substrate, and proposed a simple equivalent circuit model for the voltage generation as shown in Fig. 1. An electrical double layer is formed at the interface between the electrolyte droplet and the CNT thin film, resulting in a modulation of potential in the CNT thin film. With moving the droplet, the carriers are swept out to the electrode by the movement of the modulated potential, generating the current. The generated voltage is determined by the current and the shunt resistances of CNT thin film and the electrolyte solution. This equivalent circuit suggests that generated voltage can be enhanced by eliminating the shunt current flowing though the CNT thin film. In this work, we report a significant enhancement of generated voltage by a semiconducting CNT thin film with a high sheet resistance.

A thin film of semiconducting CNT separated by gelchromatography [4] was formed on a polyethylene naphthalate substrate. Ag-paste electrodes were formed at both ends of the rectangular (30 mm x 5 mm) CNT thin film (Fig. 2). The sheet resistance was 1.78 MW/sq. A droplet of NaCl aqueous solution (0.01 mol/l) was reciprocated on the CNT thin film, and the open-circuit voltage was measured.

The measured voltage waveforms are shown in Fig. 3. The maximum voltage of 250 mV was obtained with the semiconducting CNT thin film. Compared with a CNT thin film formed by the Floating-catalyst (FC) CVD method (a mixture of semiconducting and metallic CNTs, 24.0 kΩ/sq.), the generated voltage was significantly enhanced.

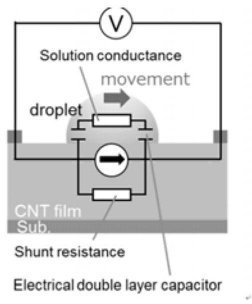

Fig. 1 Equivalent circuit.

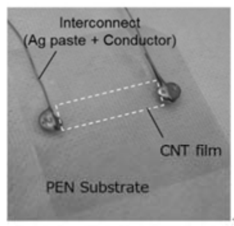

Fig. 2 Photograph of generator.

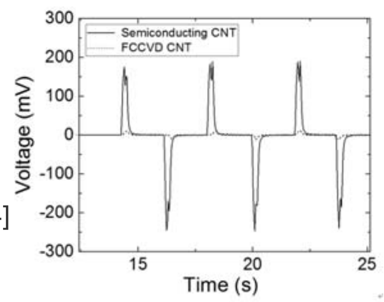

Fig. 3 Waveforms of open-circuit voltage.

Acknowledgment: This study was partially supported by JST/CREST (JPMJCR16Q2).

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Pioneer: Energy harvesting technologies/0771 C6.03

Piezoelectric Properties of ZnO Nanorod/Graphene and Vertically Aligned Phase Nanopillars for Nanogenerator Applications

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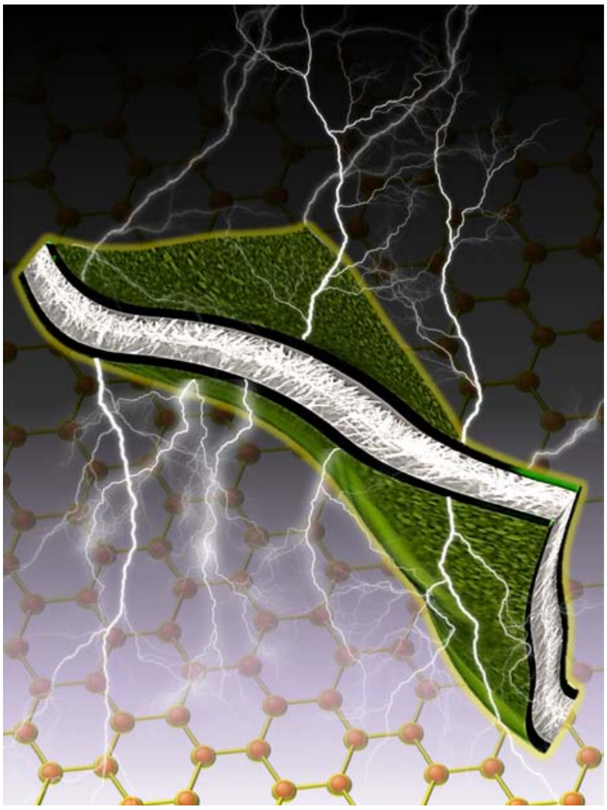
Abstract :



We present a simple strategy for fabricating the freestanding ZnO nanorods/graphene/ZnO nanorods double sided heterostructures. The characterization of the double sided heterostructures by using SEM, and Raman scattering spectroscopy reveals the key process and working mechanism of a formation of the heterostructure. The approach consists of a facile one-step fabrication process and could achieve ZnO coverage with a higher number density than that of the epitaxial single heterostructure. The resulting improvement in the number density of nanorods has a direct beneficial effect on the performance of piezoelectric nanogenerator devices.

We also present bioinspired nanogenerators based on vertically aligned phage nanopillars. Vertically aligned phage nanopillars enable not only a high piezoelectric response but also a tuneable piezoelectricity. Piezoelectricity is also modulated by tuning of the protein’s dipoles in the each phage. The sufficient electrical power from phage nanopillars thus holds promise for the development of self-powered implantable and wearable electronics.

Pioneer: Energy harvesting technologies/0695 C6.04

Solar-Thermophotovoltaic Systems Based on Controlling Unidirectional Radiative Heat Transfer with a Monolithic Absorber/Emitter

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Abstract :

Thermophotovoltaic (TPV) generation systems have been studied as one of the power generation systems from high temperature heat sources. In the TPV generation system, emission from a high-temperature body is directly converted into electricity by photovoltaic (PV) cells. The TPV system has no moving parts, high power density and can be driven with a wide range of heat sources, such as waste heat and solar energy etc. The number of research paper about TPV has been increasing in recent years.

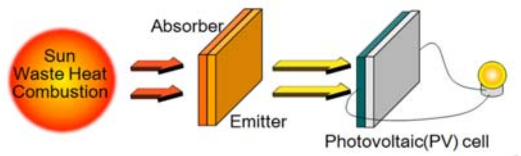

Fig.1 Schematic diagram of TPV systems

The key technologies of TPV are high efficiency narrow-gap PV cells and spectrally controlled thermal emitters. These are the key advantages of TPV systems for many potential applications. However, only several reports are available on the experiment of full TPV systems. In this report, A high-efficiency solar -thermophotovoltaic (STPV) system has been demonstrated using spectrally selective planar absorber/emitter systems and a GaSb TPV cell.

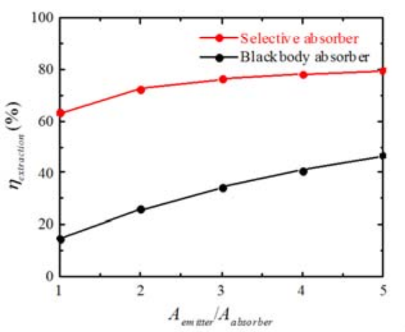

Fig. 2 Calculated extraction efficiency vs area ratio of absorber/emitter

STPV systems are mainly composed of concentrated solar energy, an absorber, an emitter and thermophotovoltaic (TPV) cells. The concentrated solar energy heats absorber, then, increases the emitter temperature and the TPV cell generates electricity by receiving thermal radiation from the emitter. The full spectrum of solar energy can be utilized in the STPV systems by controlling thermal radiation spectrum. In STPV, high conversion efficiency can be realized even with single-junction cells by matching the thermal radiation from the emitter into spectral response of the TPV cell. Previous research has shown that an STPV system's efficiency limit is 45.3%. [1] On the other hand, the experimental STPV conversion efficiency has been very low [2]. The recent studies on complete STPV systems have been advanced and the reported STPV conversion efficiency substantially increased up to 6.8% [3]. STPV have recently attracted greater attention though the efficiency is still lower than the potential high efficiency.

Here, we discuss designing high-efficiency STPV systems based on controlling unidirectional radiative heat transfer efficiency with a monolithic absorber/emitter. The experimental efficiency of STPV reached 5.1% based on high extraction efficiency. The STPV experimental results were discussed based on the extraction efficiency.

In order to achieve high-efficiency STPV systems, it is crucial to achieve high-efficiency unidirectional radiative heat extraction from the absorber to the emitter with minimal losses including reflection and emission losses from the absorber. The unidirectional radiative heat extraction efficiency $\eta_{extraction}$ is defined as the ratio of emission energy ($E^{e}_{emission}$) from the emitter transferred to the input of the absorber (E_{in}) [4]. The $\eta_{extraction}$ is expressed as

$$\eta_{extraction}=(E_{in} - E^{a}_{reflection} - E^{a}_{emission}) / E_{in}$$

where $E^{a}_{reflection}$ and $E^{a}_{emission}$ are reflection and emission losses from the absorber.

The $\eta_{extraction}$ was investigated with respect to the absorber/emitter area ratio (AR = $A_{emitter}/A_{absorber}$) as shown in Fig.2. In this calculation, the input power is varied to maintain absorber/emitter temperature at 1500 K. The both blackbody absorber and the ideal selective absorber were employed in this calculation. The contribution of spectral control of absorber to high $\eta_{extraction}$ is clearly indicated. For AR = 1, higher $\eta_{extraction}$ = 63% with selective absorber is achieved comparing to $\eta_{extraction}$ = 15% with blackbody absorber.

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Pioneer: Energy harvesting technologies/1200 C6.05

A highly-efficient, concentrating-photovoltaic/thermoelectric hybrid generator

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Abstract :

A concentrating photovoltaic (CPV) cell, where sunlight is optically focused onto the solar cell, exhibits the highest conversion efficiency among any solar cells. However, the further enhancement of the CPV efficiency is strongly limited by the heat generation at high solar concentrations. Here, we demonstrate a concentrating photovoltaic/thermoelectric hybrid generator using a single-junction, GaAs-based solar cell and a conventional thermoelectric module as a model system. Our hybrid generator gives rise to the conversion efficiency larger than the single CPV cell by ~3% at the solar concentration of 50 suns. Controlling thermal flow in the hybrid generator and Peltier cooling effect is the key to achieving high efficiency. Our result provides a framework for designing a highly-efficient hybrid generator using both photo-electric and photo-thermal effects for clean-energy production.

Pioneer: Non-equilibrium first-principles calculations for energy applications/0953 C7.01

Localized Orbital Scaling Correction for Systematic Elimination of Delocalization Error in Density Functional Approximations

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Abstract :

The delocalization error of popular density functional approximations (DFAs) leads to diversified problems in present-day density functional theory calculations. For achieving a universal elimination of delocalization error, we develop a localized orbital scaling correction (LOSC) framework, which unifies our previously proposed global and local scaling approaches. The LOSC framework accurately characterizes the distributions of global and local fractional electrons, and is thus capable of correcting system energy, energy derivative and electron density in a self-consistent and size-consistent manner. The LOSC-DFAs lead to systematically improved results, including the dissociation of cationic species, the band gaps of molecules and polymer chains, the energy and density changes upon electron addition and removal, and photoemission spectra.

References:

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Pioneer: Non-equilibrium first-principles calculations for energy applications/0096 C7.02

First-principles based non-equilibrium Green's function simulations of low-power semiconductor devices

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Abstract :

Recently, there have been increasing research efforts for development of low-power semiconductor electronic devices that overcome the thermal limit of the conventional field effect transistors. The tunnel field effect transistors, whose operation principle is based on the band-to-band tunneling current, are regarded the most promising candidate. In this talk, we report first-principles based non-equilibrium Green's function simulations of nanoscale tunnel field effect transistors. For simulations of transistors containing tens of thousands of atoms or more, we take a practical approach where the first principles electronic calculations and transport calculations are separated. Methods to reduce computational resources and time are discussed and example calculations are demonstrated.

Pioneer: Non-equilibrium first-principles calculations for energy applications/0584 C7.03

Light-induced electric- and magnetic-dipoles in dynamic photo-catalysts and directional optical switches

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Abstract :

I will talk about how light-induced electric and magnetic dipoles can be used in designing efficient photocatalysts and directional optical switches. First, by stacking conventional catalysts on high-*k* material, dynamic response to light is endowed to rapidly-changing charged-intermediate molecules and accelerate various photocatalytic reactions such as water-splitting [1]. Second, I will introduce our recent advances in understanding directional dichroism (directional optical switches) [2] using electromagnons in dynamic multiferroics [3-5]. Overall, I will highlight first-principles insight of dynamic interactions of electric- and magnetic-dipole with light in uncovering unexplored physics and designing novel functional materials.

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Inclusion of Environmental Effect to Electronic Structure Calculations using Grid-based Mean-field Coupling of MD and DFT

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Abstract :

First-principles based electronic structure theory, such as density functional theory (DFT) calculation, has been employed in a variety of complex systems. Notwithstanding its wide applications and successes, the calculation often assumes the system being *in vacuo* due to its relatively high computational cost. To extend the applicability of first-principles calculations, it is therefore important to develop new routes to effectively include dynamic environmental effect of the solvation into electronic structure calculations. In this talk, we discuss about our recent approach of grid-based seamless coupling of classical molecular dynamics simulation (to sample the dynamical environmental effect) with planewave based DFT (to investigate the electronic structure), namely DFT in classical explicit solvent (DFT-CES). By employing mean-field approximation, the computational overhead of DFT-CES is much reduced compared with that of conventional QM/MM methods. Moreover, we coupled the fast and efficient free energy calculation method based on two-phase model (2PT) into our DFT-CES method, which enables the direct and simultaneous computation of solvation free energies as well as the electronic structure changes due to solvation effect. We further discuss how our new multiscale simulation method can be applied to investigate exotic material properties where solid-liquid interface becomes important in energy applications.

Surface/Interface/Nanomaterials(F)/0542 C8.01

Ferromagnetic property of electron-doped Si(5 5 12)2 × 1

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Abstract :

The memristor characterized by a relationship between the charge and the magnetic flux is introduced as the fourth basic circuit element in addition to resistor, inductor, and capacitor. Many researches have attempted to discover the memristor material since it is suggestion [1]. However, few materials were found to show the increase of the magnetic flux with the accumulated charge. We investigate the magnetization of the Si(5 5 12)2 × 1 surface electron doping. The Si(5 5 12)2 × 1 surface has four surface structures: honeycomb, dimer, adatom, and tetramer [2]. The electron-doped Si(5 5 12)2 × 1 reveal have the spin splitting, which is mainly located at the dangling bonds of the adatom structures. The spin splitting causes the surface to transform to ferromagnetic. The surface with two electrons has a total magnetization of approximately 1.0 μ_e . As more and more electrons are doped, the magnetization of the surface increases. The total magnetization reaches the maximum value of about 2.0 μ_e when three electrons are doped with more electrons added, the system becomes less prone to magnetism.

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Surface/Interface/Nanomaterials(F)/0341 C8.02

X-ray spectroscopy study of the effects of the TiO_2 solubility in SnO_2 on the local electronic structure of SnO_2-TiO_2 nanocomposites

MOHAMED Ahmed Yousef[1], LEE Minji[1], KIM Dae Hyun[2], PARK Tae Joo[2,3], CHO Deok-Yong[*1]

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Abstract :

SnO_2/TiO_2 nanocomposite material is one of the most preferred composite materials for photocatalytic applications. The structural similarity of TiO_2 and SnO_2 gave them advantage to form a substitutional composite easily at the interface. But the interactions and the solubility of TiO_2 in SnO_2 at the interface are highly sensitive to the thermal processes and the ambient oxygen which leads to change in the electronic properties. To understand the interaction and the solubility between SnO_2 and TiO_2 at the interface, we investigate the effect of post-deposition annealing (PDA) on the local electronic structure of SnO_2/TiN thin films. We oxidized the TiN thin films on SnO_2 films using post-deposition annealing (PDA) at 700 °C under different oxygen pressures ($P(O_2)$ = 0.1, 1, and 5 Torr). The XAS results revealed that the local electronic structure of the oxidized layers is affected significantly by both the bottom layer (SnO_2) and the PDA conditions. For instance at $P(O_2)$ = 0.1 Torr, the SnO_2-TiO_2 nanocomposites are formed easily after PDA at 700 °C. On the other hand, at higher oxygen pressure ($P(O_2)$ = 5 Torr) the solubility of TiO_2 in SnO_2 increased a lot, which lead to change the layers order from Si-wafer/SiO_2/SnO_2/TiO_2 to become Si-wafer/SiO_2/TiO_2/SnO_2. Moreover, the microstructures of the SnO_2/TiN thin films were examined by FE-SEM. It was shown that the changes in the local structure have a strong correlation with the averaged grain sizes of TiO_2 nanocomposites. Besides, Volcano-like holes are created as a result of oxygen pressure effect during the PDA process. In addition, the Cs-TEM cross section images show that the SnO_2-TiO_2 nanocomposites penetrate and soluble into the Si-wafer surface at these Volcano-like holes. Finally, we suggest that the TiN-oxidation method we employed is an effective way to understand and investigate the solubility mechanism of TiO_2 in SnO_2 and its effects on the electronic properties of SnO_2-TiO_2 nanocomposites.

Surface/Interface/Nanomaterials(F)/0334 C8.03

Ultrafast dynamics of photo-excited surface carriers in the bulk-insulating topological insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$

Young Gwan Choi[1], Chan June Zhung[1], Sun-Hee Park[1], Joonbum Park[2], Jun Sung Kim[2,3], Seongheun Kim[4], Jaehun Park[4], J. S. Lee[*1]

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Abstract :

Using infrared optical-pump terahertz-probe spectroscopy, we observed an ultrafast photocarrier dynamics in a bulk-insulating topological insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ (BSTS) single crystal. Compared to *n*-type bulk-metallic Bi_2Se_3, we observed that BSTS shows peculiar behaviors in its photocarrier dynamics; the relaxation time turns out to be about ten times longer, and the photo-excited carriers' conductance spectrum nonlinearly increase as a function of the pumping power. Also, we found a significant decrease of the photocarrier scattering rate in several picoseconds after the optical pumping. We discuss these interesting experimental findings based on a phonon-mediated bulk-to-surface carrier transition with the help of the built-in electric field.

Surface/Interface/Nanomaterials(F)/0310 C8.04

Controlling Molecular Kondo Resonances Studied using Scanning Tunneling Microscopy and Spectroscopy

CHANG MinHui[1], CHANG YunHee[2], KIM Na-Young[2], KIM Howon[1], KIM Yong-Hyun[2], KAHNG Se-Jong[*1]

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Abstract :

Sensing and controlling spin states of magnetic-molecules/metal at the single molecule level is essential for spintronic molecular device applications. The exchange coupling between magnetic-molecules and metallic substrates has been actively studied by measuring Kondo resonances at Fermi level. The resonances have been controlled by small molecule bindings, but not by adsorption of metal atoms to magnetic-molecules. Here, we demonstrate that Kondo resonances of Co-porphyrin on Au(111) can be controlled by binding of metal atoms, and be sensed using scanning tunneling microscopy and spectroscopy (STM and STS). Bare Co-porphyrin showed a clear zero-bias peak, a signature of Kondo resonances in STS, whereas Co-porphyrin adsorbed metal atoms showed modified zero-bias resonances, with reduced full width half maximum or Kondo temperature. Our density functional theory calculation results explain it with spatial redistribution of unpaired spins in d-orbitals of Co-porphyrin by the adsorption of metal atoms. Our study shows that the spin-state of metallo-porphyrin can be modified in multiple ways by the adsorption of additional metal atoms, and be probed through Kondo resonances with STS.

Surface/Interface/Nanomaterials(F)/0278 C8.05

Coupling between Charge, Lattice, Orbital, and Spin in a Charge Density Wave of 1*T*-TaS_2

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Abstract :

Two-dimensional layered transition metal dichalcogenide (TMDC) materials often exhibit exotic quantum matter phases due to the delicate coupling and competitions between the charge, lattice, orbital, and spin degrees of freedom. Surprisingly, we here present, based on first-principles density-functional theory calculations, the incorporation of all such degrees of freedom in a charge density wave (CDW) of monolayer (ML) TMDC 1*T*-TaS_2. We reveal that the CDW formed via the electron-phonon coupling is significantly stabilized by the orbital hybridization. The resulting lattice distortion to the “David-star” superstructure constituted of one cental, six nearest-neighbor, and six next-nearest-neighbor Ta atoms is accompanied by the formation of quasimolecular orbitals due to a strong hybridization of the Ta t_{2g} orbitals. Furthermore, the flat band of the quasimolecular orbital at the Fermi level has a spin splitting caused by an intramolecular exchange, yielding a full spin polarization with a band-gap opening. Our finding of the intricate charge-lattice-orbital-spin coupling in ML 1*T*-TaS_2 provides a framework for the exploration of various CDW phases observed in few-layer or bulk 1*T* -TaS_2.

Surface/Interface/Nanomaterials(F)/0173 C8.06

Atomic and Electronic Properties of the Nearly Commensurate Phase in 1T-TaS_2

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Abstract :

The nearly commensurate (NC) charge density wave (CDW) phase in 1T-TaS_2 connects between the commensurate CDW-Mott and superconducting ground state in temperature-pressure phase diagram [1]. The microscopic origin of the NC phase is a key issue to understanding the phase transition. The atomic and electronic structures, however, is still not clear. We identify that the microscopic origin of the NC-CDW phase in 1T-TaS_2 by using scanning tunneling microscopic and density-functional theory calculations. We show that the origin of nearly commensurability comes from the broken CDW David-star (DS) in domain wall region due to the different center position of DS in domain. The electronic states of the broken DS locate in the middle of upper and lower Hubbard states of the Mott insulator of perfect DS and the NC phase becomes a metallic state. This metallic property of the NC-CDW phase should play an important role in phase transition to the superconducting state.

참고문헌

[1] B. SIPOS et al. Nature Materials 7, 960 (2008)

Surface/Interface/Nanomaterials(F)/0059 C8.07

Hole doping, hybridization gap, and electronic correlation in graphene on a platinum substrate

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Abstract :

The formation of an interface between two-dimensional (2D) materials and transition metals provides an opportunity to engineer physical properties of each material, such as the realization of a single-spin Dirac cone in a prototypical 2D material, graphene, and enhanced electrocatalytic effect in platinum. The key factor determining such functionalities is the interaction between two ingredients of the interface. Here we present the angle-resolved photoemission study on a graphene/platinum interface. The presence of platinum strongly influences the electronic properties of graphene resulting in deep hole-doping of graphene and strong hybridization between graphene π and platinum 5d bands. Furthermore, the electron band structure of graphene near Dirac energy deviates from the one typically observed from graphene/metal interfaces. The graphene/platinum interface provides a unique platform to utilize the intrinsic properties of both graphene and platinum, in striking contrast to all the other graphene on metallic substrates.

Surface/Interface/Nanomaterials(F)/0038 C8.08

알칼리금속 및 Cs 화합물 첨가를 통한 플랙서블 은 나노와이어 투명전극용 보호막의 내구성 향상 연구

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Abstract :

투명전극은 현재 스마트폰 등 터치패널에 널리 사용되고 있으며, 차세대 Flexible 전자기기에는 유연성이 있는 투명전극을 필요로 한다. 현재까지는 ITO(Indium Tin Oxide) 투명전극이 주로 사용되어왔지만, 인듐의 매장량 제한으로 가격이 비싸고 매우 brittle 하여 Flexible 전자기기용 투명전극으로 사용되기에는 적합하지 않다. ITO 를 대체하기 위한 차세대 유연 투명전극의 재료로 주목받고 있는 은 나노 와이어(AgNW)는 우수한 광학적/기계적/전기적 특성으로 인하여 그래핀, 탄소나노튜브(CNT), 메탈메쉬 등의 다른 소재에 비해 큰 장점이 있다. 그러나 현재 개발된 은 나노와이어는 공기 중에 노출되었을 때 수분이나 산소에 의해 쉽게 산화될 뿐만 아니라 200℃ 이상의 고온에서 열역학적 불안정성에 의해 나노와이어가 끊어지면서 전기적 특성을 잃게 되는 문제점을 가지고 있다.

본 연구에서는 이러한 내열성 문제점을 극복하기 위해 기존에 양산되고 있는 UV 보호막에 알칼리 금속을 소량 첨가하였다. 150℃ 면 저항 변화를 측정한 결과, 기존의 보호막은 3 일 만에 나노 와이어가 끊어지는 것과 달리 알칼리 금속을 소량 첨가한 보호막을 AgNW 위에 Hard Coating 한 경우 고온에서도 은 나노 와이어의 전기적 특성이 유지되는 것을 확인하였다. 이를 통하여 은 나노 와이어의 내열성, 내구성, 내화학성, 내마모성 등을 개선하여 은 나노와이어를 소재로 한 차세대 유연한 투명전극 상용화 제작에 앞당길 수 있을 것으로 기대된다.

Focus: Strongly correlated electron system: quantum material property in 4d/5d transition-metal oxides/0690

C9.01

Topological hall effect in ultra-thin $SrRuO_3$ film.

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Abstract :

Last few decades, $SrRuO_3$ system was intensively studied as an itinerant ferromagnetic metal, then we have a deep understanding on general physics of $SrRuO_3$ systems. Meanwhile, $SrRuO_3$ film was widely used for device application as a bottom electrode of oxide electronics. However, Recently, these systems become a more complicate considering with a low dimensional physics and topological behavior. Thank to recent advanced growth & measurement techniques. Critically, we can improve the quality of oxide heterostructure and address more detail physical properties. Therefore, this $SrRuO_3$ system still attract a lot of attentions on either exploring physics or developing future device application. Here, firstly we would like to introduce the way of PLD (pulsed laser deposition) growth to the high quality epitaxial $SrRuO_3$ thin film. And detail electronic and magnetic properties around ultra-thin regime will be shown. Secondly, a newly observed topological hall effect (THE) of ultra-thin $SrRuO_3$ film will be presented which is an evidence of probing the Dzyaloshinskii-Moriya interaction consequent magnetic Skyrmion.

Focus: Strongly correlated electron system: quantum material property in 4d/5d transition-metal oxides/0716 C9.02

Octahedral rotation in layered 4d and 5d transition metal oxides

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Abstract :

Functional octahedral rotation has become a novel concept in multifunctional perovskite oxides, showing great potential for property manipulation and device design. Strong coupling between spins, orbitals and lattices in transition metal oxides are responsible for these features. Fundamental understanding of such phenomena requires detailed microscopic information on each physical degree of freedom for different physical qualities of spin, orbital, and lattice. In this presentation, we will discuss how octahedral distortion can show interesting phase diagram of ruthenates via strong spin-orbital-lattice coupling. To find new routes towards controllable functional rotation, we have analyzed rotational instability of layered 4d and 5d transition metal oxides systems from first-principles. Our results show that rumpling of cation-oxygen layer is responsible for the suppression of rotational instability in layered perovskite oxides. Here we will also report related interesting experimental observations at the surface of Sr_2RuO_4.

Focus: Strongly correlated electron system: quantum material property in 4d/5d transition-metal oxides/0077 C9.03

Spin supercurrent in Sr_2RuO_4 superconductor

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Abstract :

The spin-triplet superconductor by definition should involve spin ordering. I will show how this will give rise to the spin supercurrent in the superconducting phase in the best-known candidate material, Sr_2RuO_4. Because of this spin supercurrent, the fabricated heterostructure of the the ferromagnetic $SrRuO_3$ film on the bulk Sr_2RuO_4 can act as an exceptionally high-quality spin valve; the heterostructure can furthermore be used to probe the spin dynamics of Sr_2RuO_4 in the superconducting phase.

Other optics(G)/0380 C10.01

Non-thermalized many-body quantum state of cold atoms in optical lattice

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Abstract :

An optical lattice, a crystal of light created by interfering optical laser beam, has been considered as a novel platform for studying many-body quantum pheonomena using cold atoms. Because of its high degress of isolations from its environments, the systems provide an ideal testbed not only for studying novel quantum ground state, but also for exploring non-equilibrium quantum dynamics in high energy density. Recently, a new quantum phase (many-body localization) has been discovered in out-of-equilibrium quantum system, where a disorder potential breaks a thermalization process even with strong interaction. In this talk, I will introduce experimental observation of the non-ergodic phase and its phase transition in optical lattices.

Optical information(E)/0962 C10.02

액정구조의 동역학적, 기하학적 위상변화 연구

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Abstract :

본 연구에서는 복굴절 물질을 사용하여 편광 특성을 변화시키는 LCD 구조를 이용하여 다양한 편광 변화와 그에 대한 위상 특성을 분석하였다. 상업용 LCD 들과 HWP 들을 이용하여 편광에 독립적으로 편광 상태를 보존하며 위상을 조절할 수 있는 두 가지의 공간 광 변조기를 제작하였으며, 다양한 편광에 따른 위상 조절 특성을 분석함으로써 푸앵카레 구로 표현되는 2 level 편광 계에서의 기하학적 특성과 동역학적 특성이 갖는 의미를 분석하였다.

Optical science(A)/1018 C10.03

2 색 편광형광상관분광법을 이용한 (TTAGGG)$_4$ DNA 시퀀스의 확산운동 분석

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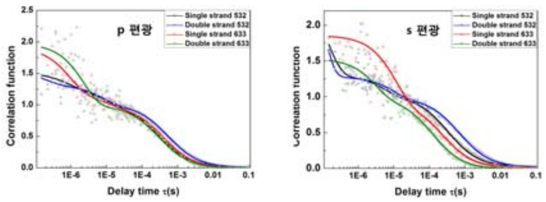
Abstract :



이색형광상관분광법은 일반적인 형광상관분광법에 비해 분자간 상호작용의 분석을 더 민감하고 정확하게 할 수 있는 이점을 가진 생물리학적 기술로서 현재 많은 연구가 진행되고 있다. 본 연구에서는 이색형광상관분광법과 편광을 결합한 이색편광형광상관분광법장치를 구성하여 입자의 형태에 따라 확산속도와 확산형태에 대해 연구하였다. 샘플로는 TAMRA 와 Cyanin5 를 부착한 Single strand(ss)와 Double strand(ds)구조의 DNA 를 사용하였으며, 각 편광상태에서 얻어지는 형광의 세기를 그림과 같이 상관함수의 형태로 변환하여 분석하였다. s 편광의 데이터에서 ssDNA 의 병진확산시간은 300 ± 27.7 ms 으로 dsDNA 의 병진확산시간 535 ± 39.8 ms 보다 짧게 나타났으며, ssDNA 의 회전확산시간은 878 ± 59.7 ns 으로 dsDNA 의 회전확산시간 207 ± 24.8 ns 보다 길게 나타났다. Single strand 와 Double strand 의 구조적 차이에 의해 병진확산시간과 회전확산시간의 차이가 발생하였다. 이 결과는 DNA 의 구조변화에 의해 발생하는 회전의 크기, 진동, 입자의 병진 이동의 변화를 분석하는데 활용될 것이다.

Vision & medical optics(F)/0549 C10.04

동축 컬러 분석 기반 포도당 검출 시스템 연구

Investigation on glucose detection based on co-axial colorimetric method

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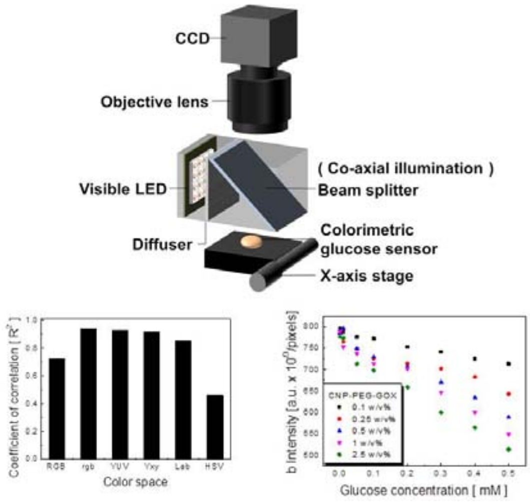
Abstract :



당뇨 환자는 고령화 사회에 따라 지속적으로 증가하고 있습니다. 당뇨병은 망막, 신장, 신경 등에서 합병증으로써, 심각한 만성 질환을 초래합니다. 따라서 혈당을 지속적으로 측정하는 것은 당뇨병 관리에서 매우 중요합니다. 현재 혈당 모니터링 기술은 주로 침습형이며, 이는 손가락을 찔러 혈액을 채취하므로, 통증, 스트레스 등을 유발하여 환자들에게 불쾌감을 유발합니다. 이러한 단점을 해결하기 위해, 비침습형 혈당 진단 연구가 활발히 진행되고 있습니다. 비침습적 연구로는 소변, 눈물, 땀 및 타액 등을 사용하며, 땀, 소변, 타액 등은 혈당을 측정하는 데 있어, 부정확하거나 다른 물질로 인한 오차 가능성이 있습니다. 지속적이고 안정적으로 채취할 수 있는 눈물을 사용하여, 당뇨를 진단하는 연구를 진행하였습니다. 세륨 나노입자(CNP)는 촉매 기술과 낮은 독성을 가지고 있으며, 산화가 되면서 깊은 황색으로 변한다. 따라서 우리는 이러한 특징과 포도당 산화효소(GOX)를 통해 컬러 측정 알고리즘을 사용하여 포도당 감지 연구를 진행하였습니다.
본 논문에서는 가시광 영역의 파장을 이용한 co-axial detection system 을 이용하여 포도당 농도 변화에 따른 색을 분석, 비교하였다.

Optical technology(B)/0263 C10.06

다중-분할 쌍원추 거울을 이용한 선형빔 형성.

The formation of line beam with a multi-segmented biconical mirror.

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Abstract :

선형 빔은 트렁케이션, 아나모르픽 광학계, 다중 광 섬유를 배열하는 방식으로 형성될 수 있다. 이 방식들은 광 손실과 불균일한 조도분포와 같은 문제점이 있다. 이를 해결하기 위해 다중-분할 쌍원추 거울을 설계했다. 이 거울은 3 개의 층으로 분할되어있다. 각 분할된 영역은 목표한 위치에 원하는 형태의 빛을 조사함으로써, 한 개의 균일한 선형 빔을 형성한다. 이때 모든 영역은 쌍원추 거울로 y 축으로는 빛을 발산시키고, x 축으로는 빛을 수렴시켜 효과적으로 선형 빔을 생성할 수 있다.

Optical technology(B)/0135 C10.07

A direct holographic method exploiting speckle-correlation scattering matrix

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Abstract :

The ‘holography’ measures the both amplitude and wavefront of incident light, while ‘photography’ cannot obtain the wavefront information, which gives volumetric and depth perception. However, direct holography has not been achieved in optical regime because of the insufficient bandwidth of current electronics unfortunately. Though reference-field-assisted interferometric methods have been popularly used in wide disciplines, introducing a reference field raises several fundamental and practical issues. To remedy the issues, several reference-free holographic methods have been proposed including Shack-Hartmann type sensor, transport-of-intensity equation, ptycography, and Fienup-type iterative algorithms, most of them have to sacrifice the generality of incident field by introducing assumptions, and/or require multiple measurements.

Here, we propose an optical diffuser as a holographic lens exploiting the speckle-correlation scattering matrix with the spatially chaotic property of diffused light. By passing through a calibrated turbid layer, the field information can be directly retrieved from the single speckle pattern snapshot. Using the proposed concept, we experimentally demonstrate a holographic camera by simply placing a commercial diffuser in front of camera successfully. We also perform numerical refocusing based upon a single captured hologram of real target. Our holographic method is simple and compact; and does not require any assumptions, additional reference light, nor multiple measurements, which is the closest realization of the ideal holographic camera. We expect this method can also be translated to other frequency regime such as infrared, X-ray, and electron beam.

Nuclear fusion(C)/0870 C11.01

플라즈마 대면 소재의 초고온 물성 연구

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Abstract :

핵융합로 내부의 플라즈마 환경은 1 억도가 넘은 초고온, 고에너지 방사의 극한 환경이다. 따라서, 핵융합로 내부에 사용되는 소재는 이러한 극한 환경을 견딜 수 있어야 하며, 가능한 한 높은 온도에서 사용될 수 있어야 발전 효율을 높일 수 있다. ITER 는 위의 조건을 만족시키는 핵융합로의 디버터 소재로써 초고온에서도 견딜 수 있는 텅스텐을 결정하였으나, 초고온에서의 텅스텐의 열물성은 잘 알려져 있지 않으며, 높은 매우 DBTT 로 인한 취성 파괴, 고에너지 조사손상에 의한 취화 거동 등이 문제가 되어 왔다. 본 연구에서는 이러한 텅스텐의 단점을 극복할 수 있는 텅스텐 신합금을 제조하고 그 특성을 조사하며, 가능한 후보 물질을 제안하고자 한다. 정전기 부양 기법으로 3000 K 이상 초고온의 텅스텐 합금의 열물성을 측정하는 기법을 소개하며, 고온에서의 기계적, 열적 물성과 텅스텐 합금 내 조사 손상에 관한 결과를 소개 한다.

Nuclear fusion(C)/0165 C11.02

Research on improving techniques of inducing, collecting and utilizing scattered photons for the KSTAR Thomson scattering system

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Abstract :

Thomson scattered photons from the interaction of injected laser and high temperature electrons in KSTAR are digitized with fast sampling digitizers. Data analysis routines for such signals are developed based on Bayesian probability theory, i.e., inferring electron density and temperature consistent with the observed data. A developed forward model for the KSTAR Thomson scattering system allows us to measure detected effective photon numbers even without absolute calibration of the optical system. Furthermore, we have developed a novel optical system allowing us to reject stray light by manipulating polarization of the laser pulse. Such optical system is also capable of generating multi-pass laser pulses which we can utilize to increase the effective signal-to-noise ratio.

Nuclear fusion(C)/0207 C11.03

핵융합로용 저방사화 철강소재 개발

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Abstract :

핵융합로용 구조용 소재는 그들의 사용환경을 고려하면, 고강도, 고인성, 크리프 (Creep) 특성, 저방사 특성, 중성자 내조사성, 용접성 등 다양한 특성이 요구된다. 핵융합 구조용 소재로 저방사강 (Reduced Activation Ferritic/Martensitic steels, RAFM steels), 산화물 분산강화강 (Oxide Dispersion Strengthening steels, ODS steels), SiC_f/SiC 복합재 등이 거론되나, 용접성, 대량/대형 생산성 등을 고려하면 저방사강이 유력한 후보소재로 평가된다. 핵융합용 저방사 철강소재는 크리프 특성이 우수한 기존의 화력발전용 내열강에서 고방사화 합금원소인 Mo, Nb 등을 저방사화 합금원소인 W, Ta 등으로 대체한 합금조성을 가지며, 통상 (8~9)Cr-(1~2)W-(0.05~0.15)Ta-0.1C (wt.%) 등을 주요합금원소로 포함한다. 핵융합용 저방사 철강소재는 템퍼드 마르텐사이트 (tempered martensite) 미세조직으로, Cr 계 $M_{23}C_6$ 탄화물과 Ta 계 MX 석출물을 포함하여, 높은 강도와 인성, 우수한 크리프 특성 등을 나타낸다. 유럽과 일본은 각각 Eurofer97, F82H 이라는 고유 합금조성의 저방사강을 개발하였으며, 이 분야에서 매우 활발한 연구를 선도적으로 진행하고 있다. 국내에서는 2010 년 원자력연구소와 재료연구소 중심으로 핵융합로 저방사 철강소재 개발을 시작하였으며, 본 발표에서는 재료연구소에서 진행하고 있는 핵융합로용 저방사화 철강소재의 개발에 대해 소개하고자 한다.

본 연구는 한국연구재단사업 (NRF-2016M1A7A1A01005873 와 NRF-2016M1A7A1A01005874)의 지원으로 수행되었습니다.

Surface, interface and thin films(G)/0713 C12.01

Formation of unit-cell step terrace structures and their electrical characteristics of (001) oriented Nb:$SrTiO_3$

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Abstract :

A variety of atomic-scale modifications of $SrTiO_3$ has been explored in order to tailor its electrical properties. In this study, we focused on n-type conducting Nb doped $SrTiO_3$ (Nb:STO) single crystals. Etching the crystals with buffered oxide etchant and annealing them at 1000^{o}C led to formation terrace structure which shows unit-cell step terrace structures. Morphological features of the terrace steps and width and shape of the terraces were studied by atomic force microscopy. Atomic arrangements of edges and central region in the terraces were also investigated. With a conducting Pt/Ir tip, electrical properties of the (001) surface were extensively examined in terms of conducting states and work function. We obtained current map and current-voltage characteristics. Rectified current-voltage curves and resistive switching phenomena were observed. Furthermore, step edges and plateau of the sample exhibited different charge transport behavior. Surface potential map was used to calculate the work function and to confirm the resistive state of sample.

Surface, interface and thin films(G)/0636 C12.02

Nanopatterning on rocking substrates by ion-beam sputtering

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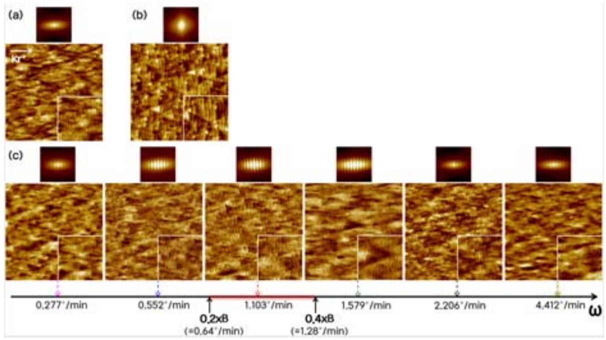
Abstract :



Ion beam sputtering (IBS) is the nano-structuring tool to yield nano patterns on surface via physical self-assembly which is induced by collision of energetic ions. When an accelerated ion hits the surface, pattern is formed by interplay and competition of the erosion by ion beam and diffusion on surface. By changing the beam energy, incidence angle, ion flux, and sources, various shapes of nanopatterns can be developed. This nanopatterning tool is fast, cheap, and easy to control, facilely scalable and applicable to any solid substrates.

The patterns developed by IBS includes significant amount of structural defects, a common trait of the self-assembly, that often limits their applications. Recently, Bradley and Harrison [1] have proposed that IBS with concurrently and periodically rocking of the sample can produce virtually defect free patterns. Their analysis is based on anisotropic Kuramoto-Sivashinski (KS) equation, in which the coefficients in the equation periodically vary in time.

We examine their predictions by rocking Si substrate. Si substrates are rocked during ion-beam sputtering(IBS) in an ultra-high-vacuum. We designed the rocking angle to pass the polar angle showing most linear behavior as suggested by the theory, and vary the rocking frequency to find the optimum one.

Figure 1 summarizes the AFM images of the patterned Si surfaces that include both rocked and stationary ones. In order to compare their order, their height-height correlation maps are also shown. For w=0.552°/min, 1.103°/min, and 1.579°/min, most pronounced peaks are observed, and show the distinctively well-defined ripple wavelength. Harrison and Bradley[1] predict a range of the rocking frequency f giving the improved order in the pattern that is shaded in red along the w axis in Fig. 1. One rocking frequency belongs to the range, and other two *w*s stay near to it. (See the position the corresponding arrows point on the w axis in Fig. 1)

For testing whether the improvement of the pattern by rocking is generic or not, we changed beam voltage to 0.5KeV and substrate to amorphous Carbon. Ripple patterns are found to have much improved order when samples were rocked in all cases, and rocking frequency predicted by the theory quite coincident with the experimental observation, which thus further supports the theoretical prediction.

Fig 1. AFM images with Height-height correlation images (3 μm x 3 μm) of Si(100) substrate after sputtering it without rocking (w= 0°/sec) for a fixed (a) θ = 65°, (b) θ = 73°, and with rocking (c) for different angular velocities(w) and Δθ = 8° (α = 65°, β = 73°). For all the cases, the fluence Ψ is 2182 ion nm^{-2}. Beam voltage, ε, is commonly 2 K eV, and fluence (normal to the surface) is 0.8751/s·nm^2. Below the images in (c) is the red line on the w axis that indicates the range of w theoretically predicted to give the best ordered patterns. The size of the inset in each image is 1 μm × 1 μm.

[1] Matt P. Harrison and R. Mark Bradley, Phys. Rev. E **93**, 040802(R) (2016)

Surface, interface and thin films(G)/0181 C12.03

MeV electron beam stimulated welding of silver nanowire networks encapsulated with graphene for flexible and transparent electrodes

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Abstract :

It is widely recognized that a prerequisite for the development of high-performance transparent electrodes is high electrical conductivity and high optical transparency. For one-dimensional conductors including Ag nanowires (NWs) and carbon nanotubes, insurmountable hurdle containing high wire-to-wire junction resistance, low corrosion resistance, and low adherence to substrates is existed. In order to overcome these issues, hybridization of nanostructures for complementary in terms of their properties and effective welding process to decrease the junction resistance are highly required. In this presentation, we rationally designed that welding of Ag NWs encapsulated with graphene was occurred by flux-optimized high-energy electron beam irradiation (HEBI) under ambient conditions for inhibition of Ag NWs oxidation induced by inevitably generated reactive ozone as well as improvement of their electrical conductivity. As a result, the lowest sheet resistance of graphene/Ag NWs was 12 Ohm/sq at 150 kGy. After the encapsulation of graphene, initial chemical states of Ag NWs were well-preserved upon flux-tuned HEBI, thereby the sheet resistance of welded Ag NWs encapsulated with graphene upon HEBI was well-maintained after 85 days.

Surface, interface and thin films(G)/0634 C12.04

Optical and electrical properties of amorphous Zn-Sn-O transparent conducting films

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Abstract :

Zinc tin oxide (Zn-Sn-O, ZTO) multicompound have received extensive attention due to their high optical transmission and high electrical conductivity. In this study, we investigated the compositional dependence on crystal structure, optical transmittance, and surface electric properties of ZTO thin films. The ZTO thin films with different composition ratio were fabricated on glass and p-silicon wafers at 300^{o}C substrate temperature by radio frequency magnetron sputtering. Crystallinity and composition of ZTO thin films were investigated by symmetric and asymmetric X-ray diffraction θ-2θ scans and scanning electronic microscopy equipped with energy dispersion spectroscopy, respectively. In addition, we constructed the band structure which contains optical band gap, work function, and band edges such as valence band maximum and conduction band minimum of ZTO thin films through ultraviolet-visible spectroscopy, kelvin probe force microscopy, and Hall measurement, respectively. Our results suggest that ZTO thin film is competitive compared to indium tin oxide, a representative material of transparent conducting oxide in application of optoelectronic devices.

Surface, interface and thin films(G)/0588 C12.05

Phase distribution of Sn-S polytypes in tin monosulfide (SnS) thin films and their electrical impacts on the thin films by local characterization

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Abstract :

Tin monosulfide (SnS) is one of the promising materials as a light absorber layer for thin-film solar cells. This is because it has suitable optical energy band gap and higher absorption coefficient. Moreover, easiness of thin-film fabrication and composition of earth-abundant elements show its possibility of usage for light absorber layer. Especially, its phase transition occurs depending on the sulfurization temperature. According to the previous reports, the temperature of between 150 and 300 °C can produce SnS_2 and Sn_2S_3 phases. Over 300 °C, SnS phase is formed. Herein, we fabricated SnS and SnS_2 thin films via e-beam evaporation for characterizing and comparing them. With the thin films, we could obtain optical energy bandgap of SnS and SnS_2 respectively; 1.68 eV for SnS, and 2.11 eV for SnS_2. Also, we grew SnS thin film by two-step process including sputtering and sulfurization. The sulfurization temperature was 400 °C, where SnS is known to be dominantly developed. To see depth profiles of it, we conducted dimple-etching on the surface with dimple grinder, so it has vicinal area on the surface. We employed Kelvin probe force microscopy (KPFM) and micro-Raman scattering spectroscopy to characterize their local electrical and optical properties and phase distribution on their surfaces. As a result, we were able to observe that a little amount of SnS_2 phase which was not transited to SnS phase exists on the surface area, while SnS single phase is developed inside the thin film. Furthermore, *I-V* curve of the surface shows less conductivity than that of inside area since SnS_2 has large bandgap and *n*-type conductivity. It can affect interface properties between the absorber and buffer layer.

Surface, interface and thin films(G)/0503 C12.06

Control of conducting states of MoS_2 layers on ferroelectric polarizations

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Abstract :

Carrier distribution of MoS_2 layers can be controlled by utilizing dielectric environments as substrate. Ferroelectrics, one of high-k dielectrics, are one of powerful tool to control the conducting states of MoS_2 layers because of their spontaneous polarizations. Here, we exploit (111)-oriented $PbTiO_3$ thin films to control the electrical properties of the MoS_2 layers. Especially, we investigated poling process in the (111)-oriented $PbTiO_3$ thin films to make polarization states with certain direction. Vertical transport characteristics of the MoS_2 layer on the $PbTiO_3$ thin films were obtained by using conductive-atomic force microscopy. Different transport properties were obtained in the MoS_2 layers with different thicknesses because of storing of electrical field in the MoS_2 layers. Because of alignment of the polarizations, we can choose the transport properties which are rectifying or resistive switching characteristics in the MoS_2 layers. In addition, mechanical stimulation is also used to control the transport characteristics in the MoS_2 layers related to strain engineering in the vertical devices. The mechanical stimulation also can give deformation of piezoelectricity in the ferroelectric thin films. Therefore, it can give additional effect to modulate the transport characteristics in the vertical heterostructure. As a result, we can utilize the ferroelectric thin films to control the carrier distribution of MoS_2 layers and mechanical stimulation related to piezoelectricity also can behave as controlling factor for the transport characteristics of the MoS_2 layers.

1/f noise study in $MoTe_2$ FET for understanding of carrier fluctuation

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Abstract :

In the electrical characterization of field effect transistor, the low-frequency (LF) noise study reveals the origin of carrier fluctuation based on the noise theory, which explains the perturbative carrier behavior with charged impurities or interfacial traps. As the channel dimension shrink to below the microscale, the relatively enlarged interfacial area became predominant for the electronic noise in a FET. While, the 1/f noise modeling in MOSFETs has been well-established, 2-dimensional (2-D) transition metal dichalcogenides (TMDs) FETs require the careful investigation of 1/f noise features for the proper modeling and the accurate parameter analysis. Considering that the uniqueness of van der Waals interactive layer-to-layer structure of 2-D TMDs, multidirectional investigation for noise characterization in TMDs FETs are newly needed.

In this presentation, we comprehensively studied $MoTe_2$ FETs in terms of the Coulomb screening and the charge distribution using DC and noise measurement under the different environmental dielectrics or the various channel thicknesses. Firstly, we suggested that the appropriate LF noise model of the combined carrier mobility and carrier number fluctuation which is parameterized with an interfacial Coulomb-scattering parameter (a) that changes for the accumulated carrier density (N_{acc}) and the charge distribution inside $MoTe_2$ channel. This model shows good agreement with the current power spectral density of $MoTe_2$ FETs for whole current regime and indicates the parameter strongly depends on N_{acc} with an exponent $-\gamma$ around -1.64~-1.18, compared with -0.5 for Si-MOSFETs. Particularly for a low current regime, the raised Coulomb scattering of carriers was observed due to the unique layered structure which accompanies the interlayer coupling and the different charge distribution to bulk materials. This newly suggested LF noise model for TMDs also explained the enhanced carrier mobility in the $MoTe_2$ FET with the gate dielectric of monolayer *h*-BN covered SiO_2 layer by demonstrating the reduced Coulomb scattering effect from LF noise analysis. Further, the more increased carrier mobility in the $MoTe_2$ FET after Al_2O_3 top passivation also can be illustrated with the reduced LF noise parameter of N_{ST}. Based on the valid LF noise modeling for TMDs FETs, other carrier fluctuating behaviors were understood well, which affect to the device performance. The thickness dependent carrier mobility in $MoTe_2$ is investigated by correlating the static device parameter of field effect carrier mobility (m_{FE}) and the LF noise parameters of interfacial Coulomb scattering (a), interface trap density (N_{ST}) in the channel thickness range of 5-15nm. The interplay of N_{ST} and a maximized the Coulomb-scattering-limited carrier mobility (m_C) at the channel thickness of ~10nm which is consistent to m_{FE}. The lopsided carrier distribution and the thickness dependent Coulomb-screening effect explained the mobility trend both for ambipolar carriers. As the more proactive way to control the carrier distribution, we modulated and enhanced the carrier mobility by adjusting the top- and bottom- gate biases in the configuration of double-gated (DG) $MoTe_2$ FET. LF noise analysis exhibited that the largely accumulated

charges by a strong bottom-gate bias screened the ionized traps at the gate dielectrics as reducing the Coulomb scattering of carriers, resulting in increased carrier mobility. And the changes of the number of effective trap sites by shifting of carrier distribution owing to the gate bias also affected to the carrier mobility values. The gate-controlled carrier fluctuating behavior in the multi-gated FET structure can provide the new handles for improving the carrier mobility in multilayer TMDs.

Pioneer: High pressure physics and superconductivity/1046 C13.01

Pressure dependent transport properties of TiZrNi quasicrystals

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Abstract :

After the first discovery of quasicrystals(QCs) from rapidly quenched AlMn alloys in 1984 and Nobel Prize in Chemistry 2011 to Shechtman for the discovery of them, a significant amount of studies on the reasons of the structural stability have been reported, but not much has been investigated their properties under extreme condition. TiZrNi quasicrystals form the second largest QCs and have many scientific and technological merits because they exhibit relatively high order of atomic coherence, vast chemical composition to form the structure with relatively easy synthesis method, thermodynamically stable, and an advanced hydrogen loading capacity potential for energy storage materials.

An interesting aspect of TiZrNi QCs is the combination of a reasonably ordered atomic structure with its electronic structure remarkably different from a free electronlike description used for normal crystalline metals. Many studies on transport properties were performed to investigate the structural stability of QCs in terms of peculiar transport properties such as a broad range of electric conductivity, 0.01-5000/(Ωcm), reasonably high thermopower, low thermal conductivity (1-3 W/mK) because of their phonon scattering due to both the inherent disorder, and band gap, but none of these properties have clearly explained the structural stability with easy formation. Electric resistivity is a good example of transport property to explain the structural stability.

We measured the pressure-induced transport properties from pristine and hydrogenated TiZrNi QCs using a DAC to maximum of 40 GPa. The results of normalized resistivity showed that hydrogenated QCs have in an order of 100 times larger variation compare to the pristine ones while much less quasi-cell volume was noted. The structural stability combining with electrical transport properties will be presented. The newly established high pressure research center at Hanyang University will be also introduced.

Pioneer: High pressure physics and superconductivity/0216 C13.02

Ultra-small angle neutron scattering (KIST-USANS) techniques and its applications

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Abstract :

It is well-known that the current small neutron angle scattering (SANS) instrument is good for investigating structures that are nano scale in size. However, most nano structures are usually connected to the micro structures in a hierarchical manner. Therefore, it was necessary to design a new instrument with an enhanced low Q resolution (Q~ 2.0 x10^{-5} $Å^{-1}$) that allows for us to measure the size of structures on a micron scale . We have built the ultra-small angle neutron scattering instrument (KIST-USANS) at the HANARO Cold Neutron Guide Hall, KAERI. The instrument adapts multi-reflecting Bonse-Hart-Agamalian channel-cut Si(111) single crystals as a monochromator and a series of analyzers in a coextensive manner. Rich structural information of polymers, rocks, ceramics, and metallic alloys can be obtained by using USANS and SANS together. In particular, mass and surface fractals can be measured in more than 11 orders in magnitude of macroscopic scattering cross-sections and 4 orders in Q scale and some results will be presented.

Pioneer: High pressure physics and superconductivity/0217 C13.03

Computational prediction of novel materials under pressure and experimental synthesis

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Abstract :

Pressure can be regarded as another dimension of science to explore broader energy landscape and to find a new phase of condensed matter. Using crystal structure searching based on density functional theory, we predicted unprecedented elements and compounds possessing intriguing physical properties, which also confirmed in experiments. In this presentation, we show a few successful examples. Using a high-pressure precursor, we stabilized a new form of silicon (Si_{24}) [1] possessing a quasi-direct band gap. I will discuss its possible applications for energy frontier research. We also found iron dioxide (FeO_2) which is more oxidized than previously known hematite (Fe_2O_3) at high pressure [2]. I will discuss its physical properties and implication to geoscience.

Pioneer: High pressure physics and superconductivity/1037 C13.04

Hydrogen in Compressed Metals: Synthesis of Superhydrides

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Abstract :

Metal superhydrides is currently actively pursued topic related to novel chemistry of hydrogen in metals at high pressures. Recent theoretical predictions of stable phases of higher hydrides (polyhydrides) pose new constraints related to their stability at the conditions of high pressure from few GPa to more than 300 GPa. We performed synthesis of hydrides of various transition metals at high P-T conditions. We searched also for new phases in laser-heating experiments at high pressure. New phases of selected metals and their the equations of state up to 200 GPa will be reported. Our use of pure hydrogen-metal chemistry favors creation of new hydrides and also provides insights into new chemical scenarios that pose constraints on the hydrogen content in the Earth's core and may be relevant for the chemistry of iron in giant planets or super-Earth exoplanet interiors.

Molecular & cellular biological physics(A)/0681 C14.01

RNA Stem Structure Governs Coupling of Dicing and Gene Silencing in RNA interference

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Abstract :

Pre-micro(mi)RNAs possess secondary structures consisting of a loop and a stem with multiple mismatches. Despite the well characterized RNA interference (RNAi) pathway, it still remains unclear how the structural features of pre-miRNA contribute to dicing and subsequent gene silencing efficiency. Using single molecule fluorescence in situ hybridization, we demonstrate that cytoplasmic mRNA, but not nuclear mRNA, is reduced during RNAi. Dicing rate and silencing efficiency both increase as a function of the loop length in a correlated manner. In contrast, mismatches in the stem drastically diminish the silencing efficiency without impacting the dicing rate. We show that such decoupling effect is not due to the loading to RNA induced silencing complex, RNA uptake or cellular dicing. We postulate that the stem mismatches perturb the hand-over of the cleaved miRNAs from Dicer to Argonaute which leads to poor strand selection. Our results imply that the stem structures prevalent in cellular miRNAs are intended for suboptimal silencing efficiency.

Other biological physics(D)/0060 C14.02

에너지 요구와 정보의 필요에 의해 조절되는 예쁜꼬마선충의 먹이섭취 동역학

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Abstract :

먹이섭취를 통한 에너지 이득과 먹이 채집에 사용되는 비용 간 균형은 동물의 건강상태에 큰 영향을 미친다. 우리는 모델생물인 예쁜꼬마선충의 먹이섭취 동역학에서 이러한 균형이 어떻게 제어되고 있는지 설명해보고자 한다. 먹이를 먹는 활동이 에너지의 획득 뿐 아니라 환경에 존재하는 먹이의 양을 측정한다는 두 가지 목적으로 사용된다는 가정에 기반하여, 예쁜꼬마선충이 주어진 환경에 적응하는 것을 설명한다. 우리의 모형은, 먹이섭취 동역학을 섭식 여부에 대한 결정들이 순차적으로 이어지는 사슬로 표현하며, 이 모형을 이용하여 실험에서 관찰된 여러가지 현상들 - 먹이섭취의 빠르기와 먹이의 양간의 상관관계, 먹이가 없는 환경에서도 먹이섭취를 시도하는 현상, 변화하는 환경에서의 간헐적 먹이섭취 등을 설명할 수 있었다.

Other biological physics(D)/0766 C14.03

당뇨병 조기 진단을 위한 기계학습의 프로토타입 모델

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Abstract :

대사질환의 한 종류인 당뇨병은 현재 완치하는 방법이 없기에 진단 후 식단 조절, 적절한 운동 등 관리를 통하여 치료하고 있다. 따라서 조기 진단은 당뇨병 관리를 위해 꼭 필요하다 말할 수 있다. 현 단계에서 당뇨병의 진단은 공복상태에서의 평균 혈당, 경구당 부하 검사, 당화 혈 색소 등 다양한 진단 기준을 토대로 이루어 지고 있다. 본 연구에서는 내 분비 호르몬의 위상 모델에서 얻은 데이터를 이용하여 당뇨병의 조기 진단이 가능한 기계학습을 목표로 하였다. 기존 연구와 달리 발전된 기술로 가능하게 된 실시간 혈당 측정을 활용하기 위한 프로토타입 모델로서 딥러닝을 적용 하였다.

Other biological physics(D)/0911 C14.04

Interferometric scattering (iSCAT) microscopy for label-free and live cell imaging

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Abstract :

Recently, a powerful imaging technique named interferometric scattering (iSCAT) microsopy was developed to identify and track the fast dynamics of nano-sized particles. However, its biological application has been mostly limited in artificial bio-mimicking systems such as extracted biopolymers, 2-dimensional lipid bilayer substrates, and unilamellar vesicles, which have no natural complexity of a living cell. Here we report label-free and live-cell imaging of mammalian cell using iSCAT microscopy, which reveal the underlying structures of a variety of cytoplasmic organelles as well as the underside structure of the cells. The contact areas of the cells attached onto a glass substrate, e.g., focal adhesions and filopodia, appear to be dark. We also found a variety of fringe-like features in the cytoplasmic area. An interesting labyrinth-like fringe in a sub-micron scale appears around the outer nucleus membrane, which reflects the folded structures of endoplasmic reticulum and Golgi apparatus. We thus anticipate that the label-free interferometric scattering microscopy can be used as a powerful tool to shed interferometric light on in vivo structures and dynamics of various intracellular phenomena.

Molecular & cellular biological physics(A)/0994 C14.05

Exonuclease processivity is controlled by dynamic coordination of two metal ions

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Abstract :

Exonuclease is an enzyme cleaving DNA. Although the functional role of exonuclease is well known, its molecular mechanism, especially the coordination of its essential cofactors (two metal ions MgA and MgB) during enzymatic cycle is not well-understood. Here, by employing kinetic analysis and mesoscopic simulation based on experimental data from single molecule FRET assay, we show that MgB dissociates from exonuclease at each catalytic round whereas the other cofactor MgA remains relatively stable. The frequent dissociation of MgB leads to the facilitation of exonuclease activity by enabling fast release of cleaved DNA fragment.

Molecular & cellular biological physics(A)/0403 C14.06

Real-time observation of ATP-independent single-strand DNA binding protein (SSB) displacement by RecO in *Deinococcus radiodurans*

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Abstract :

Deinococcus Radiodurans (DR) is the most radio-resistant organism known. It can repair hundreds of dsDNA breaks at a time via RecA-mediated DNA recombination. RecO is one of major recombination proteins in the RecA-loading pathway (i.e., RecF pathway), and is essential for the extreme radio-resistance of DR. In this work, we investigated the role of key components in RecF pathway using single-molecule techniques. We found for the first time that drRecO competes with the ssDNA binding protein (drSSB) on the freely exposed ssDNA, and can efficiently displace drSSB from ssDNA to assemble other repair-related proteins in ATP-independent manner. With biochemical analysis and mutagenesis study, we have further elucidated the overall kinetics and dynamics of the drRecO-induced drSSB displacement. These results provide a mechanistic insight into how drRecO actively displaces drSSB without using ATPs.

We suggest that drRecO facilitates the RecA-loading onto drSSB coated ssDNA by dissociating a small SSB-free space on ssDNA so that DR can survive under extreme environments with a rapid DNA repair system.

Molecular & cellular biological physics(A)/0723 C14.07

Origin of the FRET efficiency distribution in single-molecule measurement

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Abstract :

Single-molecule fluorescence resonance energy transfer (smFRET) measures the distance between two fluorescent dyes, and is commonly used to monitor the static- or dynamic structure of biomolecules. smFRET can achieve sub-nanometer resolution in principle, however the resolution is practically limited by the experimental noise. Here the distribution of the FRET efficiency was investigated to understand the origin of the noise from a single-stranded DNA labeled with a FRET pair (cy3 and cy5), immobilized on a quartz glass surface. FRET fluctuation from individual dye pair decreased as the acquired photon number from the dye increased. This decrease in fluctuation followed the power law, indicating that the noise comes from the photon shot noise. On the other hand, the distribution of FRET efficiencies from ensemble of dye pairs did not decrease with the photon number below a certain limit, suggesting that the FRET efficiency can differ for molecules at different positions on the substrate. Measuring the fluorescence decay lifetimes of the individual molecules gives the position-dependent quantum yield distribution of the dye molecules. From this, lifetime fluctuation from individual dye pair decreased as the photon number increased following the power law. By contrast, ensemble lifetime distribution did not follow the power law instead showing a similar tendency to the FRET distribution from ensemble. We show that the ensemble FRET noise arose from inhomogeneity of the local environment on which a molecule is immobilized.

Molecular & cellular biological physics(A)/0547 C14.08

Temporal separation of transcription termination and polymerase recycling

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Abstract :

It is not yet known whether during transcription termination RNA product release and RNA polymerase dissociation occur at the same time or with time delay. Here we report single-molecule fluorescence experiments that monitor the temporal order of the intrinsic termination of *E. coli* transcription. Our study reveals that RNA release precedes the polymerase dissociation rather than follows or coincides with polymerase dissociation. Furthermore, *E. coli* NusA (transcription termination/antitermination L factor) was found to accelerate polymerase dissociation without affecting RNA release in factor-independent termination. As termination stage should be defined only by release of final product RNA from transcription complex, subsequent dissociation of polymerase from template can constitute an additional stage, proposedly termed as 'polymerase recycling' stage. It is speculated that during the retention, RNA polymerase can slide along template, being capable of reinitiating at a nearby promoter if complemented by a sigma factor

적분 실험값을 이용한 중성자 입사 핵반응 단면적 평가

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Abstract :

U-238 은 핵연료의 95% 이상을 차지하는 중요 핵종이기 때문에, 중성자와의 핵반응 단면적에 대한 다양한 실험 데이터가 존재하다. 또한 U-238 은 충분히 많은 핵자로 구성되었기 때문에 Hauser-Feshbach 통계 모델 코드를 이용하면 에너지 평균 핵반응 단면적을 이론적으로 계산할 수 있다. 그럼에도 불구하고, 존재하는 실험데이터의 큰 불확정도와 핵반응 이론 모델의 한계 등으로 고정밀도의 핵반응 데이터를 생산하는 데에는 많은 어려움이 따른다. 본 연구는 핵반응 단면적 실험데이터와 적분 실험값인 k_{eff} 를 이용하여 최적의 핵반응 평가파일을 만드는 방법을 소개한다.

Nuclear reaction(B)/1023 C15.02

Status of SπRIT experiment at RIBF for nuclear symmetry energy

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Abstract :

To stringently constrain the symmetry energy term in the Equation of State (EOS) of nuclear matter at super-saturation densities, the SπRIT (SAMURAI Pion-Reconstruction and Ion-Tracker) Time Projection Chamber (TPC) was constructed at the National Superconducting Cyclotron Laboratory (NSCL) at the Michigan State University in the U.S.A. The first experiment was successfully completed at RIBF (Rare Isotope Beam Factory), RIKEN in Japan in 2016. For the experiment the four tin isotope beams (Sn132, Sn124, Sn112, and Sn108) and the two stable tin isotope targets (Sn124 and Sn112) were utilized. In addition, the cocktail beams, including p, d, t, He3, He4 and Li6 were used for calibration. The software for the reconstruction of the tracks in the SπRIT TPC has been developed to identify particle species and evaluate the momenta of (sometimes overlapped) tracks. In the software the GENFIT package was employed to reconstruct the momenta of the charged particles. The reconstruction efficiency of the software estimated by the Monte-Carlo simulation was about 90%. From the data analysis the momentum of pions can be reconstructed down to 50 MeV/c, and the particle identification (PID) were possible up to lithium. In this presentation, we provide the current status of the software development and the data analysis.

Nuclear reaction(B)/0978 C15.03

Analysis of ^{11}Li + ^{208}Pb fusion reaction using 3-channel coupled method approach

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Abstract :

We calculate total fusion cross sections for ^{11}Li + ^{208}Pb system by using a 3-channel coupled method based on barrier penetration model, and compare with the experimental data. For this study, we employ Wood-Saxon type potential with Akyuz-Winther parameters which is globally determined. Also, we used folding potential for ^{11}Li + ^{208}Pb scattering state for treating halo nuclei structure of ^{11}Li. In this study, we try to analyze of ^{11}Li + ^{208}Pb fusion experimental results by generalized 3-channel coupled method model that is coupled 3 kind scattering states for resolving unstable scatting channel i. e. ^{11}Li + ^{208}Pb, ^{9}Li + ^{210}Pb and ^{7}Li + ^{212}Pb systems. For determination of parameters, we additionally calculate ^{9}Li + ^{208}Pb fustion reaction using 2-channel coupled method. The total fusion cross sections obtained with the coupled channel effect are compared with those obtained without the coupled channel couplings. Finally, our approach is applied to understand the experimental total fusion cross section data for ^{11}Li + ^{208}Pb systems.

Nuclear reaction(B)/0732 C15.04

Excitation functions of $^{nat}Pd(p,x)$ $^{102m,g;101m,g;99m,g}Rh$ reactions and the isomer ratios of $^{102m,g;101m,g;99m,g}Rh$ pairs

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Abstract :

The excitation functions for the $^{nat}Pd(p,2pxn)$ $^{102m,g;101m,g;99m,g}Rh$ reactions within the energy range of 8.37-42.61 MeV have been determined using the stacked- target activation and off-line γ-ray spectrometric technique at the MC50 cyclotron of the Korea Institute of Radiological and Medical Sciences (KIRAMS). The isomeric ratios of $^{102m,g;101m,g;99m,g}Rh$ pairs in the $^{nat}Pd(p, x)$ reactions were also obtained from their cross-sections for the above mentioned energy range. The experimental cross sections from the present work were compared with similar literature data and results of theoretical calculations provided by the TENDL-2015 libraries based on TALYS code. The measured isomeric ratios of $^{102m,g}Rh$, $^{101m,g}Rh$ and $^{99m,g}Rh$ pairs are reported for the first time.

Nuclear reaction(B)/0725 C15.05

Fission yields in the2.5 GeV bremsstrahlung-induced fission of ^{232}Th

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Abstract :

The cumulative yields (CY) of various fission products for A= 77-153 in the 2.5-GeV bremsstrahlung-induced fission of ^{232}Th have been determined for the first time by using the recoil catcher and an off-line γ–ray spectrometric technique at the PAL, Korea. From the CY values, the mass-yield (MY) distribution was obtained after charge-distribution corrections. From the MY data, the peak-to-valley (P/V) ratio, the average value of light mass ($\langle A_L \rangle$) and heavy mass ($\langle A_H \rangle$), and the average post-fission number of neutrons ($\langle \nu \rangle$) were obtained. The present and literature data in the ^{232}Th(γ,*f*) reaction were compared with the similar data in the ^{238}U(γ,*f*) reaction at various bremsstrahlung energies to examine the role of potential energy surface and the effect of standard I and standard II asymmetric mode of fission. It was found that (i) even at the 2.5 GeV bremsstrahlung energy, the MY in the ^{232}Th(γ,*f*) reaction is triple humped, unlike in the ^{238}U(γ,*f*) reaction, where it is double humped. (ii) The P/V ratio decrease with the increase of bremsstrahlung energy. However, it is always lower in the ^{232}Th(γ,*f*) reaction than in the ^{238}U(γ,*f*) reaction due to the presence of third peak in the former. (iii) In both the ^{232}Th(γ,*f*) and ^{238}U(γ,*f*) reactions, the nuclear structure effect almost vanishes at the bremsstrahlung energies of 2.5-3.5 GeV.

Nuclear reaction(B)/0595 C15.06

Study of N* resonances in eta photoproduction

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Abstract :

We investigate η photoproduction, employing the N ∗ resonances with spin 1/2 and Reggeon exchange in the t channel. In particular, we emphasize the bump structure in the vicinity of 1685 MeV in η photoproduction, which was recently found by various experimental groups such as the GRRAL, ELSA, A2, and Tohoku groups. The identification of this bump structure is still under debate. In the present work, we assume the bump structure as an N ∗ resonance with a narrow decay width, we study its effects on η photoproduction. We present the total and differential cross sections in this talk.

Nuclear reaction(B)/0025 C15.07

Elastic alpha-carbon-12 scattering at low energies with the bound states of oxygen-16 in effective field theory

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Abstract :

The elastic alpha-carbon-12 scattering for $l=0,1,2,3$ channels at low energies is studied, including the energies of excited bound states of oxygen-16, in effective field theory. We introduce a new renormalization method due to the large suppression factor produced by the Coulomb interaction when fitting the effective range parameters to the phase shift data. After fitting the parameters, we calcuate asymptotic normalization constants of the 1_1^- and 2_1^+ subthrethold states of oxygen-16. We also discuss the uncertainties of the present study when the amplitudes are interpolated to the stellar energy region of the radiative alpha capture reaction on carbon-12.

Pioneer: Dark matter and a new physics/1191 D1.01

Searching for Axionic Blue Isocurvature Perturbations

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Abstract :

If the Peccei-Quinn symmetry breaking field is displaced from its minimum during inflation, the axion isocurvature spectrum is generically strongly blue tilted with a break transition to a flat spectrum. A test of this scenario with the Planck and BOSS DR11 data will be presented. Encouraging results and its implications for future probes of axions and inflationary cosmology will be discussed.

Pioneer: Dark matter and a new physics/0305 D1.02

COSINE dark matter search experiment

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Abstract :

COSINE is an experiment aimed at reproducing the Dark-Matter-like annual modulation signal observed by DAMA/LIBRA experiment using the same NaI(Tl) target material. The construction of the Phase-I, called COSINE-100, was completed in the summer of 2016 and physics quality data in order to reproduce the annual modulation signal have been collected since late September of 2016. Further developments of ultra-low background NaI(Tl) crystals with background levels below those achieved by DAMA/LIBRA are extensively studied for phase-II, called COSINE-200 for an unambiguous conclusion. We will present the current status of physics data of the COSINE-100 as well as our R&D and a road-map for COSINE-200 experiments.

Pioneer: Dark matter and a new physics/1208 D1.03

Higgs Precision - Formalism and Prospects

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Abstract :

We discuss an improved formalism and strategy for Higgs precision measurements at future lepton colliders (+existing data from LHC and LEP). The formalism is based on the effective-operator extension of the Standard Model. We discuss various challenges (some of which were even not identified previously) and how to overcome them systematically. We finally present precision prospects using the state-of-the art ILC expectations.

Pioneer: Dark matter and a new physics/0191 D1.04

Dark matter in Cosmology

최기영*[1]

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Abstract :

Dark matters are produced in the early Universe, decoupled from the thermal plasma and becomes relic in the present Universe. The evolutions of dark matter are different for different dark matter and affect the cosmological observations. I will talk about the connection of dark matter and the Universe.

Chaos & non-linear dynamics(C)/0088 D2.01

Intermittent many-body dynamics at equilibrium

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Abstract :

We study the loss of ergodicity in the nonlinear equilibrium dynamics of isolated many-body systems. Close to an integrable limit, the integrals of motion turn into time-dependent observables. The equilibrium values of these observables define equilibrium Poincare manifolds in the phase space of the ergodic and equipartitioned many-body system. A typical trajectory pierces these manifolds infinitely often as time goes to infinity. We use these piercings to measure the statistics of excursion times. The corresponding distribution yields power law tails, whose exponents serve as quantitative measures of the distance from a nonergodic regime (which might be still at a finite distance from the very integrable limit). We apply our method to a variety of different systems which we drive into low and high energy density limits.
Long excursions arise from sticky dynamics close to regular (periodic and quasiperiodic) localized excitations, which can be then further analyzed and studied. Our method also allows for a rigorous definition of the time need for some nonequilibrium state to relax into equilibrium by measuring the time the trajectory needs to reach and pierce an entropic equilibrium manifold.

Chaos & non-linear dynamics(C)/0050 D2.02

Amplitude death in a ring of inhomogeneous nonlinear oscillators with unidirectional coupling

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Abstract :

It has been widely studied that the interaction among subsystems can lead to the collective behavior such as synchronization and amplitude death. Among these collective behaviors in coupled oscillators, the amplitude death refers to a situation where individual oscillators cease to oscillate when they are coupled, which is a useful control mechanism for stabilizing systems to steady states. Most of the previous studies on amplitude death have dealt with bidirectional coupling cases. Here, we also studied the amplitude death in a ring of coupled nonlinear oscillators with unidirectional couplings and discuss the differences between amplitude death behavior in unidirectional and bidirectional coupling cases.

Chaos & non-linear dynamics(C)/0027 D2.03

Stable Chimeras and Independently Synchronizable Clusters

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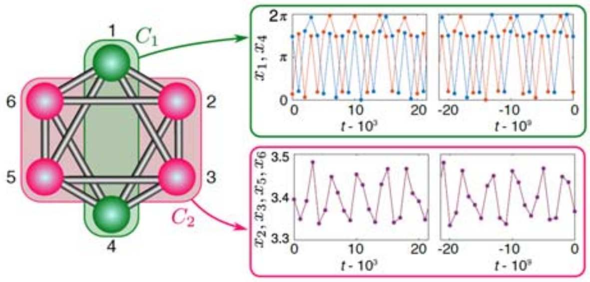
Abstract :



Cluster synchronization is a phenomenon in which a network self-organizes into a pattern of synchronized sets. It has been shown that diverse patterns of stable cluster synchronization can be captured by symmetries of the network. Here we establish a theoretical basis to divide an arbitrary pattern of symmetry clusters into independently synchronizable cluster sets, in which the synchronization stability of the individual clusters in each set is decoupled from that in all the other sets. From this framework, we suggest a new approach to find
permanently stable chimera states by capturing two or more symmetry clusters— at least one stable and one
unstable—that compose the entire fully symmetric network.

Nonequilibrium systems(B)/0952 D2.04

Additivity of multiple heat reservoirs in Langevin equation

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Abstract :

Langevin description greatly simplifies mathematical expression for the effect of thermal noise by using only two terms: dissipation and random-noise terms. This description was originally applied to a system contacting to a single heat reservoir. Recently, however, many studies have applied Langevin equation to describe a system connected to multiple heat reservoirs simultaneously. In these studies, effect of multiple heat reservoirs is simply written as sum of respective dissipation and random-noise terms in Langevin equation. However, the validity of this simple approach has been limitedly addressed and there also have been a few criticisms on it. Moreover, this additive description has never been verified experimentally or numerically, so its validity is still open question. Here, we perform molecular dynamics simulations for a Brownian system simultaneously contacting to multiple heat reservoirs to check the validity of the additivity. Our simulation results confirm that the effect of multiple heat reservoirs is additive within error range. More specifically, within the error range there is small modification which is attributed to reservoir-reservoir interaction. Thus, the additive description is practically valid when the modification effect is weaker than estimate error range.

Nonequilibrium systems(B)/0842 D2.05

Small mass limit of a Brownian motion under the Lorentz force

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Abstract :

We consider the small mass limit of a Brownian motion of a charged particle under a uniform magnetic field.
The magnetic field applies the Lorentz force to the Brownian particle.
Without Lorentz force, the Brownian motion in the small mass limit is described by the Langevin equations involving the white noise.
In the presence of Lorentz force, we show that the Brownian motion in the small mass limit is described by the stochastic differential equations involving the non-white noise.
The non-white noise is characterized by a correlation matrix which has antisymmetric components.
We demonstrate the importance of the antisymmetric components by considering the heat dissipation by the Brownian particle.

Nonequilibrium systems(B)/0046 D2.06

Nonuniversality of heat engine efficiency at maximum power

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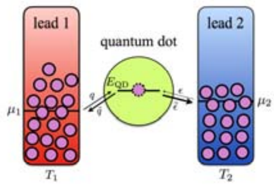
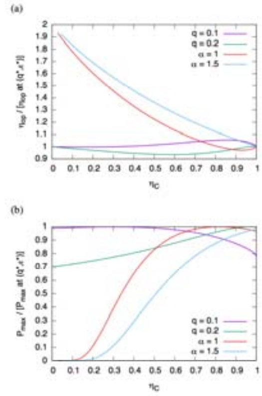
Abstract :

We study the efficiency of a quantum dot engine in the condition of the maximum power output. In contrast to the quasi-statically operated Carnot engine whose efficiency reaches the theoretical maximum, recent research on more realistic engines operated in finite time has revealed other classes of efficiency such as the Curzon-Ahlborn efficiency maximizing the power. The linear coefficient of such power-maximizing efficiency as a function of the reservoir temperature ratio has been argued to be universal as 1/2 under the tight-coupling condition between thermodynamic fluxes. By taking the quantum dot heat engine, however, we show that depending on the constraint posed on the engine, the linear coefficient can be unity, which implies that the efficiency at the maximum power actually approaches the Carnot efficiency in the equilibrium limit. As a result, we dismiss the notion of universal linear coefficient of the efficiency at the maximum power, and discuss the implication of such a result in terms of entropy production and irreversible thermodynamics. We claim that the particular scheme for the linear coefficient of unity is actually more realistic and experimentally realizable, as it corresponds to controlling the gate voltage of the quantum dot, for given temperatures and chemical potentials of the leads connected to the quantum dot.



A schematic illustration of the quantum dot heat engine composed of the quantum dot whose energy level E_{QD} in contact with the leads, which plays the role and heat and particle reservoirs with the temperatures T_1 and T_2, and the chemical potentials μ_1 and μ_2.



The relative efficiency (a) and maximum power (b) gain for local optimum case, compared to the global optimum.

Nonequilibrium systems(B)/0265 D2.07

Derivation of Markov processes without detailed balance

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Abstract :

Time-reversal symmetry of the microscopic laws dictates that the equilibrium distribution of a stochastic process must obey the condition of detailed balance. However, cyclic Markov processes that do not admit equilibrium distributions with detailed balance are often used to model systems driven out of equilibrium by external agents. I show that for a Markov model without detailed balance, an extended Markov model can be constructed, which explicitly includes the degrees of freedom for the driving agent and satisfies the detailed balance condition. The original cyclic Markov model for the driven system is then recovered as an approximation at early times by summing over the degrees of freedom for the driving agent. I also show that the widely accepted expression for the entropy production in a cyclic Markov model is actually a time derivative of an entropy component in the extended model. Further, I present an analytic expression for the entropy component that is hidden in the cyclic Markov model.

Nonequilibrium systems(B)/0717 D2.08

Role of work in matter exchange between finite quantum systems

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Abstract :

Close to equilibrium, the exchange of particles and heat between macroscopic systems at different temperatures and different chemical potentials is known to be governed by a matrix of transport coefficients which is positive and symmetric. We invetigate the amounts of heat and particles that are exchanged between two small quantum systems within a given time, and find them characterized by a transport matrix which neither needs to be a symmetric nor positive. At larger times even spontaneous transport can be observed in the total absence of temperature and chemical potential differences provided that the two systems are different in size. All these deviations from standard transport behavior can be attributed to the fact that work is done on the system in the processes contacting and separating those parts of the system that initially possess different temperatures and chemical potentials. The standard transport properties are recovered for vanishing work and also in the limit of large systems and sufficiently large contact times. The general results are illustrated by an example.

Focus: Gravitational wave astronomy/1172 D3.01

Superconducting Low-frequency Gravitational-wave Telescope (SLGT): Technical Challenge and Feasibility

Yong-Ho Lee[*1], Sang-Hyeon Ahn[2], Yeong-Bok Bae[2], Gungwon Kang[3], Chunglee Kim[2], Whansun Kim[4], John J. Oh[4], Sang Hoon Oh[4], Chan Park[3], Edwin J. Son[4], Ho Jung Paik[5]

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Abstract :

Recent success of gravitational wave (GW) detection by LIGO opened a new window to expand our understanding of the Universe. In addition to LIGO, several other developments are going on or under planning. However, each of these detectors has a specific sensitive frequency range. There is a missing frequency band, 0.1-10 Hz, where detectors loose sensitivity significantly due to Newtonian noise on the Earth. We introduce a plan to develop a Superconducting Low-frequency Gravitational- wave Telescope (SLGT), which can observe massive black holes in 0.1-10 Hz. The SLGT system consists of magnetically levitated six test masses, superconducting quantum interference devices (SQUIDs), rigid support frame, cooling system, vibration isolation, and signal acquisition. By taking the advantage of nearly quantum-limited low-noise SQUIDs and capacitor bridge transducers, SLGT's detection sensitivity can be improved to allow astrophysical observation of black holes in cosmological distances. We present preliminary design study and expected sensitivity, and its technical feasibility.

Focus: Gravitational wave astronomy/0120 D3.02

Superconducting Low-frequency Gravitational-wave Telescope (SLGT): pilot study status report

Chunglee Kim[*1], Sang-Hyeon Ahn[1], Yeong-Bok Bae[1], Gungwon Kang[2], Whansun Kim[3], John J. Oh[3], Sang Hoon Oh[3], Chan Park[2], Edwin J. Son[3], Yong Ho Lee[4], Ho Jung Paik[5]

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Abstract :

The discovery of GW150914, black hole – black hole merger via gravitational waves (GWs) opened a new window to observe the Universe. GW frequencies from heavenly bodies and early Universe are expected to span between sub-nHz up to kHz. At present, GW detectors on Earth (LIGO, Virgo, KAGRA, LIGO-India) aims frequency ranges between 10-2000 Hz. The space-borne GW detector and Pulsar Timing Array targets mHz and nHz sources. Starting in March 2017, the KKN (KASI-KISTI-NIMS) collaboration launched a pilot study of SLGT (Superconducting Low-frequency Gravitational-wave Telescope). This project is funded by NST (Korea Institute of Science and Technology). The main detection bands expected for SLGT ranges between 0.1-10Hz, which is complementary of LIGO-type detectors and LISA for multi-band GW observation. We will present an overview of the SLGT project and report the status of the NST pilot study. We will also present prospective of GW astronomy with SLGT.

Focus: Gravitational wave astronomy/0551 D3.03

Binary Black Hole Inspirals and Gravitational Wave detection in 0.1-10 Hz

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Abstract :

The pilot study of Superconducting Low-frequency Gravitational-wave Telescope (SLGT) is being performed by KASI-KISTI-NIMS (KKN) collaboration. In this presentation, we discuss the prospects of detecting gravitational waves (GWs) in the low-frequency band (0.1-10Hz) which is a target frequency band of SLGT, but beyond LIGO band. Intermediate Mass Black Hole Binaries (IMBHBs) and Intermediate Mass Ratio Inspirals (IMRIs) with total masses of 1,000-10,000 solar mass are the most probable sources in this band. We estimate horizon distances and signal to noise ratios of IMBHBs and IMRIs for different SLGT design sensitivities. Based on our calculations, detection rates for IMBHBs and IMRIs with SLGT will be discussed.

Focus: Gravitational wave astronomy/0225 D3.04

Stochastic Gravitational Wave Background in 0.1-10 Hz

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Abstract :

Stochasitc gravitational wave background (SGWB) is expected to be contributed by primordial sources (e.g. inflation signature) and astrophysical sources (e.g., incoherent superposition of a large numbers of compact binary inspirals throughout in the Universe). Theoretically, SGWB is predicted to span in a broad frequency range between less than nHz up to kHz. Many gravitational-wave (GW) detectors such as LIGO or LISA aim to detect or constrain SGWB in different frequency band that is most sensitive for each detector. In this talk, we focus on the prospectives of constraining the energy density of SGWB between 0.1-10 Hz. We introduce the characteristics of SGWB and representative models for primordial and astrophysical sources. Then, we propose a signal extraction scheme to detect SGWB using one or several omni-directional GW detectors such as SLGT(Superconducting Low-frequency Gravitational-wave Telescope). Considering SLGT sensitivity, we discuss how to observe SGWB in 0.1-10 Hz if we have SLGT network. Finally, we highlight interesting SGWB models that can be constrained in 0.1-10 Hz with SLGT.

Nuclear experimental method and instrumentation(F)/0406 D4.01

Luminescence and scintillation properties of disodium dimolybdate ($Na_2Mo_2O_7$) crystals

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Abstract :

The AMoRE (Advanced Mo Based Rare Process Experiment) is searching neutrino less double beta decay of ^{100}Mo isotopes using Molybdenum based crystals. The AMoRE pilot is running by using 1.5 kg of $^{40}Ca^{100}MoO_4$ crystals at Yangyang underground laboratory. In the meantime, we are also looking for a new Mo-based crystal for the AMoRE phase II. We have studied the luminescence and scintillation properties of the novel $Na_2Mo_2O_7$ (NMO) crystals grown by two different techniques, the conventional Czochralski (CZ) and the low-temperature-gradient Czochralski (LT-GCZ) techniques. The luminescence properties and decay times of the crystals at room and low temperatures were measured by using a light emitting diode (LED) with 280 nm wavelength. Very weak luminescence was observed at the room temperature; however, it enhanced significantly at low temperatures. The scintillation decay time was 2 μs at the room temperature and increased to ~750 μs at 10 K. Scintillation light yield was measured by a single photon counting technique using a ^{90}Sr source in the temperature range from 300 to 10 K. The luminescence and scintillation light yield of the crystal was normalized with a $CaMoO_4$ crystal. A thermoluminescence measurement was also performed. From the obtained results, the NMO crystal scintillator seems to be a promising Mo-based crystal candidate for searching 0νββ decay due to its significant luminescence and scintillation light yield at low temperature and also the purification techniques are well known for Na_2CO_3 and MoO_3.

Nuclear experimental method and instrumentation(F)/0391 D4.02

Status report for CsI detector performance test with radioisotopes

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Abstract :

Rare isotope heavy ion beams provided by RAON will play an important role for the study to understand the nuclear symmetry energy at sub-saturation densities. Low-LAMPS (Large Acceptance Multi-Purpose Spectrometer) consists of the Si-CsI and neutron detector. Si-CsI is designed for identifying particles produced in the nucleus-nucleus collisions. Specially the CsI detector in the Si-CsI system will be used for the precise measurement of full deposit energy of particles produced from the collisions. In order to verify the suitability, the characteristic energy spectrum were measured by using radioisotopes (^{137}Cs, ^{60}Co, ^{22}Na, ^{54}Mn, ^{65}Zn). In this presentation, we will report the current status of this performance study.

Nuclear experimental method and instrumentation(F)/0390 D4.03

Status report for Si-CsI detector simulation study with IQMD simulated data at Low-LAMPS (Large Acceptance Multi-Purpose Spectrometer)

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Abstract :

Low-energy radioactive ion beams provided by RAON will play an important role to study about the nuclear symmetry energy at sub-saturation densities. According to conceptual design, the low-energy Large Acceptance Multi-Purpose Spectrometer (LAMPS) consists of the Si-CsI system and neutron detector array. Specially, Si-CsI detector is designed to measure precise energies of particles produced in nuclear collisions for the particle identification. To verify the detector performance, we conduct detector simulation with Geant4 package, using IQMD simulated data. Efficiency study of the Si-CsI detector system is also performed. In this presentation, we will report the current status of this simulation study.

Nuclear experimental method and instrumentation(F)/0379 D4.04

Development of LAMPS Time Projection Chamber

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Abstract :

기초과학연구원 중이온가속기건설구축사업단 RI 실험장치팀은 핵물질의 대칭에너지 (symmetry energy) 연구를 위해 고에너지 핵물리 실험설비인 대면적 다목적 스펙트로미터 (Large Acceptance Multi-Purpose Spectrometer : LAMPS)를 개발하고 있다. LAMPS 의 주 검출기는 솔레노이드 마그넷 내부에 위치하는 시간투영검출기 (Time Projection Chamber : TPC)이다. TPC 는 중이온 충돌에서부터 생성되는 모든 하전입자의 궤도를 추적해 하전입자의 운동량 및 종류를 구분하는 것이 목적이다.

LAMPS TPC 는 1.2m 길이의 원통 형태(외경 1m, 내경 30cm)로 360 도 방위각 전체와 극각 24 도 에서 127 도의 검출영역을 가지고 있다. TPC 를 지나가는 하전입자는 혼합기체 분자들을 이온화시키며 이때 발생한 전자들은 가스 영역을 둘러싸고 있는 전기장 우리(Field Cage)에 의해 만들어진 균일한 전기장의 영향으로 TPC 의 끝 방향으로 이동하게 된다. 이동한 전자들은 기체전자증폭기(Gas Electron Multiplier : GEM)에 의해 증폭되고, 검출기 가장 끝단의 신호 수집판(readout pad)에서 전기신호로 만들어져 신호처리 시스템에 의해 읽어진다.

LAMPS TPC 개발을 위해 1/8 크기에 달하는 시작품 TPC 를 만들어 TPC 의 제작과 운영에 필요한 기술을 연구하고 있다. 시작품 TPC 의 특성 조사를 위해 양전자 빔과 우주선 뮤온을 이용하여 테스트 한 결과와 LAMPS TPC 개발 계획에 대해 발표 할 것이다.

Nuclear experimental method and instrumentation(F)/0220 D4.05

Gamma-ray tracking system in KRISS(2)

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Abstract :

Gamma-ray tracking sytem has been developed by Radiation center in KRISS.

Segmented HPGe detector is main detector for tracking gamma-ray. The shockey ramoe theorem is used for impoving the resolution of interacting point in each cell. The shape during rise time gives the information where the gamma-ray interacts with germanium atom. The calculated signals were compared with the real signals and calculated the chi-squared values. This comparing program was written with maxima. The signlas were calculated by paraview, python and maxima.

Nuclear experimental method and instrumentation(F)/0148 D4.06

차세대 실리콘 센서 개발을 위한 인베스티게이터 칩의 특성연구

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Abstract :

실리콘 센서 (Silicon sensor)는 뛰어난 공간 분해능과 효율을 가져 입자 충돌 실험에서의 차세대 검출기로서 기대되고 있다. 인베스티게이터 (Investigator)는 차세대 실리콘 센서 개발을 위한 새로운 실리콘 센서이다. 인베스티게이터는 서로 다른 특성을 가진 134 개의 미니 (8 × 8 픽셀) 매트릭스 (Mini matrix)로 구성돼 있으며, 각각의 미니 매트릭스는 다양하게 다른 크기의 픽셀 (20μm ~ 50μm), 수집 N-well (Collection N-well) 및 다른 리셋방식 (PMOS, Diode) 등을 가지고 있다. 각 픽셀들은 65MHz 의 진동수로 표본화 (Sample)된 출력을 직접적으로 할 수 있기 때문에 한개의 미니 매트릭스에서 64 개의 아날로그 신호를 전송한다. 그에 따라, 기존의 실리콘 검출기와는 다르게 입자가 검출기를 지나면서 생겨나는 전하들이 검출되는 시간에 대한 분석 또한 가능하다. 본 연구발표에서는 다양한 역전압, 문턱값 설정 등에 따른 서로 다른 미니 매트릭스에 대한 특성연구결과를 소개한다.

Nuclear experimental method and instrumentation(F)/0078 D4.07

High-resolution magnetic spectrometer in the R³B setup

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Abstract :

The international research facility FAIR (Facility for Antiproton and Ion Research) is under construction for research on the nature of matter and evolution of the universe. Among the four pillars of physics at FAIR, NUSTAR Physics (NUclear STructure, Astrophysics and Reactions) has a branch of R^3B (Reactions with Relativistic Radioactive Beams). The purpose of the R^3B project is to develop and construct a versatile reaction setup with high efficiency, acceptance, and resolution for kinematical complete measurements of reactions with relativistic radioactive beams.

In the planned setup, the High-Resolution magnetic Spectrometer (HRS) is one major part for high-resolution measurement. Commonly heavy ions are identified by the $B\rho$, TOF, and ΔE method, and this method will provide a relative momentum resolution of $\Delta p/p\sim10^{-3}$ in σ in large-acceptance measurement mode at the R^3B setup. Meanwhile, for high beam energies of 700-1000 MeV/nucleon of medium and heavy mass nuclei, the $\Delta p/p$ of 10^{-4} is required. In knockout reactions and quasi-free scattering, the orbital angular momentum of the recoiling A-1 fragment is deduced from the momentum distribution by comparison with the calculated momentum distributions. Here, to distinguish the momentum distributions for different orbital angular momenta, around 20-30 MeV/c momentum resolution in σ in the laboratory frame is needed corresponding to $\Delta p/p\sim10^{-4}$. Therefore, the HRS, consisting of quadrupole triplets, dipoles, and tracking detectors, is being developed by a simulation, and the status will be shown in the presentation.

Nuclear experimental method and instrumentation(F)/0067 D4.08

Measurement of prompt gammas for particle therapy

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Abstract :

A detection technology based on multi-layered resistive plate chamber (RPC) has been developed for the range verification in particle therapy. A six-gap RPC was constructed with 0.5-mm-thick floating glass and tested with a 5-GBq Cs-137 gamma source and with gamma rays induced using 44-MeV proton beams at the Korea Institute of Radiological Accelerator Medical Sciences (KIRAMS). The gamma-ray images were obtained using a 5-cm thick lead collimator with 10-mm-pitch 4-mm-diameter holes. The beam-activated area in a 2-cm-thick acrylic phantom is well visualized by measuring the induced gammas for a DAQ time of 6.5 s and is fairly satisfactory to confirm beam-activated areas in therapeutic tissues in particle therapy.

Quantum optics and quantum information(C)/1188 D5.01

Quantum Interference Using Single-Photon Sources from Doppler-Broadened Atomic Ensemble

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Abstract :

To realize a quantum network based on quantum entanglement swapping, bright and completely autonomous single-photon sources are essentially required. We experimentally demonstrate Hong-Ou-Mandel quantum interference [1] between two independent bright photon-pair sources to show the indistinguishability and purity in Doppler-broadened warm Rb atomic vapor. The manuscript describes bright autonomous single-photon sources based on the hot vapor cells that can work greatly simplifies the experiment. Bright autonomous single photons are operated in a continuous-wave (CW) mode with no synchronization or supplemental filters. The fourfold photon coincidence counts per hour correspond to 5000 events for a temporal range of 10 ns, one order higher than that previously reported for autonomous single photons [2, 3]. We observe an HOM dip with 83% visibility using two autonomous single photons and within an effective measurement time of 900 s [4]. The achievement of HOM interference between bright autonomous photon-pair sources is an important step towards a practical scalable quantum network.

[1] C. K. Hong, Z. Y. Ou, and L. Mandel, “Measurement of subpicosecond time intervals between two photons by interference,” Phys. Rev. Lett. 59, 2044 (1987).

[2] M. Halder, A. Beveratos, N. Gisin, V. Scarani, C. Simon, and H. Zbinder, “Entangling independent photons by time measurement,” Nat. phys. 3, 692 (2007).

[3] P. Qian, Z. Gu, R. Cao, R. Wen, Z. Y. Ou, J. F. Chen, and W. Zhang, “Temporal Purity and Quantum Interference of Single Photons from Two Independent Cold Atomic Ensembles,” Phys. Rev. Lett. 117, 013602 (2016).

[4] T. Jeong, Y.-S. Lee, J. Park, H. Kim, and H. S. Moon, “Quantum Interference between Autonomous Single-Photon Sources from Doppler-Broadened Atomic Ensemble,” Optica, to be accepted (2017).

Quantum optics and quantum information(C)/0183 D5.02

Quantum Key Distribution by Optimal Sequential State Discrimination

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Abstract :

Recently, sequential state discrimination, as a quantum-key distribution protocol, has been proposed for multiple receivers. A previous study, proposed by J. A. Bergou et al., Phys. Rev. Lett. 111, 100501 (2013), showed that
every receiver could successfully perform a sequential state discrimination of two pure states with identical prior probabilities. In our work, we extend the sequential state discrimination to mixed states with arbitrary prior probability. In addition, we compare the sequential state discrimination to the strategies of quantum reproducing and
quantum broadcasting.

Joint spectral intensity of pair photons generated by spontaneous Four Wave Mixing in a dispersion shifted fiber

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Abstract :

Pair photon generation is one of the methods to generate non-classical photon states for quantum information. The state of generated pair photon via Spontaneous Four Wave Mixing (SFWM) can be described as

$|\Psi(\omega_s,\omega_i)\rangle = g \int d\omega_s \int d\omega_i\, F(\omega_s,\omega_i)\, |\omega_s\rangle\, |\omega_i\rangle$,

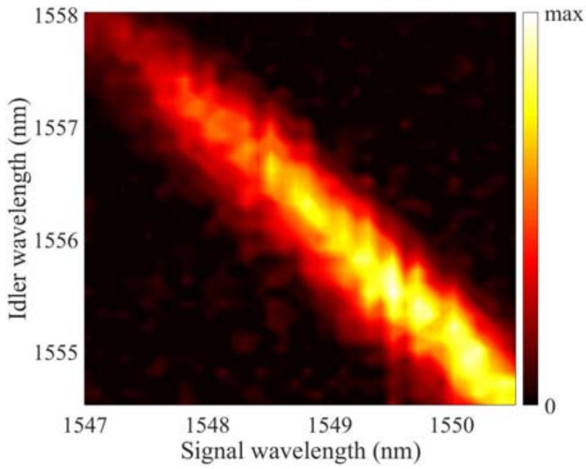

Figure 1. The measured joint spectral intensity

where g is a gain constant associated with the experimental details. The function $F(\omega_s,\omega_i)$ is the two-photon joint spectral function, which is proportional to the probability amplitude of two-photon detection at ω_s and ω_i. Thus, the measurement of joint spectral intensity allows one to obtain the information of the quantum correlations between generated photons. Full joint spectral intensity measurement of photon pairs in a dispersion shifted fiber (DSF), however, has not been reported yet.

In this research, we measured joint spectral intensity by using tunable filters. The tunable filters can cover C- and L-band wavelength region with 0.25-nm full-width at half-maximum (FWHM) bandwidth. Pump wavelength is 1552.52 nm and pulse width is about 10 ps with 18-MHz repetition ratio. In order to reduce spontaneous Raman scattering, a 500-m DSF was cooled to liquid nitrogen temperature 77K.

Figure 1 shows the measured joint spectral intensity, indicating that the generated pair photons are strongly correlated to each other. Maximum coincidence occurs at 1549.52 nm for signal photons and 1555.52 nm for idler photons with FWHM bandwidth of about 3 nm. We expect to generate factorable states by using commercially available dense wavelength division multiplexing filters, which is useful for quantum information application

Quantum optics and quantum information(C)/0186 D5.04

Maximal trace distance between isoenergetic bosonic Gaussian states

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Abstract :

We locate two Gaussian states of a single mode electromagnetic field that exhibit maximal trace distance subject to the constraint of equal expected photon number. The availability of two such states allows to achieve the minimum possible error in the task of binary distinguishability of two single mode, isoenergetic Gaussian quantum signals. In particular, we show that the logarithm of the minimal error probability for distinguishing two maximally distant, isoenergetic Gaussian states scales as $-E^2$, less than the achievable scaling of the minimal error probability for distinguishing, e.g., a pair of isoenergetic Heisenberg-Weyl coherent states with energy E or a pair of isoenergetic quadrature squeezed states with energy E. This result has basic applications in the theory of continuous variable quantum communications with Gaussian states of light.

Quantum optics and quantum information(C)/0513 D5.05

Thermalization dynamics of an Ising quantum magnet

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Abstract :

87 Rubidium single atoms are loaded by using holographic optical tweezers in a zig-zag chain. The single-atom array is prepared up to 30 atoms without any defects and entangled through collective Rabi oscillation to a Rydberg state by suddenly turning on the interaction field. The so-called quench dynamics manifest non-equilibrium phenomena of the isolated quantum system. Resulting coherent quench dynamics reveal an equilibration behavior of an observable, Rydberg fraction, to a value predicted by generalized Gibbs ensemble which is a clear evidence of pre-thermalization. Moreover, probability tomography of the entire Hilbert space directly shows typicality of the pre-quench Hamiltonian, in this case, micro-canonical ensemble result. Our quantum simulation of thermalization dynamics on an Ising quantum magnet may provide a great opportunity for experimentally investigating quantum thermodynamics.

Quantum optics and quantum information(C)/0666 D5.06

Ultrafast coherent control scheme to make leakage-suppressed qubit-subspace in a three-level quantum system

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Abstract :

Quantum information is stored and processed in a two-level subspace (qubit subspace) of a physical system. However, in many physical systems, the subspace is imperfectly isolated from unwanted energy states causing population leakage to them. This is an intrinsic problem for many physical systems to overcome to achieve high-fidelity qubit controls. Here, we consider the leakage suppression problem in a three-level system, where the first two levels are the qubit system and the third, weakly-coupled to the second, is the leakage state. We show that phase- and amplitude-controlled three pulses are sufficient to make arbitrary qubit controls, while leakage is suppressed up to the first order of perturbation. A proof-of-principle experiment was performed with shaped femtosecond optical pulses and atomic rubidium 5S, $5P_{3/2}$ and 5D states, demonstrating the result agrees well with the theory.

Pioneer: Energy harvesting technologies/0684 D6.01

Development of Printing Thermoelectric Module and Quest of New Thermoelectric Materials for Energy and Environmental

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Abstract :

Thermoelectric technology enables direct and reversible conversion between thermal energy and electrical energy. It provides a feasible way for electric power generation from waste heat of our industrial activities. The goal of our study is to clarify the energy conversion principle in the thermoelectric process and to develop key technologies for the industrial application of the thermoelectric technology.[1)] In this paper, we will introduce a few topic from our current research activities.

First topic is the development of new fabrication technique of thermoelectric modules using ink-jet technique which has been using for making fine-size LCD color filters or organic EL devices. We have developed "thermoelectric ink" by distributing small particles of p- or n-types Bi-Te thermoelectric materials into organic solvent. Planar-type thermoelectric modules were produced by ink-jet printing using the p- and n-types thermoelectric inks and Ag metal ink for electrodes. When we apply temperature difference of 12 K to the printing module with 5 p-n pair on a glass substrate, the module generates electromotive force of 20 mV. This voltage is enough to drive a low-power DC-DC converter which is utilized for harvesting low-scale-energy. Moreover, the nano-bulk thermoelectric device made from this thermoelectric-ink demonstrate quite high performance such as ZT~1.0 at room temperature. [2)]

Second topic is the quest of new environmentally-friendly thermoelectric materials.[2)] Conventional thermoelectric materials are including heavy and rare elements such as Bi, Pb or Te. This is a reason that many researchers have sought Pb-free and Te-free materials. We have been focused on sulfide thermoelectric materials as altanative candidate, and created a new thermoelectric mineral $Cu_{10.5}Ni_{1.5}Sb_4S_{13}$ (tetrahedrite) consisting mainly of environmentally friendly copper and sulfur. The dimensionless figure of merits of this new sulfide reaches to ZT =0.7 at 665 K. [3)] It is a highest ZT value in the p-type Pb-free sulfides. The discovery of tetrahedrite opens up the possibility of sulfide thermoelectric materials. We are now continuing the searching for further new environmentally-friendly materials by introducing a computer-assisted material screening based on DFT calculation. [4)]

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Pioneer: Energy harvesting technologies/0273 D6.02

Nanostructured Silicon Thermoelectric Devices

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Abstract :

Thermoelectric device interconverts thermal gradient and electricity for power generation or cooling. Traditionally, Bi_2Te_3 semiconductor has been widely used as thermoelectric material. On the contrary, silicon has been considered as the impropriate material due to the high thermal conductivity property. However, recent research revealed the possibility of silicon as thermoelectric material by incorporating nanotechnology.

In this work, top-down silicon manufacturing process is adopted to implement the n-/p-leg included silicon thermoelectric device. The 50 nm width n- and p-type silicon nanowires (SiNWs) are manufactured using a conventional photolithography and ion implantation methods on 8 inch silicon wafer. For the evaluation of the Seebeck coefficients of the silicon nanowires, heaters and temperature sensors embedded test pattern is fabricated. Also, bulk structured silicide/silicon samples are manufactured for massive power generation applications. The highest Seebeck coefficients are -170 uV/K and 153 uV/K for n- and p-type SiNWs, respectively. For silicide/silicon bulk sample, Seebeck coefficients are higher than 200 uV/K.

Pioneer: Energy harvesting technologies/0664 D6.03

Crystallization of organolead halide perovskite: vacuum deposition and real-time analysis

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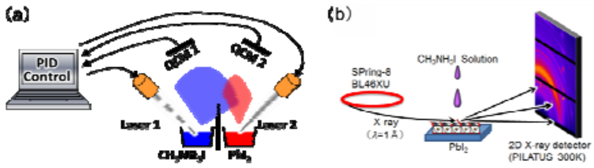
Abstract :



Organolead halide perovskite solar cells are developing very rapidly and have attracted much attention because of their high power conversion efficiencies (PCE); typically above 20%. In spite of the rapid development of this field, there still have been some difficulties in fabricating the high performance device with sufficient reproducibility. Understanding the crystallization mechanism and fabrication control of perovskite is essential for the practical application. Based on this background, we are focusing on two topics: development of the novel vacuum deposition method[1], and real-time analysis of the crystallization in solution[2].

As for the vacuum deposition, we developed laser deposition system, where the source materials were heated with 808-nm continuous-wave laser (Fig. (a)). Deposition control of amine halide has been considered to be difficult because of the gas generation during the deposition. We demonstrated the precise control of the deposition rate of the amine halide by means of laser deposition. The improved controllability can be beneficial for the fundamental analysis of the mechanism of film growth. Perovskite solar cells were fabricated based on the OPV architecture (ITO/NiO_x/PCDTBT/$CH_3NH_3PbI_3$/PCBM/BCP/Al). Power conversion efficiency of 16 % (backward scan) was obtained with reduced hysteresis.

As for the real time crystallization analysis, we used synchrotron radiation facility (Spring-8 BL46XU). CH_3NH_3I solutions were dropped onto a PbI_2 thin film and the formation process of the perovskite crystals was observed by using the X-ray diffraction method (Fig. (a)). We found that the crystallization is proceeding based on the anomalous diffusion process. Also we found that in the early stage of the reaction the formed crystals were oriented in two specific directions, but with the progress of time they changed to a random orientation. This finding suggests that the crystals changed continuously during the process of formation of the perovskite crystal. The control over these unique phenomena (anomalous diffusion and orientation change) is the key to highly reproducible fabrication of highly efficient solar cells.

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Acknowledgement: This work is financially supported by New energy and industrial technology development organization (NEDO), Japan science and technology agency (JST), and Japan society for the promotion of science (JSPS).

Pioneer: Energy harvesting technologies/0521 D6.04

Performance Stretchable Triboelectric Nanogenerators with a dielectric interlayer

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Abstract :

The main approach to enhancing the electrical output performance of triboelectric nanogenerators (TENGs) has been increasing the triboelectric charge generation. However, there have been few studies on achieving effective electrostatic induction and conserving the triboelectric charge. We present that the simple addition of an insulating interlayer between the triboelectric surface layer and collector electrode results in rapid saturation of the charging and greatly enhances the output power. The origin of the charge conservation and related performance enhancement is discussed. By using an elastic insulator of polydimethylsiloxane (PDMS) as the interlayer, we present fabrication of a stretchable single-electrode TENG (S-TENG) and Double electrode TENG with high output performance. The stretchable TENGS maintaine their high performance up to a uniaxial strain of 50% and show superb mechanical durability.

Pioneer: Energy harvesting technologies/0644 D6.05

Interface Optoelectronics for Tandem Solar Cells by Perovskite and Silicon

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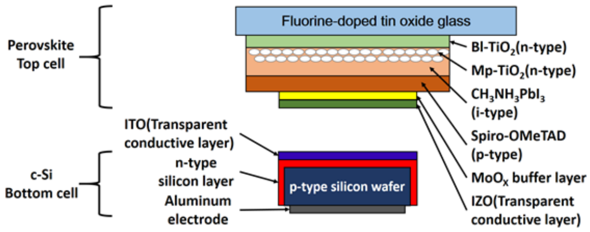
Abstract :



In order to fabricate tandem solar cells by perovskite and silicon, 5-mm square-shaped silicon solar cells have been fabricated by a facile method. Afterward, engineering of photonics for antireflection and electronics for extraction of the hole using a thin Au layer have been performed for two- and four-terminal tandem solar cells using $CH_3NH_3Pb(I\text{-}Br)_3$ perovskite (top cell) and p-type single crystal silicon (c-Si) (bottom cell) by mechanically stacking. Highly transparent connection multilayers of Au and ITO films were depositted at the interface to be a point-contact tunneling junction between the rough perovskite and flat silicon solar cells [1]. Moreover, we have analyzed the sputtering effect on spiro-OMeTAD HTM layer, which can deteriorated the photovoltaic effects of tandem devise significantly [2]. Also, the mechanically stacked tandem solar cells with several configurations as Fig. 1 were fabricated with MoOx and ITO interface layers [3]. In the conference, the detail results of optoelectronics phenomena about silicon and perovskite solar cells will be disclosed.

(Figure 1 .Structure of tandem solar cells using perovskite and silicon.)

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Pioneer: Non-equilibrium first-principles calculations for energy applications/0959 D7.01

Nonequillibrium Quantum Transport and Optical Processes in Controlled Quantum Nanostructures from First Principles

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Abstract :

Nanoscale energy efficient electronics, photonics, lighting and photovoltaics requires the understanding of ground and excited states of strongly interacting electrons out of equilibrium. We start by describing our recent theoretical work aiming at the understanding of nonequillibrium quantum transport in a few-electron field effect transistor[1,2] combining exact diagonalization techniques for correlated electrons in a quantum dot and many-body master equation for non-equillibrium population of these states driven by finite source-drain bias. The Coulomb and Spin blockade will be analyzed in the lowest dot-leads coupling strength. We next focus on theory and design of semiconductor nanocrystals for efficient lighting and lasing. The theory of Auger process will be described[3] and applied to semiconductor nanocrystals realizing lasing in flexible electronics[4]. Reducing the thickness of nanostructurers to a single atomic layer results in quantum dots in 2D crystals. In graphene, size, shape, type of edge, sublattice symmetry, topology, number of layers and carrier density allows to design graphene quantum dots with desired electronic and optical properties[5]. In particular, sublattice engineering allows design of magnetic moments tunable with voltage and light, size engineering leads to optical gaps from THz to UV while shape engineering leads to a degenerate exciton spectrum allowing for the generation of entangled photon pairs via XX-X cascade [5,6]. We describe here first-principle theory of Dirac Fermion excitons(X) and bi-excitons(XX) and discuss their observation in nonequillibrium transient absorption spectroscopy[6]. We point to the fact that graphene nanostructures realize the three functionalities of a quantum circuit: electronics, photonics and spintronics, in a single material and at the nanoscale[5]. Integration of these different functionalities may enable Carbononics - a unified approach to energy efficient Information and Communication and Energy Conversion Technologies.

* with I. Ozfidan, P. Potasz, A.D. Guclu, O. Voznyy, M.Korkusinski, A. Delgado Gran, L. Najera, Y. Saleem, L. Szulakowska, M.Bieniek.

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Pioneer: Non-equilibrium first-principles calculations for energy applications/0964 D7.02

Moving atoms and spins: non-equilibrium theory for current-driven phenomena

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Abstract :

Many devices are based on driving the dynamics of their internal degrees of freedom by an electrical current. Atoms are transported by a current in electro-migration phenomena, while the order parameter of a magnet, either the magnetization of a ferromagnet of the N´eel vector of an antiferromagnet, can be changed by a spin-polarized current. Modelling these phenomena is challenging since one usually has to match time and length scales, and treat the problem as a non-equilibrium ones with open boundary conditions. In this talk I will construct a theory for current-induced ionic and spin motion, which is based on the non-equilibrium Green's functions formalism for quantum transport combined with first principles density functional theory[1]. First I will consider the case of ionic motion and derive the expression for the current-induced forces from the expectation value of the ionic momentum operator. This is a quantity that can be computed from the non-equilibrium charge density alone. Then, as an example, I will explore the case of an H_2 molecule sandwiched between two Au. I will show that the current produces stiffening of the transverse translational and rotational phonon modes and softening of the stretching modes along the current direction. Such behavior is understood in terms of charge redistribution, potential drop, and elasticity changes as a function of the current[2]. Then, I will move to spins dynamics and will present how a multi-scale theory for spin dynamics can be constructed. The torques are derived from time-dependent DFT and can be extracted from the transport calculations[3]. Then such torques are used as an input for atomistic spin-dynamics calculations[4], with a net result that a fully ab initio theory for spin dynamics can be implemented. Together with the theory backbone I will show a few examples of such computational scheme. In particular I will look at dynamics in Fe/Co-based magnetic tunnel junctions and look at the possibility of constructing and all-antiferromagnetic current-driven device[5].

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Pioneer: Non-equilibrium first-principles calculations for energy applications/0920 D7.03

Petahertz frequency control of spins

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Abstract :

A timely and important question may be whether spin control can be achieved by employing light-wave-induced petahertz charge processing. Proposing a theoretical model of a layered ferromagnetic (FM)-nonmagnetic (NM) heterostructure under few-cycle optical driving, we render the light-wave-induced charge transport spin-asymmetric and achieve petahertz frequency control of spins.

Focus: Nano/mesoscopic system: quantum coherence in condensed matter/0264 D8.01

Direct Measurement of the energy gaps in graphene on hexagonal boron nitride

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Abstract :

We have performed electron tunneling spectroscopy measurements on graphene-hexagonal boron-nitride (*h*-BN) van der Waals heterostructures. In this device scheme, single-layer graphene flake is coupled to a rotationally aligned *h*-BN substrate and a thin *h*-BN tunneling barrier is placed on top of the graphene-*h*-BN stack, which allows us to probe the electronic structures of graphene superlattices with tunneling spectroscopy measurements. We have confirmed that energy gaps are formed at both the main and the superlattice Dirac points, whose spectra features are identified as dips in differential conductance plots at both the Dirac points. By carefully analyzing the Landau-level developments fanning out at the edges of both the energy gaps as external magnetic field increases, we accurately address how the energy gaps at both the Dirac points respond to the variations of graphene-superlattice size, electron-electron interactions, and external magnetic field.

Focus: Nano/mesoscopic system: quantum coherence in condensed matter/0117 D8.02

Quantum decoherence dynamics of defect spins in semiconductors

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Abstract :

In recent years, remarkable advances have been reported in the development of defect spin qubits in semiconductors for solid-state quantum information science and technology. Promising spin qubits include the nitrogen-vacancy center in diamond, dopants in silicon, and the divacancy spins in silicon carbide. In this talk, I will describe our recent combined theoretical and experimental study on remarkably robust quantum coherence found in the divancancy qubits in silicon carbide [1]. We show that the Hahn-echo coherence time of the divacancy spin reaches 1.3 ms, the longest Hahn-echo coherence time of an electron spin in a naturally isotopic crystal. We used a quantum bath model combined with a cluster expansion method to identify the microscopic mechanisms behind the unusually robust coherence. Our study indicates that developing spin qubits in complex crystals with multiple types of atom is a promising route to realize strongly coherent hybrid quantum systems.

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Focus: Nano/mesoscopic system: quantum coherence in condensed matter/0196 D8.03

Scattering model for Hanbury-Brown Twiss effects of two interacting electrons

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Abstract :

Electron quantum optics using single-electron pumps in solid-state devices has been experimentally studied recently. Among them, an experimental study of two-electron Hanbury-Brown Twiss effects is a significant step towards quantum information processing based on electrons. We study the Hanbury-Brown Twiss effect of a pair of hot electrons generated by quantum dot pumps. We derived two-particle scattering matrix for a beam splitter, taking into account of the Coulomb interaction between the electrons. The full counting statistics of the two-electron tunneling process shows anti-bunching or bunching behavior depending on the competition between tunneling time through the beam-splitter and a time scale characterizing the interaction. The statistics can be experimentally studied by measuring electrical current and current-current correlations.

Focus: Nano/mesoscopic system: quantum coherence in condensed matter/0201 D8.04

Intrinsic Aharonov-Bohm Interferometry at a single p-n junction in quantum Hall graphene

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Abstract :

Quantum Hall conductance across a p-n junction in graphene under a homegeneous magnetic fields is theoretically investigated by considering rough edge terminations. For higher filling factor cases, the conductance across the junction exhibits a nice oscillation as the length of the p-n junction interface, whereas the smallest filling factor case leads to clear plateau of the conductance at e^2/h. It is demostated that the conductance oscillation originates from the Ahranov-Bohm(AB) interferometry created by two separate quantum Hall edge states. This AB interferometry, which is intrnsically created at a single p-n junction, encloses a well-defined area through which magnetic fluxes penetrate. Interestingly, it is shown that the intrinsic AB effects may deteriorate as the potential step gets smoother, showing low visibility; that is why the intrinsic AB interferometry has not been evidently observed in pratical experiments.

Nano and mesoscopic physics(E)/0878 D8.05

GHz nanomechanical resonators in ballistic suspended graphene *pn* junctions

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Abstract :

Here, we demonstrate high frequency nanomechanical resonators in ultraclean suspended graphene *pn* junctions. The suspended graphene resonators are fabricated on two bottom gates (left and right) covered with lift-off resist (LOR) by using a mechanical transfer technique. After current annealing, the device exhibits a clear charge neutrality point at around zero gate voltage. Depending on the left and right bottom gate voltages, the device shows four different conductance regimes: *p-p*, *n-n*, *n-p* and *p-n* corresponding to two different carrier types in the two sides of the sample. At the *p-n* and *n-p* regime, the clear Fabry-Perot interference pattern is observed, indicating ballistic transport behavior over 1 um-long channel. Then, the mechanical resonance is measured in the same device with a frequency modulation (FM) mixing technique at 4.2 K in the vacuum chamber. The devices show the strong dependence of resonant frequency, mass and built-in tension depending on current annealing steps. We observe a resonance frequency as high as 1.17 GHz for the fundamental mode after the final current annealing step.

Focus: Strongly correlated electron system: quantum material property in 4d/5d transition-metal oxides/0227

D9.02

Spin-Orbit Coupling and Correlation in Osmates

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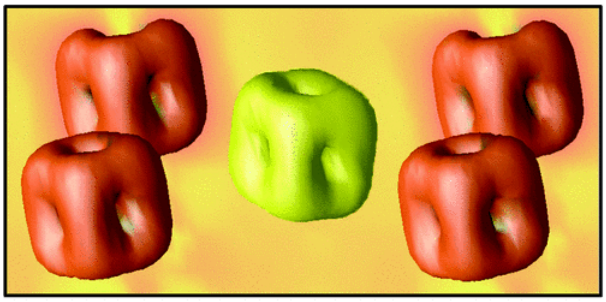
Abstract :



In condensed matter, especially when containing heavy ions, spin-orbit coupling (SOC) often leads to phenomena that are lacking without SOC. Examples of recent interest include the original topological insulators, unconventional metal-insulator transitions, compensating spin and orbital moments, and the magneto-crystalline anisotropy that is so important in spintronics applications. When SOC competes with correlation, in particular, new phenomena of matter have been emerged. In this point of view, osmates having various oxidation states are a good example to investigate this interplay.

In this presentation, we will review our recent results, obtained from first principles approaches, in osmates. First, we will address effects of SOC within a t_{2g} manifold from Os^{7+} ($5d^1$) to Os^{4+} ($5d^4$), which have a long history and have been intensively discussed recently, in a few oxomates. Then, we will extend our discussion to corresponding effects in an e_g manifold, which have rarely been considered due to the conventional wisdom that the e_g subshell ensures a perfectly quenched orbital moment.

[Acknowledgement] These researches have been supported by NRF of Korea Grants No. NRF-2016R1A2B4009579 and collaborated with W. E. Pickett (UC Davis), and Young-Joon Song, Myung-Chul Jung, and Kyo-Hoon Ahn (KU).

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Focus: Strongly correlated electron system: quantum material property in 4d/5d transition-metal oxides/0616 D9.03

Nonsymmorphic symmetry induced-instability and the nature of magnetism in Sr_2IrO_4

박진홍[*1], 이승훈[2], 진호섭[3], 양범정[1,2,4]

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Abstract :

Peierls distortion is a robust instability occurred in a partially-filled one-dimensional (1D) band with its susceptibility diverging, which is attributed to Fermi surface topology in 1D. Searching for two dimensional analog of Peierls instability is elusive since the topology of Fermi surface in higher than 1D experiences the deficit of nesting, in turn, and exhibits to weak susceptibility. In this talk, we present that such a difficulty can be overcome by non-symmorphic symmetry-protected Dirac line node (DLN) along Brillouin zone boundary in Sr_2IrO_4 whose space group is of this kind. The zone-boundary DLN provides a 1D-alike Fermi surface topology, leading to far-reaching consequence of Peierls-like instability on magnetism. Depending on the rotation angle of IrO_6 octahedron, the susceptibility grows fast and diverges at a critical angle where DLN becomes flat. The infinitesimal Hubbard U interaction is enough to develop the magnetism in Iridates 214 near the critical rotation angle. This provides a unified viewpoint on magnetic instability in Sr_2IrO_4, originating from the cooperation between non-symmorphic crystal symmetry and electron correlation. Furthermore, we can envisage unveiling hidden quantum critical behavior by varying rotation angle that might be accessible in $(Sr_{(1-x)}Ca_x)IrO_4$ system.

Focus: 2D Material photonics/1192 D10.01

Optical modulators based on graphene surface plasmons and an epsilon-near-zero effect

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Abstract :

Graphene-based optical modulators have attracted a lot of interest due to outstanding carrier mobility (103 ~ 105 cm2/Vs) and a tunable permittivity of graphene, which can be easily controlled by applying a gate voltage. However, designing the high performances modulator is difficult owing to the low absorption rate of graphene (~2.3%) and weak interaction between an incident light and a graphene layer. In this work, we show two types of optical modulators based on plasmon-induced transparency by coupling of graphene plasmonic modes and the epsilon-near-zero effect of graphene. Both schemes enable efficient modulations by increasing light-matter interaction.

Optical science(A)/0518 D10.02

Light matter interaction enhanced by metallic nanostructures

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Abstract :

We experimentally demonstrate nonlinear optical dynamics of low dimensional material and quantum condensed matter with metallic nanostructures accompanying light confinement and electric field enhancement. Pump-probe spectroscopy is useful tool for investigation of ultrafast nonlinear dynamics of condensed matters. However, nano-sized materials such as two dimensional materials, nanoparticles, and thin films weakly interact with electromagnetic waves experimentally used in pump-probe spectroscopy. Particularly, to study nanomaterials using long wavelength electromagnetic waves such as mid infrared light and terahertz waves is not a trivial task, because the wavelength is several orders of magnitude longer than the object size. Therefore, one is required to increase light-matter interaction for improvement of signal to noise ratio and foundation of new nonlinear phenomena of condensed matters. In this work, we focus electromagnetic waves down to nano-sized volume using artificial metallic nanostructure optimally designed for pump-probe spectroscopy and enhance nonlinear optical phenomena for enhanced control of quantum condensted matters. We expect many possibilities of both fundamental studies and applications when metallic nanostructures are tailored for mid infrared light and terahertz frequencies.

Optical technology(B)/0126 D10.03

Ultrasensitive Terahertz Molecule Sensor Using Nano-metamaterials

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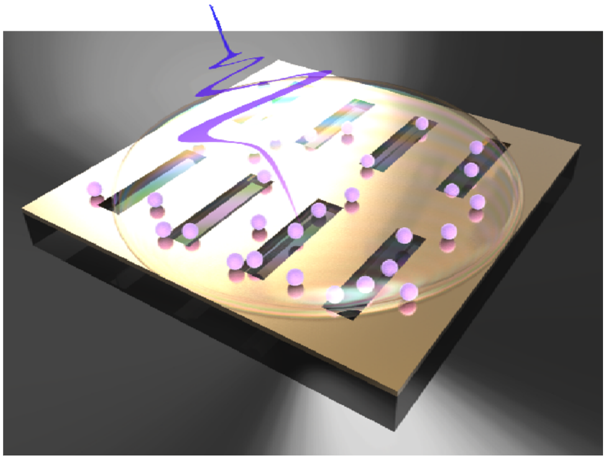
Abstract :



We report a highly sensitive and selective terahertz molecule sensing method for discrimination of small molecules including various saccharide, steroid, and virus using nano metamaterials. In order to increase detection sensitivity for such small molecules, subwavelength plasmonic metal structures in the order of lambda/10~lambda/10,000 have been suggested that can induce huge enhancement in field transmission and, in turn, colossal absorption cross section increase. Nano metal structure based terahertz sensing chip can be expected to offer new type of examination way for accurate quantification of such small molecules and subtype classification of various bio samples in a label-free and non-contact manner.

Optical science(A)/0483 D10.04

Extremely Large Nonlinear Optical Benzothiazolium Crystals for Efficient Broadband THz Wave Generation

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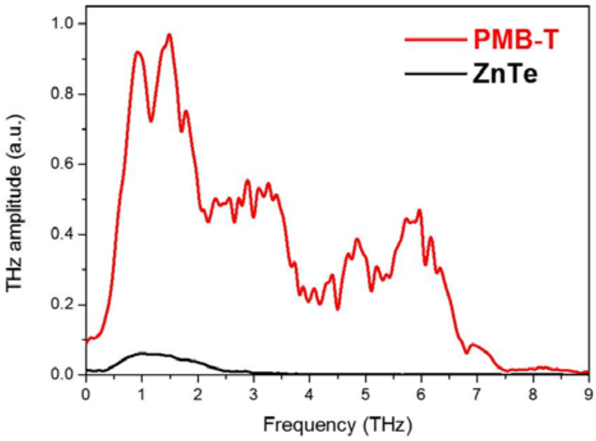
Abstract :



As table-top intense coherent terahertz (THz) sources are getting more important for advanced THz science, nonlinear organic crystals have been proposed as efficient materials for generation of broadband THz waves thanks to large nonlinear coefficient and excellent phase matching condition. Compared with inorganic crystals, organic crystals are regarded as a cost-effective solution, and it is easy to fine-tune the nonlinear optical characteristics by modifying its chemical structures. In the development of organic NLO crystals, a key issue is not only to promote the macroscopic nonlinearity of organic NLO crystals to a higher level, but also to maintain an acentric crystal structure. In this work, we have developed new nonlinear optical benzothiazolium crystal with extremely large macroscopic optical nonlinearity. In new PMB-T crystals, the strong electron donor and acceptor are incorporated with strong hydrogen bond site on molecular cations. The PMB-T crystal with a perfect molecular alignment of PMB cations in acentric structure for maximizing the second-order optical nonlinearity exhibits a linear polymer like arrangement of molecular dipoles with linear hydrogen-bonding mediated cation and anion assembly. These properties lead to 2 times higher large macroscopic optical nonlinearity than that of well-known DAST crystal. Compared to ZnTe, PMB-T exhibits a remarkably higher THz generation efficiency; 24 times higher peak-to-peak THz field. Moreover, the THz spectra generated in PMB-T are much broader than that of ZnTe. These results suggest the potential of the PMB-T crystal as a valuable source for efficient THz wave generation.

Other optics(G)/0172 D10.05

Terahertz optical characterization of DNA hybridized graphene using nano metamaterials

이상훈 [1,2], 최종호 [3], 김철기 [2], 손주혁 [1], 서민아 [*2]

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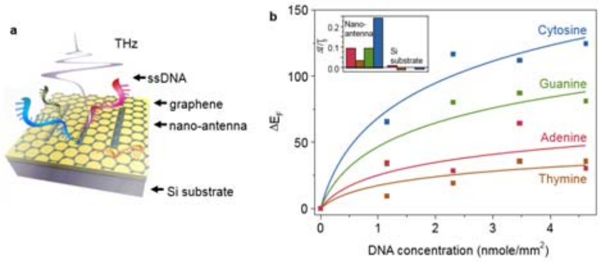
Abstract :



During decades there has been much progress in understanding of carbon nanomaterials which has attracted great attention because of their exotic physical properties. Graphene, which shows high speed carrier mobility coming from ballistic electron transport has risen as a good candidate for various applications such as high speed electronic devices, single molecule gas detectors and transparent conducting electrodes. As a chemical dopant of graphene but not carrier of genetic instruction, deoxyribonucleic acid (DNA) has also π electrons on their nucleobases so that can be tightly adsorbed onto the graphene surface. DNA can give different electronic effect as much as their various forms by its sequence, length and molecular structure.

Here, we show Fermi level tuning effect of graphene by DNA using terahertz time-domain spectroscopy (THz-TDS) with nano-slot antenna technique. To simplify the effect of structure and sequencing effect, we applied four types of single-stranded DNA (ssDNA) which consisted of single type of nucleobase. For sensitive monitoring, we applied terahertz nano-slot antenna which enlarge graphene’s absorption cross-section induced by electromagnetic field enhancement on near-field region. We were able to measure clearly distinguishable transmittance between different species of ssDNA unlike on conventional THz measurement systems. The experimental transmittance was interpreted to Fermi level shift using finite element method simulation combined with theoretical carrier transport model of graphene. We hope that such an observation will help further applications including doping on graphene transistor, trace sensor for DNA and sensitive monitoring method of 2D materials.

Figure 1. **a.** Scheme of THz measurement of ssDNA hybridized graphene. **b.** Fermi level shifts and transmission differences (inset) by four types of ssDNA.

Accelerator & beam physics(A)/0982 D11.01

원자의 운동을 관측하는 초고속 전자회절 기술 (Time-resolved Electron Diffraction Technology for Watching Dancing Atoms)

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Abstract :

Wave (or light) is the most powerful tool for human beings to understand nature. By using the wave, we can see the structure of an object or changes inside an object. The fourth-generation light, which is so-called x-ray free-electron laser (X-FEL), generates ultrashort and coherent hard x-ray pulses. The 'new light' permits us to capture stroboscopic pictures of atoms or molecules with temporal resolution of less than 100 fs and spatial resolution of ~0.1 nm. However, the fourth-generation synchrotrons have very limited number of beamlines (actually one or two for each facility, now), and it is very difficult to share their beam-time to scientists. We have developed an alternative and much compact facility by using electron bunches having a duration of tens femtoseconds, which is so-called ultrafast electron diffraction (UED) facility. We can capture the stroboscopic images of atoms or small-scale molecules with temporal accuracy of less than 100 fs, which is comparable to that of X-FEL. With this presentation, I would like to explain 'how we can see small objects' and the necessity of developing stroboscopic tools with ultrashort electron beam. And I will introduce the status and application works of our UED.

Accelerator & beam applications(B)/0121 D11.02

Development and application of high power millimeter-wave/THz sources

김동성 [1], Ashwini Sawant[2], 최문석 [1], 이인근 [2], 최원진 [1], 최은미[*1]

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Abstract :

Development of high power microwave sources is challenging since it requires infrastructure, expertise in various disciplines, and strong financial support although its outcome impacts in national security, basic science, and mega science. In this talk, I will present the recent effort in developing high power millimeter-wave/THz sources based on vacuum electronics. Recently proposed applications such as radioactive material detection and OAM communication will be discussed as well.

Accelerator & beam physics(A)/0048 D11.03

Machine imperfection study of the RAON superconducting linac and its comparison with long cryomodule design

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Abstract :

Machine imperfection study of the RAON SCL3 is done that confirms that the baseline design meets the beam loss requirement of less than 1 W/m. The study shows that the baseline design is robust and capable of the full beam acceleration even without the orbit correction. Comparison is made with the long cryomodule design which shows that the beam operation of the long cryomodule design suffers a siginificant beam loss when the orbit correction is not done.

Accelerator & beam physics(A)/1016 D11.04

Recent Progress of RFQ beam commissioning in SCL-demo for RAON

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Abstract :

The SCL-demo facility of RAON consists of a ECR-IS (electron cyclotron resonance ion source), a LEBT (low energy beam transport), an RFQ (radio-frequency quadrupole), and a MEBT (medium energy beam transport), a set of QWR (quarter wave resonator) module. Last November, the first beam commissioning of the RFQ was carried out. After modifying the system configuration from the MEBT and adding beam diagnostics, the beam commissioning of the RFQ was performed in this summer. This work is the summary of the RFQ beam commissioning result.

Accelerator & beam physics(A)/0282 D11.05

Electron emission from surface curvature for QWR cryomdoule

김희태*[1], 정유철 [1], 김영권 [1], 이민기 [1], 조용우 [1], 최종완 [1], 김주완 [1], 정회천 [1], 권영관 [1]

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Abstract :

QWR cryomdoule is introduced and electron emission phenomenon from surface curvature is investigated. Thermionic emission and field emission phenomenon are reviewed. The electron emission is applied to the surface curvature of a conductor.

Accelerator & beam applications(B)/0618 D11.06

Unfolding of Bremsstrahlung Photons Energy Spectrum from the 28-GHz ECR Ion Source Using a Matrix Inversion Method

KUMWENDA Mwingereza John[1], JUNG Keun Ahn[*1], LEE Jongwong[1], PARK Jingyong[2], M.S Won[2], SEONG-Jun Kim[2], LUGENDO Innocent Jimmy[3]

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Abstract :

Measured bremsstrahlung photon obtained by the detection system does not reproduce true spectrum due to some phenomena such as limited acceptance, photon interactions in particular Compton scattering and fluctuation produced by electronics devices. In order to reproduce true bremsstrahlung photon from the 28-GHz ECR ion source we have applied inverse matrix unfolding technique. The gamma-ray detection system consists of three NaI(Tl) scintillation detectors placed **62** cm radially from the beam axis at the extraction port, and an NaI(Tl) scintillation detector for monitoring photon intensity along the beam axis. Bremsstrahlung photon energy spectra were measured at nine azimuthal angular regions at RF power of 1kW at Busan Center of KBSI. The unfolding method will be based on a full geometry Geant4 model of the ECR ion source. Results on the azimuthal angular distributions of bremsstrahlung photons after application of inverse matrix unfolding method will be presented.

Photonics and optoelectronics(D)/0929 D12.01

Fano resonances in the microwave region supported by 3D-printable hollow dielectric resonators

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[1]Ulsan National Institute of Science and Technology, School of Material Science and Engineering

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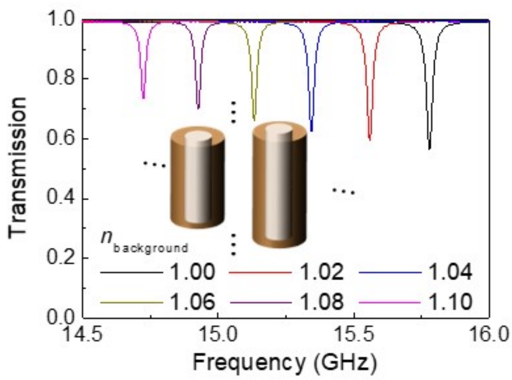
Abstract :



High-index dielectric structures have attracted much attention as Mie scatterers at visible wavelength range. Additionally, Fano resonances based on Mie resonances for the dielectric resonators can enable ultra-sharp spectral features, resulting in sharp spectral features together with strong light confinement. In the microwave region, such dielectric resonators and metamaterials can be made of 3-dimentional (3D) printable materials. 3D printing is advantageous to produce complicated 3D geometries, especially appropriate to fabricate the microwave dielectric resonators and metamaterials in the subwavelength scale.

Here we theoretically study Fano resonances in the microwave region supported by a coupled dielectric particle pair array. 3D-printable asymmetric dielectric cylinder pairs exhibits sharp asymmetric lineshape in the transmission spectra. To further enhance the performance of the structures, we introduce inner hole into the cylinder pair. By adjusting the inner hole size of the hollow dielectric resonators, we could control the Q factor and the resonance intensity of the structures. We reveal that the inner hole size is related to the degree of asymmetry of the structure. We can apply the sharp Fano resonance of the hollow dielectric resonators to the long-distance environmental sensing.

Photonics and optoelectronics(D)/0927 D12.02

The Amplificated Photocurrent by Photons in Graphene-SiO_2-Si (GIS) Heterostructure with a Low Work Function Difference

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Abstract :

이 연구에서는 얇은 산화막 (<1nm)을 가지고 있는 p 형 실리콘과 그래핀의 이종접합구조로 소자를 제작하여 매우 높은 양자효율 (Quantum efficiency)을 가지고 있는 광전자소자를 제작하였다. 기존 연구에서는 그래핀과 실리콘 사이에 일함수 (Work function) 차이가 매우 크기에 상대적으로 쇼트키 장벽 (Schottky barrier)이 매우 크기에 그래핀의 페르미 준위 (Fermi level) 변화에 의한 높은 광반응도 (photo-responsivity)를 가지는 광전자소자를 제작하지 못하였다. 따라서 본 연구에서는 그래핀과 일함수차이가 거의 없는 p 형 실리콘과의 이종접합구조를 통해서 매우 높은 양자효율을 가지고 있는 Majority carrier 소자를 제작하였고, 이를 Current-Voltage (I-V), Capacitance-Voltage (C-V) 그리고 Raman spectroscopy 를 통하여 알아보았다.

계면에 존재하는 얇은 산화막으로 인하여 광원에 의하여 유도된 Minority carrier 가 역전압에 의하여 계면에 축척 되면서, 광유도역전층(Photo-induced inversion layer)이 형성되는 것을 확인하였고, 계면에 축척되는 캐리어에 의하여 산화막 전압, 실리콘에 걸리는 전압이 변화함은 물론 그래핀의 페르미 준위도 이동하게 되면서 Majority carrier 인 정공이 그래핀에서 실리콘으로 이동하면서, 가시광선 영역의 파장에 빛에서 100% 양자효율에 50 배가 넘는 광전자소자가 제작되었음을 알 수 있었다. 또한 산화막과 어두운 상태 (Dark state)에서 상대적으로 높은 쇼트키장벽에 의하여 낮은 누설전류(Leakage current)를 가지고 있기에 파워소모가 매우 작다는 것을 확인하였다.

Photonics and optoelectronics(D)/0861 D12.03

Understanding charge transfer mechanism in surface enhanced Raman scattering (SERS) observed from 4-Mpy molecules adsorbed on 1-D ZnO substrates

김자영 [1], 박준범 [2], 김혜민 [1], 김남중 [3], 이규철 [2], 윤석현 [*1]

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Abstract :

We present large enhancement of Raman scattering intensity from 4-Mpy molecular vibrations adsorbed on one-dimensional ZnO nanostructured substrates. As there were no noble metals used in substrates, we could safely exclude plasmonic resonance as an enhancement mechanism for Raman signal. Instead, we show that enhancement of Raman response is attributed to the charge transfer between ZnO semicomconductor hosts and adsorbed molecules. We further show that the charge transfer from ZnO to molecules, not from molecules to ZnO, is mainly responsible for Raman enhancement. From systematic study of the charge transfer between ZnO hosts and the adsorbed molecules, we report the effective range of the charge transfer and suggest microscopic characteristics of the charge transfer mechanism.

Photonics and optoelectronics(D)/0580 D12.04

Optoelectronic properties and electronic structure of organic-inorganic hybrid lead halide crystals

정혜리 [1,2], NGYUEN Bich Phuong[1,2], NGYUEN Trang Thi Thu[1,2], 윤석현 [1,2], 조윌렴[*1,2], 우원석 [3], 안창원 [3], 조신욱 [3], 김일원 [3]

[1] 이화여자대학교, 물리학과, [2] 이화여자대학교, Renewable Energy Research Center (NREC), [3] 울산대학교, 물리학과

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Abstract :

Organic-inorganic lead halide perovskite, $CH_3NH_3Pb(I,Br)_3$ is taking the spotlight with outstanding performance for photovoltaic, light-emitting, memristic devices and photodetectors. Most studies of all, examinations on single crystals are demanded to comprehend the intrinsic physical characteristics. We confirm structural systems and phase purity by using transmission electron microscopy and Raman scattering spectroscopy. We also investigate its photoluminescence with the band gap energy in order to estimate the electronic structure of the crystals. We evaluate the distribution of surface electric potential by Kelvin probe force microscopy. Synthetically, we obtained the electronic band structures which reveal the semiconducting nature of the materials by consolidating the result values of the band gap energy and the work function.

Photonics and optoelectronics(D)/0563 D12.05

Simultaneous measurement of magnetic field and temperature using a few-mode microfiber knot resonator

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Abstract :

The optical transmission characteristics of a few mode-microfiber knot resonator (FM-MKR) with the simultaneous measurement of temperature and magnetic field are proposed. By mitigating the group refractive index through the adjustment of the microfiber waist diameter, the sensitivities to dual parameters like magnetic field and temperature can be effectively improved. The relevant behaviors of the resonant wavelength and spatial frequency shift in the proposed FM-MKR sensing probe correspond to the slow- and fast-varying term. The proposed sensing probe has many advantages, such as low loss, low cost, and high sensitivity.

Photonics and optoelectronics(D)/0157 D12.06

단층 WS_2-ZnO 마이크로 막대 하이브리드 구조에서의 빛-물질 상호작용 연구

정진우 [1], 강장원 [1], 백재영 [1], 조창희 [*1]

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Abstract :

이차원 물질 단층 전이금속 디칼코제나이드는 양자 구속 효과로 인한 직접 천이형 밴드구조로의 전이와 함께 0.4 - 0.9 정도의 큰 엑시톤 결합에너지를 가지고 있어, 상온에서의 높은 발광 특성을 가진다. 이러한 성질 때문에, 단층 전이금속 디칼코제나이드를 기반으로한 빛-물질 상호작용에 대한 연구가 관심을 받고 있다. 빛-물질 상호작용은 광공진기가 결합된 시스템으로부터 제어될 수 있으며, Purcell 효과에서부터 강한 빛-물질 결합에 기인한 엑시톤-폴라리톤까지 흥미로운 현상들의 구현을 가능하게 한다. 본 연구에서는 단층 WS_2 와 whispering gallery 공진기가 결합된 새로운 형태의 하이브리드 구조를 구현하였고, 이를 기반으로하여 이차원 시스템에서의 빛-물질 상호작용에 대해 연구하였다. Whispering gallery 공진기로 ZnO 마이크로 막대를 사용하였고, 수열합성법을 이용하여 깨끗한 면을 갖는 ZnO 마이크로 막대를 성장하였다. 성장된 ZnO 마이크로 막대를 단순히 단층 WS_2 위로 전사함으로써, 새로운 형태의 단층 WS_2-ZnO 마이크로 막대 하이브리드 구조를 구현하였다. Photoluminescence 분광법을 이용하여 단층 WS_2 의 엑시톤 피크를 기준으로 장파장 영역으로 일정한 모드 간격을 갖고 첨예한 특성의 새로운 피크를 제작된 하이브리드 구조에서 확인하였다. 또한, 이러한 특성 피크는 ZnO 마이크로 막대 자체의 whispering gallery 공진 모드 측정과 함께 Finite-difference time-domain 방법을 이용한 계산을 통해 이차원 엑시톤과 whispering gallery 공진 모드의 빛-물질 상호작용에 기안한 효과임을 확인하였다.

Photonics and optoelectronics(D)/0119 D12.07

Photoluminescence characteristics of co-evaporated emitters for display application

최규리 [1], 최은영 [1], 이연의 [1], 이광진 [1], 김경환 [2], 이창희 [2], D'ALÉO Anthony[1], 우정원[*1]

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Abstract :

Photoluminescence characteristics of co-evaporated emitters are studied for display application. In particular, intramolecular charge transfer emitters doped into Alq3 host were adopted to relate photoluminescence characteristics on fused silica substrate.

Applied physics(E)/1040 D12.08

Polycrystalline Au Nanomembrane as a Tool for Two-Tone Micro/Nanolithography

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Abstract :

A Au nanomembrane is utilized as a hydroxyl ion channel to develop negative and positive-tone micro/nanolithography. Less than 50 nm thick Au films, that is, Au nanomembranes, have nanopores through which ions can pass. Micro- and nanostructures can be fabricated by using an Au nanomembrane-deposited Al layer with KOH solution loading on it. Hydroxyl ions diffuse over Au nanomembranes to react with an underneath Al layer. Depending on the pH of the fabrication process, which is governed by the volume of KOH solution loaded onto an Au nanomembrane-deposited Al layer, protruded aluminum hydroxide structures (positive tone lithography) or micro/nanotunnels (negative tone lithography) are able to be obtained. A flexible THz photonic structure and microfluidic channels have been demonstrated as possible applications of these structures.

Pioneer: High pressure physics and superconductivity/0211 D13.01

Probing Higgs and Leggett modes in superconductors with charge density waves

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Abstract :

Collective excitation modes are a characteristic feature of symmetry-broken phases of matter. Their properties are of fundamental interest due to the distinguishing feature of any symmetry-broken phase such as superconductors, charge density waves or antiferromagnets. An amplitude Higgs mode and a phase modes of a superconductor are the radial and angular excitations in the Mexican-hat potential of the free energy. There exist an additional Leggett phase mode for a two-band superconductor. Here a superconductor $NbSe_2$, sharing the common simplified phase diagram with cuprates, is chosen to show how we detect Higgs and Leggett modes in this two-band superconductor by using Raman scattering technique and how these modes evolve upon compression. The implications of such observations to the understanding of superconductivity in two-dimensional superconductors, cuprates, and our newly discovered molecule superconductors will be discussed.

Pioneer: High pressure physics and superconductivity/0214 D13.02

Phenomena and findings related to superconductivity in pressurized materials from simple to complex systems

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Abstract :

It has been established that the superconductivity in a material is dictated by its crystallographic structure, electronic charge, orbital and spin degrees of freedom, which can be manipulated by the controlling parameters such as pressure, magnetic field and chemical composition. Pressure is a 'clean' way to tune basic electronic and structural properties without changing the chemistry, and can help to search for new phenomena and findings. In this talk, I will present some of our results obtained recently from high-pressure studies on superconductivity in materials from simple system to complex ones. New phenomena such as electron-hole balance and the anomalous pressure-dependent superconductivity in black phosphorus, separation of the charge density wave and superconducting states by an intermediate semimetal phase in pressurized $TaTe_2$, pressure-induced superconductivity in heavy fermion compound $CeRhGe_3$ and related non-centrosymmetric compounds, observation of a bi-critical point between antiferromagnetic and superconducting phases in pressurized single crystal $Ca_{0.73}La_{0.27}FeAs_2$, and robust zero resistance in a superconducting high entropy alloy against pressure up to 190 GPa will be presented.

Pioneer: High pressure physics and superconductivity/0974 D13.03

Physical property tuning in two-dimensional transition metal dichalcogenides via high pressure

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Abstract :

The tuneable interlayer interactions in two-dimensional (2D) transition metal dichlcogenides (TMDs) offer an exciting platform for exploring new physics and applications by thickness, stacking sequence [1], electromagnetic filed, and stress/strain [2]. Compared with the four methods mentioned above, high pressure is a clean and powerful tool to induce dramatic changes in lattice parameters and physical properties for 2D TMD materials. The unique symmetry of WTe_2 endows the significant anisotropy and the corresponding unexpected properties including the giant magnetoresistance, pressure-induced superconductivity and Weyl semimetal states [3]. In our work, upon increasing pressure, the Raman peaks for WTe_2 at ~120 cm^{-1}, are gradually red shifted and totally suppressed above 10 GPa, attributed to the possible structural instability of orthorhombic T_d phase under high pressure and phase transition to a new monoclinic T' phase with inversion symmetry. Distinct electronic structures near Fermi level between the T_d and T' phases may pave a feasible way to achieve the Weyl state tuning in one material without doping. Besides, we realize effective tuning of interlayer interaction in bilayer WSe_2-$MoSe_2$ heterostructures (HSs) via pressure, where both direct and indirect band transitions in WSe_2-$MoSe_2$ HSs are sensitive to external pressure. The original PL peaks A and B experience blue and red shift separately under the pressure of 0-0.64 GPa. After a turning point (~1.0 GPa), the changeover of band transitions from A, B to C, D occur and then both C and D peaks show red shift after 1.6 GPa. This study provides a means to reversibly tune interlayer interaction and electron-phonon coupling in TMDs via high pressure and will also guide the design of their future applications in pressure sensing and actuating systems.

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Methods in biological physics(B)/0669 D14.01

20-nm resolution brain imaging via next-generation expansion microscopy

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Abstract :

The identification and localization of proteins and other biomolecules, throughout entire organs with nanoscale precision would enable many fundamental insights into the mechanisms underlying the operation of normal and pathological biological circuits. We recently discovered that we could physically magnify specimens by embedding them in a dense swellable polymer, anchoring key biomolecules to the polymer mesh, and adding water to swell the polymer, a process we call 'expansion microscopy'[1,2]. Despite the high isotropy of the expansion process, the initial polymer recipe enabled just 4-4.5x expansion, or roughly 60-70 nm spatial resolution. Ideally it would be possible to improve the expansion chemistry so as to enable, ultimately, the imaging of membrane boundaries, as well as protein complexes. Here, we report on a next-generation ExM chemistry that can achieve ~15-20x physical magnification of mouse brain tissues, or 20-nm lateral resolution on conventional optical microscopes[3]. As with the first version of ExM, next-generation ExM-processed samples are optically clear. Thus, next-generation ExM may be useful for imaging nanoscale neuronal structures such as synapses over entire neural circuits in intact mammalian tissues. Brain circuit mapping using next-generation ExM may open up a variety of insights into the underpinnings of behavior, cognition, and disease. We continue to refine the chemistry and to explore how affinity tags can be adapted to work in this new expanded environment.

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Methods in biological physics(B)/0408 D14.02

Setup for Probing Protein Ion Channel in a Free Standing Lipid Membrane with Simultaneous Electrophysiological Recording

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Abstract :

Membrane protein ion channels are pore-forming membrane proteins that control ion flows across a cell membrane. The ion channels open or close in response to specific stimulus such as a mechanical stress or ligand molecules. An Atomic Force Microscopy (AFM) can scan a lipid membrane by feedback control of an AFM tip and a membrane surface. Two chambers on a AFM sample stage were constructed to accommodate a micrometer size of free standing lipid membrane, and the free standing lipid membrane containing non-gating protein ion channel was scanned by a AFM tip while simultaneously measuring ionic current through the free standing planar lipid bilayer. This novel patch-clamped scanning AFM will be useful for both stimulating single molecule of ion channel and investigating detailed gating process of the ion channels.

Methods in biological physics(B)/0481 D14.03

광 회절 단층 촬영법을 이용한 꽃가루 관측

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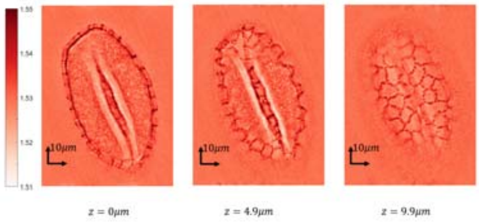
Abstract :



ODT를 통해 얻은 범부채의 3차원 굴절률 분포도 단면

광 회절 단층 촬영법 (Optical Diffraction Tomography; ODT)은 시편의 3 차원 굴절률 분포를 정량적으로 측정할 수 있는 기술이다. 시편에 여러 입사각으로 빛을 쏘아주어 얻은 홀로그래피 이미지들을 푸리에 회절 정리 (Fourier diffraction theorem)을 이용하여 3 차원 푸리에공간에 위치시켜 최종적으로 시편의 굴절률분포를 구해낸다. 광 회절 단층 촬영법은 기존의 전자현미경이나 형광 촬영법과는 달리 시편에 대한 별다른 화학처리 없이 비표지적 측정이 가능하며, 이러한 장점 덕분에 살아있는 세포 촬영에 자주 쓰이고 있다.

우리는 금계국, 범부채, 메꽃, 배롱나무, 무궁화, 니시안셔스, 원추리, 백합, 도라지, 스파트필름, 분꽃 등 다양한 꽃가루 시편들의 3 차원 영상을 염색 없이 촬영하였다. 이를 위해 Tomocube 사의 HT-1S 장비를 이용하였다. 측정한 3 차원 굴절률 분포도를 통해 꽃가루의 해부학적 구조를 관측하였으며, 특히 몇몇 샘플에서는 특징적인 식물 세포벽(Exine) 구조가 관측 가능하였다. 또한, 3 차원 굴절률 분포도 상에서 꽃가루와 매질과의 경계를 설정하여 시편들의 정량적인 부피도 측정하였다.

Methods in biological physics(B)/0504 D14.04

Investigating 3D Structure, Chemical Content, and Membrane Stiffness of Frog Erythrocytes Using Optical Diffraction Tomography

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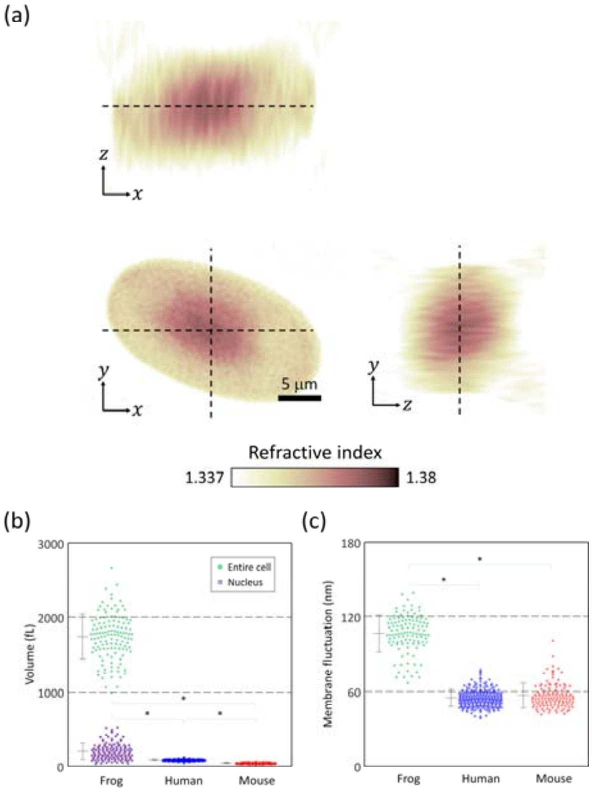
Abstract :



Although amphibian erythrocytes have been known to contain nuclei unlike human erythrocytes, the 3D structure of live amphibian erythrocytes has not been thoroughly investigated, mainly due to the limitations of imaging techniques. Here we present characterizations of live erythrocytes from frogs by measuring and analyzing their 3D refractive index (RI) tomograms. Using optical diffraction tomography, the 3D RI maps of live erythrocytes from frogs *Pelophylax nigromaculatus* was measured without using labeling agents. A nucleus of an amphibian erythrocyte was identified as a high-RI region at the center of the cell. Furthermore, morphological, biochemical, and mechanical properties of each erythrocyte were extracted from the corresponding RI map. The volume occupied by the nucleus in each erythrocyte was extracted by exploiting the aforementioned distinction of RI between a nucleus and the rest of the cell. In addition, comparisons of volume, surface area, sphericity index, hemoglobin concentration, hemoglobin content, and membrane fluctuation of erythrocytes were conducted between frogs and previously studied mammals, highlighting interspecific differences of erythrocytes.

Methods in biological physics(B)/0238 D14.05

Single-molecule Force-Fluorescence Spectroscopy in Expanded Focal Depth

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Abstract :

Single-molecule force-fluorescence spectroscopy (smFFS) is a highly powerful tool for observing spatiotemporal localization and manipulating single target molecules simultaneously. A conventional method of obtaining a fluorescence signal outside of the depth of focus is to use a piezo stage (piezo scanning) to move the sample itself in the axial direction by the intended distance. However, in smFFS, the piezoelectric scanning can not be introduced because it forces the probe coupled with the surface to move, which results in interfering with force signals. This limits the experimental design of the smFFS in the axially thin plane. Here we present a new method for increasing the focal depth of a confocal microscope by moving the focus in an axial direction using an electrically variable lens (ETL) while the position of the sample is fixed. By changing the focus in the axial direction within the exposure time (ETL scanning), we were able to trace the spread of the quantum dots labeled with the MutS protein on the DNA stretched along a axial axis by Optical Tweezers over a wide focal range of a few μm. In addition, we were able to track the movement of epidermal growth factor receptor (EGFR) in the elongated filopodium and demonstrate the relationship with a retracting force of the filopodium trapped by an optical tweezers. This simple method is expected to broaden the scope of smFFS.

Methods in biological physics(B)/0122 D14.06

3 차원 굴절률 측정을 통한, 단일 미세조류 세포에 저장된 지질성분의 정량화 방법

정재황 [1], 김한별 [2], 홍성주 [2], 김건 [1], 이무성 [1], 신승우 [1], 이상윤 [1], 김동진 [3], 이철균 [2], 박용근 [*1]

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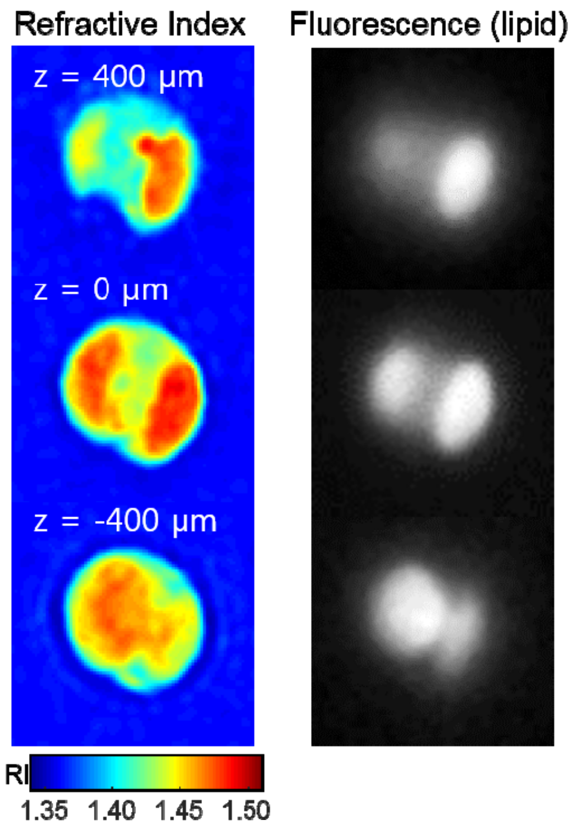
Abstract :

본 연구에서는 3 차원 굴절률 측정을 이용하여 미세조류(microalgae) 세포 내 지질 성분을 정량화 하는 연구결과를 소개한다. 비침습, 비표지방식으로 얻어진 개별 미세조류 세포의 3 차원 굴절률 이미지와 지질을 형광 염색한 결과와 비교함으로써 세포 내부에 저장된 지질성분이 굴절률 값을 통해 구분될 수 있음을 확인하였다. 또한, 3 차원 이미지상에서 구분된 지질의 부피 정보를 통해서 세포 내에 저장된 지질의 함량을 정량 할 수 있었다. 정상 환경과 질소 결핍 환경에서 성장한 조류를 시간에 따라서 측정함으로써 질소 결핍 환경이 미세조류의 지질 생성에 미치는 영향을 개별 세포 수준에서 관측하였다. 각 세포 별로 측정된 세포 크기, 건조 중량, 지질 중량 정보를 이용하여 세포의 크기와 지질 생산량 간의 상관관계를 분석하였다. 본 연구에서 제안한 방법론을 활용하면 유기용매 등을 활용하여 화학적으로 추출하여 정량하는 기존방식을 대체할 수 있는, 빠르고 비파괴적인 지질함량을 측정 분석이 가능함을 보였다.



Methods in biological physics(B)/0055 D14.07

High-speed super-resolution imaging with FRET-PAINT

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Abstract :

We report high-speed super-resolution fluorescence microscopy named FRET-PAINT. Compared to conventional DNA-PAINT, the imaging speed of the microscopy increases more than 40-fold. As demonstrations, we show that 20-50 second imaging time is long enough to provide high-quality super-resolution reconstruction of microtubules and mitochondria of COS-7 cells.

Special Sessions(A)/1218 D15.01

과학기술인력 현황과 수급전망을 통해 본 과학기술인력 발전방안

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Abstract :

파괴적 혁신에 의한 제 4 차 산업혁명, 저출산·고령화, 장기적인 경기침체로 인한 저성장·고실업 등 환경적 변화를 타개하기 위해서는 창의적 역량을 보유한 인적자본이 중요하며, 이 중심에는 과학기술인력이 존재하고 있다. 이에, 본 발표에서는 4 차 산업혁명 등 급변하는 기술변화와 사회·경제환경 하에서 가장 핵심적이고 창의적인 역할을 수행할 것으로 보이는 과학기술인력의 그간의 노동시장 변화 동향 및 특성, 수급전망 결과를 살펴보고 이를 토대로 과학기술인력 정책의 방향성을 제시해보고자 한다.

Accelerator-based particle physics experiments (C)/0235 E1.01

Study of Drell-Yan differential cross section with 2016 data

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Abstract :

Study of the differential Drell-Yan cross section in the dilepton channel is presented. The analysis is based on the full 2016 dataset, corresponding to an integrated luminosity of 36 fb -1 of proton-proton collision data collected by the CMS detector. The results are corrected for muon momentum and electron energy scale, and efficiency difference of data and simulation is taken into account, which is measured by Tag&Probe method. Background estimated using data-driven method is discussed.

Accelerator-based particle physics experiments (C)/0862 E1.02

Initial state radiation at LHC

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Abstract :

We study initial state radiation (ISR) in the LHC data. Drell-Yan event is chosen to analyze ISR effect becuase of no final state radiation (FSR). We measure the dependence of the averaged pt of dilepton on the averaged invariant mass of diletpon using the CMS data.

Accelerator-based particle physics experiments (C)/1118 E1.03

A study of Initial State gluon Radiation at Tevatron using CDF data

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Abstract :

We present a study of Initial State gluon Radiation(ISR) in Drell-Yan events at Tevatron. Tevatron provides proton-antiproton collisions at sqrt(s) = 1.96 TeV. Drell-Yan event is chosen to analyze ISR effect becuase of no final state radiation (FSR). We measure the dependence of the averaged pt of dilepton on the averaged invariant mass of diletpon using the CDF data.

Accelerator-based particle physics experiments (C)/0607 E1.04

Differential cross section measurement of ttbb in the lepton + jets decay mode

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Abstract :

In 2016, Large Hadron Collider (LHC) has accumulated proton-proton collision data corresponding to an integrated luminosity of 35.9 fb^{-1} at a center-of-mass energy of 13 TeV with the CMS detector. Several million top quark candidates are produced in this data set. This large date set allows us to measure the differential cross section of two additional b jets in association with the top quark pair production. We present the differential cross section result using the events of one lepton, 4 jets and two b jets final state.

Accelerator-based particle physics experiments (C)/0246 E1.05

Higgs to WW measurements with 15.2/fb of 13 TeV proton-proton collisions

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Abstract :

Results on the measurements of the standard model Higgs boson decaying to a W-boson pair at sqrt(s)=13 TeV at the LHC with 2015 and early 2016 data are reported. The event sample corresponds to integrated luminosities of 2.3/fb and 12.9/fb, collected by the CMS detector in 2015 and up to August 2016 respectively. The W+W- candidates are selected in events with an oppositely charged electron-muon pair and large missing transverse momentum, and with different number of jets.

Accelerator-based particle physics experiments (C)/0812 E1.06

Quark Gluon Classification with Deep Learning

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Abstract :

In many searches for new physics signals at the LHC, jets are initiated by light-flavour quarks, while the jets in Standard Model background processes are initiated by gluons. An effective quark/gluon jet discrimination algorithm would, therefore, be an important tool for beyond the Standard Model searches. Current methods for quark/gluon jet discrimination based on traditional machine learning techniques, however, have only marginal discrimination ability. Recent breakthroughs in image classification, in particular a class of techniques training deep neural networks, have revolutionized machine learning in recent years. These techniques can be applied to quark/gluon discrimination by transforming jets into images based on energy deposition. In this study, we train deep learning models on jet images and evaluate their performance for quark/gluon discrimination using simulated data of the CMS detector at the LHC.

Accelerator-based particle physics experiments (C)/0859 E1.07

Update on a Level-1 pixel based trigger feasibility study for HL-LHC

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Abstract :

In Phase II upgrade, LHC plans to increase peak luminosities to 5x10^34 /cm^2/s or 7.5x10^34 /cm^2/s to increase the capability for new physics and precision physics.The CMS experiment will replace the entire tracker system(inner pixel and outer strip tracker) to allow for efficient data taking at such high collision rates.This brings an opportunity to deploy the tracker into the trigger system and the new outer strip tracker will be used at Level 1(L1) for the first time at CMS. On top of that we perform feasibility studies on a L1 pixel based trigger exploiting the new inner pixel tracker to see how the pixel detector can further improve the trigger performances at the first stage of trigger process on electrons, jet vertexing and b-tagging.

Accelerator-based particle physics experiments (C)/0712 E1.08

Muon ID for CMS Phase II Upgrade

PARK Inkyu[*1], LEE Jason Sang Hun[1], JEON Dajeong[1]

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Abstract :

The Large Hadron Collider (LHC) has planned upgrades during the second and the third Long Shutdown (LS), which will increase the LHC luminosity to $5\times10^{34}cm^{-2}s^{-1}$. Together with ageing and the expected high pile-up conditions, the performance of the CMS muon system is expected to significantly degrade. The muon system will be upgraded to improve the trigger and reconstruction performance and we present the expected muon identification performance.

Improving Muon Isolation for CMS Phase II Upgrade

KO Byeonghak[1], PARK Inkyu[*1], LEE Jason Sang Hun[1]

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Abstract :

In particle physics, it is important to extract rare signals which may come from new physics under the enormous QCD background, and muon isolation is crucial in reducing this background. In the Phase II run of the Large Hadron Collider, at sqrt{s} = 14 TeV, the luminosity will be increased to 5x10^34 cm^-2 s^-1 and we expect that Compact Muon Solenoid detector will see ~200 pile up events per bunch crossing. In this situation the existing methods for muon isolation, track isolation and particle flow isolation must be upgraded. We are investigating ways to improve these isolation methods for the high-pileup environment.

Granular systems & soft matters(E)/0910 E2.01

Algebraic Test of Material Conservation in Mean Field Theory of Polymers and the Use of Finite Volume Method

KIM Jaeup*[1], Yong Daeseong[1]

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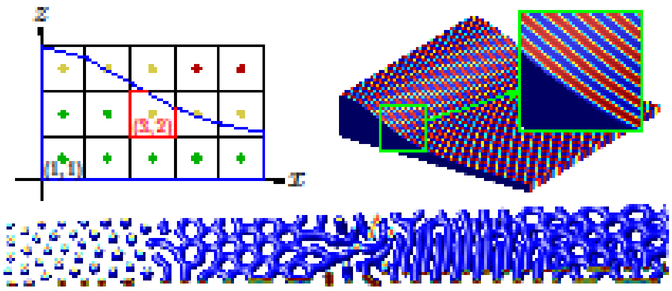
Abstract :



The self-consistent field theory (SCFT) is one of the most successful theories explaining statistical behavior of polymers, and it has been especially powerful in predicting the nanostructures created by heterogeneous polymers. For the purpose of checking material conservation of various numerical methods used in SCFT, we develop an algebraic test using matrix and bra-ket notation, which traces the Hermiticity of the product of the volume and evolution operators. The algebraic test reveals that the popular pseudo-spectral method in the Cartesian grid conserves material perfectly. The story is more complicated for the real space SCFT methods but the use of finite volume method (FVM) is recommended in general. With the combination of FVM and alternating direction implicit method, accurate SCFT tools are developed and using them, calculations are performed for systems with irregular geometries.

Biophysics(F)/0926 E2.02

Stretching elasticity of a hinged wormlike chain

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Abstract :

It is known that local defects in the bending rigidity of double-stranded DNA, such as denaturation bubbles and singe-stranded nicks, significantly affect its configurational properties and elastic response. In this talk, we present an analytic calculation of the force-extension relation of a wormlike chain with a fixed hinge defect. We show that the gain in configurational entropy allowed by the defect has a significant effect on the stretching compliance of the polymer.

Biophysics(F)/0749 E2.03

Modeling on target search problem in chromosomes

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Abstract :

We study on target search problem in chromosomes. Transcriptional factors (TFs) which is binding to DNA have to find their motifs to bind. It is known as intermittent search that TFs (searchers) are doing 1 dimensional local search and 3 dimensional relocation without search. Since newly translated
TFs come into nucleus through nuclear pore, we model searchers reset to the resetting position with a rate s. We propose an intermittent search process with resetting. By simulation, we investigate phase space of resetting rate s and relocation rate r. We found optimal set (s*,r*) having shortest searching time for various initial conditions.

Biophysics(F)/0538 E2.04

Probing live cell mechanics and dynamics with multimodal optical force microscopy

LEE Ga-Young[1], JANG You-Na[2], LEE Kea Joo[2], KIM Kipom[*1]

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Abstract :

Living cells are composed of active, delicate, and elastic materials with different mechanical properties. Many recent studies have shown how a mechanical stress is integrated into a coherent biological response of molecules inside living cells. To study the diverse mechanical properties of living cells, we have been developing an optical microscopy combined with optical manipulation tools for delivering piconewton-scale force to the local surface sites of cells through micron-sized particles attached to the cell surface. Basically, the optical microscopy is used to observe the living cells and visualize biological processes inside living cells in real time. Simultaneously, manipulating focused infrared laser beams enable us to characterize rheological properties and stochastic mechanical properties of microcompartments in individual cells. Here we present the operating principles of the optical force microscopy, experimental results, and future applications of this fascinating microscopy. We expect that this microscopy would contribute to a better understanding of biological responses of living cells under diverse changes in mechanical environments.

Biophysics(F)/0198 E2.05

How to build an optimal nose: Toward the statistical design principles of the olfactory receptor system

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Abstract :

Olfaction, or the sense of smell, is the oldest and most primitive mode of biological sensing. In humans, olfactory sensing begins when odorants (the smell particles in the air) bind the olfactory receptors (ORs), which in turn activate the olfactory sensory neurons to transmit the information to the brain. Interestingly, this odorant-OR map (or the "odor code") poses a very particular statistical problem, with sparse input states and combinatorial output states. Here we formulate the olfactory sensing map as an information channel mediated by the ORs, and discuss its optimization under environmental constraints and goals specific to olfaction. To describe the interaction space, we model the pairwise odorant-OR binding affinity as a random variable that follows some fixed distribution, which can be inferred from the experimental data.

Biophysics(F)/0057 E2.06

Stochastic Burst Synchronization in A Scale-Free Neural Network with Spike-Timing-Dependent Plasticity

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Abstract :

We consider an excitatory population of subthreshold Izhikevich neurons which cannot fire spontaneously without noise. As the coupling strength passes a threshold, individual neurons exhibit noise-induced burstings. This neuronal population has adaptive dynamic synaptic strengths governed by the spike-timing-dependent plasticity (STDP). In the absence of STDP, stochastic burst synchronization (SBS) between noise-induced burstings of subthreshold neurons was previously found to occur over a large range of intermediate noise intensities through competition between the constructive and the destructive roles of noise. Here, we study the effect of additive STDP on the SBS by varying the noise intensity *D* in the Barabasi-Albert scale-free network (SFN) with symmetric preferential attachment with the same in- and out-degrees. This type of SFN exhibits a power-law degree distribution (i.e., scale-free property), and hence it becomes inhomogeneous one with a few “hubs” (i.e., super-connected nodes). Occurrence of a “Matthew effect” in synaptic plasticity is found to occur due to a positive feedback process. Good burst synchronization gets better via long-term potentiation (LTP) of synaptic weights, while bad burst synchronization gets worse via long-term depression (LTD). Consequently, a step-like rapid transition to SBS occurs by changing *D*, in contrast to the relatively smooth transition in the absence of STDP. Emergence of LTP and LTD of synaptic weights are investigated in details via microscopic studies based on both the distributions of time delays between the nearest burst onset times of the pre- and the post-synaptic neurons and the pair-correlations between the pre- and the post-synaptic IIBRs (instantaneous individual burst rates). We also investigate the effect of network architecture on SBS for a fixed *D* in the following two cases: (1) variation in the symmetric attachment degree and (2) asymmetric preferential attachment of new nodes with different in- and out-degrees. Finally, a multiplicative STDP case depending on the states is also investigated in comparison with the above additive STDP case (independent of the states).

Astrophysics theories (A)/0029 E3.01

Stability of Horizon in Kerr-Sen Black Hole

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Abstract :

The validity of the cosmic censorship conjecture for the Kerr-Sen black hole, which is a solution to the low-energy effective field theory for four-dimensional heterotic string theory, is investigated using charged particle absorption. When the black hole absorbs the particle, the charge on it changes owing to the conserved quantities of the particle. Changes in the black hole are constrained to the equation for the motion of the particle and are consistent with the laws of thermodynamics. Particle absorption increases the mass of the Kerr-Sen black hole to more than that of the absorbed charges such as angular momentum and electric charge; hence, the black hole cannot be overcharged. In the near-extremal black hole, we observe a violation of the cosmic censorship conjecture for the angular momentum in the first order of expansion and the electric charge in the second order. However, considering an adiabatic process carrying the conserved quantities as those of the black hole, we prove the stability of the black hole horizon. Thus, we resolve the violation. This is consistent with the third law of thermodynamics.

Astrophysics theories (A)/0888 E3.02

Exact Solution of Wormhole Embedded in Expanding Universe

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Abstract :

We found the exact solution of a wormhole in Friedmann-Lemaitre-Robertson-Walker universe. The solution satisfies the Einstein's field equation. The apparent horizons of the spacetime were found and the Hawking temperature was also derived near a cosmological horizon. The causal structure and dynamics of the spacetime were discussed.

Astrophysics theories (A)/1104 E3.03

Revisiting the Blandford-Payne Process

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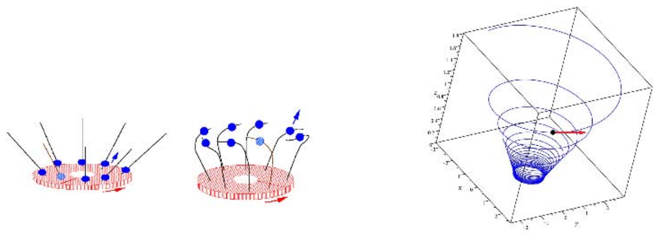
Abstract :

We build a simplified model of astrophysical system to investigate the mechanism of jet production by the Blandford-Payne process. For our model, first, the poloidal magnetic field is constructed by solving Maxwell's equations in the background of a Kerr black hole with the accretion charge forming a disc around the black hole. Then, the toroidal magnetic field is generated as the magneto-centrifugal force drives the charged gas particles from the disc to move along the poloidal magnetic field lines and to twist them around at the same time. By means of the magnetohydrodynamic (MHD) analysis, the equation of motion for the charged gas is obtained, and the trajectory of the gas is determined by integrating the equation, which shows the basic mechanism of powering the MHD jets.



[L] Generation of the toroidal magnetic field due to the magneto-centrifugal acceleration on the charged gas particles moving along the poloidal magnetic field lines.

[R] The trajectory of a charged gas particle moving along a magnetic field line (poloidal field + toroidal field).

Astrophysics theories (A)/0143 E3.04

Cosmic observables as building blocks of Modified gravities

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Abstract :

The current accelerated expansion of the Universe can be explained either by dark energy or modified gravity theories. Compared to dark energy models, modified gravity theories can explain the phenomena without introducing the exotic energy density the so-called dark energy. However, one needs to introduce unknown model functions in order to match with observations. We introduce reconstruction method of these model functions from observations

Astrophysics theories (A)/0028 E3.05

Heat capacity of a self-gravitating spherical shell of radiations

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Abstract :

We study the heat capacity of a static system of self-gravitating radiations analytically in the context of general relativity. To avoid the complexity due to the conical singularity at the center, we excise the central part and replace it with a regular spherically symmetric distribution of matters of which specifications we are not interested in. We assume that the mass inside the inner boundary and the locations of the inner and the outer boundaries are given. Then, we derive a formula relating the variations of physical parameters at the outer boundary with those at the inner boundary. Because there is only one free variation at the inner boundary, the variations at the outer boundary are related, which determines the heat capacity. To get an analytic form for the heat capacity, we use the thermodynamic identity $\delta S_{rad} = \beta \delta M_{rad}$ additionally, which is derived from the variational relation of the entropy formula with the restriction that the mass inside the inner boundary does not change. Even if the radius of the inner boundary of the shell goes to zero, in the presence of a central conical singularity, the heat capacity does not go to the form of the regular sphere. An interesting discovery is that another legitimate temperature can be defined at the inner boundary which is different from the asymptotic one β^{-1}.

Astrophysics theories (A)/0780 E3.06

Cosmological Constraint on Anisotropic Conformal Gravity in Five Dimensions

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Abstract :

We introduced a five dimensional conformal gravity theory with anisotropic extra dimension which is implemented by a parameter z. Reducing the theory to four dimension yields Brans-Dicke theory with a potential, and the anisotropy of extra dimension might be thought as being responsible for the extreme smallness of dark enrgy density.

Astrophysics theories (A)/0031 E3.07

General Relativity and Closed String Field Theory

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Abstract :

I will discuss the relation between the general relativity and the closed srting field theory by comparing the scattering amplitudes of multi-gravitons of the closed string field theory with those of the Einstein gravity. Some details of the explicit calculations will be given. I will also attempt to describe the black hole as a classical solution of the closed string field theory.

Other astrophysics (C)/0030 E3.08

Entropy evolution of moving mirrors and the information loss problem

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Abstract :

We investigate the entanglement entropy and the information flow of two-dimensional moving mirrors. Here we point out that various mirror trajectories can help to mimic different candidate resolutions to the information loss paradox following the semi-classical quantum field theory: (i) a suddenly stopping mirror corresponds to the assertion that all information is attached to the last burst, (ii) a slowly stopping mirror corresponds to the assertion that thermal Hawking radiation carries information, and (iii) a long propagating mirror corresponds to the remnant scenario. Based on such analogy, we find that the last burst of a black hole cannot contain enough information, while slowly emitting radiation can restore unitarity. For all cases, there is an apparent inconsistency between the picture based on quantum entanglements and that based on the semi-classical quantum field theory. Based on the quantum entanglement theory, a stopping mirror will generate a firewall-like violent emission which is in conflict with notions based on the semi-classical quantum field theory.

Pioneer: Structure of nuclei and hadrons, invited only/0981 E4.01

Direct measurement of the ^{7}Be(n,α)^{4}He reaction cross sections for the cosmological Li problem

KAWABATA Takahiro[*1], FURUNO T.[1], HASHIMOTO T.[1], ICHIKAWA M.[1], ITOH M.[2], IWASA N.[3], KANADA-EN'YO Y.[1], KOSHIKAWA A.[1], KUBONO S.[4], MIYAWAKI E.[1], MIZUTANI K.[1], MORIMOTO T.[1], MURATA M.[1], NANAMURA T.[1], NISHIMURA S.[4], SAWADA R.[5], TAKEDA T.[1], TSUMURA M.[1], WATANABE K.[1], YOSHIDA S.[6]
[1]Kyoto University, Department of Physics, [2]Kyoto University, Research Reactor Institute, Nuclear Engineering Science Division, [3]Tohoku University, Department of Physics, [4]RIKEN, Japan, [5]Kyoto University, Department of Astronomy, [6]The University of Tokyo, Department of Physics

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Abstract :
The primordial abundances of the light elements produced in the Big Bang nucleosynthesis (BBN) provide important insights into the early universe. Accurate estimation of the primordial abundances is crucial to test the cosmological theories by comparing the predicted values with the observations.

A comparison between the theoretical predictions of the primordial abundances and the observations is in good agreement with those for the helium and deuterium. However, there remains a serious problem: The ^{7}Li abundance does not agree with any theoretical BBN calculations. This discrepancy is known as the cosmological lithium problem, and has been of great interest in recent years.

Several ideas have been proposed to solve this problem. One idea is to improve the current understanding of the stellar processes that exhaust lithium in metal-poor stars. Other ideas are to find new physics beyond the standard BBN model, *e.g.*, cosmological variation of fundamental constants, decay of supersymmetric particles, and so on. However, there is no experimental evidence to confirm these models.

From a view of nuclear physics, nuclear-reaction rates involved in the BBN theory should be examined. The main process of the ^{7}Li production in the BBN is the electron-capture decay of ^{7}Be, which is synthesized in the ^{3}He(^{4}He, γ)^{7}Be reaction. Direct measurements of the cross section for the ^{3}He(^{4}He, γ)^{7}Be reaction were extensively carried out in the past by several groups, and uncertainties in this thermonuclear reaction rate are now very small. There is no room to modify the ^{7}Be production rate to solve the lithium problem.

It was pointed out that the ^{7}Li abundance will be greatly reduced in the BBN calculation if the destruction rate of ^{7}Be is enhanced. One of the candidate channels to destruct ^{7}Be is the ^{7}Be(n, α)^{4}He reaction. Unfortunately, the cross section for the ^{7}Be(n,α)^{4}He reaction at the cosmological energy has been scarcely measured.

Recently, we have measured the cross section for the ^{4}He(α, n)^{7}Be reaction, which is the time reverse reaction of the ^{7}Be(n, α)^{4}He reaction, and determined the cross section for the ^{7}Be(n, α)^{4}He reaction at low energies down to $E_{c.m.}$ = 0:20 MeV for the first time. The obtained cross sections are significantly smaller

than the theoretical estimation widely used in the BBN calculations. The preset results suggest the ^{7}Be(n, α)^{4}He reaction rate is not large enough to solve the cosmological lithium problem.

Pioneer: Structure of nuclei and hadrons, invited only/0056 E4.02

Big Bang Nucleosynthesis and Beyond

Myung-Ki Cheoun[*1], Motohiko Kusakabe[2], T. Kajino[3], G. Mathews[4]

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Abstract :

Nowadays, Big Bang nucleosynthesis (BBN) turns out to be a useful test bed for any new theory regarding particle physics, general relativity, neutrino physics and nuclear physics. In this talk, after a brief summary of related nuclear physcs, we discuss some of such test examples of new physics. In particluar, roles of sterile neutrino and some exotic particle beyond Standard Model in the BBN are addresed with a short summay of effects of modified general relativity in the early universe.

Pioneer: Structure of nuclei and hadrons, invited only/0758 E4.03

γ-ray spectroscopy in the closest vicinity of ^{78}Ni at RIBF

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Abstract :

In-beam and decay experiments in the closest vicinity of ^{78}Ni were performed at RIBF. The doubly magic ^{78}Ni is an unique subject to study both proton and neutron shell structures and their interplay in the exotic neutron-rich nuclei. Particularly a single particle states in odd-mass isotopic and isotonic chains along the magic numbers, Z = 28 and N = 50, shows the single-particle evolutions towards ^{78}Ni. For the proton part of shell evolution, an inversion of proton $p_{3/2}$ and $f_{5/2}$ orbits was previously pointed out by the observation of change of ground-state's spin-party from 3/2– to 5/2– at N = 46 in the Cu isotope. In addition, excitation energy of a proton one-hole state at $f_{7/2}$ provides quantitative estimation of the shell-gap size at Z = 28. In the N = 49 isotonic chain, evolution of the intruder states shows reduction of the shell-gap size between $d_{5/2}$ and $s_{1/2}$ implying new sub-shell closure at N = 58 in the neutron-rich nuclei. We investigate level structures of exotic nuclei around ^{78}Ni by means of in-beam and β-decay spectroscopy at RIBF in RIKEN Nishina Center. The neutron-rich nuclei was produced by in-flight fission of ^{238}U and identified by the BigRIPS spectrometer. The in-beam spectroscopy was conducted as a part of the SEASTAR campaign using a thick liquid hydrogen target with a recoil proton tracker, MINOS, combined with NaI(Tl) based scintillator array, DALI2. One nucleon knockout reaction induced by the proton target, namely (p,2p) and (p,pn) reactions, produces selectively hole states of produced nuclei and provide their spectroscopic strength. The β-decay spectroscopy was performed as a part of the EURICA program using Si active stopper, WAS3ABi, with 12 EuroBall cluster Ge array. Complete low-lying level structures are obtained thanks to the high resolution and efficiency of the γ-ray detector array. In this contribution, brief overview of EURICA and SEASTAR campaigns for β-γ and in-beam spectroscopy, respectively, will be given and proton- and neutron shell evolution towards doublymagic ^{78}Ni will be discussed.

Nuclear structure(A)/0711 E4.04

Nuclear structure study on iodine and tellurium isotopes using in-beam and β-delayed γ-ray spectroscopy

MOON Byul[1], MOON Chang-Bum[*2], HONG Byungsik[1]

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Abstract :

The iodine (I, $Z = 53$) and tellurium (Te, $Z = 52$) nuclides locate close to the proton magic number 50. These two nuclides with neutrons below 82 are great interest since both valence protons and neutrons move in the same intruder $h_{11/2}$ orbitals. The interplay between single particle motion of valence nucleons in the $h_{11/2}$ orbital and collective motion brings about the variety of nuclear structures; singles shell states, collective vibrational and rotational modes, distinctive isomeric states, and non-collective oblate shapes at high spins. Iodine nuclei provide excellent examples of the transitional regime between distinctly vibrational and rotational characteristics. For the odd-odd I isotopes, the band structure built on the proton $h_{11/2}$ orbital coupled to the neutron $h_{11/2}$ orbital is important for tracing such a transitional feature. In contrast, beyond the doubly magic nucleus ^{132}Sn, the coupled configuration of the proton $h_{11/2}$ orbital to the neutron $h_{9/2}$ orbital plays a dominant role in understanding the nuclear shell structure under the extreme proton and neutron imbalanced conditions. In particular, the $\pi h_{11/2} \nu h_{9/2}$ configuration is closely associated with the Gamow-Teller interactions, leading to the allowed β-decay transition which affects strongly the r-process paths.

The experimental results from two different facilities are presented. Firstly, the in-beam experiments for I isotopes near the mass number (A) 120 were performed at Heavy-Ion Accelerator Facility (HIAF) of Australian National University (ANU). The ions of interest were produced by the fusion-evaporation methods using the 14UD tandem accelerator. The pulsed beams with the period of 1.7 us bombarded on the target for both in-beam and isomeric decay spectroscopy. The emitted γ rays were detected by the CAESAR array composed of six hyper-purity germanium (HPGe) detectors and two low-energy photon spectrometer (LEPS) detectors. Secondly, the experiment for the decay spectroscopy of neutron-rich isotopes were carried out at Radioactive Isotope Beam Factory (RIBF) in RIKEN. The secondary beams were produced by the in-flight fission of the ^{238}U primary beams at the BigRIPS spectrometer. The fragmented ions were implanted on the 5 layered active Si stoppers, WAS3ABi. The γ rays from the β decay of unstable nuclei were detected by the EURICA array which was consisted of twelve 7-segmented HPGe clusters.

In this presentation, by using the in-beam γ-ray spectroscopy, the band structure and the shape coexistence for I isotopes around A ~ 120 will be discussed. Moreover, newly defined 1^{+} levels from the G-T transitions for ^{140}I and the ground-state band structure for $^{138, 140}$Te will be introduced by the mean of the β-delayed γ-ray spectroscopy.

Physics teaching(A)/0799 E5.01

중학생들의 '운동' 관련 그래프 문제 해결 과정에서의 시선이동 분석

송혜영 [1], 윤은정 [2], 박윤배 [*2]

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Abstract :

그래프를 구성하거나 해석하는 능력은 과학에서 중요하게 다루어지는 기능 가운데 하나이다(Beichner, 1994). 특히 물리에서 물체의 운동과 관련된 그래프의 해석과 이해는 중요한 내용전달의 수단이자 교수학습 도구임에도 불구하고 학생들이 그래프 이해에 상당한 어려움을 겪고 있음이 강조된 바 있다(Mun & Kim, 1999). 본 연구에서는 중학교 학생들이 운동에 관련된 그래프를 해석하는 과정을 객관적이고 정량적으로 조사하기 위하여 시선추적법을 도입하고, 시선 이동 특성과 그래프 이해 정도를 비교 분석해 보았다. 중학교 수준에서 시간, 위치, 속력의 관계를 나타내는 그래프 2 개를 선정하고, 그래프에 대한 이해도를 묻는 문항을 각 3 문항씩 총 6 문항을 개발하였다. 시선추적 장비는 SMI 사의 REDn scientific 을 사용하였고, '운동' 단원을 이미 학습한 중학교 3 학년 학생 60 명을 대상으로 검사를 진행하였다. 정량적인 결과 해석의 타당성을 확보하기 위하여 검사를 종료한 후 개별 사후 면담을 실시하여 참고하였다. 학생들에게 제시된 화면을 그래프 영역과 텍스트 영역으로 구분하고, 그래프 영역은 다시 핵심 영역과 비핵심 영역으로 구분한 뒤 시선의 고정 시간, 고정 빈도, 재응시 빈도 등을 분석하였다. 분석 결과 그래프에 대한 이해가 높은 학생들은 텍스트 보다는 그래프 영역에 시선이 오래, 그리고 자주 머물렀고 그래프 영역 가운데에서도 핵심 영역에 대한 시선 고정 횟수와 비율이 높았다. 이와는 반대로 그래프에 대한 이해가 낮은 학생들의 경우 그래프보다는 텍스트에 주로 시선이 머무르고 그래프의 핵심영역에 대한 시선 고정 회수와 비율이 그래프 이해도가 높은 학생들에 비해 유의미하게 낮은 것으로 나타났다.

Physics teaching(A)/1129 E5.02

한국물리학회 여고생 물리캠프 참여 경험에 대한 여학생의 인식 조사

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Abstract :

국내 물리분야에서 여성의 활동을 진작시키기 위한 목적으로 한국물리학회에서는 2002 년부터 매년 한국물리학회 여고생 물리캠프를 실시하고 있다. 본 연구는 그동안 실시된 여고생 물리캠프가 참가 학생에게 어떤 영향을 주었는지를 알아보고자 하였다. 2017 년 본선 진출 학생 전원 및 2011 년~2016 년까지 입상자 중 희망자를 대상으로 하여 물리정체성 및 여고생 물리캠프에 참여한 경험에 관한 설문조사를 실시하였다. 설문 문항의 내용은 물리캠프에서 실시된 R&E 활동이 얼마나 취지에 맞게 잘 운영되었으며 어떤 영역에서 도움이 되었는지를 확인하는 내용들로 구성되었다. 설문결과를 분석하여 여고생 물리캠프가 학생들에게 어떤 물리 관련 경험을 제공하였는지를 알아보았으며 앞으로 여고생 물리캠프의 지속적 운영을 위한 개선, 발전 방안을 제시하였다.

Physics teaching(A)/1117 E5.03

물리정체성 검사도구 개발 및 우리나라 여학생 물리정체성의 특성 연구

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Abstract :

2015 년 OECD 에서 발표한 국제학업성취도평가(PISA) 결과에 따르면 우리나라는 수학, 과학 영역에서 여학생이 남학생보다 높은 성취도를 보였다. 2016 년 4 년제 대학 계열별 재적 학생수 중 공학계열의 여학생 비율은 17.6%이며, 2014 년 과학기술연구개발인력 중 여성 비율은 18.7%로 나타나 우리나라는 수학, 과학 과목의 높은 성취도에 비해 관련 분야로 진출하는 여성의 수가 적음을 보여주고 있다. 따라서 여학생의 이공계열 진학을 촉진하고 관련 진로로 진출하는 여학생의 비율을 높이기 위한 기초연구가 필요함을 인식하고 본 연구를 계획하였다. 과학정체성이 과학 및 과학관련 분야를 지향하는데 영향을 준다는 선행연구결과를 바탕으로 물리정체성 검사도구를 개발하였고 이를 고등학교에서 물리교과를 선택한 여학생과 물리와 관련한 학부로 진학한 여학생에게 적용하여 물리교과를 선택하거나 물리관련 진로를 희망하는 여학생의 물리정체성에 어떤 특성이 있는지 알아보고자 하였다. 물리정체성 검사도구는 Hazari(2010)가 제시한 물리정체성의 구성요인을 바탕으로 하여 문항을 개발하였으며 남녀 고등학생 200 여명에게 예비투입을 거친 후 여학생 200 여명을 대상으로 검사를 실시하였다. 통계적 분석을 통해 여학생 물리 정체성의 특성을 파악하였으며 결과를 바탕으로 추후 연구 대상 중 일부를 선정하여 면담 조사를 실시하고 물리정체성과 물리관련 진로선택 사이에는 어떤 관련이 있는지를 알아보고자 한다.

Physics teaching(A)/1113 E5.04

효과적인 교수 자료의 개발을 위한 물리 예비교사의 튜토리얼 수정 내용 분석

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Abstract :

교수 자료의 평가와 수정은 효과적인 교수-학습을 위해 중요하다. 선행연구들은 교사들이 비판적으로 교수 자료를 개선하는 것의 중요성을 지적하고 있다. 특히 초임 교사들은 기존 자료를 비판적으로 바라보고 자신의 수업에 적합하도록 적용하는 것을 어려워하는데, 이는 예비 교사 교육에서 대비할 필요가 있다. 본 연구는 Tutorials in Physics(2001)의 전자기 영역 튜토리얼을 선정하여, 물리교육 전공 학부생들이 튜토리얼을 수정한 내용과 그 이유를 분석하였다. 분석을 위해, Duncan 등(2010)의 분석틀을 학생들의 수정 내용을 통해 도출한 귀납적 범주 결과를 고려하여 수정하였다. 분석 결과, 예비교사들은 튜토리얼의 구조, 삽화, 문제, 편집, 교육적 효과 등의 개선이 필요하다고 응답했다. 튜토리얼 수정 사항은 미시적인 수준이 거시적인 수준보다 많았으며, 그 수준에 따라 예비교사들이 설명한 수정 이유도 차이가 있었다. 연구 결과를 토대로, 본 연구는 물리 교수 자료 개발과 지속가능한 활용을 위한 시사점을 제공하고자 한다.

Physics teaching(A)/0893 E5.05

‘교사를 위한 일반상대론’ 강의개발 및 적용 : 원전 논문 활용의 가능성

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Abstract :

본 연구는 사범대 일반상대론 강좌 개발의 과정과 내용, 그리고 적용결과를 소개하는 것이다. 시공간에 대한 새로운 이해방식을 제공하는 일반상대론의 주요 내용은 이미 우리나라 2009 개정 교육과정에 들어와 있다. 그러나 예비교사들을 위한 사범대 내의 체계적인 일반상대론 강좌는 찾아보기 어렵고, 현직 교사를 위한 일반상대론 연수 강의도 드물다. 이에 따라 현장에서는 일반상대론을 가르치는 현직 교사들과 학생들이 많은 어려움을 겪고 있는 실정이다. 본 연구자들은 교사 교육의 관점에서 자연대의 일반상대론 강좌와는 차별화된 사범대 고유의 ‘교사를 위한 일반상대론’ 강좌 개발이 필요하다고 인식하고 이에 대한 탐색적인 시도를 하였으며 그 과정에서 발견한 몇 가지 결과를 이번 발표에서 보고할 예정이다. 우선 아인슈타인의 1916 년 원전 논문을 주 교재로 삼아 진행된 강좌의 개발 과정을 소개한 후, 구체적인 차시별 학습 내용을 소개할 것이다. 수강생들의 설문과 면담 내용을 바탕으로 원전 논문을 직접 읽으면서 학습한 경험이 예비/현직교사들에게 어떠한 영향을 주었는지 유형별로 범주화하여 분석한 결과를 다룰 것이다. 이를 통해 교사를 위한 일반상대론 강의에 있어서 원전 논문의 활용 가능성을 점검해보고, 향후 강좌 개발에의 시사점을 논의할 것이다.

Physics teaching(A)/0493 E5.06

디즈니 문화를 기반으로 한

인공지능 시대의 한국 과학교육 콘텐츠 개발

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Abstract :

끝없이 변화하는 현대 사회에서 행복하게 살아가기 위해서는 논리적이고 창의적이며 폭넓은 사고와 함께 인간중심적 과학교육 문화의 형성이 필요하다고 할 수 있다(Lehman, 1994; Treffinger, 2004; Song, 2003). 최근 한국은 4 차 산업혁명 시대를 맞이하여 힘찬 도약과 변화를 위해 노력하고 있다(교육부, 2017). 본 연구는 학생들이 행복을 느낄 수 있는 과학학습 문화를 위하여 디즈니 문화의 특성을 살펴보고 한국의 문화를 기반으로 하는 문항을 통해 과학교육의 대중화를 이룩하는데 이바지하고자 하였다.

1) 과학교육의 독창성 : 디즈니는 독창적인 캐릭터들을 중심으로 국제적인 문화를 형성하였으며 특히, 중국 상하이 디즈니랜드는 12 지신과 같은 전통 문화를 접목하였다. 동아시아는 전통 문화가 번영한 지역이며(Hong, 2009) 과학교육도 민족 문화를 도입할 필요가 있다(Hvitfeldt, 1986; Oh et al, 1999). 우리나라의 경우 CNN 의 아름다운 한국 50 선에 선정되기도 한 아름다운 자연환경과 문화유산을 독창성으로 볼 수 있으므로 이를 과학교육과 접목할 필요가 있다고 할 수 있다.

2) 과학교육의 통합성 : 디즈니 영화 '겨울왕국(2003)'은 통합적 상황의 기반위에서 진실한 사랑을 주제로 환상적 과학 세계를 표현하였다(England et al., 2011; Kowalski & Bhalla, 2015; Lee et al., 2015). 다양한 상황의 제시는 학생들의 창의적이고 통합적 사고를 활성화할 수 있으며(Lee & Park 2015) 특히, 놀이 상황은 과학에 대한 학생들의 흥미를 일깨운다고 볼 수 있다(Jo & Kim, 2006). 우리나라의 롯데 월드 'Seoul Sky'는 한국의 아름다움과 자부심을 주제로 최첨단 엘리베이터를 설치하는 등 통합적 상황의 놀이 문화를 제시하였다고 볼 수 있으며 이 상황을 과학교육에 도입할 필요가 있다고 할 수 있다.

3) 과학교육의 시대성 : 디즈니의 여성 캐릭터는 초기의 연약하고 수동적인 이미지에서 점차 적극적인 이미지로 변화하였으며 특히, 영화 '겨울왕국'은 운명을 개척하는 강인한 여성의 이미지를 보여준다고 할 수 있다. 또한 컴퓨터 애니메이션의 도입은 상상의 세계에 대한 자유로운 표현을 가능하게 하였다. 이러한 상상은 오늘날 인공지능(AI: Artificial Intelligence) 로봇과 같은 최첨단 기술을 통해 현실화되어간다고 볼 수 있다. 그러나 AI 의 발달은 인간의 존재에 대한 의문을 불러일으킨다(Jang, 2017). 우리나라의 경우 'Pokemon Go'와 같은 모바일 게임과 'MRA(Mixed Reality Adventure) 페스티벌' 등 최첨단 놀이 문화가 형성되고 있으나 이러한 문화가 인간성의 아름다움을 추구한다고 보기는 어렵다.

따라서 본 연구는 한국의 문화를 기반으로 통합적 상황의 문항(PIK: Problems of integrated context based on Korea culture)을 제작하고 대구지역 고등학교 3 학년 학생들의 문제해결 과정에 나타난 논리적, 창의적, 통합적 사고를 살펴보았으며 이를 기반으로 학생들의 새로운 아이디어(novel idea)와 의견을 청취함으로써 첨단기술 시대와 조화를 이룰 수 있는 '인간중심적 과학교육'의 가능성을 제시하고자 한다.

Focus: Dirac/Weyl Semimetals/0128 E6.01

What Topology Gives Physics and Does Not

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Abstract :

Unlike usual focus sessions, this one is for an introduction to (rather than seminal discussions of) the Weyl semimetal, one of the topological states of matter that have recently attracted much interest. In this talk, starting from the differences of the topological states from the more conventional symmetry-broken states, I will introduce the general conditions for topologically non-trivial states. Then I will discuss a few unusual transport properties in hybrid system of Weyl semimetal and superconductors and/or magnetic systems. Most of the discussions will cover only non-interacting electron systems or equivalent models (e.g., spin models or Josephson junction arrays that can be mapped to non-interacting fermion models).

Focus: Dirac/Weyl Semimetals/0079 E6.02

Role of chiral anomaly in anomalous transport phenomena of Weyl metals

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Abstract :

Landau's Fermi-liquid theory is the standard model for metals, characterized by the existence of electron quasiparticles near a Fermi surface as long as Landau's interaction parameters lie below critical values for instabilities. Recently, this fundamental paradigm has been challenged by the physics of strong spin–orbit coupling, although the concept of electron quasiparticles remains valid near the Fermi surface, where Landau's Fermi-liquid theory fails to describe the electromagnetic properties of this novel metallic state, referred to as Weyl metal. A novel ingredient is that such a Fermi surface encloses a Weyl point with definite chirality, referred to as a chiral Fermi surface, which can arise from breaking of either time reversal or inversion symmetry in systems with strong spin–orbit coupling, responsible for both the Berry curvature and the chiral anomaly. As a result, electromagnetic properties of the Weyl metallic state are described not by conventional Maxwell equations but by axion electrodynamics, where Maxwell equations are modified with a topological-in-origin spatially modulated $\theta(r)\ E \cdot B$ term. This novel metallic state was realized firstly in $Bi_{1-x}Sb_x$ around $x \sim 3\%$ under magnetic fields, where the Dirac spectrum appears around the critical point between the normal semiconducting ($x < 3\%$) and topological semiconducting phases ($x > 3\%$) and the time reversal symmetry breaking perturbation causes the Dirac point to split into a pair of Weyl points along the direction of the applied magnetic field for a very strong spin–orbit coupled system. In this introductory talk, we discuss how the topological structure of both the Berry curvature and the chiral anomaly (axion electrodynamics) gives rise to anomalous transport phenomena in $Bi_{1-x}Sb_x$ around $x \sim 3\%$ under magnetic fields, thus modifying the Drude model of Landau's Fermi liquids.

Focus: Dirac/Weyl Semimetals/0138 E6.03

Breakdown of Ohm's law as a hallmark of the Weyl metal state

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Abstract :

Ohm's law is a fundamental paradigm in the electrical transport of metals. Any transport signatures violating Ohm's law would give an indisputable fingerprint for a novel metallic state. Here, we uncover the breakdown of Ohm's law owing to a topological structure of the chiral anomaly in the Weyl metal phase. We observe nonlinear I-V characteristics in Bi0:96Sb0:04 single crystals in the diusive limit, which occurs only for a magnetic-feld-aligned electric feld (E//B). The Boltzmann transport theory with the charge pumping effect reveals the topological-in-origin nonlinear conductivity, and it leads to a universal scaling function of the longitudinal magnetoconductivity, which completely describes our experimental results. As a hallmark of Weyl metals, the nonlinear conductivity of a Weyl metal opens the door for nonlinear optical applications and the development of a topological Fermi-liquid theory beyond the Landau Fermi-liquid theory.

Focus: Dirac/Weyl Semimetals/0370 E6.04

Exploring Dirac and Weyl Semimetals with Angle-Resolved Photoemission Spectroscopy

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Abstract :

Dirac and Weyl semimetals are interesting quantum phases of matter that can be characterized by their unusual band structures and boundary states. Angle-resolved photoemission spectroscopy (ARPES) is a powerful technique, which can not only directly measure the electronic band dispersion of solids, but also provide information on their spin structure. Indeed, ARPES has been widely employed to study various topological phases of matter, leading to the experimental discovery of topological insulators, and three-dimensional (3D) Dirac and Weyl semimetals. In this talk, I will first introduce how ARPES has been exploited to identify the Dirac and Weyl semimetals. Also, I will propose a novel way of studying a hitherto unoberved class of Dirac and Weyl semimetals by artificially creating a topologically nontrivial state at the surface of topologically trivial 2D semiconductors

Pioneer: Oxides for energy application/0073 E7.01

Flexible ferroelectric nanowires and films for mechanical and thermal energy harvesting in harsh environments

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Abstract :

The development of an effective energy harvesting system is an increasingly important issue because of the large consumption of energy in modern society. Nanogenerators (NGs), in particular, have demonstrated an effective conversion of typically wasted ambient energies in our daily life into electricity. Piezoelectric, triboelectric, and pyroelectric NGs can be used to scavenge ubiquitous mechanical vibrations and thermal fluctuations, respectively. One of the key factors to increase the energy harvesting efficiency of NGs is to choose appropriate materials and develop innovative device structures. Ferroelectric oxide materials could be a strongest candidate due to their large piezoelectric and pyroelectric coefficients.

In this talk, I will briefly introduce our group research works on the ferroelectric oxide KNbO3 nanowire and Pb(Zr,Ti)O3 film based NGs. In KNbO3 nanowire based NG, we showed their possible used in an environment-friendly pressure sensor application. In Pb(Zr,Ti)O3 film based NG, we showed their effective energy harvesting capability in harsh environments.

Pioneer: Oxides for energy application/0101 E7.02

Thermoelectric behavior in epitaxial polycrystalline thin films

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Abstract :

Transition metal oxide thin films show emergent physical properties that are relevant for many different energy functions. By introducing structural defects and strain via the macroscopic grain boundaries, the electrical, magnetic, and thermal properties of polycrystalline solids can be modified. In this talk, we report on the magnetic and thermoelectric properties of epitaxial polycrystalline $SrRuO_3$ thin films. By using epitaxial stabilization technique based on the polycrystalline substrate, the epitaxial polycrystalline thin film could be fabricated. The coalescence occuring at the grain boundaries decreases the compressive strain and eventually affects the interatomic distances. This results in an enhancement of the ferromagnetism in the itinerant ferromagnetic thin film. The structural variations associated with the coalescence at the grain boundaries further reduce the thermal conductivity via strain gradient and breaking of the long-range ordering. This leads to enhanced thermoelectric efficiency in the epitaxial polycrystalline thin films.

Pioneer: Oxides for energy application/0822 E7.03

X-ray Scattering Studies of Functional Oxides for Energy Systems

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Abstract :

Functional oxides can provide new routes to overcome the current limits of energy conversion and storage systems. Understanding electrochemical reactions at oxide surfaces and interfaces is far from complete. To elucidate the complex phenomena, it is necessary to employ *in situ* experimental tools combined with a model system, epitaxial thin films. In this talk, I will introduce recent synchrotron studies [1-4] that combine structural and spectroscopic characterization on the model systems: coherent Bragg rod analysis (COBRA) and resonant inelastic x-ray scattering (RIXS). By using COBRA and RIXS, we can monitor the modulation of lattice parameters and electronic structure of model systems, respectively. *In situ* x-ray studies can provide new insight for the hidden relation between electrochemical activity and physical properties of energy materials.

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Pioneer: Oxides for energy application/1212 E7.04

Energy related application of HfO_2-ZrO_2 solid solution thin films and their scale-up for the electrostatic supercapacitors

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Abstract :

The ferroelectricity and field-induced-ferroelectricity of doped HfO_2 based thin films, which was first reported in 2011, is now considered to result from the orthorhombic crystal structure of $Pca2_1$ [1]. Recently, the energy related characteristics of field-induced-ferroelectric $Hf_{1-x}Zr_xO_2$ (0.7<x<0.9) thin films were reported, such as pyroelectric energy harvesting, electrocaloric cooling, infrared sensing, and electrostatic energy storage [2,3]. However, to date, the high energy storage performances observed in the field-induced ferroelectric HfO_2- or ZrO_2-based films have had an obstacle to scale-up due to the involvement of low-k monoclinic phase at the large thickness (>~10nm). Considering that the monoclinic phase formation is closely related with the in-situ (partial) crystallization during the atomic layer deposition (ALD) process, in this work, the ALD temperature of $Hf_{0.5}Zr_{0.5}O_2$ thin films was lowered, and its influence on the energy storage performances was systematically examined. Carbon and nitrogen dopants incorporated at a low deposition temperature in combination with grain size decrease change the polymorphism of $Hf_{0.5}Zr_{0.5}O_2$ thin film from the genuine ferroelectric to field induced (incipient) ferroelectric crystal structure. The $Hf_{0.5}Zr_{0.5}O_2$ thin film deposited at 210°C shows improved resistance to degradation by monoclinic phase involvement up to ~ 40 nm compared to the previously-reported $Hf_{0.3}Zr_{0.7}O_2$ thin films. By investigating $Hf_{0.5}Zr_{0.5}O_2$ thin films with wide ALD temperature and thickness ranges, the maximum energy storage density of ~55 J cm^{-3} was optimized, and the notable bipolar switching (10^{10} cycle) and thermal (up to 175 ^oC) endurance were confirmed [4].

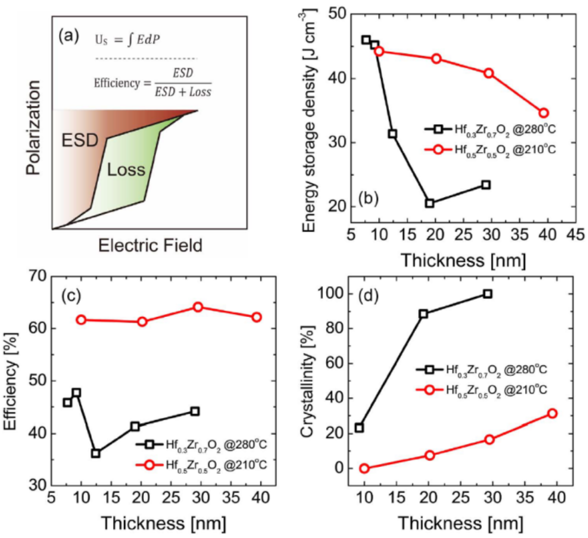

Fig 1. (a) Schematic picture illustrating the energy storage behavior in the P-E diagram. (b) Energy storage density, (c) efficiency, and (d) crystallinity as a function of the film thickness for the $Hf_{0.3}Zr_{0.7}O_2$ films deposited at 280^oC and the $Hf_{0.5}Zr_{0.5}O_2$ films deposited at 210^oC.

[1] M. H. Park et al., Adv. Mater. 27, 1811 (2015)

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[4] K. D. Kim et al., Nano Energy 39, 390-399 (2017)

Focus: Orbital polarization & Rashba spin-momentum coupling/0880 E8.01

Competing orbital angular momenta of Rashba states localized in an interface between two heavy elements

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Abstract :

In a periodic crystal with time-reversal and inversion symmetries, electronic bands have to be spin degenerate by the Kramer's theorem. When electronic bands from high-Z materials are localized at surfaces or interfaces where the inversion symmetry is broken, the spin degeneracy is lifted in the energy. This phenomenon, called Rashba effect, features a pair of spin bands with opposite chiralities at a constant energy contour. In the conventional interpretation, the Rashba splitting is caused by the magnetic dipole interaction between the relativistic magnetic field and electron spins when electrons move in an electric field. However, this mechanism fails to predict experimentally observed splitting energies and its relation with atomic spin orbit coupling (SOC).

In 2011, we suggested a new Rashba mechanism based on orbital angular momentum (OAM). The local OAM induces an electric dipole, and the interaction between the electric dipole and the surface electric field results in the energy splitting of spin-polarized bands. The chiral spin structure of the Rashba effect, therefore, can be understood through the spin-orbit interaction because the direction of the local OAM has chirality in the momentum space. Indeed, OAM-based interpretation fully describes the Shockley surface state on Au(111), a prototypical Rashba system. Recently, we also found that, the giant Rashba spin splitting in 2D surface alloy systems such as Bi/Ag(111) is closely related with hybridization between Bi and Ag atoms. This hybridization can generate a very strong effective field by anisotropic hopping of two spin states even in the absence of the conventional electric field. Therefore, understanding OAM and hybridization of atoms will be the key to elucidating the microscopic mechanism of the Rashba effect more clearly.

In this study, we investigated Rashba states on W(110) surface covered with 1 monolayer adsorbates. Even though the surface states of clean W(110) have negligible spin splitting due to dominant in-plane orbital components, strong hybridization between topmost W and adsorbed atoms drastically enhances the splitting energy by increasing the out-of-plane orbital occupation. Contrary to expectations, Rashba states from Au/W(110) showed much reduced splitting energy than other lighter metal atoms such as Ag. Moreover, the calculated spin chirality of Au/W(110) was found to be reversed when the SOC of W is turned off. From the results we suggest that (i) local OAM components from Au and W atoms contribute to the total OAM in the opposite way, and (ii) W atoms have larger OAM magnitude than Au atoms due to the stronger d-orbital character in W. Our findings not only support our OAM-based interpretation, but provide

another factor to consider in controlling and maximizing the Rashba splitting energy.

Focus: Orbital polarization & Rashba spin-momentum coupling/0587 E8.02

Spin-momentum coupling through spin-orbit entanglement

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Abstract :

Spin-momentum coupling plays important roles in spintronics in various context including spin generation, spin transistor, and spin-orbit torque. Here we show that for the spin-momentum coupling to arise, the entanglement between spin and orbital degree of freedom is indispensible. We also discuss implications of the spin-orbit entanglement on spin split energy bands.

Focus: Orbital polarization & Rashba spin-momentum coupling/0039 E8.03

Silicon, germanium, gallium arsenide, MoS_2, WSe_2 에 숨은 궤도 분극

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Abstract :

본 발표에서는 공간 반전 대칭성과 시간 반전 대칭성을 동시에 갖고 있어서 전자 에너지 밴드 구조가 축퇴되어 있는 물질도 숨어 있는 궤도 분극을 (hidden orbital polarization) 가질 수 있음을 논의한다. 숨은 궤도 분극 현상이 매우 일반적임을 보이기 위해서 다이아몬드, Si, Ge, GaAs 등 가장 보편적인 반도체와 보편적인 3 차원 층상 구조물인 MoS_2, WSe_2 등의 전이금속 칼코젠 화합물들을 예로 들어서 현상을 설명한다. 특별히 이러한 숨은 궤도 분극이, 최근에 발견되어 스핀트로닉스의 지평을 매우 넓힌 것으로 평가받고 있는 숨은 스핀 분극을 [hidden spin polarization: Zhang et al., Nat. Phys. **10**, 387 (2014)] 생성하기 때문에 숨은 스핀 분극보다 더 근본적인 물리 현상임을 논한다. 스핀-궤도 상호작용이 작은 물질은 숨은 스핀 분극은 없지만 숨은 궤도 분극은 큰 경우가 흔하다. 반도체 물질에서는 숨은 스핀 분극이 매우 작고 (스핀-궤도 상호작용이 다이아몬드, Si, Ge 중에 가장 큰 Ge 의 경우에도 1% 미만) 층상 구조물에서는 숨은 스핀 분극이 매우 큰데 (거의 100%), 하나의 통일된 이론 체계 안에서 두 현상을 모두 설명할 수 있음을 설명한다. 더불어 압력이 가해진 층상 구조물에서 숨은 스핀 분극이 현격히 감소할 수 있음을 예측한다. 이미 출판된 광전자분광학 실험에서 스핀 측정을 통한 숨은 궤도 분극의 증거를 논하였고, 스핀-궤도 상호작용이 없는 물질에서도 circular dichroism 실험을 통한 발견 방법을 제시하고자 한다. 끝으로, 강자성을 이용한 전통적인 스핀트로닉스에서 벗어나서 최근에 연구자들이 많은 관심을 갖고 있는 반자성을 이용한 정보 처리와 저장에 숨은 궤도 분극이 숨은 스핀 분극보다 훨씬 중요한 역할을 할 수 있음을 실리콘 반도체에 대한 계산 결과를 갖고 설명한다.

참고문헌: Ji Hoon Ryoo and Cheol-Hwan Park, “Hidden orbital polarization in diamond, Si, Ge, GaAs and layered materials”, NPG Asia Materials **9**, e382 (2017).

Focus: Orbital polarization & Rashba spin-momentum coupling/0925 E8.04

Switchable Rashba Effect by Bi-epitaxial Strain

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Abstract :

Using the first-principle calculations, we studied the tunability of the Rashba effect on 2DEG formed on oxide thin films sandwiched by ferroelectric materials, where the ferroelectricity is induced and controlled by strain. The ferroelectric polarization as well as the orientations of each atoms were tuned by the bi-epitaxial strain: one of the out-of-plane-polarized phase (OP phase) and in-plane-polarized phase (IP phase) can be more energetically stable at a large compressive strain while a phase transition between the two phases is observed at a large tensile strain. We also observe that a large Rashba spin splitting induced by the ferroelectric polarization in the strained hetero-perovskite structure. In addition, the spin splitting in momentum space is shown to be controlled and switched by the direction of ferroelectric polarization that can be managed by the epitaxial strain. Our results highlight the importance of the strong coupling between spin-orbital interaction and ferroelectricity to realize new spintronic devices.

Focus: Orbital polarization & Rashba spin-momentum coupling/0831 E8.05

Intrinsic spin and orbital Hall effect form the atomic orbital hybridization

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Abstract :

Spin Hall effect (SHE) is of paramount importance in spin transport phenomena in that it allows for generation and detection of the spin current by electrical means [1]. In the intrinsic mechanism, the SHE is driven by the spin-dependent Berry curvature. However, except for a few theoretical models [2,3], it is not yet clear how the spin-dependent Berry curvature emerges from the electronic structure. In this talk, I will show that the atomic orbital degree of freedom and their hybridization can give rise to an orbital-dependent Berry curvature, leading to the intrinsic orbital Hall effect (OHE). The spin-orbit coupling aligns the spin and orbital moment parallel or antiparallel to each other, thus the SHE follows OHE. As a proof of principle, we performed a numerical simulation on a tight-binding model considering *s* and *p* orbital degrees of freedom. We found that OHE and SHE drive substantial amount of the orbital and spin accumulation at the boundary of the sample, which can be experimentally measured by magneto-optical Kerr effect (MOKE) or X-ray magnetic circular dichroism (XMCD) spectroscopies.

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Pioneer: Pseudo-gaps in high Tc superconductor/1198 E9.01

Nematic phase transition at the onset of pseudogap in YBCO and Hg1201

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Abstract :

A long-standing controversial issue in the quest to understand the superconductivity in cuprates is the nature of the enigmatic pseudogap region of the phase diagram. Especially important is whether the pseudogap state is a distinct thermodynamic phase characterized by broken symmetries below the onset temperature T*. Here we report torque-magnetometry measurements of anisotropic susceptibility within the 2D CuO2 planes in orthorhombic YBCO and tetragonal Hg1201 with exceptionally high precision. We find that in both compounds the in-plane anisotropy displays a significant increase with a distinct kink at T*. These results provide thermodynamic evidence that the pseudogap onset is associated with a second-order nematic phase transition. Surprisingly, unlike YBCO, the diagonal nematicity along [110] direction develops in Hg1201. Moreover, nematicity is suppressed below the onset temperature of the CDW order, implying that the nematicity is intertwined with CDW but not its precursor.

Investigation of pseudo-gap and Lifshitz transition in electron-doped cuprate high-*Tc* superconductor $Pr_{1-x}LaCe_xCuO_{4-\delta}$ by means of angle resolved photoemission spectroscopy

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Abstract :

It has been believed that pseudo-gap of electron-doped cuprate originates from the correlation between electron and antiferromagnetic (AF) order. Thus, investigation of doping dependent pseudo-gap behavior near the AF phase boundary is expected to reveal the relation between AF order and superconductivity. However, doping uncertainty due to oxygen non-stoichiometry has interrupted observation of the intrinsic doping dependence and thus it has been highly required to establish the phase diagram of electron-doped cuprate as a function of actual carrier concentration by considering both dopant Ce content and oxygen non-stoichiometry.

In this study, we performed systematic ARPES experiments on Pr1-*x*LaCe*x*CuO4- (PLCCO) single crystals (*x* = 0.10, 0.15, and 0.18) prepared under various annealing conditions. From the Fermi surface volume, we extracted actual electron carrier density (*n*) and successfully established the phase diagram of PLCCO as a function of *n*. In the phase diagram, we found that pseudo-gap feature weakens as superconductivity develops, indicating that long-range AF phase boundary might not overlap with superconducting dome. Besides, we observed small gap opening at nodal region in the under-doped superconducting samples, which results in Lifshitz transition inside superconducting dome. In this presentation, I will show *n* and temperature dependent electronic structure of PLCCO and discuss evolution of the pseudo-gap and nodal region gap.

Pioneer: Pseudo-gaps in high Tc superconductor/0152 E9.03

Infrared Pseudogap in $(Sr_{1-x}La_x)_2IrO_4$

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Abstract :

Charge-carrier-doped Sr_2IrO_4 is predicted to be an unconventional superconductor due to its close similarities with the high-T_c cuprates. A number of spectroscopic studies of doped Sr_2IrO_4 uncovered parallel phenomenology to the cuprates including the pseudogap, *d*-wave gap, and a broken-symmetry phase. In this presentation, I will present the *ab*-plane infrared conductivity data of $(Sr_{1-x}La_x)_2IrO_4$ revealing the formation of the pseudogap. The conductivity is barely frequency dependent at high temperatures. Upon lowering the temperature below 100 K, the conductivity below about 17 meV is gradually suppressed to show a threshold structure. I will discuss roles of the electronic correlations and the antiferromagnetism for the pseudogap in $(Sr_{1-x}La_x)_2IrO_4$.

Pioneer: Pseudo-gaps in high Tc superconductor/1195 E9.04

The three superconducting phases in iron-chalcogenides

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Abstract :

Three superconducting phases have been observed in bulk iron-chalcogenide superconductors. We present a model to discuss the nature of the three distinguished superconducting phases and suggest the possible coexisting hidden intertwine orders behind them

Focus: 2D Material photonics/0559 E10.01

High optical gain in MoS_2 using a wafer-scale plasmonic substrate

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Abstract :

Transition metal dichalcogenides (TMDs) are layered materials that can be exfoliated or grown down to monolayer. MoS_2, in particular, present a direct bandgap of ~1.8 eV, a strong spin-orbit coupling leading to a valley dependent optical selection rules, and a relatively stable structure, which are promising for various opto-electronic and valleytronic applications. Conventional monolayer MoS_2, however, suffers from a low quantum yield (ranging from 0.01 to 6%) and a low light absorption (~3% at 532 nm), regardless of the relatively high absorption coefficient (~10^6 cm^{-1} at 532 nm). Over the past few years, various efforts have been made in order to increase the photoluminescence (PL) intensity of the 2D TMDs.

In this presentation, I will show our recent data on a high optical gain in MoS_2 using a wafer-scale plasmonic substrate. To this purpose, Si substrates were nanostructured into arrays of tip-like structures using a fast, wafer-scale nanosphere lithography where Au could be deposited with a thickness of ~100 nm. The Au tip-like structures are 500 nm high with a curvature of ~84 nm and a period of ~267 nm. Compared to the PL of MoS_2 on SiO_2, we observed a peak-to-peak increase up to a 30-fold in the PL of MoS_2 transferred onto the tip-like Au nanostructures. These results demonstrate an ideal platform of substrate engineering towards a wafer-scale optical gain with 2D materials, combining free standing configuration, charge transfer or doping, and plasmonic excitations of promising 2D materials.

Focus: 2D Material photonics/0472 E10.02

Optoelectronic manipulation of valley-locked spin-polarized photocurrent in WSe_2-graphene-topological insulator heterostructures

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Abstract :

We report an optoelectrically-controlled electronic transport of valley-coupled spin photocurrent in a lateral heterostructure consisted of WSe_2-graphene-topological insulators (TIs). Using a circular photogalvanic effect, we generate the valley-coupled, in-plane spin-polarized electrons in WSe_2 TMDs. The spin-polarized electrons are subsequently diffused across single-layer graphene, and the spin-polarized currents are electrically and non-locally detected in the Bi_2Se_3 topological insulator, whose detection principle is based on the spin-momentum-locking. All measurements were performed at room temperature in a vacuum cryostat, demonstrating great feasibility of merging the valleytronics and spintronics in this novel heterostructure device.

Focus: 2D Material photonics/0089 E10.03

Layer-by-layer Assembly of Atomically Thin Films for Designing 2D Metamaterials

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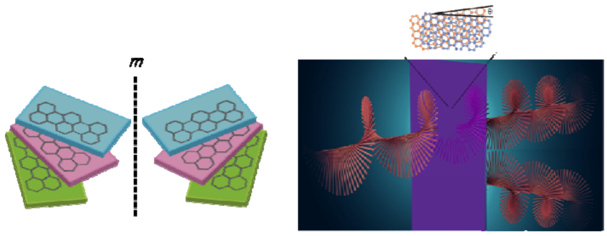
Abstract :



Thin film technology including material growth and device fabrication has been the cornerstone of modern solid-state physics. The development of related technologies have led to scientific discoveries and new applications, from quantum Hall effects to quantum cascade lasers. The main approach here was to sequentially grow various materials with atomic precision, in order to program the intrinsic electronic structure of the final composite. However, this approach of layer-by-layer growth limits arbitrary tailoring of the interfacial structures due to lattice mismatch between the different layers. Here, we present a different approach, namely layer-by-layer assembly, where atomically thin crystalline films are stacked one-by-one with precise control of the interlayer rotation (θ) and polarity. Based on the approach, we produced chiral bilayer graphene film for the first time, which has left- and right-handed counter parts, connected by mirror symmetry. The film displays one of the highest intrinsic ellipticity values (6.5 deg μm^{-1}) ever reported, and a remarkably strong circular dichroism (CD) with the peak energy and sign tuned by θ and polarity. We show that these chiral properties originate from the large in-plane magnetic moment associated with the interlayer optical transition. Furthermore, we show that we can program the chiral properties of atomically thin films layer-by-layer by producing three-layer graphene films with structurally controlled CD spectra.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/1202 E11.01

The current status of superconducting cavities development for RAON

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Abstract :

TEM-like mode superconducting cavities of three different types are adopted for RAON. For low energy linear accelerators, quarter wave resonators(QWRs) and half wave resonators(HWRs) are developed and tested in cryomodules in this year. For a high energy linear accelerator, modified half wave resonators(single spoke resonators, SSRs) are fabricated and tested in a test stat.

*This work was supported by the Rare Isotope Science Project of Institute for Basic Science funded by Ministry of Science and ICT and National Research Foundation of Korea.(2013M7A1A1075764)

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/1201

E11.02

KOMAC 초전도 가속기 개발 현황

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Abstract :

양성자가속기연구센터에서는 상전도 기반의 RFQ 와 DTL 로 구성된 100 MeV 선형 양성자가속기를 구축하여 이용자들에게 빔을 공급하고 있으며, 양성자 빔의 에너지를 100 MeV 이상으로 높이기 위하여 초전도 가속기에 대한 기초 연구가 진행 중이다. 100 MeV 에서 160 MeV 영역에서 사용될 초전도 가속공동으로 Half wave resonator (HWR)를 선정하여 설계 연구를 진행 중에 있다. 설계된 HWR 의 공진주파수는 350 MHz 이고 형상 beta 는 0.58 로서, 양성자를 100 MeV 에서 160 MeV 까지 가속시키는데 총 28 개의 가속공동이 소요되며, 이는 현재 100 MeV 가속기가 설치된 가속기 터널 내의 여유 공간에 수용이 가능하다. 본 발표에서는 현재까지 양성자가속기연구센터에서 수행된 초전도 가속공동의 개발 현황에 대해 발표한다.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/0650

E11.03

Operation experience of PLS-II Superconducting RF System

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Abstract :

포항가속기의 초전도고주파 시스템은 3 기의 CESR-B type 초전도 공동기 (제작사 : RI-전 Accel) 와 700 W 급 헬륨 냉동기 (제작사 : AL), 그리고 300 kW 급 klystron (제작사 : Thales) 및 Klystron supply unit (제작사 : Ampegon-전 Thomson) 각 3 기, 그리고 LLRF system 으로 구성된다. 현재 400 mA 상용운전이 가능한 상황으로 360 mA ~ 400 mA 범위에서 Topup mode 로 운전 중이다. 이 발표에서는 PLS-II 초전도고주파 시스템 운영 중 발생한 RF pickup probe 에서 읽히는 field signal 이 이상현상을 보이는 현상 (RF cavity field pickup probe signal blip)과 Cold turbine 손상에 의한 헬륨 냉동기의 운전 정지와 복구 사항에 대해서 발표한다.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/1203

E11.04

The current status of superconducting magnet for IF(In-flight Fragment) separator of RISP

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Abstract :

The RAON of Rare Isotope Science Project (RISP) in Korea will provide not only rare isotope (RI) beams, but also stable heavy ions, ranging from protons to Uranium. Both of the In-flight Fragment(IF) separation and the isotope separation on-line(ISOL) will be used in RAON. The IF separator is divided into the pre-separator and main-separator. The magnet in the hot cell region of pre-separator is composed of one dipole magnet, 7 quadrupole magnets and one sextupole magnet. The magnet of main-separator is composed of 7 dipole magnets, 13 quadrupole triplet magnets and one sextupole magnet. The high-tc superconductor(HTS) is used in the hot cell region because of high radiation, and the low-tc superconductor(LTS) is used in the main-separator magnets.

In this paper, the current status of RAON is presented. The HTS prototype quadrupole magnet was fabricated and tested. The test results show that the prototype magnet was fabricated successfully in terms of cooling, quench protection and etc. The LTS prototype quadrupole triplet was also fabricated and tested. The required magnetic field was achieved after a few quench. The reliability was verified based on the test results.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/0451

E11.05

Processing of Superconducting Cavities

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Abstract :

Superconducting cavities with high quality factor, made of niobium, accelerate ion beams in a linear accelerator. Unlike a normal conducting cavity, usually made of copper, superconducting cavity requires relatively complex and delicate process. For example, highly delicate e-beam welding for guaranteeing residual resistance, high pressure rinsing, and high temperature heat treatment must be optimized to produce decent superconducting cavities. In this talk, several necessary important processing for superconducting cavities are introduced.

Advanced materials syntheses and charcterizations(B)/0851 E12.01

Preferential growth of In_2S_3 films in [103] direction and their unusual photoluminescence property

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Abstract :

The tetragonal β-In2S3 films were synthesized by using simple chemical vapor deposition in a hot wall tube furnace. X-ray diffraction and energy dispersive X-ray spectroscopy data showed the synthesized In2S3 films were extremely high quality tetragonal β-In2S3 with preferred growth direction of (1 0 3). The unusual preferential growth direction was confirmed by TEM and XRD data. The bandgap of the synthesized films, measured by absorption, was approximately 2.6 eV. They showed remarkable photoluminescence (PL) efficiency at room temperature which is almost comparable to that of GaAs quantum wells. Excitation power dependence of the strong PL intensity indicated that the strong PL signal is due to excitons related to some defects.

Advanced materials syntheses and charcterizations(B)/0720 E12.02

Solvent Dynamics of Several Deep-Eutectic Solvents Measured by Time-Correlated Single Photon Counting

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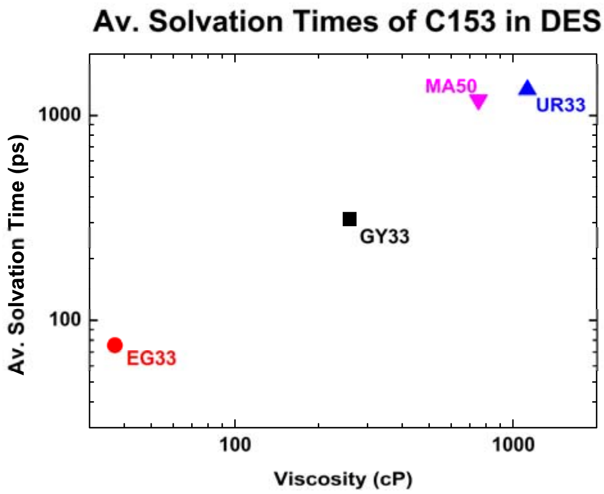
Abstract :



Deep-eutectic solvents (DES) are class of materials in liquid state formed by mixing two or more components resulting in a suppressed melting point. The melting point is suppressed through intermolecular hydrogen bonding and gain of entropy on mixing [1]. DES materials have gained popularity for their ease of synthesis, biodegradability, lower toxicity, and cost effectiveness, and received significant recent interest as environmentally friendly solvent systems for large-scale industrial applications [2].

Fluorescence decays have been used to investigate the solvation dynamics of the coumarin-153 dye (C153) in 4 DESs, 1:2 mixtures of choline chloride with glycerol (GY33), urea (UR33) or ethylene glycol (EG33), and a 1:1 mixture with malonic acid (MA50) at room temperature. The correlation function of the dynamic Stokes shift resulted in a multicomponent decay in contrast to the single component decay of the molecular solvent [3]. Average solvation times (τ_{av}) of the DES (Figure 1) were found to increase with viscosity. Average rotation times (τ_{rot}) of C153 in the DES deduced from rotational anisotropy decay also showed an increase with viscosity. Differences in τ_{av} and τ_{rot} between DES of similar viscosity are likely due to differences in the nature of the hydrogen bonds within those DESs.

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Advanced materials syntheses and charcterizations(B)/0589 E12.03

화학용액성장법에 의한 Cu_2ZnSnS_4/CdS 광기전력 태양전지 제조 및 특성

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Abstract :

Cu_2ZnSnS_4 (CZTS)는 $CuIn_xGa_{1-x}Se$ (CIGS) 및 CdTe 대비 원재료가 친환경적이고 매우 저렴하기에 차세대 p-type 화합물 반도체 태양전지 재료로 주목 받고 있다. 특히 CZTS 는 태양전지에 이상적인 밴드갭 (1.3-1.5 eV)을 가질 뿐만 아니라 우수한 광흡수 특성을 보이면서 비교적 최근 연구가 시작되었지만 10% 이상의 높은 전기변환 효율을 보이고 있어 CIGS 나 CdTe 를 대신할 유망한 차세대 태양전지 재료로서 부각되고 있다. 박막 CZTS 는 스퍼터링, e-beam 진공증착이나 화학용액합성법 등의 다양한 방법으로 제조되고 있으나 스퍼터링법이 대량생산의 가장 유력한 방법으로 연구되고 있다. 그러나 치열해지는 태양전지 시장에서 절대적 효율뿐만 아니라 생산단가가 큰 요인으로 고려되고 있어 시설비용이 큰 진공증착법보다는 화학용액성장법이 최근 주목받고 있다. 특히 chemical bath deposition (CBD)법은 간단한 설비에서 대면적의 기판에 빠른 직접 성장이 기능하기에 저비용 대량생산에 유리할 것으로 기대된다. 그러나 CZTS 다원계 화합물재료 합성의 복잡성으로 CBD 직접성장에 의한 우수한 품질의 CZTS 결과가 발표되지 않고 있다. 본 연구에서는 다양한 complex agents 와 각 원소의 precursors 의 적절한 조합으로 유리/Mo 기판 위에 균일한 고품질 CZTS 박막을 성장시킬 수 있었다. CBD 법에 의해 성장된 CZTS 박막 특성과 더불어 precursors 의 조합과 complex agents 가 CZTS 직접성장에 미치는 영향에 대해 논의하고자 한다.

Low-frequency Raman Spectroscopy of Few-layer 2H-SnS_2

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Abstract :

SnS_2 is among the most important sulfide compounds of tin [1], which has the structure of PbI_2 with the band gap of 2.18 eV for the bulk and 2.41 eV for few-layer and monolayer materials [2]. The band gap remains indirect as the thickness decreases from bulk to monolayer. This material has been widely known for its promising properties and applications such as earth-abundant, low-cost, low-toxicity, useful thermal and hydrolytic stability, high carrier mobility, high on-off current ratio, high optical absorption and photovoltaic activities, and flexible photodetectors from UV to IR [3-5]. Moreover, this material has fast photodetection response time [6], high charge storage capacity, and a long cycle life as anodes for Li- or Na-ion batteries [7]. However, it has not been studied thoroughly as a two-dimensional (2D) material. Specifically, Raman studies on 2H-SnS_2 remain very few in the literature. Raman spectroscopy is a major characterization technique used to reveal optical properties of 2D layered materials.

Using low-frequency Raman systems, interlayer vibrational modes below 50 cm^{-1} can be measured. Although SnS_2 has more than 70 polytypes, based on our Raman results we identified the material as 2H-SnS_2 that has the main peaks associated with out-of-plane A_{1g} and in-plane E_g modes at ~314 cm^{-1} and ~206 cm^{-1} [8], respectively. Our investigations focus on low-frequency Raman measurements on mechanically exfoliated few-layer 2H-SnS_2 samples obtained from a single crystal. We used an atomic force microscope (AFM) to determine the thickness of mechanically exfoliated samples. Raman investigation was then carried out using various excitation sources with a power of less than *100 μ*W in a backscattering geometry micro-Raman setup, in which the samples were measured in vacuum chamber to avoid photo-oxidation. The intralayer E_g and A_{1g} peaks are resolved in few-layer 2H-SnS_2. Despite the band gap of ~ 2.41 eV [2] for monolayer and few-layer SnS_2, which is close to the excitation energy of 514.4 nm laser, among excitation energies of red (632.8 nm), green (532 nm, 514.4 nm) and blue (441.6 nm) lasers that we used, the 532 nm laser provides the strongest signals of intralayer modes A_{1g} and E_g as well as the two shear modes (S1, S2) and two breathing modes (B1, B2), which are associated with in-plane and out-of-plane interlayer vibrations, respectively. These interlayer modes are observed to red-shift as the thickness increases from bilayer to higher layers. The results of interlayer modes provide the characteristics for thickness determination of few-layer 2H-SnS_2 by Raman spectroscopy.

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Advanced materials syntheses and charcterizations(B)/0087 E12.05

Na 첨가에 따른 NiO 의 결함과 비저항의 상관관계 연구

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Abstract :

NiO 는 화학적으로 안정하고 넓은 밴드갭 에너지 (3.6 ~ 4.0 eV)를 갖는 동시에 p-type 전도특성을나타내기 때문에 투명 전도성 산화물로 연구가 많이 진행되고 있다. 그러나 Ni 의 d-오비탈 전자 사이에서 발생하는 강한 전자-전자 상호작용으로 인해 비저항 ($\rho \sim 10^{13}$ Ω cm)이 매우 높아 소자의 상용화에 어려움이 있다. 이에 NiO 의 비저항을 낮추기 위한 연구들 (1 가 원소를 첨가, 결정립 크기 성장 등)이 많이 진행되고 있다 [1, 2]. 본 연구에서는 NiO 에 1 가 이온인 Na 을 첨가하여 그에 따른 전기적, 구조적, 화학적 특성 변화를 조사하였다. XRD 측정으로부터 Na 첨가량이 9% 이상 첨가될 경우 $NaNiO_2$ 의 2 차상이 형성됨을 확인할 수 있었다. Na 가 첨가된 NiO 의 비저항은 Na 의 첨가량이 증가할수록 비저항이 감소하는 것을 확인하였다 (<9%). X-선 광전자 분광 측정을 통해 Na 첨가에 따라 산소공공이 유발되어 산소공공으로부터 형성된 전도전자에 의해 비저항이 감소하였음을 확인하였다. 이 결과로부터 p-type NiO 시편을 얻기 위해서는 시료 내의 산소 공공의 양을 제어해야 하는 것이 중요한 변수임을 확인할 수 있었다 [3].

Advanced materials syntheses and charcterizations(B)/0084 E12.06

2 차원 음향 루네버그 렌즈의 구현

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Abstract :

면 중심 입방 (face-centered-orifice-cubic: FCOC) 단위 셀의 오리피스 직경을 음파의 진행 방향에 따라 다르게 줌으로써 원하는 형태의 공간적 굴절률 분포를 구현할 수 있다. 반지름 R 인 음향 루네버그 렌즈는 매질의 굴절률 값이 중심으로부터 떨어진 거리 r 에 따라 √[2-(r/R)2)]와 같이 변화하는 구형 렌즈로서 입사되는 음파를 렌즈의 대척 점 위에 집속시킬 수 있으며 수차가 없는 특징을 가지고 있다. 우리는 3 차원 구형으로 쉽게 확장시킬 수 있는 FCOC 단위 셀을 이용한 2 차원 음향 루네버그 렌즈를 구현하였다. 2 차원 구형의 근사인 팔각형(Octagon) 형태를 가지며 중심에서의 굴절률이 1.414 이며 r 에 따라 순차적으로 감소하여(stepwise decrease) 경계에서는 1 의 값에 접근하는 굴절률 분포를 갖는 2 차원 음향 루네버그 렌즈를 제작하였다. 이와 같은 음향 메타 물질에서 주파수에 따른 음파의 전파 과정을 살폈으며 이를 전산 시뮬레이션 결과와 비교하였다.

Pioneer: Non-equilibrium first-principles calculations for energy applications/0777 E13.01

Non-Equilibrium Inelastic Transport: Recast in the Scattering Theory Perspective

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Abstract :

We discuss the inelastic electron transport under the non-equilibrium condition, in which electrons can exchange their energy with bosons such as local vibrations. We first review experimental works observing the inelastic conductance jump, which is one of the main features of the inelastic transport implying the onset of opening the inelastic transport channel. Next we discuss theoretical and computational approaches to investigate features of the inelastic transport, which are mainly based on non-equilibrium Green's functions. We introduce the scattering-theory approach to better understand scattering processes accompanied by energy exchange with bosons, by clarifying the relationship between non-equilibrium Green's functions and scattering states. This scattering state description can specify the competition between elastic and inelastic scattering processes, which provides a key explanation for conductance jumps, and a condition to determine the sign of the inelastic conductance jump. Motivated by the inelastic current noise measurement, we extend the scattering-state approach to theoretically understand the inelastic current noise. We further make an argument that the competition between elastic and inelastic scattering processes can generally occur for any other properties of inelastic electronic transport.

Condensed-matter computational physics(G)/0480 E13.02

The charge density waves and the correlation effects in Na2Ti2P2O (P = Sb, As)

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Abstract :

To explore the origin of the phase transitions in Na2Ti2P2O (P = Sb, As), we have investigated their band structures and phonon dispersions based on the ab initio density functional theory. We have found the phonon softening instabilities for both compounds at qX and qM, which lead to charge density wave (CDW) instabilities through the electron-phonon coupling. When the Coulomb correlation e
ect of Ti d electrons is taken into account, the CDW transition to a 2┐1┐1 supercell driven by the normal mode at qX produces the most stable state for both compounds. In the CDW ground states, Na2Ti2Sb2O and Na2Ti2As2O have the partial and full gap openings in the band structures, respectively, which are in good agreement with the observed transport and angle-resolved photoemission spectroscopy results. Our study reveals that the Coulomb correlation e
ects of Ti d electrons are essential to describe properly the CDW transitions in Na2Ti2P2O.

Condensed-matter computational physics(G)/0164 E13.03

Magnetic Solitons in a Coupled Double Peierls Chain

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Abstract :

A soliton is a physical concept of the solo state emerging at the boundary of the two different phases in condensed matter physics. One of the example systems of the soliton is In/Si(111)-8×2 in which the solitons have chirality in the phase space due to the four different phases of the ground state. Lee *et al*. [1] elucidate the origin of the distinct solitons by mapping the system to the theoretical model for the double Peierls chain based on the non-spin polarized calculation. However, the soliton states should have magnetic properties in the ground because the soliton is a half-filled fermion state, hence the spin-involved calculation is required. In this talk, we present magnetism of the solitons in the coupled double Peierls chain. The electron-electron interaction (U/t) term is added to the previous model Hamiltonian and the mean-field approximation is used to solve it. The chiral solitons exhibit magnetism in the interaction range U/t > 0.1, but the non-chiral soliton does not. We find interesting topology of the spin state that the spin flips during the phase space evolution due to the $Z_2 \times Z_2$ topological symmetry.

[1] S. C. Cheon, T. Kim, S. Lee, and H. W. Yeom, Science **350**, 182 (2015).

Condensed-matter computational physics(G)/0349 E13.04

Continuum Model of Gas Uptake for Inhomogeneous Fluids

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Abstract :

We describe a continuum model of gas uptake for inhomogeneous fluids (CMGIF) and use it to predict fluid adsorption in porous materials directly from gas-substrate interaction energies determined by *first principles* calculations or accurate effective force fields. The method uses a perturbation approach to correct bulk fluid interactions for local inhomogeneities caused by gas-substrate interactions, and predicts local pressure and density of the adsorbed gas. The accuracy and limitations of the model are tested by comparison with the results of Grand Canonical Monte Carlo simulations of hydrogen uptake in metal-organic frameworks (MOFs). We show that the approach provides accurate predictions at room temperature and at low temperatures for less strongly interacting materials. The speed of the CMGIF method makes it a promising candidate for high-throughput materials discovery in connection with existing databases of nano-porous materials.

Condensed-matter computational physics(G)/1006 E13.05

Novel 2D Semiconductors ZrNCl and HfNCl: Stability, Transport, and Thermoelectric Properties

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Abstract :

Enormous research efforts have been focused on two-dimensional (2D) layered semiconductors due to the potential applications in nanoscale optoelectronics, photonics, valleytronics, photovoltaics, spintronic devices, and so on. For this reason, searching for novel 2D semiconducting materials is a challenging issue in the field of low-dimensional systems. Ternary transition-mental nitride halides (TMNH) are known to be changed to superconductors with moderately high transition temperatures up to 25.5 K upon electron doping by means of intercalation through the interlayer space. Indeed, during the last few decades, ternary TMNH have been intensively studied mainly for their superconductivity. Hence, not only their 2D structures but also the realization possibilities have received little attention. Nevertheless, a single-layer (1L) TMNH has been recently suggested simply from the fact that the layers of TMNH are bonded by van der Waals (vdW) interaction. However, fundamental physical properties of 1L-TMNH including its stability are absolutely lacking. In this work, performing the first-principles calculations to examine extensively the stability, electronic structure, electric transport, and thermoelectric properties, we propose and discover novel promising 2D semiconductors 1L-ZrNCl and 1L-HfNCl. As a result, both of them are shown to be easily isolated from the parent bulk materials and also thermodynamically stable based on the *ab initio* molecular dynamics and phonon dispersion calculations. In addition, strain engineering is found to be available for both 1L-ZrNCl and 1L-HfNCl, where a transition from an indirect to direct band gap is attained under a tensile strain. Detailed discussion of transport and thermoelectric properties of 1L-ZrNCl and 1L-HfNCl will be given.

Condensed-matter computational physics(G)/0377 E13.06

Doping induced phase transitions in single-layer 1T'-$MoTe_2$ and WTe_2

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Abstract :

We explore doping induced phase transitions in single-layer 1T'-TMDs, $M\mathrm{Te}_2$ (M = Mo and W), based on first-principles calculations. As increasing electron doping, we find that several new collective phases with nontrivial topological properties stabilize. At a low doping region, we obtain a dome-shaped conventional superconducting phase and the transition temperature reaches around 9 K. At an intermediate doping region, we find a 2 x 5 charge-density wave (CDW) phase with nontrivial topological properties. Such a peculiar lattice distortion retains a nonsymmorphic symmetry with/without inversion symmetry that gives rise to symmetry-protected Dirac/Weyl points. At a high doping region, we find a 2 x 2 CDW with the diamond shape chain structure with rather larger energy gap. The 2 x 2 CDW phase also supports the symmetry protected Weyl points. We anticipate that present results will pave the way for the research on the correlated phenomena and nontrivial topological aspect in TMDs by controlled manner.

Condensed-matter computational physics(G)/0840 E13.07

Origin of very fast diffusion of Na^+-solvent cointercalation species in graphite vs. slow diffusion of Li^+-solvent case

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Abstract :

Despite its high reversibility for Li^+ intercalation, graphite is known to be electrochemically inactive for Na^+ intercalation. On the contrary, recent studies have demonstrated that graphite is active and shows excellent rate and cycle performance for Na^+-solvent cointercalation but it exhibits poor performance for Li^+-solvent cointercalation. Herein, we elucidate the mechanism of Li^+- and Na^+-solvent cointercalation into graphite and the origin of the strikingly different electrochemical performance of Li^+- and Na^+-solvent cointercalation cells by using density functional theory calculations. Na^+ intercalation into graphite is thermodynamically unfavorable, but Na^+-diglyme cointercalation is very favorable. The diglyme–graphene van der Waals interaction reinforces the interlayer coupling strength and thereby improves the resistance of graphite to exfoliation. The transport of solvated Na ions is so fast that the diffusivity of Na^+-diglyme complexes is markedly faster (by five orders of magnitude) than that of Li^+-diglyme complexes. The very fast Na^+-diglyme diffusivity is attributed to facile sliding of flat diglyme molecules, which completely solvate Na ions in the interlayer space of graphite. The slow Li^+-diglyme diffusivity is ascribed to steric hindrance to codiffusion caused by bent diglyme molecules that incompletely solvate Li ions. The bent and flat diglyme molecules surrounding Li and Na ions, respectively, are highly associated with the strong Li^+–graphene and weak Na^+–graphene interactions, respectively.

Special Sessions(A)/1207 E14.01

여성물리학자? 평생물리학도!

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Abstract :

물리학도로 첫발을 내딛은 1971 년부터 정년퇴임을 앞두고 있는 오늘까지를 돌이켜보며, 남송시대의 유학자 주희의 한시 몇 구절을 재배열하니 현재의 마음이 표현되었다.

"階前梧葉已秋聲"(섬돌 앞의 오동 잎에는 벌써 가을의 소리)인 때에
"少年易老學難成"(나이를 먹기는 쉬우나 학문을 이루기는 어렵구나)임을 되새기며,

"日月逝矣歲不我延"(날과 달은 가고, 나 역시 그러하니)
"嗚呼老矣是誰之愆"(아! 늙었구나. 이 누구의 허물인고.)

그럼에도 불구하고 계속 공부하고 싶은 것들이 쌓여만 가니 정년퇴임 후에는 훨훨 자유롭게,
"여성학자"라기보다는 "평생학도"로 지내고 싶은 꿈을 간직하고 있다. 시대와 상황이 많이 달라졌고 빛나는 성취를 이룬 "여성물리학자"들이 다수 배출되고 있으나, 나름대로 한 시대를 살아가며 고군분투했던 나의 지난 날이 후학들에게 작은 참고가 될 수 있기를 바란다.

Special Sessions(A)/1213 E14.02

Developing Gender Indicators in Science and Technology from National Innovation Systems (NIS) Perspective

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Abstract :

During the last few years, gendered innovations in science and technology came into spotlight as it not only improves equality among the people in S&T, but also ensures scientific excellence. Although many studies in gendered innovations have been conducted, limited systematic policy package has been developed. In the field of innovation research, measuring innovation and development of indicators have been significant issues. In this context, we will propose a practical framework which could be used to develop indicators related to gendered innovations by using the concept of National Innovation Systems and categorizing the elements shaping gendered innovations in a system. In addition, this research derives indicators to reveal national capabilities of gendered innovations from the framework and suggests an indicator system, called Gendered Innovations Index (GII).

Special Sessions(A)/1223 E15.01

Resolving Singularities in General Relativity

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Abstract :

I will discuss the simple modification of General Relativity at high curvatures which allows us to avoid singularities in contracting Friedmann universe, in anisotropic Kasner Universe and inside black holes.

Accelerator-based particle physics experiments (C)/0874 F1.01

Search for Heavy Majorana Neutrinos in the Events with Di-lepton and Jets Using the CMS Detector in pp Collisions at sqrt(s) = 13 TeV

김재성[*1], John L. Almond[1], 전시현 [1], 이경필 [1], 이한얼 [1], 오성빈 [1], 배달민 [1], 양운기 [1]

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Abstract :

We performed analysis for heavy Majorana neutrinos in the events with di-lepton and jets, using the CMS detector in pp collisions at the center of mass energy 13 TeV. In 8 TeV analysis, we obtained the world-best limit on the mixing parameters between the standard model neutrino and the heavy Majorana neutrino, with heavy neutrino mass large than 40 GeV. The increasement of the production cross-section of heavy Majorana nuetirno and the collected data, we expect to improve the previous result.

Accelerator-based particle physics experiments (C)/0160 F1.02

Search for high mass resonances decaying into four lepton final state at 13 TeV with the CMS detector

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Abstract :

A search for heavy resonances decaying into four-lepton final states in pp collisions is presented. The search is based on the data collected in CMS detector at the LHC. The data sample corresponds to an integrated luminosity of 36 /fb at the center-of-mass energy of 13 TeV. Benchmark signal samples are generated using Monte Carlo simulation. Analysis strategies and event selection to improve the inefficiencies by the boosted signature are discussed.

Accelerator-based particle physics experiments (C)/0745 F1.03

Search for the standard model four top quark production in same-sign and multi lepton decay channel

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Abstract :

We search for the standard model four top quark production (two top anti top pairs), using the events either two leptons (e, mu) of the same charge or at least three leptons. The events are produced in proton-proton collisions with center of mass energy of 13 TeV at the CERN LHC and recoded by CMS detector. We use the full 2016 data sets, which corresponds to total luminosity of 35.9 fb^{-1}. In this analysis, we use both the multivariate and the cut and count method to maximize the sensitivity of the signal.

Accelerator-based particle physics experiments (C)/0613 F1.04

Search for the flavor-changing neutral higgs decaying to bb bar using deep learning method with 36 fb^{-1} at 13 TeV

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Abstract :

In this presentation, the results of searching for Higgs-mediated flavor-changing neutral current of top decay modes are presented. In 2016, Large Hadron Collider (LHC) has accumulated proton-proton collision data corresponding to an integrated luminosity of 35.9 fb^{-1} at a center-of-mass energy of 13 TeV with the CMS detector. Using this dataset, the search is performed with the events of the final state of one lepton, 4 jets and three b jets. Several machine learning methods are used to improve discrimination power between signal and background.

Accelerator-based particle physics experiments (C)/0752 F1.05

Search for Charged Higgs Boson Decaying to W Boson and Pseudo-scalar Higgs Boson at 13TeV using CMS Detector

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Abstract :

A search for charged higgs bosons produced from decay of top quark pairs using 35.9/fb of 13TeV pp collision data recorded by CMS detector in 2016 is presented. In the search, we search for top pair events that one of top decays to charged higgs and b-quark, and the other top decays to W boson and b-quark, and the charged higgs decays to W boson and pseudo-scalar higgs(A), and the A decays into dimuons, and at least one of W bosons decays to leptons subsequently. The search is performed using events with trileptons where at least 2 of them are muons with opposite charge.

Accelerator-based particle physics experiments (C)/0412 F1.06

Search for a light charged Higgs boson decaying to c b-bar in pp collisions at sqrt(s) = 13 TeV

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Abstract :

We present the search result of charged Higgs boson in top quark pair events using the CMS data from pp collisions at 13 TeV. In this search where charged Higgs bosons are lighter than top quark, they can appear in top quark decays as like t->H+b. In particular, the branching ratio of charged Higgs decay into c b-bar can be enhanced in type-Y two Higgs doublet model.
In the lepton+jets channel of the Standard Model top pair events, the final state has one lepton, four jets (two b-jets and two light jets), and missing transverse energy. If the charged Higgs is produced from top decay, three b-jets are expected in the final state. Thus, a search for the light charged Higgs at two & three b-jets channel is performed using 36.4/fb of the data.

Accelerator-based particle physics experiments (C)/0419 F1.07

Tests of thin double-gap RPCs at the Gamma Irradiation Facility for the CMS experiment

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Abstract :

In the future Phase-2 LHC runs, the particle rate expected in the CMS RPC detectors in the maximum eta region of 2.4 will exceed 600 Hz cm^-2 when the luminosity reaches 7 X 10^34 cm-^2 s^-1. In the past few years, we have studied high-sensitive thin phenolics double-gap RPC models to improve the rate capability. Prototype RPC modules with gap thicknesses of 1.2 and 1.4 mm with various detector sizes were constructed and tested with intensive gamma background provided by the new Gamma Irradiation Facility (GIF++) and 100-GeV H4 muon beams at CERN. In 2017, a full-size double-gap RPC constructed with 1.4-mm gaps and with a previous RE4/2-RPC geometry was tested with a maximum gamma rate of about 4 kHz cm^-2. The detector performance obtained from the tests fairly satisfies the operational condition required in the future Phase-2 LHC.

Accelerator-based particle physics experiments (C)/0133 F1.08

Upgrade of the RPC system of the CMS Muon Spectrometer

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Abstract :

In the next decades, the Large Hadron Collider (HL-LHC) will run at very high luminosity (7 x 10^{34} cm^{-2} s^{-1}). In view of the expected background conditions, the CMS muon system will be extended up to eta region of 2.4 to ensure efficient muon triggering and reconstruction in that region. In particular, the last two stations will be equipped with a new generation of improved Resistive Plate Chamber (iRPC), which must be able to sustain the background conditions. The design of the iRPC has been defined and prototypes have been tested. The performance has been studied (efficiency, cluster size, rate capability) at the Gamma-radiation Facility (GIF++) at CERN with muon beam. Moreover, a dedicated consolidation program is ongoing which must certify the present CMS RPC system for the HL-LHC running period. Few RPC detectors will be under irradiation at GIF++ for a period, equivalent to the expected integrated charge at HL-LHC. The main parameters (currents, rate, resistivity) are under monitoring as a function of the integrated charge and the performance studied with muon beam. Preliminary results will be presented.

Complex systems(D)/1199 F2.01

Enhanced storage capacity with errors in scale-free Hopfield neural networks: an analytical study

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Abstract :

The Hopfield model is a pioneering neural network model with associative memory retrieval. The analytical solution of the model in mean field limitrevealed that memories can be retrieved without any error up to a finite storage capacity of \$O(N)\$, where \$N\$ is the system size. Beyond the threshold, they are completely lost. Since the introduction of the Hopfield model, the theory of neural networks has been further developed toward realistic neural networks using analog neurons, spiking neurons, etc. Nevertheless, those advances are based on fully connected networks, which are inconsistent with recent experimental discovery that the number of connections of each neuron seems to be heterogeneous, following a heavy-tailed distribution. Motivated by this observation, we consider the Hopfield model on scale-free networks and obtain a different pattern of associative memory retrieval from that obtained on the fully connected network: the storage capacity becomes tremendously enhanced but with some error in the memory retrieval, which appears as the heterogeneity of the connections is increased. Moreover, the error rates are also obtained on several real neural networks and are indeed similar to that on scale-free model networks.

Complex systems(D)/0136 F2.02

Computational solution for the three-person public-goods game

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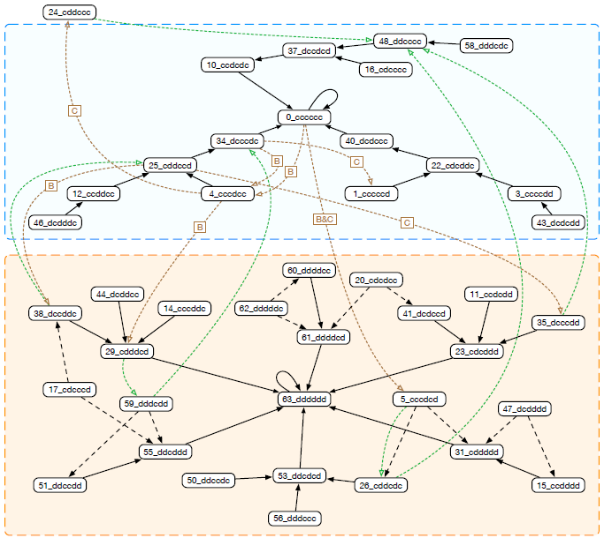
Abstract :

We study the repeated three-person public-goods game and design a strategy such that forms a cooperative Nash equilibrium in the presence of implementation error with a guaranetee that the resulting payoff will be no less than any of the co-players'. By enumerating strategic possibilities of memory length m, we prove that the desired solution requires m>=3. This observation leads to a conjecture that m must be greater than or equal to n to find such a solution for the n-person public-goods game.



Biophysics(F)/0845 F2.03

음성인식과 문자인식에서 딥러닝의 차별성

Yeol-heon Seong[1], Hyunjae Kim[1], Minseong Kim[2], Maruchan Park[1], Jaeyun Yoo[1], Wooseok Lee[1], Kang-Hun Ahn[*1]

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Abstract :

MNIST 등의 숫자 (0,1,2,..9)손글씨 데이터는 신경망을 이용하여 90 프로 정도의 정확성을 얻을수 있으며 CNN 을 사용하면 99 프로의 정확도까지 구사 할 수 있다. 본 연구에서는 이러한 정확도가 모음 음성을 나타내는 아,에,이,오,우 에도 나타낼 수 있는가 알아보았다. 75 명의 목소리를 녹음하여 그 정확도를 알아보았는데 여러가지방법을 시도 하였다. MFCC 를 사용하거나 아니면 날 데이터를 그냥 사용하는 경우, CNN 을 사용하거나 Fully connected layer 를 사용하는 경우 등을 모두 시도하였는데 결과는 60~85% 근방으로 나타났다. 즉 손글씨 만큼 그 정확도가 나타나지 않는 것이다. 그 이유에대해 생각해보고 이것을 99 프로까지 인식할 수 있는 방법은 무엇일까 논의하였다.

Phase transition & critical phenomena(A)/0784 F2.04

Finite-size scaling and dynamic fluctuation in the Kuramoto model with generalized unimodal distribution of natural frequencies

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Abstract :

We consider the Kuramoto model with generalized unimodal distribution of natural frequencies and investigate the finite-size scaling of the order parameter and dynamic fluctuation near the onset of the synchronization transition numerically and theoretically. The generalized unimodal distribution is given by $g_m(\omega) \sim (|\omega|^m + \Gamma^m)^{-1}$, where ω and Γ are the frequency and width, respectively, which shows not only the Cauchy-Lorentzian with m=2, also the uniform distribution with infinite m. Consequently this model shows both the continuous transition with finite values of m and the discontinuous transition for infinite m. Varying the exponent m we explore the dependency of critical exponents on m and find that the exponents of order parameter and finite-size scaling depend on m, but the dynamic fluctuation exponent is independent of m.

Phase transition & critical phenomena(A)/0905 F2.05

Machine Learning classification of phases in two-dimensional Ising model

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Abstract :

Machine Learning (ML) may be one of the strongest methods which can be used in many-body physics because the infomation of a many-body system can be handled in the scheme of processing a big data in the frame of artificial intelligence (AI). Insipred by recent development of AI understanding the phase transitions and recognition of a phase in classical and quantem models, we study thermal phase transitions in two-dimensional Ising model. With combined strategy of ML and Monte Carlo method, we show that the critical point can be identified with a good precision. We also discuss a possible research candidates of ML to quantum systems and preliminary results.

Phase transition & critical phenomena(A)/1124 F2.06

Solution of non-enclaves percolation on the Bethe lattice.

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Abstract :

Percolation phenomena have been the centre of much attention in the last decades, developed from mathematics and statistical physics into complex systems and network science. The subject of our study is the non-enclaves percolation (NEP) model recently proposed by Sheinman *et al.* [1], in which the originally unoccupied sites inside an enclave become occupied collectively. In 2D lattice, this so-called non-enclaves rule turned out to drive discontinuous transition to fully-percolated phase at the same critical density as the ordinary random percolation. Here we study the NEP on the Bethe lattice by deriving the self-consistency equations for the order parameter and susceptibility, as well as by performing Monte Carlo simulations. Our solution of NEP on the Bethe lattice suggests similarity and difference from the 2D case. On one hand, the NEP transition on the Bethe lattice occurs at a lower critical density than ordinary random percolation and the fully-percolated phase is attained at a different, higher density. On the other hand, at the percolation transition, the obtained critical exponents correspond to those of ordinary random percolation. Our results highlight the distinct role of non-enclaves rule in the mean-field regime.

[1] Sheinman, M., *et al.* "Anomalous discontinuity at the percolation critical point of active gels." Phys. Rev. Lett. 114, 098104 (2015)

Phase transition & critical phenomena(A)/0574 F2.07

Scaling and criticality of the Manning transition

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Abstract :

We consider a system consisting of a charged cylinder in the presence of neutralizing counterions. This system is well known to exhibit the Manning transition of counterion condensation onto the charged cylinder. We study the criticality and the scaling properties of the Manning transition, analyzing involved thermodynamic quantities such as condensed fraction, its fluctuation, and heat capacity. Through the Monte Carlo simulations and finite-size scaling analysis, we find that near the transition point the examined quantities exhibit scale-invariant behaviors with specific exponents, which provides an evidence that the Manning transition is a critical phenomenon having a scale-invariant property, analogous to bulk phase transitions. Furthermore, we numerically confirm that such scaling properties are not affected by the coupling strength.

Phase transition & critical phenomena(A)/0097 F2.08

Partition function zero calculation of q-state clock model using higher-order tensor renormalization group

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Abstract :

We investigate the partition function zeros of 2D q-state clock model on the square lattice by using higher-order tensor renormalization group (HOTRG) method. We use the higher-order singular value decomposition (HOSVD) to truncate the bond dimension of contracted tensor up to D=50. For q=5, 6, 8, and 10, we perform the finite size scaling of the leading zero up to the system size 128 x 128. We find that the scaling behavior of the leading zeros for q>=6 at the high-temperature transition region is of the BKT form including the XY-limit, while the behavior for 5-state clock model differs from the larger q's.

Pioneer: Structure of nuclei and hadrons, invited only/0639 F4.01

Progress on structure functions of hadrons

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Abstract :

I discuss recent progress and future prospects on structure functions of hadrons including exotic ones. First, I explain tensor structure functions of the spin-1 deuteron. There are new polarized structure functions for a spin-1 hadron, and they are named b_1, b_2, b_3, and b_4. Among them, the twist-2 structure functions are b_1 and b_2, which are expressed by tensor-polarized parton distribution functions. The most simple and stable spin-1 target is the deuteron in deep inelastic scattering, and the structure function b_1 was measured by the HERMES collaboration [1]. However, its errors are large, so that accurate measurements are planned at JLab from 2019 and it should be also investigated at EIC. Furthermore, the proton-deuteron Drell-Yan measurement is considered in the Fermilab E1039 experiment for measuring tensor-polarized antiquark distributions, and the tensor-polarization asymmetry is theoretically estimated for such an experimental proposal [2]. Since the standard convolution estimate for b_1 with D-state admixture is very different from the HERMES result [3], the studies of tensor-polarized structure functions could lead to a new finding in hadron physics.

Second, I explain our recent studies on hadron tomography. Three-dimensional structure functions have been investigated by generalized parton distributions (GPDs), transverse-momentum-dependent parton distribution (TMDs), and generalized distribution amplitudes (GDAs). The GPDs and GDAs are related with other by the s-t crossing of the Mandelstam variables, and they contain spacelike and timelike form factors of the energy-momentum tensor, so that they probe gravitational-interaction sizes of hadrons [4]. We determine the GDAs from cross-section measurements of the hadron-pair production process gamma^*+gamma to h+hbar [4]. The GDAs are expressed by a number of parameters and they are determined from pion-pair production data of KEKB. We discuss the dependence on parton-momentum fraction z in the GDAs and also the timelike form factor of the energy-momentum tensor [4]. Our studies should be valuable for probing three-dimensional structure of hadrons, especially for applications to exotic hadron candidates which cannot be used as fixed targets for GPD and TMD measurements [5]. Furthermore, for finding internal configurations of exotic hadrons, it is possible to use the constituent counting rule of perturbative QCD in high-energy exclusive reactions [6]. The GDA studies are also possible by the two-photon process of ultra-peripheral collisions at LHC and RHIC. In future, there is a possibility to measure the GPDs at J-PARC [7]. Therefore, much progress is expected on the hadron tomography in the near future.

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Pioneer: Structure of nuclei and hadrons, invited only/0054 F4.02

Effective Lagrangian of high-spin baryons

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Abstract :

Recent experiments of photon-nucleon scatterings have accumulated a lot of data for vaious meson production processes. One of the purposes of those experiments is to search for the missing resonances which are yet to be discovered but predicted by theories. Since many missing resonances are expected to have spin higher than 3/2, it is required to develop effective Lagrangian formalism for high-spin baryons which determines the couplings with pseudoscalar mesons or vector mesons. In the present work, we revisit the formalism of high spin resonances and construct the relation between the coupling constants of effective Lagrangian with the decay widths that can be predicted by hadron models.

Pioneer: Structure of nuclei and hadrons, invited only/0761 F4.03

Nucleon Spin Physics at RHIC and EIC

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Abstract :

Since the beginning of polarized proton collisions in 2001 at Relativistic Heavy-Ion Collider (RHIC) in Brookhaven National Laboratory (BNL), great progress has been made for understanding the nucleon spin. In 2014, global QCD analyses of experimental data including the double helicity asymmetry of neutral pions from the PHENIX experiment and that of jets from the STAR experiment revealed positive gluon polarization comparable to that of quarks in the nucleon. The parity-violating asymmetry of weak-boson production has also been measured. It will give us flavor dependence of quark and anti-quark polarizations. In addition to the one-dimensional understanding of the nucleon spin along the collision axis, there is progress in multi-dimensional understanding. In transversely polarized proton collisions at RHIC, large single-spin asymmetries of particle production in the forward direction have been found. In 2017, weak-boson production data was taken at STAR for further development of the multi-dimensional structure of the nucleon. At PHENIX, large scale detector upgrades have been ongoing using a superconducting solenoidal magnet from the Babar experiment at SLAC. High statistics asymmetry measurements of jet, photon, hadrons and heavy-quarks will start in 2022 with the upgraded detector to measure precision gluon polarization and multi-dimensional structure of the nucleon.

As a future program in USA, Electron Ion Collider (EIC) project has been developed. EIC is a collider of polarized electron beam with polarized proton and ion beam to be built in BNL or Jefferson Lab. It develops novel QCD regions and expands diversity of the nuclear and hadron physics. BNL has planned to build a new accelerator of polarized electron beam colliding with RHIC beam which is called eRHIC, and start operation in 2025.

One of the goal of EIC is to understand multi-dimensional structure of nucleon and nuclei base on QCD with Generalized Parton Distribution (GPD). EIC will give us precision measurement of orbital-angular momentum and the polarized gluon distribution in the nucleon. Another goal is a measurement of gluon density with small momentum fraction in the nuclei. It is expected to show saturation and collective behavior of the gluon.

Pioneer: Structure of nuclei and hadrons, invited only/0132 F4.04

Hadrons in nuclear medium

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Abstract :

I will discuss the origin of hadron masses in QCD. In particular, I will relate chiral symmetry breaking and confinement to the properties and masses of light and heavy quark system. I will also discuss how some of these effects could be probed at RAON.

Low dimensional nano-materials(F)/1164 F5.01

단일층 WSe_2 valley 의 선택적 여기에 따른 exciton valley dynamics

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Abstract :

WSe_2 는 transition metal dichalcogenides(TMDC) 물질중 하나로 층과 층 사이에는 반데르발스 힘으로 결합되어 있으며 graphine 과 유사하게 hexagonal lattice 구조를 가지고 있다. 또한 monolayer 에서의 band structure 는 K point 에서 conduction band 와 valence band 의 spin state 가 K_+와 K_- valley 에 따라 서로 반대가 되어 입사하는 빛의 spin 방향에 따라 exciton 이 만들어 지는 valley 가 정해져 있는 특징을 가지고 있다. 우리는 CVD 로 성장시킨 monolayer WSe_2 를 sample 로 사용하였으며 투과율 실험을 통해 100K 에서 monolayer WSe_2 의 exciton resonance 가 719.6 nm 에 해당하는 것을 확인 하였다. 그리고 exciton resonance 영역에서 dynamics 를 보기 위해 Ti:sapphire laser 를 이용하여 중심파장이 714.5 nm 이고 반치폭이 19.8 nm, 펄스 폭이 50 fs 에 해당하는 pulse 를 pump probe 실험에 사용하였다. Beam splitter 를 사용하여 pulse 를 pump beam 과 probe beam 으로 나눠 준 후 λ/4 plate 를 사용하여 pump pulse 와 probe pulse 을 원편광 시켜 pump beam 의 원편광 방향을 바꿔가면서 WSe_2 에 입사시켜 시간에 따른 투과율 변화를 측정하였다. 또한 원편광 된 pump beam 과 선편광 된 probe beam 을 WSe_2 에 입사시켜 pump beam 의 원편광 방향을 바꿔가면서 Kerr rotation experiment 라고 불리는 시간에 따른 probe beam 의 polarization angle 변화를 측정하였다. Sample 을 투과한 probe beam 은 transmittance grating 과 slit 을 통과하여 시간에 따른 투과율 변화와 probe beam 의 polarization angle 변화를 probe beam 의 파장에 따라서 보았고 시간에 따른 exciton state 의 변화를 측정하였다. Pump beam 과 probe beam 의 Time Delay 가 0.5ps 일 때 투과율 실험에서 714.8 nm 에 파장에서 투과율이 가장 크게 측정이 되었고, kerr rotation 실험에서 713.7 nm 에 파장에서 polarization angle 변화가 0 되는 것이 측정 되었으며 Time Delay 가 길어질수록 두 신호 모두 장파장으로 이동하는 것을 확인하였다.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 – 2017.10.27, 경주 화백컨벤션센터

Excitation energy dependence of coherent phonon in single-layer $MoSe_2$

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Abstract :

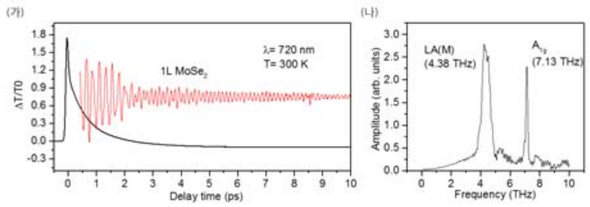

그림 1 (가) 단일층 $MoSe_2$에서의 시간에 다른 여기 탐침 실험 결과. 실험은 300 K에서 720 nm 파장을 이용 하여 측정되었다. 검은색 선은 시간에 따른 투과율의 변화를 보여준다. 빨간색 선은 느리게 변하는 투과율의 변화를 제거한 후의 빠른 투과율의 변화를 보여준다. (나) 빠르게 진동하는 투과율의 변화의 푸리에 변환 결과. 4.38 THz는 단일층 $MoSe_2$의 LA(M) 모드이며, 7.13 THz는 A_{1g}이다.

우리는 초고속 펄스 레이저를 이용하여 시간에 따른 여기-탐침 실험을 통해 단일층 $MoSe_2$ 에서의 결맞음 포논을 연구하였다. $MoSe_2$ 는 전이금속 원소 1 개와 칼코겐 원소 2 개가 합쳐져 만들어진 전이금속 칼코겐 화합물이다. 전이금속 칼코겐 화합물은 그래핀과 비슷한 층상 물질로 밴드 갭을 가지고 있는 준 2 차원 물질이다. 전이금속 칼코겐 화합물의 단일층은 직접천이 에너지 갭을 가지고 있으며 다른 층수는 간접천이 에너지 갭을 가지고 있다. 우리는 직접천이 에너지 갭을 가지고 있어 포톤의 흡수율이 큰 단 일층 $MoSe_2$ 에서 여기-탐침 실험을 수행하였다. 실험에는 715 nm 에서 845 nm 까지 파장 가변 되는 티타늄 사파이어 레이저를 사용하였다. 레이저에서 출력되는 펄스의 폭은 약 80 fs 이며, 반복률 76 MHz 를 가지고 있다. 우리는 여기 펄스에 의하여 단일층 $MoSe_2$ 에 만들어진 캐리어 밀도 변화와 결맞음 포논에 따른 탐침 펄스의 투과율의 변화를 시간에 따라 측정했다. 그림 1(가)의 검은색 선은 여기 펄스에 의하여 물질 내에 만들어진 캐리어 밀도에 따른 투과율의 변화를 보여준다. 그림 1(가)의 빨간색 선은 캐리어의 밀도에 따른 투과율의 변화를 제외한 후 나타나는 빠른 투과율의 변화 보여준다. 그림 1(나)는 빠른 투과율의 변화의 푸리에 변환 결과를 보여준다. 빠른 투과율의 변화는 4.38 THz 와 7.13 THz 의 진동수를 가지고 있다. 이 진동수는 라만 결과에서 나타나는 LA(M)모드와 A_{1g} 의 모드에 해당된다. LA(M) 신호의 세기는 A-exciton 에 캐리어 한 개가 결합된 Trion 의 에너지를 가지고 있는 805 nm 을 중심으로 양쪽 사이드로 크게 측정되었다. 그리고 B-exciton 의 Trion 의 에너지인 720 nm 를 기준으로 장파장 영역에서 크게 측정되었다. A_{1g} 모드는 A-exciton(792 nm)에너지 중심으로 크게 측정되었다. 우리는 LA(M)모드의 포논 신호가 A 와 B-exciton 의 trion 의 에너지 위치를 기준으로 양쪽 사이드에서 크게 측정되며, A_{1g} 모드의 경우 A-exction 에너지 영역에서 크게 측정됨을 확인했다. 우리는 LA(M)와 A_{1g} 가 다른 공명에너지를 가지고 있음을 확인했다.

Low dimensional nano-materials(F)/0864 F5.03

Conformal growth of atomic thick MoS_2 on rugged substrates using metal-organic chemical vapor deposition

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Abstract :

Chemical vapor deposition (CVD) has been widely used to grow monolayer MoS_2 based on solid-phase precursors such as MoO_3, $MoCl_5$, and S. The disadvantages of this method is that the growth temperature is quite high at above 800 ^oC and MoS_2 is likely impossible to conformally grow on the rugged surface. Here, we employ the metal-organic precursors including molybdenum hexacarbonyl and diethyl sulfide as the room temperature evaporation chemicals to use in metal-organic CVD. From this method, the reaction rate is controlled to be extremely slow for 11 hours at 500 ^oC. Therefore, the large scale of conformally continuous atomic thick MoS_2 is successfully grown on the rugged substrates. The as-grown MoS_2 is characterized using (1) Raman spectrometer to initially realize the monolayer behavior of samples based on the different frequency of in-plane (E_1^{2g}) and out-of-plane (A_{1g}) optical vibration of S; (2) scanning electron microscope (SEM) and (3) atomic force microscope (AFM) to clarify the large scale atomic thick morphologies of samples; and (4) high-resolution transmission microscope (HR-TEM) to perform the conformal growth of monolayer MoS_2 on rugged surface.

Low dimensional nano-materials(F)/0843 F5.04

Hydrogen interaction with sulfur vacancies on a slipped MoS_2 surface

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Abstract :

Recently, the monolayers of two-dimensional transition dichalcogenides (TMDs) with inversion symmetry breaking has attracted a great interest showing a larger direct bandgap, a valley polarization, a spin-valley coupling, and so on together with a wide range of emergent application devices as compared to their bulk counterparts. The crystal structures of bulk 2H–MX_2 (M=Mo, W; X=S, Se, Te) and monolayer 1H-MX_2 belong to D^4_{6h} and D^1_{3h} point groups, respectively. The prototypical MoS_2 is known to have two naturally occurring polytypes of hexagonal (2H) and rhombohedral (3R) symmetries. Both phases have trigonal prismatic coordination, but two and three S-Mo-S layers stack in the 2H and 3R symmetries per each unit cell, respectively. The former is more dominant in nature. Although 2H- and 3R-MoS_2 polytype crystals have similar band structure, the broken inversion symmetry in the latter due to the non-centrosymmetric structure has induced a valley-dependent spin polarization [1,2], similar to the monolayer [3,4]. However, a few studies have been paid to understanding and controlling the 3R phase. Here we report that the presence of mono-sulfur vacancies on a slipped MoS_2 surface (3R-like phase) is extremely sensitive to the enviroment and plays a significant role to the electronic strcuture by using low energy electron diffraction, angle-resolved photoemission and density functional theory calculations.

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Low dimensional nano-materials(F)/0694 F5.05

Multiple, identical solid-state quantum emitters on-a-chip

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Abstract :

Future quantum information processing relies on solid-state quantum systems that integrate multiple quantum emitters, waveguides, beamsplitters, and detectors on the same chip, and therefore all quantum operations are efficiently possible on-a-chip. Semiconductor quantum dots have attracted much attention as a bright source of quantum light with high single photon purity and indistinguishability. However, solid-state quantum emitters have many problems such as low photon collection efficiency and randomness in their frequency and position, and strong interaction with the environment which limits them to be used for practical applications. Integrating these emitters into nano-photonic structures can provide a way to solve these existing problems. Here, I present recent research on quantum dots in a photonic crystal structure for quantum photonics applications. Quantum dots, engineered electronic band structures, are able to generate quantum light, and the photonic crystal, engineered photonic band structures can enhance the brightness and spontaneous emission rate of the coupled emitters. By combining these two important electronic and photonic structures, we observe bright indistinguishable single photons at telecom wavelengths.[1] Also by controlling the spectral randomness of multiple emitters and cavities using several local engineering methods, we achieve multiple, identical quantum emitters on-a-chip and demonstrate two-photon interference between the photons from separated quantum emitters.[2] Our approaches, therefore, pave the way for the scalable, controllable quantum devices involving multiple, identical quantum emitters on a chip.

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Low dimensional nano-materials(F)/0610 F5.06

One-atom thick mask and etch stop of fluorinated graphene for van der Waals heterostructure devices

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Abstract :

Two-dimensional (2D) materials and their van der Waals (vdW) heterostructures provide a variety of platforms for observation of unprecedented physical phenomena in atomically confined 2D sheets and fabrication of multifunctional advanced electronic devices. As thickness of the vdW heterostructures decreases, however, it becomes extremely difficult to etch or pattern these ultrathin heterostructures with atomic precision. Here we report a novel technique to etch and pattern the vdW heterostructures using one-atom thick graphene as a etch mask and etch stop. By exposure to XeF_2 gas, monolayer graphene is fluorinated, leading to formation of sp^3 bonds with fluorine; meanwhile other 2D materials, such as hexagonal boron nitride (hBN), transition metal dichalcogenides (TMDs), and black phosphorus (BP), are effectively etched away. Therefore, in the heterostructures of 2D materials, embedded graphene can be used as a etch mask and etch stop. Using this graphene mask, we first fabricated hBN-encapsulated graphene devices with pinhole contacts, where metal touches fluorinated graphene region and graphene channel is perfectly protected by top and bottom hBN sheets. The pinhole contacts showed extremely low contact resistance of 200 – 400 Ω μm. Strikingly, the mobility of graphene reached 140,000 $cm^2V^{-1}s^{-1}$ at room temperature, which is compatible to the theoretically estimated value. We also fabricated various graphene devices, which have via contacts connecting doubly-stacked two graphene sheets or suspended structure applicable to a resonator. Our work shows a new way to selectively etch and pattern vdW heterostructures, leading us a step closer to realization of all-2D-material-based electronic devices.

Low dimensional nano-materials(F)/0528 F5.07

van der Waals epitaxial growth of α-MoO_3 nanosheets on various 2D substrates

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Abstract :

Since successful isolation of graphene with one-atom layer, various two-dimensional (2D) materials, such as hexagonal boron nitride (hBN) and transition metal dichalcogenides (TMDs), have attracted an increasing attention due to their unique properties and remarkable potential in electronic applications. So far, the 2D transition metal oxides (TMOs) have been less studied compared to other 2D families due to lack of their production methods. As electrical/optical properties of TMOs are broadly tunable owing to the diverse chemical compositions, crystal structures, and oxygen vacancies, it is expected that 2D TMOs are a family of the most promising 2D materials and beneficial for many applications. We fabricated highly oriented α-MoO_3 layers (ranging from bilayers to few layers) on hexagonal boron nitride (hBN), graphene, mica, and TMDs) The formed oxide layers have a textured structure with single crystallinity and well stitched grain boundaries with no misfit.

Here we report a novel van der Waals epitaxial growth method of mono/a-few-layered α-MoO_3 nanosheets on the diverse 2D substrates including graphite, hexagonal boron nitride (hBN), graphene, mica, and transition metal dichalcogenides (TMDs). Grazing incidence X-ray diffraction (GIXRD) spectrum shows that MoO_3 nanosheets has a pretty dominant peak corresponding to (020) with the narrow full width at half maximum (FWHM) of ~ 0.3^o. Also, the Raman spectra show the strong 820 cm^{-1} peak that is associated with the stretching vibration of the Mo-O_2-Mo bond along an A_g mode axis. Also, other various physical, electrical properties of MoO_3 surface/interface of MoO_3 was observed. Our results indicate that van der Waals epitaxial growth is an effective way to fabricate highly crystalline MoO_3 nanosheets. Also, various surface characterization techniques were employed to show that MoO_3 works as an effective insulator even in a few nanometer scale and electrical properties such as surface potential can be modulated by modifying the surface chemical properties. Our work shows a promising way to produce high quality 2D oxides with epitaxial relation and a possibility of MoO_3 as a dielectric and insulating material.

Low dimensional nano-materials(F)/0182 F5.08

고 품질의 단일 층 h-BN 합성 및 응용

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[1]Chonbuk National University, School of Semiconductor and Chemical Engineering, [2]Korea Institute of Science and Technology, Applied Quantum Composites Research Center

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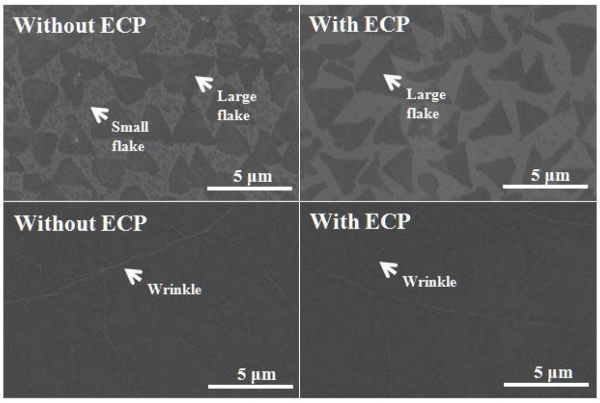
Abstract :



절연특성, 산화방지막 등의 특성을 가진 Hexagonal Boron nitride(h-BN)는 절연층, 전기적 소자의 기판, 부식 또는 산화 방지코팅, 2D 나노 물질 성장의 기판 등으로 응용되고 있다. h-BN 은 유연한 절연체로써의 역할을 하기 위하여 결정성이 좋고 균일하며 원자수준의 단일 층으로 합성 되어야 한다. 원자수준 단일 층으로 합성되는 h-BN 에서는 결함이나 도메인 사이에서 생기는 누설전류가 원인이 되어 특성이 저하되고, 이로 인하여 응용에 한계성을 가지게 된다. 그러므로 이러한 결함은 줄이고 도메인크기를 증가시켜 도메인 사이에서 생기는 누설전류를 감소시키는 것이 중요하다. 이러한 문제들을 해결하기 위하여 우리는 h-BN 합성의 촉매가 되는 구리 포일을 Electro Chemical Polishing(ECP) 처리해 주었고, 그 결과 ECP 처리를 한 구리 포일 위에서 합성된 h-BN 은 불순물과 결함들이 제거되고 도메인의 크기가 증가되어 높은 품질의 h-BN 을 합성하였다. 그리고 합성된 고품질 h-BN 을 LED 의 누설 전류를 막아주는 표면 패시베이션 박막, 가스 차단 막 그리고 내부 식 코팅 등의 다양한 분야에 적용시켰다.

Focus: Dirac/Weyl Semimetals/0856 F6.01

Scanning tunneling microscopy observation of Weyl semimetal

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Abstract :

Weyl semimetal shows a new topological phase, which is characterized by crossings (Weyl nodes) of two non-degenerate bulk bands. The surfaces of Weyl semimetals are expected to have topologically protected surface states with open Fermi surfaces (Fermi arcs). The Fermi arcs are predicted to join two surface projections of the Weyl nodes with opposite Chern numbers. In contrast to topological insulators, Weyl semimetals have a unique topological feature such as surface-bulk connectivity. Simply speaking, the electrons on the Fermi arcs can penetrate into the Fermi sea of bulk Weyl cones. In this talk, I will review recent research activities using scanning tunneling microscopy/spectroscopy to identify the surface-bulk connectivity of Weyl semimetals.

Focus: Dirac/Weyl Semimetals/0865 F6.02

Coulomb interaction effects on Dirac/Weyl semi-metals

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Abstract :

Recently discovered topological states open a new era of condensed matter physics. Topological natures intinsically provide a novel flatform for stable electronic properties protected by topology. Among them, Dirac / Weyl semi-metals is electrically not insulating, so their electrical properties could be used for "topological " electronic engineering. There have been intensive researches in non-interacting Dirac / Weyl semi-metals, but the Coulomb interaction effects in the semi-metals are relatively less understood. In this talk, we survey the reserach in the Coulomb interaction effects in the semi-metals and provide some new recent results.

Low dimensional nano-materials(F)/0179 F6.03

붕소, 탄소, 질소의 원자로 구성된 sp2 구조의 이차원 반도체 물질 성장 및 응용

Kim Hee Su[1,2], Seo Tae Hoon[2], Yeo Dong Kyu[1,2], Suh Eun-Kyung[1], Kim Myung Jong[*2]

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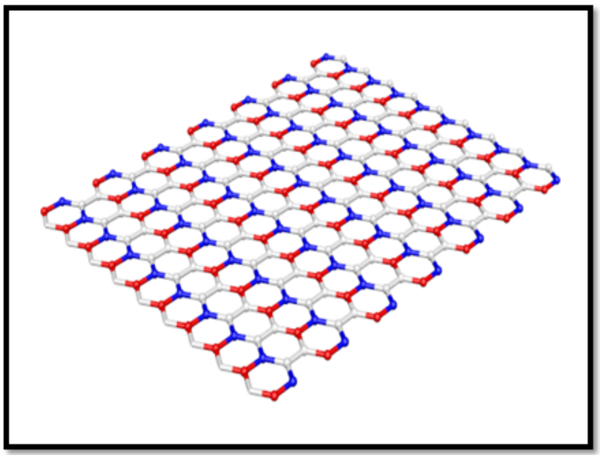
Abstract :



그래핀은 전자 이동도가 높은 장점을 가지고 있지만, Bandgap 이 존재하지 않아 응용이 제한적이라는 단점이 있다. 그래핀 나노 리본, 이중 층 그래핀, 그래핀 양자점 등을 통하여 Bandgap 을 열기 위한 시도가 있었지만 낮은 Bandgap 과 구조적 불완전성의 문제가 있다. 이러한 한계를 극복하고자 새로운 소제인 Hexagonal boron carbon nitride(h-BCN)물질을 연구하였다. h-BCN 은 탄소, 붕소 및 질소의 원자의 규칙적인 배열을 통하여 반도체 특성을 띄게된다. h-BCN 의 합성을 확인하기 위하여 Raman spectroscopy, Scanning electron microscope(SEM), X-ray Photoelectron Spectroscopy (XPS), Transmission electron microscopy(TEM), Photoluminescence(PL), UV Visible spectroscopy 등의 특성 분석을 통하여 h-BCN 이 합성되고, 특정 Bandgap 을 갖는 것을 확인 하였고, Organic light emitting diode(OLED)의 발광층으로 응용하였다.

Low dimensional nano-materials(F)/0141 F6.04

UV oxidation induced layer control of phosphorene and improvement of electrical property

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Abstract :

Black phosphorus (BP) has attracted a significant attention due to its excellent optical and electrical properties. However, the rapid degradation of BP under ambient air limits further investigation on its properties and application in various fields. This degrading behavior deteriorates the potential of BP-based electronic devices and also results in malfunction when exposed to air. The degraded surface with bubbles (phosphoric acid) was restored by rinsing with deionized water and annealing process. The degradation of BP surface was systematically investigated using optical microscopy, Raman spectroscopy, atomic force microscopy and electrical characterization of field effect transistors. Water rinsing of the degraded BP flakes also allowed us to thin BP down since phosphorus atoms are consumed while forming bubbles. Therefore, the recovery of the pristine surface not only results in a smooth and thinner morphology, but also improves the device performances. The field-effect mobility of the FETs was maintained while a significant enhancement in the current modulation was achieved in conclusion. The possibility of reversing the inevitable degradation that occurs once exposed to ambient condition can open up researchers to new opportunities for further applications of BP that was limited due to its instability.

Low dimensional nano-materials(F)/0890 F6.05

Synthesis and optical properties of Er^{3+}/Yb^{3+}-codoped sodium yttrium fluoride nanocrystals

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Abstract :

Temperature is a very basic constant in many fields, such as medical science, industry and daily life, so its accurate measurement and monitoring is very important. Currently, the optical temperature sensor based on upconversion (UC) emission of the rare-earth doped nanocrystals by the fluorescence intensity ratio technique has drawn much attention because of its advantages of real-time detection, high sensitivity and high spatial resolution. Although some impressive results have been obtained in optical temperatures, much attention still should be made to further improve their sensor sensitivities. In present work, we chose the sodium yttrium fluoride ($NaYF_4$) as the upconverting host material due to its low phonon energy and $NaYF_4$ Er^{3+}/Yb^{3+} upconverting nanoparticles were synthesized *via* a conventional hydrothermal method. With controlling the reaction condition, the synthesized compounds are found to possess different sized nanoparticles. Under 980 nm light excitation, the as-prepared nanoparticles exhibited the characteristic emissions of Er^{3+} ions. The temperature sensing behaviors based on the thermally-coupled levels of Er^{3+} ions were systematically studied by analyzing the temperature-dependent UC spectra in the range of 303-703 K. Ultimately, the effect of pump power on the sensor sensitivity of the resultant nanoparticles were also systematically studied.

Organic semiconductors(E)/1119 F6.06

Optical properties of $CH_3NH_3PbI_3$ crystal grown using inverse temperature crystallization

JO Hyunjun[1], SO Mogeun[1], PARK Daeyoung[2], JEONG Munseok[2], KIM Jongsu[*1]

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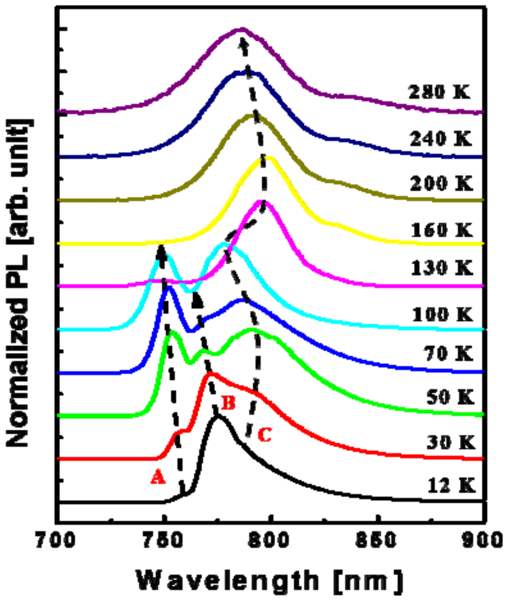
Abstract :

Hybrid perovskite of $CH_3NH_3PbI_3$ ($MAPbI_3$) exhibits an abnormal photoluminescence (PL). $MAPbI_3$ crystal was grown using inverse temperature crystallization (ITC) process. The PL spectrum at 12 K shows three peaks at 758 (A), 775 (B), and 790 nm (C). As temperature increases, all peaks shift to short wavelength (high energy) and peak C shows phase transition behavior from 100 K. The PL signals of $MAPbI_3$ are shown in Fig. 1. From temperature dependence, the activation energies (E_a) of three peaks are calculated and E_a of A and B peaks are 70 and 8.3 meV, respectively. E_a of C peak is 6.2 and 98 meV at low and high temperatures, respectively. These abnormal PL behavior and two E_a of peak C as function of temperature are due to tetragonal–orthorhombic phase transition. The analysis of optical properties due to phase transition of $MAPbI_3$ will enhance the performance of new optoelectronic devices.



Organic semiconductors(E)/0489 F6.07

Optical absorption and anomalous photoconductivity in Methylammonium lead halide single crystals

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Abstract :

Organic-inorganic mixed halide perovskite ($MAPbX_3$; MA = $CH_3NH_3^+$, X = Cl^-, Br^-, or I^-) single crystals have been highlighted as candidate materials for high efficiency photovoltaics and optoelectronics. However, the outstanding success in increase perovskite device performance like a solar cell, the underlying photophysical mechanism remain unclear.The persistent photoconductivity (PPC) effect, which is persisted light-induced conductivity for a long period of time after illumination, has been a critical problem in optoelectronic devices. In spite of negative feature of it, the PPC is a useful tool for understanding the metastable properties of defects. Nonetheless, the PPC effect of perovskite single crystals has not been studied yet. In this study, optical absorption (OA), photoconductivity (PC), and PPC measurements were employed to analyze deep levels in mixed halide perovskite ($CH_3NH_3PbBr_{3-x}I_x$) single crystals with the planar contact configuration. Mixed halide perovskite single crystals showed abnormal PPC behavior which were related to the existence of metastable gap state from defect sites.

Instrumentation and big facilities(I)/0488 F7.01

Investigation of femtosecond XFEL interaction with matter using x-ray spectroscopic techniques

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Abstract :

The ultrafast, ultraintense, and coherent x-ray pulses generated x-ray free electron lasers (XFELs) have enabled investigating new area of light-matter interactions. I present several experiments and simulations on the interaction of intense XFEL pulses with matters. X-ray emission and absorption spectroscopies have provided fruitful information on ultrafast core-level electron dynamics, modification of electronic structures, and properties of exotic states of matter. Investigation on XFEL-matter interactions at various scales will allow to test our fundamental understanding of the interaction physics in this wavelength regime.

This is work was supported by the National Research Foundation (NRF-2016R1A2B4009631 and NRF-2015R1A5A1009962).

Focus: Synchrotron and x-ray free electron laser studies of condensed matter/1047 F7.02

Structural analysis using focused X-ray beam – X-ray microdiffraction

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Abstract :

Many materials like oxide thin films have physical properties widely varying under different strain states. Sometimes the variation of strain states itself can generate the flexoelectric field, which is strong enough to change the polarization states of ferroelectic films. But the variations of strain states are hard to be measured with conventional X-ray diffraction setups due to large probing volumes. To see the spatial variations of crystal structures, small focused X-ray beam is essential and also new analysis technique is required due to the limitation of conventional diffractometry equipments.

X-ray microdiffraction is a new structural analysis tool using focused X-ray beam, with typical size of ~1um. In this talk, X-ray microdiffraction using white beam from 3rd generation synchrotron radiation sources will be introduced and many study examples, mainly oxide thin films, will be discussed. Laue images at various locations are analyzed and structures are determined by specially developed software. The software has been improved to analyze overlaped Laue patterns from many grains.

Focus: Synchrotron and x-ray free electron laser studies of condensed matter/0781 F7.03

Band gap control of MoS_2 by using K^+ ions

CHUNG Jinwook[*1,2], KIM Jingul[1], LEE Sang-Hoon[1], LEE Paengro[1], RYU Mintae[1], PARK Heemin[1], JHI Seung-Hoon[1], NOH Do Young[2]

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Abstract :

With the graphene epidemics, molybdenum disulphide (MoS_2) has been extensively reinvestigated as a promising two-dimensional (2D) semiconducting material seeking extensive applications of its rich electronic and optical properties. Controlling the band gap of MoS_2 is the opening gate to seek such applications. We report that the doping of low energy K^+ ions on MoS_2 at 120 K forms a stack of MoS_2 bilayers separated by intercalated potassium (K^+) ions as suggested by our photoemission data. We further show that the band gap E_g of the bilayer MoS_2 can be fine-tuned artificially by deliberately adjusting the dose (q) of the intercalated K^+ ions by up to $DE_g = 0.51$ eV. Our theoretical calculations reveal that E_g indeed decreases drastically with increasing the transverse electric field E produced by the intercalated K^+ ions. We find that E increases proportionally to q, and a semiconductor-metal transition takes place when E>2.0 V/Å. Our calculated band gaps for three different values of E match quite well with the measured band gaps. We thus report an efficient and pragmatic means of tailoring the band gap of bilayer MoS_2 simply by controlling q of the doped K^+ ions with no extra treatment. This scheme of engineering the band gap of bilayer MoS_2 may thus facilitate the development of MoS_2-based nano-electronics.

Focus: Synchrotron and x-ray free electron laser studies of condensed matter/0210 F7.04

Electron-electron interaction in graphene studied using a synchrotron source

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Abstract :

In graphene, when the Dirac energy is aligned to the chemical potential, the unscreened Coulomb interaction has an important long-range contribution, so that the charge carrier dynamics become beyond the scope of the theory that describes conventional metals. This exceptional property of the charge carriers in graphene is further modified by a substrate and temperature. Here I address the characteristics of electron-electron interation in graphene on dielectric substrates via the electron band structure studied using high-resolution angle-resolved photoemission spectroscopy (ARPES).

Instrumentation and big facilities(I)/1178 F7.05

Upgrade of the coherent x-ray scattering beamline (9C) at PLS-II

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Abstract :

The coherent x-ray scattering beamline of PLS-II was used to investigate coherent x-ray diffraction imaging (CXDI) since 2012. Insufficient coherent flux of the x-ray beam and restricted sample environment had made it difficult to activate CXDI related researches. Recently, the beamline has been upgraded to build the experimental environment better suited for CXDI. The upgrade was performed on the sample environment (diffractometer, sample chamber) and the optical systems (mirror, slit). The sample chamber was designed to facilitate biological sample imaging as well as in-situ imaging of nanomaterials. In addition, the KB mirror and the scatter-less slit system were employed to increase coherent flux better than 5-fold compared to the previous system. In this presentation, details of the beamline upgrade will be introduced and also resulting improvements on imaging data.

Focus: Synchrotron and x-ray free electron laser studies of condensed matter/1107 F7.06

Measurement on spatial coherence in hard x-ray free electron laser apart from the intensity noise and its dependance on the focusing process.

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Abstract :

We examined the spatial coherence property of a hard x-ray free electron laser at the experiment station of SACLA. Our Young's double slit experiment with 100 um thick tungsten slit revealed the spatial coherence length of the unfocused beam in the vertical direction as 300 um. The coherence length of the focused beam was determined by analyzing the x-ray diffraction pattern of double gold nanosphere, which resulted in 1.1 um in horizontal and 1.4 um in vertical direction. Further we resolved the visibility decrease due to the incident intensity difference, which is a common problem in Young's experiment. The ratio of the coherence length to the beam size, what we call the coherent portion, was investigated whether to be the conserved quantity during the focusing. The coherent mode expansion proved the conservation of the coherent portion in ideal focusing, though the experimental result showed significant decrease from in focusing process, from 86 % to 70%. This lowering of the spatial coherence may originate from the finite spatial acceptance of the mirror and machining error in processing the mirror.

Focus: Orbital polarization & Rashba spin-momentum coupling/0556 F8.01

Giant Rashba-type spin splitting without an electric field

Jisook Hong[1], Jun-Won Rhim[2], Inkyung Song[3], Changyoung Kim[3,4], Seung Ryong Park└[5], Ji Hoon Shim[*1,6]

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Abstract :

There has been a recent surge in the studies of Rashba-type spin splitting (RSS) due to its role in the field of spintronics such as spin field effect transistor, spin orbit torque and spin to charge conversion. In addition to the controllability, a major goal in the research is to make the splitting energy large. For that reason, there have been extensive studies on the so-called giant RSS systems such as Bi/Ag(111) and Pb/Ag(111). However, the exact mechanism is poorly understood as currently known theories require unreasonably large electric field to account for the giant splitting. For a guided design of systems with a large RSS, it is imperative to understand the microscopic mechanism. Here we show that the anisotropic hopping of each spin states in Bi/Ag(111) works as a strong effective field and induces the giant RSS even in the absence of the conventional electric field. The effective field from the hopping energy difference between the split bands amounts to be around 18 V/ᅡA. This new perspective on the RSS by the anisotropic hopping should give us a hint for the giant RSS mechanism and provide a strategy for designing new RSS materials by controlling asymmetry in hopping between the neighboring atomic layers.

Focus: Orbital polarization & Rashba spin-momentum coupling/0889 F8.02

Theoretical studies of Rashba effect on a two-dimensional topological insulator and monolayer of 5*d* transition metal oxides 2DEG.

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[1]Ulsan National Institute of Science and Technology, Department of Energy and Chemical Engineering, [2]Seoul National University, Department of Physics and Astronomy, [3]Institute for Basic Science, Center for Correlated Electron Systems

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Abstract :

Interlocking between spin and the crystal momentum of electrons resulting from the spin-orbit coupling in two dimensional semiconductors was introduced in 1984 by Rashba and Bychkov, named as the Rashba effect. Since then, the field of Rashba effect has been greatly expanded to a vast number of materials beyond semiconductors. Recently, it shows the effective spin generation, manipulation and detection are possible via Rashba effect, relating its importance to spin Hall effect, spin galvanic effect, topological states and so on. Not only that, but a new concept of spin device utilizing the Rashba effect, Das Datta-type transistors, has been also realizing. In this talk, we briefly introduce the physics of Rashba, and two theoretical studies of the Rashba effect ongoing in our group: (i) a two-dimensional topological insulator, where the possibly flappable electric polarization allows us to effectively control spin textures. (ii) 2DEG formed on 5*d* transition metal oxides monolayer sandwiched by ferroelectric materials in which the soft phonon modes coupled to the spin greatly enhances the Rashba effect. In the end, we will also talk about the future direction of the current studies.

Focus: Orbital polarization & Rashba spin-momentum coupling/0171 F8.03

Orbital angular momentum analysis for giant spin splitting in solids and nanostructures

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[1]Yonsei University, Department of Physics

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Abstract :

Giant spin splitting (GSS) of electronic bands, which is several orders of magnitude greater than the standard Rashba effect has been observed in various systems including noble-metal surfaces and thin films of transition-metal dichalcogenides. Previous studies reported that orbital angular momentum (OAM) is not quenched in some GSS materials and that the atomic spin-orbit interaction (SOI) generates spin splitting in some solid states via the interorbital hopping. Although the unquenched OAM may be closely related to the interorbital hopping, their relationship is hardly studied in the aspect of using the unquenched OAM as a control parameter of GSS. Here, we analyze OAM in GSS materials by using the interorbital-hopping mechanism and first-principles calculations. We report that the interatomic hopping between different-parity orbitals, which is generated by specific broken mirror symmetry, produces k-dependent OAM, resulting in valley-dependent GSS in WSe_2 monolayer, Rashba-type GSS in Au (111) surface, and Dresselhaus-type GSS in bulk HgTe. We also demonstrate systematic control of OAM by pressure, external fields, and substrates, thereby controlling the spin splitting, and discuss the temperature dependence of OAM. Our results provide a simplified picture for systematic design and control of GSS materials. This work was supported by NRF of Korea (Grant No. 2011-0018306). (Ref. S. Oh and H. J. Choi, Sci. Rep. 7, 2024 (2017).)

Focus: Orbital polarization & Rashba spin-momentum coupling/0178 F8.04

Spin/valley Hall effect from broken mirror symmetry in monolayer MoS_2

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Abstract :

For the monolayer MoS_2, we calculate the Berry curvature, which generates the intrinsic spin/valley Hall effect in the material. By using the k·p perturbed Hamiltonian, we investigate the effect of mirror symmetry breaking in monolayer MoS_2. We show that the Berry curvature depends on the gate voltage which breaks the mirror symmetry and induces the Rashba spin-momentum coupling. We find that the coupling enhances Berry curvature significantly. We calculate the spin/valley Hall conductivity which can explain recent experimental results. We also extend this analysis to bilayer MoS_2.

Pioneer: Pseudo-gaps in high Tc superconductor/1196 F9.01

Pseudogaps and symmetry-broken electronic states in iron-pnictide superconductors

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Abstract :

The pseudogap observed in the normal state of the high T_c copper oxide superconductors remains a mysterious state of matter. It has been attributed to several mechanisms such as a precursor pairing and a novel form of spin/charge ordering. To gain further insights into the relationship among the high T_c superconductivity, pseudogap, and the possible symmetry breaking, the exploration of normal states in other high T_c superconductors, namely iron-pnictides, is highly desired.

Here we provide an evidence of the pseudogap and related symmetry-broken electronic states via angle-resolved photoemission spectroscopy (ARPES) in the high T_c $BaFe_2As_2$ family. Our results reveal a composition-dependent pseudogap formation in the multiband electronic structure of isovalent $BaFe_2(As_{1-x}P_x)_2$ system [1]. The pseudogap develops well above the magnetostructural transition for low x, persists above the nonmagnetic superconducting dome for optimal x, and is destroyed for $x > 0.6$, thus showing a notable similarity with cuprates. In addition, the pseudogap formation is accompanied by inequivalent energy shifts in the *zx*/*yz* orbitals of iron atoms, indicative of a peculiar iron orbital ordering instability which breaks the fourfold rotational symmetry. In relation to these anomalous normal states, a recent result on hole-doped $(Ba,K)Fe_2As_2$ system will be also presented, which provides the clear signatures of antiferroic instability existing in the wide doping region [2].

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Superconductivity(C)/0170 F9.02

Frustration-driven C_4 symmetric orders in a hetero-structured iron-based superconductor

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Abstract :

A subtle balance between competing interactions in strongly correlated electron systems can be easily tipped by additional interfacial interactions in a heterostructure. This often induces exotic phases with unprecedented properties, as recently exemplified by high-T_c superconductivity in FeSe monolayer on top of the nonmagnetic $SrTiO_3$. When the proximity-coupled layer is magnetically active, even richer phase diagrams are expected in iron-based superconductors (FeSCs), which however has not been explored due to the lack of a proper material system. One promising candidate is Sr_2VO_3FeAs, a naturally-assembled heterostructure of a FeSC and a Mott-insulating vanadium oxide. Here, using high-quality Sr_2VO_3FeAs single crystals and high-accuracy ^{75}As and ^{51}V nuclear magnetic resonance (NMR) measurements, we provide evidence that a novel electronic phase is emerging in the FeAs layer below $T_0 \sim 155$ K without either static magnetism or a crystal symmetry change, which is reminiscent of hidden orders in underdoped cuprates or heavy fermion URu_2Si_2 systems. We find that the interfacial coupling induces a charge/orbital order with C_4-symmetry in the FeAs layers, while suppressing the Neel antiferromagnetism in the $SrVO_3$ layers. Both effects are triggered by frustration of the otherwise dominant Fe stripe and V Neel fluctuations, demonstrating that the magnetic proximity coupling is effective to stabilize a hidden order in FeSCs and, more generally, in strongly correlated heterostructures.

Pioneer: Pseudo-gaps in high Tc superconductor/0794 F9.03

Band dependent pseudogap in iron-based superconductor

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Abstract :

Pseudogap is one of the most remarkable feature in high transition temperature (T_C) unconventional superconductivity. Understanding its origin is believed to hold the key to understanding the high T_C superconductivity, thus extensive and intensive studies have been performed to reveal the pseudogap origin. The pseudogap is first discovered in cuprate superconductors and most of pseduogap studies have been focused on cuprates that, unfortunately, can give limited evidence to solve the problem. Iron-based superconductors, a new member of unconventional superconductors, are expected to provide additional evidence to unveil pseudogap, however, only a few number of studies have been performed so far.

In this study, an angle-resolved photoemission spectroscopy measurement was performed on iron pnictide Sr_2VO_3FeAs, of which T_C is 37 K and multiple bands cross the Fermi level like other iron pnictide superconductors. I report the recent result, band dependent pseudogap opening, that a gap opened only in hole band even above T_C until 150 K among electron and hole bands of iron pnictide. This dichotomous gap opening behavior would imply that the observed pseudogap is not from preformed Cooper pairs, and is likely driven by competing order as two-gap behavior of cuprate superconductors. With the similarity to cuprate pseudogap, this new result can be expected to lead a new insight on the long-standing pseudogap issue.

Pioneer: Pseudo-gaps in high Tc superconductor/1197 F9.04

Distinctive electronic phase diagram of electron-doped FeSe studied via in-situ surface

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Abstract :

Most Iron-based superconductors share a similar Fermi surface topology: the Fermi surface consists of both hole and electron pockets. However, for the heavily electron-doped FeSe, such as $K_xFe_{2-y}Se_2$ and 1 monolayer FeSe thin film, they belongs to another category where the Fermi surface consists of only electron pockets at the zone corner. It is still not clear what the pairing mechanism is for electron-doped FeSe and how it correlates with other iron-based superconductors. Here, utilizing the angle-resolved photoemission spectroscopy (ARPES) and in-situ surface doping, we studied the detailed electronic phase diagram of FeSe and $FeTe_{0.5}Se_{0.5}$ single crystals. The carrier doping was tuned precisely by evaporating potassium onto the cleaved surface. Our result suggests that the pairing channel of electron-doped FeSe is different from those of iron-pnictides superconductors. The inter pocket scattering between the electron pockets should play a critical role.

Focus: 2D Material photonics/0327 F10.01

Mid-infrared tunable plasmonics in graphene

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Abstract :

Graphene is an interesting material for mid-infrared active nanophotonics. Recent studies have shown that the effective optical index of graphene depends on the local Fermi level, which can be varied greatly via electrostatic gating techniques. More interestingly, the low carrier concentration and the atomic thinness of graphene allows for highly confined plasmonic modes whose properties are also widely tunable as a function of doping density. We showed that these plasmonic modes can play a dominant role in controlling the optical properties of periodically patterned graphene at mid-infrared frequencies. We showed that the energy-momentum dispersion relation of graphene plasmons are fundamentally different from the conventional noble metal surface plasmons and that the wavelength of graphene plasmons is more than 100 times shorter than the free space wavelength. As a consequence of such extreme field confinement, we further demonstrated that graphene plasmons strongly interact with substrate phonons, forming hybrid modes called surface phonon plasmon polaritons. By placing a reflector to block transmission channels and engineering the spacing between the reflector and the graphene resonators, we demonstrated that the absorption in a single layer of graphene resonators can be dynamically tuned from 0 to 25% by electrostatic gating. We also showed that the absorption modulation by graphene resonantors can be 2.67 fold enhanced by incorporating EOT(extra-ordinary transmission) metallic resonant restructures. By further advancing the idea of overlapping various scales of resonances in a narrow spectral and spatial window, we recently demonstrated that it is possible to achieve perfect mid-infrared absorption modulation based on graphene plasmonic metasurfaces. Finally, Kirchhoff's law of thermal radiation, which states the absorptivity and the emissivity of an object are equal, also allows for dynamic control of thermal radiation from heated graphene plasmonic nanoresonators. These tunable plasmonic modes offered by graphene and other 2D materials provide new opportunities to create electo-optically active devices with novel functionalities that have thus far been impossible to be realized by using conventional media.

Focus: 2D Material photonics/1179 F10.02

Ultrafast optical studies of valley states in 2D transition metal dichalcogenides

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Abstract :

The valley degree of freedom in 2D transition metal dichalcogenides (TMD) recently emerged as a novel information carrier in addition to spin and charge. The valley electronic states are shown to be easily accessible via circular polarization of photoexcitation. In addition, the intrinsic valley lifetime is expected to be remarkably long due to the unique spin-valley locking behavior. Here, we report efficient generation of microsecond-long lived valley polarization via ultrafast charge transfer process in WSe_2/MoS_2 heterostructures. This valley polarization has near unity degree and several orders of magnitude longer lifetime than previously reported values. Our ultrafast optical studies reveal promising potential of valley electronic states in TMD monolayers for novel valleytronics and spintronics applications.

Focus: 2D Material photonics/0433 F10.03

Photon and Energy Conversion through Atomically Thin Semiconductor Heterojunctions

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Abstract :

The recent advent of semiconducting transition metal dichalcogenides (TMDCs) with exceptional optical properties, combined with the ability to build artificial van der Waals heterostructures, enables the realization of unique atomically thin heterojunctions for applications in photon (or energy) conversion as well as fundamental studies at an ultimate thickness limit. In this talk, I will first discuss photon coversion processes in vertically-stacked *p-n* junctions (WSe_2/MoS_2) and monolithically-fabricated oxide/semiconductor heterojunctions (WO_3/WSe_2), which exhibited highly efficient and fast conversion. In addition, using such an ultrafast charge transfer at the interface, the atomically thin type-II heterojuction can be utilized as a catalyst for photoelectrochemical (PEC) water splitting. As the second subject of the talk, I will present the *in-situ* characterizaiton of enhaced PEC performances of the MoS_2/WS_2 heterojunciton catalyst for hydrogen evolution reaction. Lastly, I will further present the wafer-scale growth of monolayer TMDCs and their epitaxial heterojunction bilayers using metal-organic chemical vapor deposition (MOCVD) for future practical applications.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/0061 F11.01

Realization of ultra-stable Hard X-ray Free Electron Laser

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Abstract :

PAL-XFEL has achieved the world's best performance of timing stability, the jitter of 24.7 fs in rms between XFEL and optical laser pulses. It allows us to observe Bi(111) phonon dynamics without using a timing-jitter correction, which would prove PAL-XFEL to be an extremely useful tool for hard X-ray time-resolved experiments. The recently achieved three bunch compressor scheme is expected to help to get a timing jitter better than 20fs in rms.

Focus: Recent advances in accelerator technology: superconducting technology and PAL-XFEL/0523 F11.02

New Science Opportunities at the PAL-XFEL Facility

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Abstract :

In this presentation, the status of overall PAL-XFEL facility, including both hard and soft X-ray FEL beamlines and three experimental stations equipped with six scientific instrumentations are reviewed. An introduction to possible new scientific applications will be discussed with the results of recent demonstration experiments. And It will be concluded with a brief comment on future research directions and plans.

Focus: Nanomaterials for energy applications/0095 F12.01

Flexible Capacitive Energy Storage Devices Based on Graphene Electrodes

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Abstract :

With increasing demand for high performance energy storage systems, the feasibility of reliable and functional energy storage devices that well operates under extreme conditions is of prime importance for special applications of electrical vehicle, flexible and wearable electronics, and integrated on-chip systems. The highly bendable and compressible energy storage devices are expected to be adopted in these applicative fields as long as they preserve good performance even under electrochemical and mechanical stresses. Moreover, advanced electrode materials are essential for developing the afore-mentioned functional energy storage devices. In this talk, I will introduce bendable and compressible supercapacitors based on graphene electrodes that can efficiently deliver electrical energy under electrochemical, mechanical and thermal stresses.[1-4] In order to achieve high performance supercapacitor devices under various stresses, the micro- and macroscopic structures and chemical compositions of graphenes are delicately controlled by chemical modification. The solution chemistry described herein would pave the way to obtain high performances of energy storage materials/devices that are otherwise difficult to realize with current, conventional technologies, leading to breakthroughs for important emerging applications.

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Focus: Nanomaterials for energy applications/0983 F12.02

Vertical semiconductor crystals and graphene hybrid optoelectronic devices

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Abstract :

The hybridization of different types of materials, for instance, hybridization of vertical semiconductor crystals with 2D atomic layered materials, enables the construction of 3D architectures and the imposition of multi-functionalities. Here we present the synthesis and fabrication of the semiconductor nanocrystal arrays and graphene hybrid structures and the potential applications for pixel-type optoelectronic devices. We first demonstrate the step-by-step growth of hierarchical 3D architecture ZnO crystals in low temperature solution and then heteroepitaxial overgrowth of GaN on the core ZnO templates. In addition, to create high performance or multi-functionality, we introduced semiconductor nanocrystals and graphene hybrid arrays for pixel-type optoelectronics. In especial, owing to its one-atom thickness, low density of state near the Dirac point, and tunable work-function, graphene is also substantially permeable to an electric-field when external bias is applied over the graphene. These features enable the semiconductor crystals and graphene hybrid structures to have many interesting properties and related electronic and optoelectronic applications.

Focus: Nanomaterials for energy applications/0763 F12.03

Novel multi-dimensional nanocarbons hybridized with silicon oxides and their application for high performance electrochemical capacitors

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Abstract :

In this presentation, we report a facile and versatile strategy to prepare multi-dimensional nanocarbons hybridized with mesoporous SiO2. Carbon nanoplatelets (CNPs, two dimensional structure of nanocarbons) were combined with carbon nanotubes (CNTs, one dimensional nanocarbons) to form multi-dimensional carbons (2D-1D, CNP-CNTs). The CNP-CNTs were synthesized by directly growing CNTs on CNPs. A simple solution-based process using TEOS (tetreathyl orthosilicate) resulted in coating or hybridizing CNP-CNTs with mesoporous silica to produce CNP-CNTs@SiO2 . The mesoporous SiO2 is expected to enhance the capacitive characteristics of nanocarbons due to its high surface area. Electrochemical characterizations of CNP-CNTs@SiO2 as supercapactior electrodes including cyclic voltammetry and galvanostatic charge-discharge in gel electrolyte reveal excellent specific capacitance and stable charge-discharge operation. Our work demonstrate mesoporous SiO2 on nanocarbons have great potential in electrochemical energy storage.

Focus: Nanomaterials for energy applications/0676 F12.04

Aligned carbon nanotube sheets with polymer dispersed liquid crystal for photo-electro-thermal actuator

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Abstract :

Polymer dispersed liqid crystal (PDLC) has been a well-known active material for a photo triggered actuator. In this report, the aligned carbon nanotube (CNT) sheets was combined with the PDLC to form a free-standing film. In this case, the PDLC was a mixer of a liquid crystal as an active material, 5CB, dispersed in an inert polymer, PVA. Interestingly, such as-made film showed the well alignment of 5CB on the aligned CNT sheets without a pre-stretch of the film. As a result, the hybrid film represented the deformation activated by the visible light source due to the photo-thermal effect motivated the phase change transition from the nematic phase to the isotropic phase. Moreover, the film also actuated by Joule heating effect. The Joule heating induced temperature on the film was carried out by using the thermal mapping infrared scope QFI. The deformation of the film was characterized with both the visible light source and the electrical power. The results enable a great opportunity to utilize such hybrid film for the actuations, especially for an application in a time temperature indicator.

Focus: Nanomaterials for energy applications/0074 F12.05

Interdigital electrode based triboelectric nanogenerator for effective energy harvesting from water

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Abstract :

Despite high voltage output, the low current output of triboelectric nanogenerators (TENGs) limits their expansion into practical applications. The incorporation of additional machinery, such as transformers and gear trains, has been proposed to remove this bottleneck. Here, we report a simple and cost-effective strategy that employs a compact interdigital electrode (IDE) to increase the current output in TENG devices. A foldable, twistable, and rollable IDE-based TENG, comprised of finger-like aluminum electrodes sandwiched between polytetrafluoroethylene and polyester films, was fabricated to harvest triboelectric energy from water. This IDEbased TENG exhibited a triboelectric charge threefold higher than that of a single electrode-based TENG. Triboelectric charge is greatly enhanced when the width of the IDE is comparable to the size of the water droplet being harvested. Using a cone-shaped IDE-based TENG, we showed that the folding angle of the device and the water droplet volume rate are important for enhancing triboelectric currents. Using a cylinder-shaped IDEbased TENG, we demonstrated the powering of 10 light emitting diodes and the charging of a 0.1-μF capacitor to 15 V within 20 s.

Condensed-matter computational physics(G)/0601 F13.01

Catalytic effect of Ag_2Se for decomposition of water: a first-principles study

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Abstract :

Using ab initio calculations based on density functional theory, we investigate possibility of water decomposition on silver selenide (Ag_2Se). In the calculations, the energy cutoff was 400 eV, and the wave function was expanded using a plane wave basis set. In order to check whether Ag_2Se acts as a catalyst for decomposing water molecules, several model structures were considered: a H_2O molecule, a hydroxyl (-OH) group, and an oxygen atom on a slab of Ag_2Se. An Ag_2Se <100> direction was chosen for a 2-nm thick slab. We made a path for a decomposition reaction as follows: (1) Water molecules come to a Ag_2Se surface, and are adsorbed to the surface with a van der Waals interaction. (2) Hydroxyl (-OH) groups are bonded to the Ag_2Se surface, and molecular hydrogen gas is formed. (3) Only oxygen atoms are chemically adsorbed on the silver selenide surface. In the case of -OH group adsorption, it prefers the ontop site of a selenium atom with adsorption energy of -0.97 eV. For an atomic oxygen adsorption, it is placed at the bridge site between a silver atom and a selenium atom with adsorption energy of -3.34 eV.

Condensed-matter computational physics(G)/0967 F13.02

First-principles study of co-doping effect to enhance photo-catalytic activity in Fe2O3 hematite

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Abstract :

Hematite has been considered a promising semiconductor for photo-electrochemical reaction because it is abundant, nontoxic, stable and in-expensive. However, pure hematite has a large band-gap and a poor hole conductivity and it is hard to excite electrons in visible region because of its indirect-transition characteristics of electron within the band-gap. One of the strategies for overcoming these shortcomings is doping one element to reduce the band-gap and now many researchers focus on finding co-doping effects of various synergetic dopants. Using first-principle DFT calculations, we show the synergetic effects of heterogenous dopants for reducing the band-gap, inducing the direct transition, and increasing electron-hole mobilities in hematite. In particular, we will discuss how to stabilize a popular n-type dopant Si with a proper co-doping scheme

Condensed-matter computational physics(G)/0968 F13.03

Prediction of a new superconducting silicon allotrope

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Abstract :

The cubic diamond phase of Si is the thermodynamic ground state at ambient conditions and widely used as the most consummate element in modern semiconductor technology. While cubic diamond Si is a semiconductor with an indirect band gap of about 1.1 eV, it transforms to the metallic β-Sn and subsequently to simple hexagonal structure under compression. The superconductivity of Si has been observed in the covalent diamond phase heavily doped with boron and in the high-pressure β-Sn and simple hexagonal phases. However, the β-Sn and simple hexagonal phases do not maintain their structural stability when pressure is released to ambient conditions. Until now, no superconducting pure silicon phase has been reported at ambient pressure.

In this work, we predict a novel metallic clathrate structure of silicon at ambient pressure, which is composed of open channels embedded in the simple hexagonal lattice. The new Si_6 clathrate can be obtained by removing Na atoms from a chemical precursor $NaSi_6$ in the $P6/m$ space group that is discovered using evolutionary crystal structure search at high pressure. We find that both the metallic Si_6 and $NaSi_6$ clathrates are superconducting with the critical temperatures of about 12 and 13 K at zero pressure, respectively. Through phonon spectra calculations and molecular dynamics simulations, we confirm that the new Si allotropes are stable even at ambient pressure.

Topological Crystalline Insulator and High Thermopower in Perovskite $ThTaN_3$

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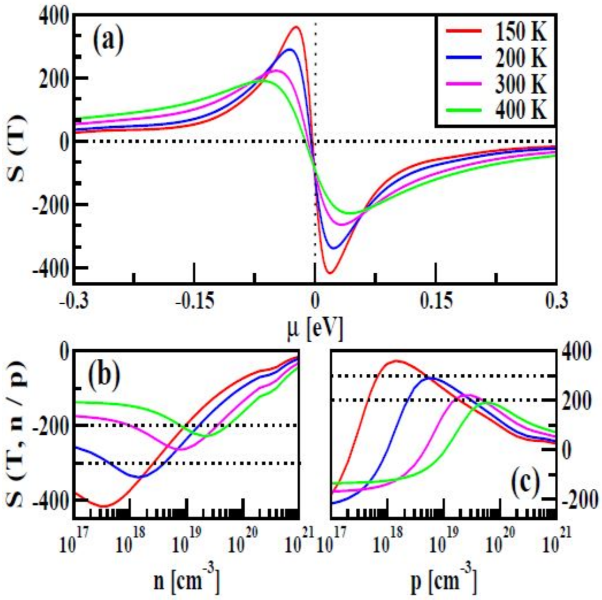
Abstract :



In the condensed matter physics, several distinct types of topological phases have been proposed and realized for last ten years. One of them is the named topological crystalline insulator (TCI) protected by crystal symmetries, while ordinary Z_2 topological insulators are protected by time-reversal symmetry. TCI has been observed in a few rocksalt-type IV-VI semiconductors, though predictions as well as realizations are very limited.

In the cubic $ThTaN_3$, a rare nitride perovskite, we have investigated its topological characters and thermoelectric properties through first principles methods. Spin-orbit coupling leads to inverting bands and opening a gap of 0.15 eV at the zone center. This system shows the trivial Z2 indices, but two pairs of surface bands appear at the zone center. As a result, $ThTaN_3$ is a TCI with the mirror Chern number of 2, protected by the mirror and four-fold rotation symmetries. Additionally, $ThTaN_3$ shows a large Seebeck coefficient with a maximum of S ~ 400 μV/K at 150 K for 10^{-4} – 10^{-6} carrier doping per formula unit. We suggest that this compound can be a good thermoelectric application.

[Acknowledgements] This research has been collaborated with W. E. Pickett at UC Davis. This research was supported by NRF of Korea Grants No. NRF-2016R1A2B4009579

Condensed-matter computational physics(G)/0085 F13.05

A new phosphorus allotrope discovered by *ab initio* materials design

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Abstract :

Black phosphorus has attracted much attention as an emerging two-dimensional (2D) material due to its high carrier mobility and moderate band gap and can be exfoliated to a few layers. Recently, it has been shown that black phosphorus undergoes a topological phase transition by varying pressure, doping alkali metal ions, and oxidation, enriching non-trivial topological materials. Besides black phosphorus, elemental phosphorus exists in various allotropes such as red, white, and violet phosphorus. Furthermore, a number of phosphorus allotropes have been predicted theoretically, and blue phosphorene, one of the suggested P allotropes, has been successfully synthesized on the Au substrate.

In this work, we report the discovery of a new P allotrope, called green phosphorus, using a combined approach of conformational space annealing for global optimization with density functional theory calculations for materials design. Green phosphorus has a layered structure with the interlayer interaction comparable to that of black phosphorus, indicating that it should be exfoliated to thin films. As the number of layers decreases to one, termed green phosphorene, the band gap increases from 0.7 to 2.4 eV, without altering the direct band gap nature. Calculating electron-phonon interactions and solving the Bethe-Salpeter equation with the quasiparticle G_0W_0 approximation, we find that green phosphorene has strong anisotropy in optical and transport properties, suggesting possible device applications like black phosphorene. We examine the effects of temperature and substrate on the stability of green phosphorene and provide a possible route for synthesizing green phosphorene.

Condensed-matter computational physics(G)/0388 F13.06

A comparative study of DFT+U functionals: Double counting, spin density, and Hund interaction

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Abstract :

A systematic study has been performed to investigate the DFT+U (density functional theory + U) functionals. Motivated by the recent DFT+U studies reporting unreasonable Hund interaction (J) dependence in several transition metal compounds, we focused on the J-dependence in DFT+U. To understand the general behavior of the method, a comprehensive analysis of DFT+U formulations and their relation to standard exchange-correlation functionals are provided. Two representative double counting forms, namely "fully localized limit" and "around mean-field", are also investigated. Unphysical J-dependence originated from the spin density energy is clearly noticed in energetics and spin up/down potentials for both double countings. Applications to different types of materials (MnO, NiO, $SrRuO_3$, and $BaFe_2As_2$) are also performed using our new implementation into OpenMX software package. It further elucidates the undesirable effects on the ground state magnetic properties arising from the spin density. We demonstrate that a common practice of using DFT+U based on the spin density exchange-correlation functional has a serious drawback in predicting material properties while the theory based on the charge-only density functional is a promising scheme.

Condensed-matter computational physics(G)/0917 F13.07

First-principles modeling of electron tunneling through ferroelectric tunnel junction

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Abstract :

Owing to the recent advances in the oxide growth technology, ferroelectricity has been stabilized even in a few nm-thick ferroelectric film, which makes it possible to realize the ferroelectric tunneling junction (FTJ) combining the quantum-mechanical tunneling and switchable spontaneous polarization into novel device functionality. Here, using density functional theory calculations, we estimated the tunneling potential profile (TPP) across the $SrRuO_3$/$BaTiO_3$/Pt junction, and then based on the TPP, the tunneling current during the electric polarization reversal was for the first time modeled with our homemade numerical code. We expect our first-principles tunneling modeling in FTJ to provide a key ingredient into the development of optimal FTJ-based non-volatile memory devices.

Pioneer: Non-equilibrium first-principles calculations for energy applications/0041 F13.08

Phonon-driven spin-Floquet magneto-valleytronics

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Abstract :

Two-dimensional (2D) materials equipped with strong spin-orbit coupling can display novel electronic, spintronic, valleytronic and topological properties originating from the breaking of time- or inversion symmetry. By performing *ab initio* time dependent density functional simulation on MoS_2, here we show that the spin is not only locked to the valley-momenta but strongly coupled to the optical *E''* phonon that lifts the lattice mirror symmetry. This phonon-coupled spin-dynamics can be resolved into discrete spin-Floquet-phononic states. Once the phonon is pumped such as to break time-reversal symmetry, the resulting spin-Floquet state carries a net out-of-plane magnetization (≈ 0.024 for single phonon quantum) even though the original system is non-magnetic. This phonon-dressed spin state is an intrinsic, spin-orbit mediated, excitation that can be probed and controlled by infrared coherent laser excitation. These findings are general for all semiconducting transition-metal dichalcogenides and open an avenue towards the ultrafast optical control of magnetization and spin dynamics.

Special Sessions(A)/1216 F14.01

정부지원 기초연구사업 현황 및 2018 년 사업 방향

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Abstract :

2017 년도 한 해 동안의 기초연구사업 지원내역, 주요 제도 개선사항 등에 대한 추진실적을 연구자들과 공유하고 2018 년도 기초연구사업의 주요 추진방향에 대해서도 소개할 예정입니다. 이번 학회가 자연과학 분야의 발전 뿐만 아니라, 기초연구사업에 대한 연구자들과 연구지원기관 간의 실질적인 교감과 원활한 소통의 자리가 될 수 있는 만큼 많은 연구자들이 참석하여 도움이 되는 자리가 되었으면 합니다.

Special Sessions(A)/1217 F14.02

문재인 정부의 과학기술 투자 방향 고찰

이장재*1

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Abstract :

지난 5 월에 조기대선을 통해 출범한 문재인 정부는 4 차 산업혁명시대라는 거대 담론에 대한 대응과 함께 일자리 창출이라는 현실적 문제를 풀어 가야 하는 상황을 맞이하고 있다. 과학기술정책은 이러한 상황에서 양수겸장의 혜안을 제공할 수 있는 정책으로 과학기술 투자방향에 대해 많은 관심이 쏠리고 있다.
국정운영 5 개년계획에 나타난 정부 과학기술 투자 방향의 핵심 키워드는 '기초분야 연구와 중소기업 R&D 에 대한 혁신적 지원(임기까지 2 배 증액)', '제 4 차 산업혁명 대응 투자 확대', '기술창업', '사회혁신 및 사회문제 해결'로 나타난다. 본 발표에서는 이번 정부의 연구개발 투자방향을 분석하고, 국가과학기술심의회가 확정한 2018 년도 정부 연구개발사업예산 배분·조정(안)을 통해 실행여부를 점검하고자 한다.

Special Sessions(A)/0484 F15.06

Rare K and B decays as crucial keys to understand heavy particles

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Abstract :

One of the important contributions of Benjamin Lee's to particle physics is study of rare meson decays to obtain information about yet-unknown heavier particles. In particular, by studying the properties of strange mesons, he was able to predict key properties of charm particles, of which the existence had not been established. This also had a substantial impact on later development of heavy-flavor physics, in particular in understanding physics of B mesons and its rare decays. In this talk, we briefly review Ben Lee's achievements in this and show a few crucial experimental findings in line of Ben Lee's theory in K and B meson systems.

Special Sessions(A)/1224 F15.01

The early days of the Standard Model - remembering Benjamin Lee

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Abstract :

In the 1960, the idea of renormalized quantum theories was thought to be a difficult and confusing topic, so that most researchers were searching for more direct ways to understand the elementary particles. Yet there were several pioneers with a wider view on this subject, and Benjamin Lee was one of them. Then, in a rapid succession, new developments took place and new insights were found. Experimental and theoretical particle physics were still focusing on the same issues, so these were exciting times.

Special Sessions(A)/1219 F15.02

A hard working genius

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Abstract :

As one of those privileged to have collaborated with the late Professor Benjamin W. Lee, whom friends simply called “Ben Lee”, I would like to describe my experience with him. I wrote 2 papers with him as collaboration and one more, which was written by myself, but actually based on discussions with him. Based on these papers and related episodes, I would like to tell the “living Ben Lee” to the young generations of Korean physicists.

Special Sessions(A)/1220 F15.03

내가 아는 이휘소 박사

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Abstract :

내가 이휘소 박사를 처음 만난 것은 45 년여전 뉴욕에서 이제는 작고하신 조순탁 교수와 함께였다. 그 이후 이휘소 박사와 물리적 관심사에 대해 그리고 개인적인 일에 대해서도 상의한 많은 기억이 있다. 이휘소 박사와의 개인적인 소회에 대해 몇가지 이야기하고자 한다.

Special Sessions(A)/1215 F15.04

Ben Lee in 1977

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Abstract :

Ben Lee was at the prime in his research career before the tragic accident in July, 1977. With S. Weinberg, he collaborated two important papers in that year one of which still remains as the opening example on the WIMPs.
On one Wednesday in mid-May, he, I and Fermilab theorists including visitors were informed of the PQ symmetry from Helen Quinn. After two months from this day, he passed away. At Fermilab on October 20-22, there was the Ben Lee Memorial Conference on "Unification of Elementary Forces and Gauge Theories" where several future Nobel Laureates participated. There, F. Wilczek and S. Weinberg announced a pseudoscalar with lifetime of 10^{-8} second. Many researchers from UPenn were there also, and UPenn became the mecca on the solutions of the strong CP problem, among which the "invisible" axion, still present in the Universe, has survived. The "invisible" axion I worked so long has a connection to Ben Lee.

Special Sessions(A)/1214 F15.05

The role of the Higgs-boson mass

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Abstract :

In this honarary talk I review the content of two of the most renowned works by Benjamin W. Lee [B.W. Lee, C. Quigg, H.B. Thacker, Phys. Rev. Lett. 38 (1977) 883 and Phys. Rev. D 16 (1977) 1519]. Then, I describe their follow-up theoretical and experimental developments, leading to the eventual discovery of a Higgs boson at CERN in 2012.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/1167 G1.01

Neutrino phenomenology

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Abstract :

In this talk I will give a brief overview of the experimental status of the field. We are at the cusp of seeing leptonic CP violation and I will review the progress to date and future developments, as well as the role New Physics will play in this context.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/1170 G1.02

Synthesizing Data: Sterile Neutrinos

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Abstract :

Sterile neutrinos are singlets of the Standard Model gauge symmetries which do not have the standard weak interactions but can couple to the active neutrinos through the Lagrangian mass term. The possible existence of sterile neutrinos is currently a hot topic of theoretical and experimental research which could provide valuable information on the physics beyond the Standard Model.

I shall review the global status of light sterile neutrinos at the eV mass scale. The reactor, gallium and Liquid Scintillator Neutrino Detector anomalies are briefly described and interpreted as indications of the existence of short-baseline oscillations which require the existence of light sterile neutrinos. The global fits of short-baseline oscillation data in simplest 3 + 1 scheme are discussed, with the emphasis on the latest results of IceCube, NEOS, MINOS and the Daya Bay reactor fuel evolution data. Finally, I shall conclude with with a summary of future perspectives.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/1169 G1.03

Global Experimental program for Sterile Neutrino Searches

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Abstract :

The discovery of a light sterile neutrino would have profound implications for particle physics, astrophysics, and cosmology. A number of short baseline neutrino oscillation measurements may be indicative of the active neutrinos mixing to at least one sterile flavor. A worldwide program, involving reactor, source, and accelerator-based experiments is currently underway and searching for these new oscillations. This talk will provide an overview and status of this crucial experimental effort, with a focus on accelerator-based searches.

Accelerator-based particle physics experiments (C)/0161 G2.01

Search for a high-mass resonance decaying into a dilepton final state using pp collisions at √s = 13 TeV

오민석[1], 유휘동[*1]

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Abstract :

A search for new heavy resonances in dielectron and dimuon spectra is performed using data obtained from 2016 proton-proton collisions at 13 TeV. The search exploits data collected by the CMS experiment at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 36 /fb. No significant deviations are observed from the Standard-model expectation. Dimuon signal acceptance times efficiency has been obtained from MC simulated events and scale factors are applied to take into account the difference between data and MC. Upper limits on the production cross-section times branching ratio relative to production cross-section times branching ratio of Z boson have been calculated.

Accelerator-based particle physics experiments (C)/0294 G2.02

Search for supersymmetry in pp collisions at sqrt(s) = 13 TeV in final states with boosted Wbosons and b jets using razor variables

HUH Changgi[*1], LEE Sehwook[1], SEKMEN Sezen[1], YE Ryonghae[1]

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Abstract :

A search for supersymmetry in hadronic final states with highly boosted W bosons and b jets is presented, focusing on compressed scenarios. The search is performed using proton-proton collision data at a center-of-mass energy of 13 TeV, collected by the CMS experiment at the LHC, corresponding to an integrated luminosity of 35.9 fb^{-1}. Events containing candidates for hadronic decays of boosted W bosons are identified using jet substructure techniques, and are analyzed using the razor variables MR and R^2, which characterize a possible signal as a peak on a smoothly falling background. The observed event yields in the signal regions are found to be consistent with the expected contributions from standard model processes, which are predicted using control samples in the data. The results are interpreted in terms of gluino pair production followed by their exclusive decay into top squarks and top quarks.

Accelerator-based particle physics experiments (C)/1026 G2.03

Search for CP violating anomalous top quark coupling in pp collisions with the CMS detector at 13 TeV

Seungkyu Ha[1], Suyong Choi[*1], Sehwook Lee[2]

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Abstract :

We conduct the study of the T-odd correlations in tt events produced in pp collision at the LHC that can be used to search for the CP violation. We select events which have dilepton final states to idenfiy tt events and measure counting asymmetries of a physics observable. Based on the result, we search the top quark anomalous coupling at the production vertex at the LHC experiment and we used the dataset which is collected at 13 TeV with CMS detector.

Accelerator-based particle physics experiments (C)/0174 G2.04

CMS muon reconstruction and identification performance of 2017 data

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Abstract :

The performance of CMS muon system is crucial for many physics results in CMS. Before 2017 data taking, many upgrades affecting muon performance have been carried out such as the installation of new pixel detector and the development of new algorithm in muon high-level trigger, compared to the 2016 operation. The performance of CMS muon reconstruction and identification has been studied based on the data collected with the CMS detector at sqrt(s)=13 TeV with 2017 dataset. Muon reconstruction and identification efficiencies in both online and offline are measured using tag and probe method, and the results are compared to previous performance with 2016 dataset.

Accelerator-based particle physics experiments (C)/1102 G2.05

Search for Heavy Stable Charged Particles with CMS RPC system in the upgrade scenario

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Abstract :

The CMS experiment is planing upgrade of muon system to operate in very high luminosity (7*10^34 cm^-2 s^-1) of the HL-LHC. New improved RPC detectors will be installed to extend up to eta<2.4, also existing RPC detectors are planned to be equipped with new electronics. Precise timing measurement can be achieved with the upgrade, time resolution at the order of 1-2 ns is expected in the single hit level with our baseline design. The precise timing of new RPC system opens physics potentials. We studied possible improvement to search for Heavy Stable Charged Particles (HSCPs) using the Time of Flight (TOF) technique. Trigger algorithms using the RPC TOF technique is designed and studied. The study shows that our trigger algorithm can recover inefficiency of reguar muon triggers in v < 0.7c, up to 90% of efficiency.

Particle physics theory(A)/1060 G2.06

Spectral Decomposition of Missing Transverse Energy at Hadron Colliders

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Abstract :

A spectral decomposition is proposed as a systematic method to extract information of dark sector at hadron colliders. We consider the decomposition of a missing transverse energy distribution with the K"all'en-Lehmann spectral density, which corresponds to a dark matter invariant mass distribution. This method allows us to identify dark matter production mechanisms at hadron colliders.

Particle physics theory(A)/0884 G2.07

The many signatures of composite Higgs models

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Abstract :

Composite Higgs models provide a potential solution to the hierarchy poblem of the Standard Model. The Higgs is realized as a composite pseudo-Nambu-Goldstone boson (PNGB) of a strongly coupled sector. We show that ultra-violet embeddings of the composite Higgs paradigm -- in which the undelying strong dynamics is specified -- predict the presence of additional PNGBs beyond the Higgs. These new resonances are expected to be lighter than other bound states of the strong sector (top-partners, vector and scalar resonances). We discuss the implications for LHC phenomenology of these additional light states in isolation as well as in interplay with heavier resonances.

Particle physics theory(A)/1054 G2.08

Study of neutral Higgs boson pair production in the H(->bbar{b})H(->gammagamma) channel at the HL-LHC

Jung Chang[1,2], Kingman Cheung[2,3,4], Jae Sik Lee[*1,2,5], Chih-Ting Lu[4], Jubin Park[1,2,5]

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Abstract :

Higgs boson has been observed by the ATLAS and CMS experiments at the LHC. The next important step would be to measure precisely the nature of this particle. Among them the determination of the Higgs self-coupling is one of the urgent challenges that sheds light on the puzzle of electroweak symmetry breaking mechanism. We therefore study the neutral Higgs-boson pair production at the high luminosity LHC(HL-LHC). In particular, HL-LHC detector environments, namely, detector simulations are considered, and the expected significances about Higgs self coupling are evaluated. As a result, the Higgs boson self coupling is limited to some interval in confidence levels neglecting systematic uncertainties.

Astrophysics experiments/observations (B)/0578 G3.01

Operation the ISS-CREAM experiment and Performance of the Silicon Charge Detector in Space

Lee Jik[*1,2], Park Il Hung[1,2], JEONG Soomin[1,2], TAKEISHI Ryuji[1], Hong GiHan[1], CHOI Gwangho[1], KIM Sangwoo[1]

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Abstract :

The ISS-CREAM experiment was successfully launched to the International Space Station (ISS) in August 15, 2017. It was installed in Japanese Experiment Module-Exposed Facility of ISS and was turned on August 22. Its instruments including the Silicon Charge Detector have been undergoing various calibration and tuning processes since the turn-on. We will present the operation of the ISS-CREAM experiment and the performance of the Silicon Charge Detector in space.

Astrophysics experiments/observations (B)/0460 G3.02

Status of Top and Bottom Counting Detectors of ISS-CREAM Experiment at The International Space Station

KANG Sinchul[1], KIM Hongjoo[*1], PARK H.[1], JEON H.B.[1], HYUN H.J.[2], HWANG Y.S.[3], PARK J.M.[4]

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Abstract :

The Cosmic Ray Energetics And Mass (CREAM) at the International Space Station (ISS) is an experiment to study the origin, acceleration and propagation mechanism of high-energy cosmic rays. The ISS-CREAM instrument was launched on the 14th of August 2017 to the ISS aboard a SpaceX Dragon spacecraft. The Top and Bottom Counting Detectors (TCD/BCD) are one of the detectors of the ISS-CREAM instrument. TCD/BCD are designed to separate electrons from protons for studying electron and gamma-ray physics. In this presentation, we present the status of the TCD/BCD at the ISS.

Astrophysics experiments/observations (B)/1163 G3.03

Korean contribution to Telescope Array x4 experiment for understanding of UHECR

정수민[*1], 박일흥 [1], 정효민 [1], 이광호 [1], 천병구 [2], 김항배 [2], Sagawa Hiroyuki[3]

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Abstract :

The Telescope Array experiment measures the properties of ultra high energy cosmic ray induced extensive air showers by determining the energy spectrum and chemical composition of the primary particles. The origin and mechanism of ultra high energy cosmic ray is one of century puzzles. To confirm the hotspot and search other candidates, TAx4 experiments is now under construction by building larger number of surface detectors. We will briefly report here the status of our Korean role in TAx4.

Astrophysics(L)/0891 G3.04

Solar Atmospheric Neutrino Searches with IceCube Neutrino Telescope

Seongjin In[*1], Carsten Rott[1]

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Abstract :

The Sun is well understood through variety of observations with different astrophysical messenger particles. Solar magnetic fields and cosmic ray transport in the inner solar system is still subject to intense studies. Solar atmospheric neutrinos could help to understand these effects but have never been observed. These energetic neutrinos are expected to be produced by interactions between cosmic rays and the solar atmosphere. IceCube has unique opportunity to observe these particles. We have obtained discovery potentials for the several theoretical models of solar atmospheric neutrinos in IceCube. We present an analysis method and sensitivity for solar atmospheric neutrinos.

Astrophysics experiments/observations (B)/1142 G3.05

Heavy decaying dark matter search with the IceCube Neutrino Telescope

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Abstract :

In many theories predicting heavy dark matter particles, the dark matter particles are not stable. They are predicted to decay into various standard model particles. Neutrinos from such decays could reach the Earth unattenuated and be observed by neutrino telescopes. This makes the IceCube detector, the world's largest neutrino telescope, uniquely to search for heavy decaying dark matter. In this presentation the latest results from a dedicated IceCube analysis looking for such a signal will be presented. The nonobservation of a dark matter signals allows the analysis to set the best experimental lifetime limits for dark matter particles above 100 TeV in various decay channels.

Astrophysics experiments/observations (B)/0251 G3.06

Platform Nodal Analysis of Superconducting Low-frequency Gravitational-wave Telescope

KANG Gungwon[1], AHN Sang-Hyeon[2], BAE Yeong-Bok[2], KIM Chunglee[2], KIM Whansun[3], OH John J.[3], OH Sang Hoon[3], PARK Chan[1], SON Edwin J.[3], JEONG Minjoong[*1], NORTON Ronald S.[4], PAIK Ho Jung[4]

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Abstract :

SLGT (Superconducting Low-frequency Gravitational-wave Telescope) platform has three arms whose ends support six superconducting test masses. Therefore, any motion of the platform could cause noises on measuring the displacements of test masses which contain the effect of gravitational waves passing by. Thermal motions of the platform are the main noise source, and are related to resonant motions of the platform structure. We briefly report preliminary results of nodal analysis in finite element method performed for various platform configurations including 2-m, 30-m, 50-m and 100-m arm lengths. Platform designs giving resonant frequencies outside of the signal bandwidth (*e.g.,* 0.1~10 Hz) have been identified.

Astrophysics experiments/observations (B)/0825 G3.07

Cosmology with Deep Lens Survey using galaxy clustering and galaxy-mass correlation

윤미진[*1], 지명국 [1], Tony Tyson[2]

[1] 연세대학교, 천문우주학과, [2]University of California, Davis, Department of Physics

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Abstract :

The large scale structure of the universe contains information on the initial conditions of our universe. Since galaxies are biased tracers of the dark matter distribution, their spatial clustering signal alone cannot constrain cosmological parameters. In this study, we overcome this limitaion by using gravitational weak lensing. We successfully measured subtle distortions of background galaxies by foreground lens galaxies and quantified the galaxy-mass correlation. This enables us to constrain both the matter density and its power spectrum normalization. Our results are in good agreement with the recent Planck CMB results without suggesting any tension between early and late time universe.

Astrophysics experiments/observations (B)/0410 G3.08

Properties and Large-scale Environment of High-redshift Galaxy Clusters

이성국[*1], 임명신[1], 현민희[1], 박보미[2], 김재우[3], 김도형[1], 김용정[1]

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Abstract :

Galaxy cluster is the most massive, gravitationally bound system in the Universe. Therefore, study of these galaxy clusters can provide valuable constraints on cosmology, formation and evolution of large-scale structures, as well as the evolution of galaxies.

At local, majority of galaxies in the dense environment, such as galaxy cluster, are red and quiescent with little star-formation (SF) activity.

However, a different picture emerges as we go to high redshift: (1) there exist non-negligible fraction of galaxies still forming stars actively even in dense environment, and (2) there is a significant cluster-by-cluster variation in the SF properties, such as quiescent galaxy fraction.

In this presentation, we show the results of our study about the variation of quiescent galaxy fraction among high-redshift (z~1) galaxy clusters, based on the multi-object spectroscopic (MOS) observation with IMACS on the Magellan telescope.

Our main result is that galaxy clusters which are connected with significant large-scale structure (LSS), well beyond the cluster scale, are more active in their SF activity, i.e., the quiescent galaxy fraction for these clusters is lower compared to the clusters which are detached from LSS.

Relativistic heavy ion collisions(D)/1135 G4.01

Status of the measurement of electrons from beauty-hadron decays in pp collision at 13 TeV in ALICE

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Abstract :

Heavy quarks (charm and beauty), due to their large masses exceeding the QCD parameter, are produced via hard scatterings in early stage of heavy-ion collisions, compared to the formation time of the Quark-Gluon Plasma (QGP). Due to their long life time, heavy quarks can experience the full evolution of the system created by such collisions. Therefore, heavy quarks are natural probe of the QGP. By separating beauty quarks from charm quarks, the mass dependence of the parton energy loss in the QGP can be studied. To quantify medium effects in heavy ion collisions, measurements in pp collisions are essential as a reference. In addition, the measurements of beauty production in pp collisions can be tests for perturbative QCD calculations. Long lifetime of the beauty hadrons leads larger impact parameter of decay products from beauty-hadron. Thanks to excellent vertex and impact parameter resolution of ITS and electron-identification capability provided by TPC and TOF in the ALICE experimental setup, measurements of beauty production in pp, p-Pb and Pb-Pb collisions were done via electrons from semi-leptonic decays of beauty hadrons. We will present the current status of the measurements of beauty-decay electrons in pp collisions at $\sqrt{s_{NN}}$ = 13 TeV in ALICE.

Relativistic heavy ion collisions(D)/0750 G4.02

Transverse single spin asymmetry measurement of inclusive very forward neutron production in *p+p* collisions at sqrt[s]=510GeV

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Abstract :

One of main purposes in RHICf(RHIC forward) experiment is to measure transverse single spin asymmetry(A_N) of neutrons with high pseudo-rapidity generated in proton-proton collisions at sqrt[s]=510GeV. Interesting results of A_N for forward neutrons measured by Zero Degree Calorimeter(ZDC) and Shower Maximum Detector(SMD) at PHENIX have been reported at 62 GeV, 200GeV and 500GeV and dedicated in extending interaction models in soft QCD process. In RHICf experiment, by virtue of higher position resolution of RHICf EM calorimeter then SMD and convenience in detector position, we are able to measure A_N more precisely over wider *p*_T range(from 0.1 GeV/c to 1 GeV/c) than that of SMD at PHENIX. RHICf collaboration have completed data taking successfully for 5 days in 2017 June. In this talk, I will report completion of RHICf operation and analysis status for A_N of forward neutron.

Relativistic heavy ion collisions(D)/0701 G4.03

Elliptic flows of charmonia in heavy ion collisions

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Abstract :

We discuss elliptic flows of charmonium states by focusing on their formation from coalescence of charm and anticharm quark elliptic flows in a quark-gluon plasma. Starting from the studies on the measurements of elliptic flow for charmed hadrons, we investigate the dependence of charmonia elliptic flows on their constituent quark elliptic flows. We show that the production of charmonia by recombination of charm and anti-charm quarks from the quark-gluon plasma is closely related to the elliptic flows of charmonium states in heavy ion collisions.

Relativistic heavy ion collisions(D)/0506 G4.04

Improved measurement of very forward transverse single spin asymmetry for pi0 production in polarized p + p collisions at sqrt(s) = 510 GeV

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Abstract :

Transverse single spin asymmetries in very forward neutral particle productions have been measured by a new experiment (RHICf) in the STAR at Relativistic Heavy Ion Collider for polarized p + p collisions at sqrt(s) = 510 GeV. In order to measure them precisely, an electromagnetic calorimeter with high position resolution was installed 18 m away from the beam collision point at zero degree. The detector geometry and a dedicated beam polarization angle allowed a wide pT coverage of neutral particles from 0 to 1 GeV/c by keeping the maximum sensitivity to the spin asymmetry measurement. Since the production rate is much larger for the hadrons than pi0s within the detector acceptance, it was necessary to optimize a trigger condition to take the enough pi0s. The trigger system was also designed to enhance the pi0 yield relative to the single photon events which were another dominant background source. In this talk, a monitor system to convince the dedicated beam polarization direction and the Monte Carlo study to optimize the RHICf trigger system for effective pi0 measurement will be presented. Current analysis status and expected data quality of spin asymmetry of pi0 will also be described with the corresponding detector performance.

Relativistic heavy ion collisions(D)/0366 G4.05

Di-jet photoproduction in ultra-peripheral collisions in the CMS experiment

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Abstract :

Ultra-peripheral collisions (UPCs) of heavy ions involve long-range interactions at impact parameters larger than the sum of their radii. Therefore, the hadronic interactions are largely suppressed in UPC. Without any hadronic processes in UPC, the jets can yet be produced via some other ways, such as gamma-nucleus interactions. This presentation shows the first observation of the photonuclear jets analyzed by CMS at the LHC. The CMS experiment has excellent capabilities for the measurements of jets and charged tracks, which are advantageous for this analysis. The distribution of di-jet photoproduction variables in ultra-peripheral PbPb collisions using the data taken in 2015 will be presented.

Relativistic heavy ion collisions(D)/0354 G4.06

Mass Chip Test(MCT) and Outer Barrel Hybrid Integrated Circuit(OB HIC) Assembly Project for ALICE-ITS Upgrade

방혜선 [1], 권민재 [2], 권지연 [1], 김민정 [1], 박종한 [1], 박소영 [2], 엄종식 [2], 이상현 [2], 임봉휘 [2], 조소연 [1], 권민정 [1], 유인권 [*2], 윤진희 [1]

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Abstract :

대형 이온 충돌 실험(A Large Ion Collider Experiment, ALICE)에서는 중이온 충돌로 부터 생성될 것으로 예측되는 쿼크-글루온 플라즈마(Quark Gluon Plasma, QGP)를 관측하고 연구한다. ALICE 에서는 QGP 연구에 이용되는 낮은 횡방향 운동량 영역에서의 입자들의 정밀한 측정과, 입자 궤적의 위치분해능 및 수집 속도의 향상을 위해 내부 궤적 장치(Inner Tracking System, ITS) 업그레이드를 진행하는 중이다. 현재 ITS 에 사용할 최종버전의 앨리스 픽셀 칩(ALICE Pixel Detector, ALPIDE)의 개발이 완료되어 양산 단계에 진입했다. 현재 부산대학교와 인하대학교 팀이 공동으로 부산대에 있는 ALICIA(ALICE Integrated Circuit Inspection and Assembly) 장비를 이용하여 대량 칩 테스트(Mass Chip Test, MCT)와 복합집적회로 조립(Hybrid Integrated Circuit Assembly, HIC Assembly) 을 진행하는 중이다. 2017 년부터 2020 년까지 계획 된 이 프로젝트에서는 전체 6 만개의 ALPIDE Chip 의 50%에 해당하는 3 만개의 MCT 테스트와 전체의 20%인 406 개의 HIC Assembly 를 진행하고 있다. 본 발표에서는 ITS Upgrade 에 대해 참여중인 부산대-인하대 팀의 진행상황 및 MCT & HIC 에 대한 테스트 방법과 조립 제작 과정에 대해 소개할 예정이다.

Relativistic heavy ion collisions(D)/0249 G4.07

Plans for the elliptic flow of electrons from beauty hadron decays in PbPb collisions at $\sqrt{s_{NN}}$=5.02TeV with ALICE

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Abstract :

In ultra-relativistic heavy-ion collisions, heavy quarks are mainly produced via hard scattering in the early stages of such collisions. Due to their long life time, they can experience the full evolution of the system becoming a powerful tool to investigate hot and dense matter formed in such collisions. Because of their large masses, they can interact with medium differently than light quarks and gluons(Dead Cone effect) allowing to test various parton energy loss models and by separating beauty quarks from charm quarks, mass dependence of parton energy loss in the medium can be studied. One of the most important observables that is sensitive to the properties of this matter is the azimuthal distribution of particles in the plane perpendicular to the beam direction. The azimuthal distribution of particles can provide insight into collective expansion of the system and its equation of state. In this presentation, we will describe a method that can extract the elliptic flow v_2 of electrons from semi-leptonic decays of beauty hadrons step-by-step. The method is based on event plane and the fit of impact parameter distribution.

Relativistic heavy ion collisions(D)/0205 G4.08

Suppression of excited Υ states relative to the ground state in PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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Abstract :

The relative modifications of Υ mesons produced in pp and PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV have been studied by the CMS experiment with reconstructed dimuon decay channel. To quantify the effect of Quark-Gluon-Plasma, the double ratios, which are the ratios of the excited states (2S, 3S) with respect to the ground state (1S) in pp and PbPb, are measured. The upper limit calculation is used for Υ(3S), because the signal of Υ(3S) is too low to observe clearly in PbPb collisions, which indicates that Υ(3S) appears almost being melt at $\sqrt{s_{NN}}$ = 5.02 TeV, as expected from the sequential melting scenario. The results will be represented as functions of centrality, transverse momentum and rapidity.

Relativistic heavy ion collisions(D)/0180 G4.09

Constructing probability density function of net-proton multiplicity distributions using Pearson curve method

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Abstract :

The Pearson curve method is used to construct the probability density functions of net-proton multiplicity distributions from the Beam Energy Scan results of the first four cumulants of the STAR experiment. For the first time, the 6th and 8th order cumulants of net-proton multiplicity distributions are estimated from the constructed probability density functions from 7.7 GeV to 200 GeV. The transverse momentum dependence of the ratio of 6th and 8th order cumulants to 2nd order cumulants are also discussed. This method provides a unique opportunity to study the O(4) criticality near the chiral crossover transition and estimating the higher-order cumulants. It is also shown the usefulness of Pearson curve method to determine the probability density function uniquely of an experimental data if the first four cumulants are given.

단광자원 효율 증대를 위한 위치 제어 가능한 단일 피라미드 양자점 마이크로 공정 연구

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Abstract :

반도체기반의 양자점은 전류주입을 통한 구동이 가능하며 공진기, 도파로 등의 광구조(Photonic structure)와 결합할 수 있는 단광자광원으로서, 양자통신 구현에 높은 가능성을 지니고 있어 각광 받고 있다. 그 중 III-V 족 직접천이형 화합물 반도체인 질화갈륨을 기반으로 하는 InGaN 양자점은 높은 엑시톤 결합 에너지로 상온 구동이 가능하며, 편광된 발광특성으로 양자통신에 응용하기 유용한 특징을 지닌다. 특히 유기 금속 화학 증착법 (MOCVD : Metal organic chemical vapor deposition)을 이용하여 선택적 영역 성장(Selective area growth)을 통한 피라미드 모양의 3 차원구조체의 꼭지점에 양자점을 형성 할 경우, 대량생산뿐만 아니라, 위치 제어 가능한 단광자원으로서 제작이 가능하다. 그러나, 피라미드의 꼭지점을 제외한 다른 영역에 형성된 양자선(Quantum wire) 및 양자우물 (Quantum well)은 배경신호(Background signal)로 작용하여, S/B (Signal to background) 비율을 낮추게 하는 주요 원인이 된다.

따라서 본 연구에서는 피라미드 구조 위에 형성된 양자점의 S/B 비율을 향상시킬 수 있는 효과적인 광구조(Photonic structure) 구현하기 위한 공정을 개발하였다. S/B 의 비율을 높이기 위해 보호막(Protect layer)을 피라미드 꼭지점에 선택적으로 증착하였고, 양자점을 제외한 영역을 물리적방법의 식각을 통하여 배경신호를 제거하였다. 따라서, 양자점을 제외한 양자선과 양자우물의 영역을 최소화하여, S/B 가 높아짐을 micro-photoluminescence 을 통해 확인하였다.

III-V compound semiconductors(C)/0795 G6.02

Synthesis and characterization of $Na_3GdV_2O_8$ phosphor materials

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Abstract :

Trivalent rare-earth ions (RE^{3+})-based phosphor-converted white-light emitting diodes have been marked to be one of the most lighting sources to solid-state lighting industry due to their high luminesce efficiency, low power consumption, long working life-time and eco-friendly characteristic as compared with those of conventional fluorescent lamps. Citrate-based sol-gel method is one of the finest synthetic methods to prepare the phosphor materials. The $Na_3GdV_2O_8$:RE^{3+} phosphors were synthesized by a citrate-based sol-gel method. The XRD patterns of the host lattice and RE^{3+} ions activated $Na_3GdV_2O_8$ phosphors confirmed the monoclinic phase. Field-emission scanning electron microscope images revealed agglomeration of microcrystalline morphology. Under ultra-violet excitations, their emission properties were investigated. Furthermore, temperature-dependent photoluminescence properties were studied for the optimized phosphor samples and exhibited excellent thermal stability with reliable activation energies.

III-V compound semiconductors(C)/0673 G6.03

Periodic metal nano-structure on GaAs substrate calculated by finite-difference time-domain method

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Abstract :

To achieve high power conversion efficiency for solar cell, many researchers approach the cell fabrication with various challenging method. As the attempt to improvement of solar cell, there is optical way utilizing the effect of localized surface plasmon resonance by using metal nano-structure because optical wavelength of solar cell has hundreds of nanometers for its major intensity by black body radiation. In this study, we simulated a periodic metal nano-structure to demonstrate the localized surface plasmon effect by using finite difference time domain (FDTD) method as a preliminary step of research on GaAs solar cell. Various metal nano-structures were examined with manually coded software using C language. We compared also our result with reported articles to see the effectiveness of simulation. In coding part of FDTD, light source was introduced by external way using scattering field/ total field method, and auxiliary field perfectly matched layer (PML) was used for minimization of boundary reflection of simulation field. To verify the proper propagation, hard point source was used. All data was sampled at each spatial point after stabilization of electromagnetic field.

III-V compound semiconductors(C)/0175 G6.04

The effects on defect generation during thermal and electrical stress in InAs MOS capacitor

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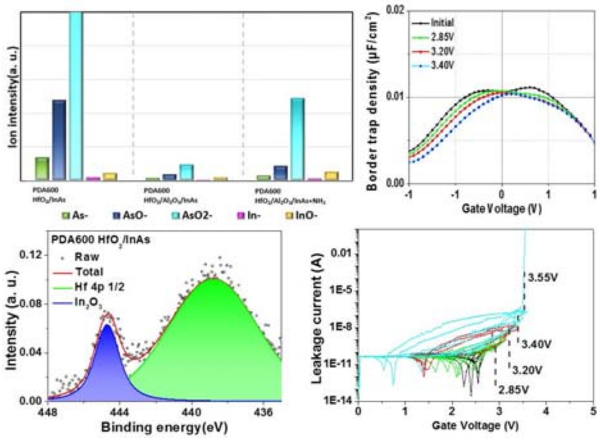
Abstract :



Defect analysis based on indium and arsenide diffusion within HfO_2 grown on InAs were investigated. The deposited HfO_2 on InAs at a temperature of 200°C was in an amorphous phase with low interfacial defect states. During post-deposition annealing (PDA) at 600°C, In–As bonding was dissociated and In and As diffused out to HfO_2 layer from InAs. Fortunately, we could control the diffusion by using 1nm thick Al_2O_3 passivation layer and control the trap density by using nitrogen doping process. To investigate the dissociation of InAs, we analyzed the ratio of elements on surface of oxide layer and the chemical states by using TOF-SIMS and XPS, respectively. We evaluated thermal and electrical stability for those samples through the change in trap density before and after PDA600 process and stress induced leakage current (SILC), respectively. In conclusion, we could attain following result: i.e., the passivation layer effectively improved the thermal and electrical stability, while nitrogen doping process does not. In addition, the results of DFT calculation show the possibility that the nitrogen incorporation could locally weaken some bonding, which could induce the degradation of device characteristics.

Elemental & group IV semiconductors(A)/0894 G6.05

Anisotropic thermoelectric properties of n-type $SnSe_2$ single crystal

PHAM Anh Tuan[1], VU Thi Hoa[1], CHO Sunglae[*1]

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Abstract :

Thermoelectric are perhaps the simplest technology for direct thermal to electric energy conversion. High ZT is a counter-indicated property of matter. Recently, the layered chalcogenides have attracted a lot of attention from the scientific community. They show promising thermoelectric properties. The tin diselenide ($SnSe_2$) layered crystals are also potential candidates for thermoelectric applications because of their high Seebeck coefficient and electrical conductivity. In this work, we have synthesized bulk $SnSe_2$ single crystal to investigate the thermoelectric properties. The Seebeck coefficient of $SnSe_2$ is negative in the whole temperature range, indicating n-type semiconducting behavior. The electron concentration at 300 K is about -10^{18} cm^{-3}. Highest power factor (PF) reached at 673 K along ab-plane directions. The thermoelectric performance along c-axis, however, reached the even highest value at same temperature due to extremely low thermal conductivity. Specific results will be discussed.

Elemental & group IV semiconductors(A)/0093 G6.06

First-principles study of nonisovalent Si_2AlP and Si_2ZnS alloys: Covalent, ionic, and mixed phases

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Abstract :

Obtaining optically active Si-based materials is a challenge that holds great potential for solar energy conversion with silicon. Of the progress that has been made in recent years, one of the promising methods is to make use of molecular precursors for the nonequilibrium growth of nonisovalent Si-III-V alloys such as Si_3AlP. In this presentation, we propose a new class of nonisovalent Si_2AlP (or Si_2ZnS) alloys in which the Al-P (or Zn-S) atomic chains are as densely packed as possible in the host Si matrix. As a hybrid of the lattice-matched parent phases, Si_2AlP (or Si_2ZnS) provides an ideal material system with tunable local chemical environments around Si atoms within the same composition and structural motif. Using hybrid functional calculations, we discuss how the local chemical orders affect the electronic and optical properties of the nonisovalent alloys. We also identify a direct-bandgap Si_2ZnS phase with strong absorption in the visible range [1].

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2016R1C1B2016046).

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II-VI compound semiconductors(B)/1158 G6.07

Magnetic field and polarization independence of time-resolved photoluminescence in ZnSe/CdS (core/shell) type-II quantum dots

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Abstract :

Type-II quantum dots (QDs) enable to control optical properties precisely by shell thickness, which is an important benefit to photonic device applications. We have synthesized ZnSe/CdS core/shell colloidal QDs, where the center-to-center distance ranges from 5 nm to 10 nm and the uniformity of QD separation was evaluated in terms of a Fourier-transformed TEM image. X-ray diffraction confirmed ZnSe cores are coated by CdSe shells, and energy dispersive X-ray analysis also confirm the homogeneity of constituent atoms. By increasing shell thickness from 1.5 nm and 5.5 nm, a broad absorption edge becomes significant resulting from electron separation from the core. The absorption edge spectrum is also consistent with the calculated energy levels. While type-I colloidal QDs show a magnetic field dependence, our ZnSe/CdS type-II QDs are nearly insensitive up to 5 T, where we found both the photoluminescence life time and the degree of polarization are nearly constant. Those results suggest that our type-II QDs have a large energy separation between bright and dark states with a small g-factor compared to those of type-I QD.

Focus: flexoelectricity/0656 G7.01

Controlled manipulation of oxygen vacancies using nanoscale flexoelectricity

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[1]Center for Correlated Electron Systems, Institute for Basic Science (IBS), Department of Physics and Astronomy, Seoul National University, [2]The Pennsylvania State University, Department of Materials Science and Engineering, [3]Oak Ridge National Laboratory, Center for Nanophase Materials Sciences, [4]Oak Ridge National Laboratory, Institute for Functional Imaging of Materials

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Abstract :

The lack of inversion symmetry, which spontaneously polarizes a medium, forms the basis of the two most celebrated dielectric phenomena in condensed matter physics–ferroelectricity and piezoelectricity. Due to the symmetry requirement, these phenomena are however restricted to the noncentrosymmetric materials. Nonetheless, the inversion symmetry in an otherwise centrosymmetric material can be lifted, when subject to an inhomogeneous strain field. This so-called flexoelectric effect, thereby, couples the strain-gradient to the induced polarization, and is allowed by all crystalline symmetries [1]. Despite being universal, unlike ferro/piezo-electricity, flexoelectricity has received much less attention. This is because of the difficulties involved in inducing large strain-gradient over a macroscale, inhibiting the generation of a sizable electrical polarization. However, since the strain-gradient inversely scales with dimension, this paradigm changes at the nanoscale, where flexoelectricity becomes strong enough to rival ferro/piezo-electricity. This allows the exploration and manipulation of numerous cross-coupled functionalities [2-5]. Accordingly, flexoelectricity is emerging as a topical field of research in nanostructured materials, especially in oxide thin films.

Moving a step forward, in this study we explored a new possibity–manipulation of oxygen vacancies in oxides using flexoelectric effect. Oxygen vacancies, especially their distribution, are directly coupled to the electromagnetic properties of oxides and related emergent functionalities that have implication in device applications. Using a homoepitaxial strontium titanate thin film, we demonstrate a controlled manipulation of the oxygen vacancy distribution using the mechanical force from a scanning probe microscope tip. By combining Kelvin probe force microscopy imaging and phase-field simulations, we show that oxygen vacancies can move under a stress-gradient-induced depolarization field. When tailored, this nanoscale flexoelectric effect enables a controlled spatial modulation. In motion, the scanning probe tip thereby deterministically reconfigures the spatial distribution of vacancies. The ability to locally manipulate oxygen vacancies on-demand provides a tool for the exploration of mesoscale quantum phenomena, and engineering multifunctional oxide devices [6].

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Focus: flexoelectricity/0241 G7.02

Nonlinear flexoelectricity in non-centrosymmetric systems

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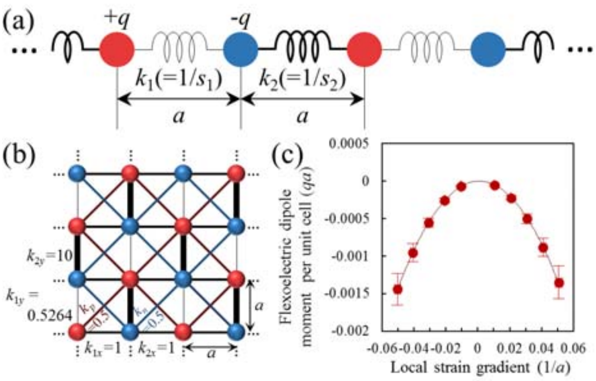
Abstract :

Flexoelectricity, the inducement of an electric polarization by strain gradients, is a ubiquitous electromechanical phenomenon inherent in all dielectric materials. Considering the crystal symmetry, the nonlinear flexoelectric phenomena can occur in the noncentrosymmetric materials such as ferroelectrics and piezoelectrics. We explore the elastic, dielectric, piezoelectric, and flexoelectric behaviors with respect to microscopic model parameters such as ionic positions and spring constants in the one- and two-dimensional ionic chain models. Monte Carlo simulation reveals that a difference in the given interaction strength via the diagonal springs, each of which connects the same cations or anions, is responsible for the linear flexoelectric effect in the model. We show the quadratic flexoelectric effect is present only in noncentrosymmetric systems and it can overwhelm the linear effect in feasibly large strain gradients. It can also be seen that the linear flexoelectric effect is suppressed by increasing the degree of inversion symmetry breaking due to rigid dipolar feature.



(a) One-dimensional ionic chain model.
(b) Noncentrosymmetric two-dimensional ionic square-lattice model with rocksalt type ionic arrangement.
(c) Flexoelectric dipole moment per unitcell

Focus: flexoelectricity/0130 G7.03

Enhanced Energy Harvesting via Flexoelectric Effect in Ferroelectric Nanostructures

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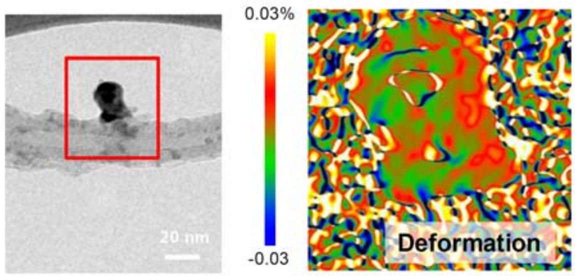
Abstract :

<PZT nanoparticle - CNT>



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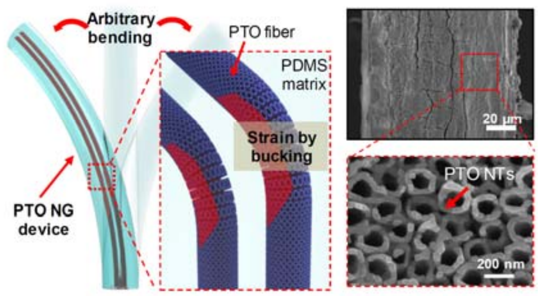

Nanogenerators (NGs) that harvest energy from mechanical vibration are an attractive area of energy environment fields. Recent, many recent researches have focused on flexible NG with the direct growth of a piezoelectrics on flexible materials such as a paper, a virus, a fiber, and a carbon nanotube. We report a successful growth of $Pb(Zr_x,Ti_{1-x})O_3$ (PZT) nanoparticles (NPs) interconnected with MWCNTs (PZT NPs-CNT) through injection method of sol-gel solution into a filter for squeezing them and annealing for crystallizing them. By periodic tapping movements, the open-circuit voltage and short-circuit current of the PZT NPs-CNT reaches about 8.6 V and 47 nA, respectively. Direct grown piezoelectric nanogenerators generate a higher voltage and current than that of simple blending PZT and CNTs, resulting from the stronger connection between PZT crystals and CNTs and an enhanced flexoelectric effect caused by the strain gradient. In addition, the fiber-type perovskite $PbTiO_3$ nanotubes (PTO NTs) array by hydrothermal method using TiO_2 NTs are reported. The method is easy, simple, and effective to realize the fiber-type NGs because they are not need the annealing process in high temperature. The PTO NTs with perovskite phase were well transformed from the TiO_2 NTs by hydrothermal method. We found that the NG measurements by using a PTO NTs/Ti core shell fiber exhibit a polarity property, output signals of 620 mV by periodic bending movements, and generation of output voltage regardless of the direction of the strain. This improvement in power generation property can be explained by the strain gradient that occurs as nanotubes with thin walls collide with each other. We will discuss the mechanism of power generation when the ferroelectric nanostructures are strained.

Dielectrics/Functional oxides(H)/0727 G7.04

Investigation of temperature-induced ferroelectric domain evolution in a strained $BiFeO_3$ thin film via second harmonic generation

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Abstract :

We investigate temperature-dependent evolutions of ferroelectric domain distributions in a strained $BiFeO_3$ thin film by using second harmonic generation technique. At room temperature, the azimuth-dependent SHG intensity has two maximal lobes at 45 and 225 degrees which reflect the Mc crystallographic phase. As the temperature increases up to above 400 K, we observed clear signatures of the Mc-Ma phase transitions; the SHG intensity exhibits an abrupt change, and the maximal SHG intensity appears at different azimuth angles being rotated by +90 or -90 degrees depending on the sample position. From the large-area mapping of the SHG intensity with a diffraction-limited spatial resolution, we found that the domain distribution undergoes a large change across the phase transition upon at the first heating run, but it remains almost the same even after the successive phase transitions in both cooling and heating runs. We discuss such domain evolutions appearing differently depending on the thermal cycles in terms of the formation of local chemical or mechanical defects which can prefer specific orientations of ferroelectric domains.

Dielectrics/Functional oxides(H)/0502 G7.05

Domain dynamics in ferroelectric vortices

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Abstract :

Ferroelectric domains are strongly dependent on structural characteristics and orientation of ferroelectric thin films is one of critical factor to determine the ferroelectric performance. Here, we exploit ferroelectric $PbTiO_3$ thin films with two different orientations, (001) and (111). Especially, we compared the (001)- and (111)-$PbTiO_3$ thin films in terms of ferroelectric performance; domain configurations and domain dynamics. In the (111)-$PbTiO_3$ thin films, three different domain states can be obtained resulting in various domain structure and it is investigated by second harmonic generation measurement. We used piezoresponse force microscopy to observe time-dependent piezoresponse images with poling process obtained by external bias. Because of three polarization states, ferroelectric vortex domains can be obtained in the (111)-$PbTiO_3$ thin films and it is decisive role to give different domain dynamics relative to that of the (001)-$PbTiO_3$ thin films. The dynamical change of the polarizations is given by random walk process in each of the thin film, however, rapid decay of the poled states was obtained in the (111)-$PbTiO_3$ thin films related to temporal dipole frustration at the domain boundary. With newly designed domain configuration, we can investigate various polarization states with possibility of vortex domain and different features in the domain dynamics in the ferroelectric thin films with regards to external electrical field.

Dielectrics/Functional oxides(H)/1083 G7.06

Electric-field induced modulation of oxygen vacancy in Ca doped bismuth ferrite

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Abstract :

Modulation of ionized oxygen vacancy has been significantly investigated because it influences local physical properties and functionalities in oxide materials. Inhomogeneous distribution of oxygen vacancy in resistive switching memory creates the local conducting paths or bulk conducting regions. Solid oxide fuel cell can transfer stored chemical energy to electrical energy with oxygen ions migration through electrolyte materials. Therefore, understanding the motion of oxygen vacancies is important to design effective oxide devices and enhance their functionalities. Ca-doped bismuth ferrite (Ca-BFO) is one of the promising oxide system to study the motion of oxygen vacancy. It contains large amounts of oxygen vacancies due to stabilization of the oxidation number of Fe^{3+} ion. Migration of oxygen vacancies using an external electric field results in the dark-colored hole doped region. In this study, we introduce a visualization of oxygen vacancy propagation through optical microscope during the electrical forming process. Tracing the color change of Ca-BFO films can quantify their thermodynamic variables. In-situ current measurement and X-ray diffraction can elucidate an evolution of electrical conductivity and a structural transition with respect to the concentration of oxygen vacancy.

Magnetism(A)/0114 G8.02

Room-temperature ferromagnetism from array of asymmetric zigzag edge nanoribbon in graphene junction

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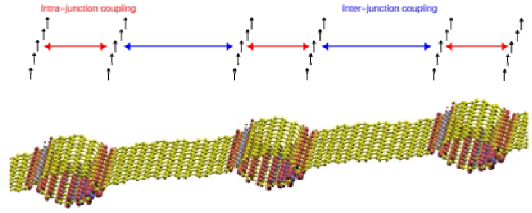
Abstract :



Electron spins in single–double–single layer graphen junctions are ferromagnetically coupled along the grain boundary and between junctions.
The estimated Curie temperature is well–above room temperature.

Room-temperature ferromagnetism in defected graphene layers has been measured in recent experiments. In spite of skeptical viewpoint on the intrinsic origin of the carbon magnetism, experimental evidences of paramagnetism or ferromagnetism have been suggested in the literature in these decades. However, convincing theoretical explanations have not been suggested yet. In this work, based on density functional theory calculations, we suggest a plausible explanation of this phenomenon as observed at the zigzag grain boundaries of a mismatched single-double-single-layer graphene junction. We found asymmetric zigzag edge graphene nanoribbons, which have ferromagnetic correlations in the graphene junction structure. While the two ferromagnetic asymmetric zigzag graphene nanoribbon show antiferromagnetic coupling in defect-free structure at the grain boundary, the vacancy or N substitutional defect structure is found to destroy magnetism on one side whereas, on the other side, a ferromagnetic nanoribbon with large exchange
coupling remains. The ferromagnetic nanoribbon in the junction can have ferromagnetic correlations with other nanoribbons in two-dimensional array of the junctions resulting well-above room temperature Curie temperature. Moreover, the ferromagnetic correlation can be sustained regardless of arrangement of magnetic layer maximizing possibility of ferromagnetic ordering in the array of graphene junction.

Magnetism(A)/0605 G8.03

3 차원 위상절연체 Ce-doped Bi_2Se_3의 각분해 광전자 분광 연구

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Abstract :

3 차원 위상절연체 (Topological insulator: TI)란 물질 내부 bulk 는 에너지 갭을 가진 절연체이나 표면에서는 에너지 갭이 없는 금속 상태를 가지는 물질들이다. 대표적인 3 차원 TI 물질로 Sb_2Te_3, Bi_2Te_3, Bi_2Se_3 와 같은 물질들이 있으며, 그 중 Bi_2Se_3 는 특히 매우 큰 bulk 띠 갭과 표면 상태에서 간단한 디락 원뿔 (Dirac cone) 모양의 띠를 가지는 물질로 최근 많은 연구가 되고 있다. Bi_2Se_3 의 결정 구조는 다섯 개의 층이 쌓여 있는 구조로 세 개의 Se 층 사이에 두 개의 Bi 층이 번갈아 존재하고 있다. 이전 연구에 의하면 Bi_2Se_3 의 디락 점 (Dirac point) 이 ~ 0.3 eV 근처에 존재하며, 디락 점 근처 bulk 가전자 띠 (bulk valence band) 와 표면 상태 띠 (surface-state band) 사이의 에너지 갭은 보이지 않는다. 그런데 Bi^{3+} 자리에 Fe^{2+}의 자성 불순물이 치환되면 디락 점 근처에서 에너지 갭이 생긴다고 보고된 바 있다. [1] 그러나 여기서는 2 가 (2+) 이온이 치환 되었으므로 자성 불순물이 치환될 때 전하 운반자 (charge carrier)도 동시에 함께 도핑이 되기 때문에 자기 질서 (magnetic ordering) 효과만을 관찰하기는 힘든 문제점이 있다. 따라서 Bi^{3+} 대신 3 가 (3+) 물질인 Ce^{3+} 나 Gd^{3+} 와 같은 3 가 (3+) 희토류 이온을 치환한다면 위와 같은 문제를 해결할 수 있을 것으로 예상된다. [2] 이 연구에서는 Bi_2Se_3 의 Bi 대신 Ce 희토류 원소가 치환된 $(Bi_{2-x}Ce_x)Se_3$ (x=0.02, 0.06, 0.12) 를 대상으로 방사광 각분해 광전자 분광법 (angle resolved photoemission spectroscopy: ARPES) 실험을 수행하여 이들의 전자 구조를 연구하였다. 페르미 면 (Fermi Surface)과 띠구조 (band structures) 를 측정함으로써 치환량에 따른 페르미 면의 변화와 디락 점 근처의 변화를 관찰하였다. 이 발표에서는 $(Bi_{2-x}Ce_x)Se_3$ 에서 Ce 치환에 따른 전자 구조의 역할에 관하여 논의할 예정이다.

[1] Y. L. Chen et al., Science 329, 659 (2010).

[2] S. W. Kim, et al., Appl. Phys. Lett. 106, 252401 (2015).

Magnetism(A)/0846 G8.04

Current-controlled magnetization using interfacial localizations in complex oxide heterostructure

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Abstract :

An electrical manipulation of magnetism has been an exciting research area due to its better efficiency than control by magnetic field. Various approaches to reverse the polarity of magnetization by means of local electric fields and currents have been tried to achieve the efficient electrical manipulation of magnetism. Especially, complex oxides offer huge changes in magnetism via electrical manipulations since it has strong correlations between spin, charge, orbital degrees of freedoms. There are several interesting examples of electrical control of magnetism; multiferroic materials using magnetoelectric coupling, heterostructure composed of ferromagnetic and ferroelectric layers using interfacial exchange bias, and interfacial strain, and superlattice exhibiting magnetoelectric behavior but sole composed of non-ferroic layers using interfacial charge transfer and lattice distortion. As shown in the above examples, the interfaces between dissimilar layers are a kind of reservoir containing a potential of various coupled phenomena. Here, we report a new type of controlling magnetization by current using the interfacial localization induced magnetoelectric coupling. The interfacial localization driven ME coupling is found in a tunnel magnetoresistance (TMR) structure, an antiferromagnetic and insulating layer sandwiched by two ferromagnetic (FM) metallic layers, [SrRuO3/CaMnO3/SrRuO3] and [SrRuO3/Pr0.5Ca0.5MnO3/SrRuO3]. A large coercive field in the trilayer, pinning effect in the AFM layer, a charge transport at the interface between FM SrRuO3 and insulating manganite, an induced FM behavior in the antiferromagnetic (AFM) manganite layer have been reported [1]. The above mentioned behaviors happen below Curie temperature of ferromagnetic SrRuO3. Further below the Curie temperature, here, we found current-dependent coercivity manipulated by cross weak localization (WL) to weak anti-localization (WAL) behaviors. We propose a new mechanism for interface-based control of magnetism in complex oxides which is based on tuning interfacial localizations by applying a current. It is a new type of method for the magnetization by electrical way.

[1] J.W. Seo, W. Prellier, P. Padhan, P. Boullay, J.Y. Kim, H. Lee, C.D. Batista, I. Martin, E.E. Chia, T. Wu, B.G. Cho, C. Panagopoulos, Tunable magnetic interaction at the atomic scale in oxide heterostructures, Phys Rev Lett, 105 (2010) 167206.

Magnetism(A)/1210 G8.05

Ga-substitution effects on spin-waves in hexagonal $RMnO_3$ (R= Y, Ho) systems

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Abstract :

We present a study of nonmagnetic-ion substitution effects on the spin-wave scattering in the hexagonal manganite $HoMn_{1?x}Ga_xO_3$ (x=0, 0.05, 0.10) thin films and $YMn_{1?x}Ga_xO_3$ (x=0, 0.02, 0.05, 0.10) single crystals through Raman spectroscopy. By nonmagnetic Ga-ion substitution, the spin-wave energy is not affected, while the spin-wave intensity is significantly reduced in $HoMn_{1?x}Ga_xO_3$: ~ 50% intensity drop with 10% Ga doping. Our results suggest that the spin-wave in hexagonal $HoMn_{1?x}Ga_xO_3$ thin films could only be excited in the Mn-Mn plane. The spin-wave energy is still determined by the intrinsic Mn-Mn spin interaction; while the spin-wave intensity is affected by not only Ga concentration, but also by the network of the Mn^{3+} sublattice. We extended our investigation to $YMn_{1?x}Ga_xO_3$ single crystals for Y^{3+} does not have any 4f electrons unlike Ho^{3+}. Our results suggest that the effect of the nonmagnetic Ga-ion substitution on the spin-wave scattering is limited to the near neighbors of Mn^{3+} ions, i.e., very much localized to the neighbors.

Magnetism(A)/0418 G8.06

Growth of epitaxial FeNi thin films on Al_2O_3 substrates

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Abstract :

FeNi thin films have been extensively used in practical device applications due to their higher magnetic moment and low magnetostriction.They are widely used as magnetic data storage technologies: the soft underlayer for perpendicular recording media, sensor element in magnetoresistive playback heads and in magnetic random access memories. From the application point of view atomically smooth and highly oriented film structure is desired in most cases. In this study, (111) FeNi films were grown epitaxially on (0001) Al_2O_3 substrates by radio frequency magnetron sputtering. The films were grown by varying substrate temperatures in the range from room temperature (RT) to 400˚C. The films were found to be crystallized at 300˚C or higher. Magnetic measurements were performed by a vibrating sample magnetometer at room temperature. The coercivity (H_c) and saturation magnetization (M_s) values of the films increase upon increasing the growth temperature from RT (H_c= 30 Oe and M_s = 480 emu/cc) to ~400˚C (H_c = 335 Oe and M_s=1370 emu/cc) due to crystallographic and shape anisotropy induced by high temperature processing. Additionally, we performed a thickness dependent study and observed that, at the initial stage, the film growth is strongly affected by the nucleation process leading to higher roughness. But with further increase in thickness the roughness decreases due to smoothening mechanism possibly due to surface diffusion. Surface roughness of the samples grown for the period of 5, 10 and 20 mins are 12Å, 8.2Å and 7.8Å respectively obtained from atomic force microscope. Structural parameters of the samples such as thickness, roughness and electron scattering length density were also obtained from x-ray reflectometry fitting. With increase in growth time from 5 min to 20 minute at 400 °C, the saturation magnetization of FeNi does not change significantly, however coercivity decreases from 335 Oe (for 5 min. grown sample) to 25 Oe (for 20 min. grown sample). This research was supported by BK21 Plus program (the Center for Creative Next-Generation Physicists) Pusan National University and the Basic Science Research Program through the NRF funded by the Ministry of Education (NRF-2015R1D1A1A02062175).

Magnetism(A)/0353 G8.07

Thickness driven spin reorientation of epitaxial $LaCrO_3$ films

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Abstract :

Bulk $LaCrO_3$ (LCO) has been known as the G-type antiferromagnet (AFM) and its Neel temperature (T_N) is approximately 290 K. We have investigated magnetic properties of LCO films in a strained single crystalline form. Fully strained LCO films were epitaxially grown on $SrTiO_3$(001) single crystals. Using Cr $L_{2,3}$ edge X-ray magnetic linear dichroism (LD), the films showed magnetic ordering with the T_N around 280 K. LD intensity was found to change its sign with varying thickness, which indicates that spin axis filps from the out-of-plane to the in-plane direction in films as the thickness increases. We suggest that spin reorientation in LCO films occurs due to the decreasing contribution of the surface magnetic anistropy (K_S) with increasing thickness.

Magnetism(A)/1143 G8.08

Effect of grain size on magnetoresistance of Pt/Fe_3O_4 thin films

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Abstract :

Polycrystalline Fe_3O_4 thin films have been extensively studied due to the role of natural grain sizes and grain boundaries, which govern magnetic and electrical properties of Fe_3O_4 thin films. A new type of angle-dependent magnetoresistance (ADMR), the so-called spin Hall magnetoresistance effect (SMR) was recently discovered at the interface of Pt/Fe_3O_4 bilayer [1]. The origin of the SMR has been a controversial issue, where the theoretical models were developed based on intrinsic or extrinsic contributions to explain this effect. Investigation of the effect of Fe_3O_4 grain sizes (or density of grain boundaries) on magnetoresistance in the Pt/Fe_3O_4 bilayers, could be important to get further insight into the mechanism of SMR.

In this work, we report magnetoresistance in Pt-Hall bar on the top of Fe_3O_4 thin films with different Fe_3O_4 grain sizes ranging from 10 nm to 100 nm, determined by atomic force microscopy. Our results show that a MR increases as grain sizes increase. We obtain MR of 0.1% for 100 nm of large grain sizes and 0.001% for 10 nm of small grain sizes. Our finding indicates that controlling the grain sizes to reduce grain boundary density play an important role in enhancing the SMR effect of Pt/Fe_3O_4 thin films.

[1] Z. Ding, B. L. Chen, J. H. Liang, J. Zhu, J. X. Li, and Y. Z. Wu, Phys. Rev. B **90**, 134424 (2014).

Magnetism(A)/0364 G8.09

Reinvestigation of magnetization dynamics in weakly canted antiferromagnet using terahertz magnetic pulse

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Abstract :

Ultrafast manipulation of magnetization in antiferromagnetic oxide has been archived intensively through terahertz magnetic pulse for applications of antiferromagnetic spintronics. So far, while the inertia-driven switching has been known as general mechanism, accurate equation of motion and rigorous interpretation should be necessary. Here, we re-investigate switching process, triggered by the strict phase matching between effective driving torque, d***h***/dt, and antiferromagnetic order parameters, ***l***. Our analytical results enable us to estimate the magnetic parameters of canted antiferromagnets including Dzyaloshinskii–Moriya (DM) interaction. Finally, we measure successfully static parameters, such as exchange, DM, and anisotropy energies, from magnetization trajectories of $YFeO_3$, using terahertz time-domain spectroscopy.

Strongly correlated systems(B)/1153 G9.01

Anomalous phase shift in the coherent phonon oscillation across the magnetic ordering of Ca_2RuO_4

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Abstract :

We utilized near-infrared femtosecond pulses to investigate coherent phonon oscillations of single crystalline Ca_2RuO_4. The lowest coherent A_g phonon oscillation changes abruptly its amplitude and especially oscillation-*phase* as the spin order develops. The anomalous shift of the oscillation-*phase* of 90 degrees across the Neel temperature has been firstly observed without any apparent structural distortion, and this cannot be understood by the conventional generation mechanism of coherent phonon oscillation in reflectivity. Our density functional theory calculation figured out eigenmode of the oscillation, and confirmed that the mode exhibits strong spin-phonon coupling in the magnetic ordered state of Ca_2RuO_4. Accordingly, the oscillation-*phase* sensitive observation provides unique aspects of coherent phonon oscillations as another evident features of spin-lattice interactions in Mott physics.

Strongly correlated systems(B)/0872 G9.02

Non-zero Berry phase and anomaly in Hall resistivity on GdB4 : a new type of a magnetic semimetal with nontrivial topology

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Abstract :

Electrical transport measurements were performed on high-quality GdB4 single crystal with high residual resistivity ratio (RRR) > 300 under applying magnetic fields up to 14 T. In the absence of magnetic field, the temperaturedependent electrical resistivity ρ(T) shows a metallic behavior with antiferromagnetic and hidden transitions at TN = 43 K and Tt = 6 K, respectively. With increasing magnetic fields, this metallic behavior turns into a seemingly “insulating” one with saturation at Tt < 6 K, which indicates partial gapping of the Fermi surface. At Tt < 6 K, evidences for a topologically non-trivial metallic state are found, such as extremely large magneto-resistance (73,000 % at 2 K, 9 T), non-zero Berry phase, anomalous contribution in Hall resistivity, and negative longitudinal magnetoresistance (LMR). Here we argue that the anomalous contribution in Hall resistivity and non-zero Berry phase are manifestations of a topological metallic state realizable when either spin chirality in the real space or topological node in the k space exists. The observation of negative LMR with weak antilocalization whose origin is Adler-Bell-Jackiw anomaly further supports the former scenario.

Strongly correlated systems(B)/0863 G9.03

In-situ Electronic Structure Investigation for a Possible Surface Metallic State on a Surface of a Semiconducting $BaBiO_3$ Thin Film

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Abstract :

Experimental electronic structure investigations using *in-situ* technique has been a smoking-gun to study physical properties and emergent phenomena. Particularly, systems with thin-film geometry such as oxide heterostructures and superlattices can be good candidates. Combined thin film growth system and electron spectroscopy, one can experimentally determine electronic structures of a certain material system, which leads us to detailed understanding of physical properties of the system. In this presentation, I will present recent results from *in-situ* electronic structure investigation on $BaBiO_3$ (BBO). I adopted the combined system with pulsed laser deposition and micro angle-resolved photoemission spectroscopy for film fabrication and spectroscopic investigation.

I investigated the possibility of metallic surface states in a BBO film predicted in a density-functional-theory calculation. Using photoemission spectroscopy, I studied the emission-angle dependence of Ba 3*d* and Bi 4*f* core-level spectra, and determined that the BBO film is terminated by a BiO_2 layer. However, the predicted surface metallic state was not observed. Instead, surface states around –3.8 eV predicted by VGL were observed as confirmed by K deposition onto the surface.

Strongly correlated systems(B)/0567 G9.04

Microscopic observation of highly coherent 2D metallic behavior on disordered surface of metallic delafossite PdCrO2

정진오 [1], 옥종목 [2], 최형준 [3], 오세훈 [3], 장원준 [4], 이영훈 [1], 이성빈 [1], 김준성 [2], 이진환 [*1]

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Abstract :

The extraordinarily strong in-plane conductivity of metallic delafossites such as $PdCoO_2$ and $PdCrO_2$ and their possible origins have been subjects of considerable attentions. We performed Scanning Tunneling Microscopy/Spectroscopy (STM/STS) study on the cleaved surfaces of single crystal $PdCrO_2$. The CrO_2-terminated surface shows a 0.5 eV gap, which is consistent with Mott insulating state of CrO_2 layer. The Pd-terminated surface has metallic density of states and shows hexagon-shaped phase domains of Pd atoms displaced from their bulk-like Oxygen(O) on-top sites to O-O bridge sites. On the Pd-terminated surface, we observed incommensurate quasiparticle interferences with long coherence lengths due to Pd 5s band in the empty states, whereas strongly localized 4d electronic states on individual Pd atoms in the filled states. The extraordinarily long coherence length of the empty-state quasiparticle interferences that extends beyond multiple phase boundaries on Pd-terminated surface may be attributed to the coupling to the sqrt(3) by sqrt(3) R30° spin texture in the underlying CrO_2 layer and is consistent with the unusually high in-plane conductivity in this class of materials.

Strongly correlated systems(B)/0427 G9.05

Single ferroelectric transition of weak first-order in multiferroic hexagonal manganite $RMnO_3$

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Abstract :

Hexagonal manganite materials are multiferroic materials with two highly-dissimilar phase transitions: a ferroelectric transition (from $P6_3/mmc$ to $P6_3cm$) at a temperature as high as 1450 °C and an antiferromagnetic transition at T_N~75 K. Despite its critical relevance to the intriguing ferroelectric domain physics, the details of the ferroelectric transition are yet not well known to date primarily because of the ultra-high transition temperature. Here using high-resolution & high-temperature X-ray diffraction experiments we show that the ferroelectric transition is a single transition of weak first order and R-O_p displacement is the primary order parameter. This structural transition is then simultaneously accompanied by MnO_5 tilting and the subsequent development of polarization. Our work clarifies the question about the nature of the ferroelectric transition of hexagonal manganites, and shed light on the intriguing mechanism behind the domain physics of this material.

Strongly correlated systems(B)/0315 G9.06

Quantified Degeneracy and Metal-insulator Transition in first-principles study

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Abstract :

While degeneracy can play an important role in determining the material characteristics, e.g., metal-insulator transition, there is no well-defined way to quantify it in real materials having complicated band structure. In this presentation, we suggest a way to quantify the ‘effective degeneracy’ by introducing entropy-like terms. This new quantity well describes the electronic behaviors of the real materials, i.e., transition-metal oxides. DFT+*U* and +DMFT calculations of the 3*d* titanates, 4*d* ruthenates, and 5*d* iridates show that the ‘effective degeneracy' provides useful insight to understand these systems and their origin of metal-insulator transition.

Strongly correlated systems(B)/0311 G9.07

Electrical detection of surface state spin polarization of candidate topological Kondo insulator SmB_6

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Abstract :

SmB_6 is an example of Kondo insulator compound where hybridization between conduction and core band electron level induces a gap at low temperature. Recently this material system has emerged as a strong candidate for a realization of topologically nontrivial state of matter in strongly correlated system, the topological Kondo insulator, which can be novel platform for investigating interplay between nontrivial topology and correlation driven emergent phenomena in solid state system. While the property of surface conduction with bulk insulating nature at low temperature has been revealed through electronic transport measurement, until now, there has been no direct electronic transport measurement which shows spin momentum locking on the surface of SmB_6. In this presentation, I will discuss potentiometric spin voltage measurement performed on the surface of SmB_6 supporting chiral spin texture. Applied current, temperature and an external magnetic field dependence of the measured spin voltage are consistent with spin-momentum locking property, which can support that the surface state of SmB_6 is metallic surface with chiral spin texture which is a feature of a topological insulator.

Strongly correlated systems(B)/0035 G9.08

Giant thermal hysteresis in Verwey transition of single domain Fe_3O_4 nanoparticles

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Abstract :

Fe_3O_4, magnetite, has been studied widely to find the origin of Verwey transition, which is the complex mixture of four different degree of freedoms in a solid: spin, lattice, charge and orbital. How they couple and correlate with each other is an important question in field of strongly correlated electron system. Here we report, another unreported feature, that high stoichiometric Fe_3O_4 nanoparticles (NPs) have a giant thermal hysteresis of Verwey transition (ΔT_V), of which hysteresis width passes a maximum of 11 K. According to several experiments such as magnetization, nuclear magnetic resonance (NMR), x-ray diffraction (XRD) and resonant inelastic x-ray scattering (RIXS), we found that ΔT_V have a clear size dependence as same as that of coercivity (H_c) in typical ferromagnetic materials. Also, ΔT_V and H_c share the same critical size of 120 nm. We interpret it as a manifestation of charge and spin ordering correlation in a single domain. This work paves a new way of undertaking researches in the field of strongly correlated electron physics combined with nanoscience.

Strongly correlated systems(B)/1020 G9.09

Electron-lattice coupling in correlated materials of low electron occupancy

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Abstract :

In correlated materials including transition metal oxides, electronic properties and functionalities are modulated and enriched by couplings between the electron and lattice degrees of freedom. These couplings are controlled by external parameters such as chemical doping, pressure, magnetic and electric fields, and light irradiation. However, the electron-lattice coupling relies on orbital characters, i.e., symmetry and occupancy, of t_{2g} and e_g orbitals, so that a large electron-lattice coupling is limited to e_g electron system, whereas t_{2g} electron system exhibits an inherently weak coupling. Here, we design and demonstrate a strongly enhanced electron-lattice coupling in electron-doped $SrTiO_3$, that is, the t_{2g} electron system. In ultrathin films of electron-doped $SrTiO_3$ [i.e., $(La_{0.25}Sr_{0.75})TiO_3$], we reveal the strong electron-lattice-orbital coupling, which is manifested by extremely increased tetragonality and the corresponding metal-to-insulator transition. Our findings open the way of an active tuning of the charge-lattice-orbital coupling to obtain new functionalities relevant to emerging nanoelectronic devices.

Focus: 2D Material photonics/0517 G10.01

저차원 물질 포화 흡수체 기반 고출력 펨토초 전광섬유 레이저

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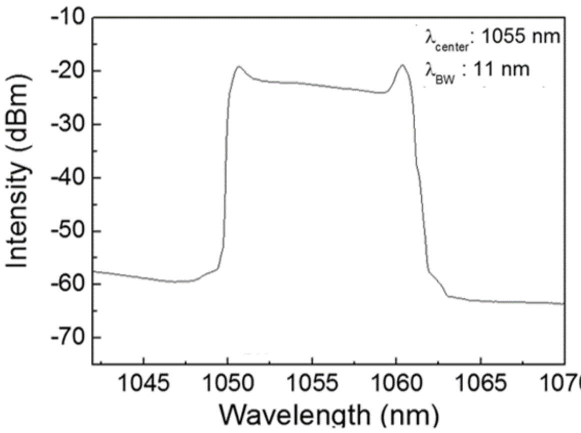
Abstract :



펨토초 전광섬유(all-fiber) 레이저는 광 정렬의 불 필요성 및 경제성 등의 장점과 광원의 소형화 및 경량화가 가능한 장점을 가지고 있다. 이러한 장점을 이용하여 극초단 펄스 전광섬유 레이저는 미세 전자 소자 비열 가공, 의료, 국방, 및 정밀 계측 분야 등 다양한 분야에 응용이 가능하다. 펨토초 광원을 구현하기 위하여 포화 흡수체를 이용한 수동 모드 잠금 방식이 이용되고 있다. 광섬유 레이저의 경우 상업적으로 판매되고 있는 반도체 기반 포화 흡수체인 SESAM (semiconductor saturable absorber mirror)이 널리 사용되고 있으나 최근 들어 저차원 물질인 그래핀, 탄소나노튜브, 및 위상 절연체 기반 포화 흡수체가 제안되고 있다. 특히 그래핀 및 탄소 나노 튜브는 높은 3 차 비선형 광학 특성을 가지고 있으며 낮은 삽입 손실을 가지고 있어 수동 모드 잠금을 위한 광 스위치 소자로써 적합하다.

본 연구에서는 비선형 물질-빛 간의 안정적인 소멸파 상호작용이 가능한 저차원 물질 기반 측면 연마 광섬유 포화 흡수체를 제작하였다. 또한 상부 클래딩 구조를 적용함으로써 광 소자의 비선형 광 특성을 향상 시켰다. 측면 연마 광섬유 타입 포화 흡수체는 상대적으로 긴 상호작용 길이, 낮은 삽입 손실 및 높은 손상 문턱 값을 가지고 있어 고출력 레이저 구현에 매우 적합한 광 소자이다. 제작한 고품질의 포화 흡수체를 이용하여 이터븀, 어븀, 툴륨 파장 대역에서 안정적으로 동작하는 높은 출력의 펨토초 전광섬유 레이저를 제작 하였다. 추가적으로 각 파장 대역에서 공진기의 분산 조건을 조절함으로써 레이저의 출력 특성을 향상시키고자 하였다.

아래 그림은 고성능의 그래핀 포화 흡수체를 이용하여 제작한 이터븀 파장 대역에서 동작하는 정상 분산 펨토초 전광섬유 레이저의 스펙트럼 특성을 보여주고 있다. 발진된 dissipative 솔리톤 펄스는 중심 파장 1055 nm 에서 선 폭 11 nm 의 스펙트럼 특성을 나타내고 있다. 측정된 펄스의 최대 평균 출력 값은 199 mW 이다. 측정된 펄스의 반복률은 27.6 MHz 이며 이를 이용하여 계산된 펄스 에너지는 7.2 nJ 이다. 측정된 펄스의 펄스 폭은 12.5 ps 로써 dissipative 솔리톤 펄스의 특징 중 하나인 선형 처프된 펄스가 구현된 것을 확인할 수 있었다. 추가적으로 선형 처프된 펄스를 격자 쌍을 이용하여 펄스 압축을 수행하였으며 측정된 펄스의 펄스 폭은 336 fs 이다. 예상되는 펄스의 첨두 출력 값은 20 kW 이다. 추가적으로 본 발표에서는 제작한 고품질의 포화 흡수체를 이용하여 안정적으로 동작하는 고출력 어븀 첨가 dissipative 솔리톤 전광섬유 레이저 및 6 nJ 의 펄스 에너지를 갖는 툴륨 첨가 솔리톤 전광섬유 레이저에 관하여 보고하고자 한다

Quantum electronics(D)/0572 G10.02

400W 급 고출력 탠덤 펌핑 Yb 광섬유 레이저 개발

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Abstract :

광섬유 레이저는 높은 효율, 우수한 빔질을 가지면서 소형화가 가능하고 유지보수가 뛰어난 장점을 갖고 있기 때문에 수 kW 급 고출력 레이저가 필요한 산업, 국방 등 많은 분야에서 사용되고 발전되어 왔다. 특히 이터븀(Ytterbium)이 첨가된 광섬유 레이저는 넓은 흡수 및 방출 스펙트럼, 작은 양자 결함(~10%), 긴 형광수명을 가지고 있기 때문에 고출력 연속 발진 레이저 시스템 제작에 유리하다. 그러나 이러한 장점에도 불구하고 수 kW 급 이상의 고출력 레이저는 비선형 문제와 열 문제로 인해 단일 광섬유에서 얻을 수 있는 출력에 한계가 있다. 열 문제를 해결하는 방법 중에서 양자 결함을 줄이는 탠덤 펌핑 방식이 최근 많은 연구가 이루어지고 있다. 이는 기존 900 nm 영역대의 다이오드 레이저를 직접 펌핑 광원으로 사용하는 것이 아닌 레이저의 방출 파장과 가까운 1010 ~ 1030 nm 의 광섬유 레이저를 펌핑 광원으로 사용하여 양자결함을 약 5% 까지 줄여 열문제를 효과적으로 줄이고 고출력 레이저 빔을 얻는 방식이다.

이에 본 연구에서는 탠덤 펌핑 용 고출력 광섬유 레이저 광원을 개발하고, 이를 여기광원으로 사용한 MOPA (Master Oscillator Power Amplifier) 구조의 광섬유 레이저 시스템을 제작하고 연구하였다. 씨앗 광원은 1080 nm 에 중심파장을 둔 공진기 구조로 제작하였고 최대출력 약 60 W 의 빔을 얻었다. 증폭단은 탠덤 펌핑 방식을 적용하여 구축하였고, 이때 사용한 펌프 광원은 개발한 광섬유 레이저 광원을 사용하였다. 펌프용 광섬유 레이저는 55 W 976 nm 다이오드 레이저와 코어직경 10 um Yb 광섬유를 사용하였고 1018 nm 에 중심파장을 둔 FBG pair 를 사용하여 공진기 구조로 제작하였으며, 1018 nm 에서 100 W 이상의 안정적인 발진을 하는 레이저 시스템을 얻었다. 동일한 구조의 펌프용 광섬유 레이저 5 대를 구성하여 증폭단의 Yb 광섬유를 펌핑하였다. 증폭단의 이득 광섬유로는 코어 30 um, 클래딩 250 um 의 코어/클래딩 면적 비율이 높은 이터븀이 첨가된 광섬유를 사용하였다. 이로부터 탠덤 펌핑한 광섬유 레이저의 출력 특성 및 효율 빔 특성을 보고하고자 한다.

Quantum electronics(D)/0569 G10.03

광섬유 기반 고출력 광대역 형광 광원 개발 및 특성 평가

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Abstract :

광대역 광원(Broadband light source)는 특정 파장 영역에서 수십 내지 수백 나노 미터 파장 범위의 빛을 내면서 짧은 결맞음 길이(low coherence)를 가지고 있는 광원으로 통신, 센서, OCT, 이미징, 백색 간섭계, 분광학 등 많은 분야에서 연구되었고 여러 현장에서 이미 사용되고 있다. 현재까지 개발되고 사용된 광대역 광원은 제논, 아르곤 등 가스 램프를 기반으로 한 광원과 다이오드 기반 광대역 광원(superluminescent diode)이 있는데 이들은 발산각이 크고 전송 손실이 크며, 출력이 상대적으로 낮다는 문제점 등이 있다. 이러한 기존 광대역 광원들의 한계를 넘기 위해 그 대안으로 제시되어 최근 많은 관심을 끌고 있는 것이 광섬유 기반 형광 광원(superfluoresecent fiber source)이다. 이 광원은 광섬유 이득 매질에서 자발 방출(spontaneous emission)에 의해 발생한 빛이 광섬유 내에서 증폭이 되어 증폭 자발 방출(amplified spontaneous emission)이 일어나 이 빛이 출력으로 나오는 광원으로 선폭이 수십 nm 이상으로 매우 넓을 뿐 아니라, 광섬유 코어를 전파하여 나오므로 빔의 공간적 특성 및 전파 특성이 광섬유 레이저빔의 특성과 일치하는 우수한 전파 특성을 가지고 있다. 출력 또한 수 W 에서 수백 W 고출력으로 확장가능하다고 알려져 있어 최근 여러 가지 연구가 이루어지고 있다. 본 연구에서는 광섬유 기반 고출력 형광 광원을 제작하고 그 특성을 보고하고자 한다. Yb 가 도핑된 광섬유를 사용하여 MOPA 시스템을 구축, 선폭이 100 nm 에 이르는 >20 W 급 고출력 연속발진 광대역 형광 광원을 생성하고 출력 특성 및 빔특성을 조사하였다. 그리고 형광 광원의 선폭에 따른 결맞음 길이를 측정하기 위하여 이론적 모델링과 함께 마이켈슨 간섭계를 사용하여 실제 결맞음 길이를 측정하고 그 결과를 보고할 것이다.

Quantum electronics(D)/0573 G10.04

툴륨 광섬유 레이저 펌핑 홀뮴 광섬유 레이저

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Abstract :

지난 수십 년 간 여러 가지 활성 이온이 첨가된 광섬유 레이저의 발전으로 인하여 다양한 파장 영역의 고출력 레이저가 넓은 분야에서 사용 되고 있다. 그 중에서 2 마이크로미터 영역의 레이저는 출력 및 빔 특성에 있어 지난 10 여년간 많은 발전이 이루어져 의료, 라이다, 분광학, 군사 등의 기존 응용 분야 뿐 아니라 플라스틱, 폴리머 소재 가공 등 산업체 응용 목적으로도 큰 기대를 받고 있다. 이를 위해 많이 사용되는 레이저 매질은 Tm 혹은 Ho 이 도핑된 매질로, 특히 이들 활성 이온들을 도핑한 광섬유 레이저는 고출력, 고효율, 좋은 빔특성 등으로 인해 많은 연구 개발이 이루어졌고 이미 많은 분야에서 사용되고 있다. 하지만 793 nm 다이오드 레이저로 효율적인 레이저 발진이 가능한 Tm 도핑 광섬유 레이저에 비해 Ho 도핑 광섬유 레이저는 펌핑에 적합한 고출력 다이오드레이저의 부재, 실리카 호스트의 높은 전파 손실, 낮은 손실의 고품질 광소자의 부재로 인해 많은 응용 분야에도 불구하고 연구 개발에 어려움이 많았는데, 최근 들어 이들 문제들이 많이 해결되어 2015 년에 >100 W 출력을 얻는데 성공한 후 활발한 연구가 이루어지고 있다. 특히 펌핑 광원으로 사용할 수 있는 고출력 Tm 광섬유 레이저의 본격적 상용화와 함께, 열 발생을 줄일 수 있는 in-band 펌핑 구조, Tm 광섬유 레이저로 펌핑할 수 있는 텐덤 펌핑 방식의 장점으로 인해 2 um 영역에서 고에너지 펄스 레이저를 얻을 수 있는 방식으로 큰 관심을 받고 있다.

본 연구에서는 회절 격자를 이용한 외부 피드백 공진기를 사용하여 파장 가변이 가능한 고출력 Tm 광섬유 레이저를 제작하고, 이를 이용하여 Ho 광섬유 레이저를 펌핑, 2.1 um 영역에서 고출력 레이저빔을 얻는 연구에 대해 보고할 것이다.

이 연구는 경찰청과 치안과학기술연구개발사업단 주관 치안과학기술연구개발사업(PA-B000001)과 한국연구재단 기초연구사업(No. NRF-2016R1A6A3A1193 2897)의 지원을 받아 수행된 연구임.

Optical technology(B)/0685 G10.05

Brillouin fiber ring laser with narrow linewidth based on a micro knot resonator

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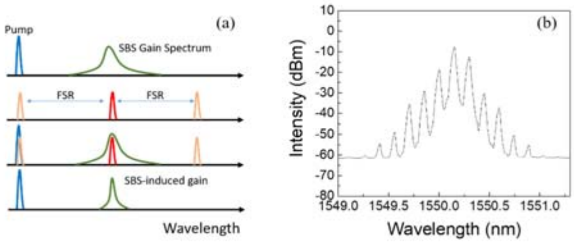
Abstract :



Narrow linewidth Brillouin lasers are used in a wide range of application, such as coherence communications, high resolution spectroscopy and sensor, due to their high coherence laser operation. For achieving the extremely narrow linewidth laser, laser need working on single longitudinal mode (SML) operation. Because of the long cavity of fiber laser, narrow mode spacing become an important issue limiting the SLM operation. Many approached have been introduced suppressing multi-mode to generate SLM fiber laser. The most popular technique is the use of fiber Bragg gratings (FBGs) and saturable absorber in the laser resonator. For example, SLM erbium-doped fiber ring laser based on high finesse FBGs Fabry–Pérot etalon, stable SML erbium-doped fiber laser with narrow linewidth utilizing parallel fiber ring resonator incorporating saturable absorber and FBGs, etc. Other techniques have also been demonstrated, such as emission narrow linewidth using an approximately 1 cm long erbium-doped waveguide channel, ultra-narrow linewidth laser based on Rayleigh scattering in non-uniform optical fiber. In this experiment, narrow linewidth Brillouin fiber ring laser based on micro knot resonator have been demonstrated. By matching the frequency of the phonon in Brillouin process with the optical mode spacing of the micro knot resonator, SLM can be generated in long cavity Brillouin fiber ring laser.

Optical technology(B)/0679 G10.06

Effect of extinction ratio of optical signal on coherence noise in phase optical time domain reflectometer

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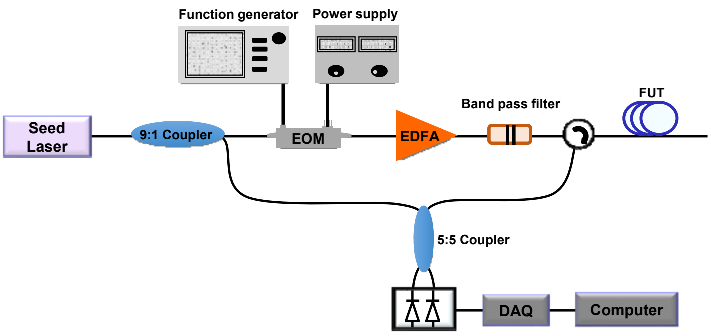
Abstract :



Phase optical time domain reflectometer(Phase-OTDR)은 광섬유를 기반으로 하는 분산형 음향 센서로 측정 광섬유 외부에서 가해지는 진동의 주파수를 측정하는 시스템이다. Phase-OTDR 에서 사용되는 펄스 레이저는 좁은 선폭의 연속파 레이저가 electro-optical modulator 를 통해 펄스를 생성하는 external modulation 방법을 사용하고, 부족한 파워는 EDFA 를 통해 증폭한다. 측정 광섬유 내부를 펄스가 통과하면서 발생하는 후방 레일라이 산란 신호의 위상 변화 관측을 통해 주파수를 측정한다. 높은 민감도와 장거리 측정이 가능하지만, 비선형성 효과, 광원의 frequency noise, 신호감지기의 white noise 등의 요소가 주파수 측정에 방해가 되기 때문에 Phase-OTDR 의 성능 향상을 위해서는 noise 의 원인 분석이 중요하다. 본 논문에서는 electro-optical modulator 에서 생성한 펄스의 extinction ratio 에 따라 발생하는 coherence noise 가 Phase-OTDR 의 신호에 미치는 영향을 분석할 것이다.

Optical technology(B)/0647 G10.07

감쇄 기반 Weak value amplification 을 이용한 높은 민감도를 가지는 광섬유 인장력 센서

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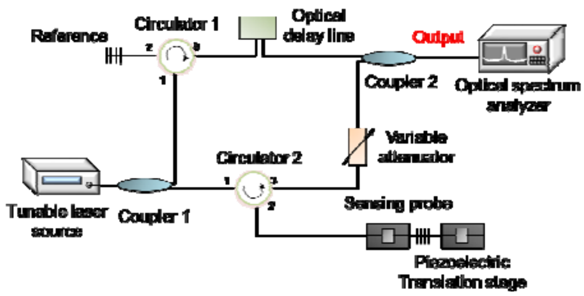
Abstract :

본 연구에서는 광 감쇄기를 이용하여 weak value amplfication 효과를 획득하여 광섬유 인장력 센서의 민감도 향상을 연구하였다. WVA 효과에 의한 amplification factor 는 광 감쇄기를 이용하여 제어할 수 있고, 최적화된 amplification factor 조건에서 인장력을 측정하여 WVA 효과가 적용되지 않은 광섬유 인장력 센서보다 민감도를 향상시켰다.



Optical technology(B)/0544 G10.08

양자폭포레이저 및 중적외선 분광 광학계 기반 ppb 급 고감도 암모니아 가스 검출 시스템 연구

Investigation on ammonia gas detection using mid-infrared spectroscopy with quantum cascade laser

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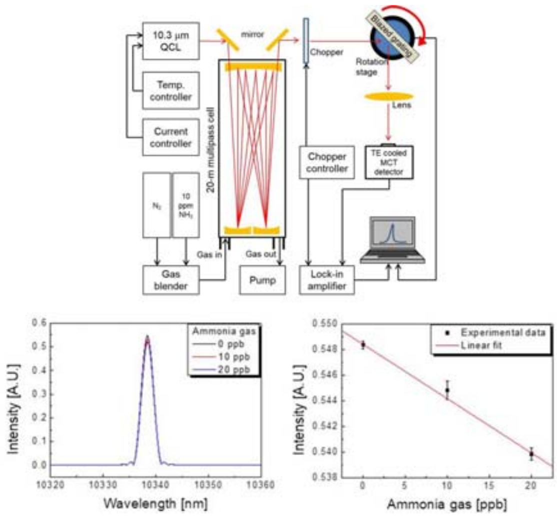
Abstract :



암모니아는 폭발물, 비료 및 산업용 냉각제 생산에 널리 사용되어 왔다. 대기 중 암모니아의 존재는 생태계에 잠재적인 위험을 초래한다. 이산화황(SO_2)과 질소 산화물(NO_x)을 통해 대기 중에 생성된 산의 상당 부분이 암모니아 증기로 변형 된다. 암모니아 가스는 소량만 흡입해도 급성 중독을 일으킬 수 있다. 때문에 암모니아 가스의 실시간 검출에 대한 연구는 계속적으로 진행 되어지고 있다. 최근에는 양자폭포레이저(quantum cascade laser, QCL)를 기반으로 한 고감도 가스 검출 시스템이 보고된 바 있다. 고감도 가스 검출 방법은 광 흡수 스펙트럼 분석을 이용한다. 암모니아 가스는 10.3 um 의 파장 부근에서 강한 흡수 스펙트럼을 형성하고 있다. 정확한 광 흡수율을 측정하기 위해서는 보다 정확한 파장에서의 광 흡수율을 측정해야 한다. 분광광학계 기반 가스 검출 시스템은 가스셀을 통해 가스와 반응한 광원을 grating 을 통해 분광 한 후 입사 각도를 조절하면서 파장정보에 따른 광 세기를 획득하는 방법을 사용하였다. 특정 가스의 파장별 광 투과율은 실험적 매개변수, 기압, 가스의 농도, 광 진행거리를 통해 분석이 가능하다. 본 논문에서는 10.3 um 부근의 파장을 포함하는 양자폭포레이저 및 중적외선 분광 광학계를 이용하여 파장에 따른 광 세기를 측정하여 암모니아 가스 농도를 실시간 측정 및 분석하였다.

Nuclear fusion(C)/0024 G11.01

The Behavior of in-vessel pressure gauge in the KSTAR plasma

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Abstract :

The in-vessel pressure gauge refers to a vacuum gauge installed inside a vacuum vessel of tokamak. The inside of the vacuum vessel in which the fusion reaction occurs have to discharge the impurities and ashes those generated as a byproduct of the fusion reaction to sustain efficient state. And the impurities and ashes of the plasma impinging on the divertor plate along the magnetic field are transformed into neutral gas and then exhausted. At this time, the divertor in contact with the high-temperature plasma experiences a enormous heat load and installs an in-vessel pressure gauge on the back of the diverter to analyze and control the incident amount of the particles impinging on the divertor. Although it is installed on the backside of the divertor, it requires a special design to overcome extreme noise caused by high temperature (~ 2000 ° C), high magnetic field (~ 4 Tesla), etc. IPP, Germany developed the ASDEX Pressure Gauge (APG), which is capable of operating under these conditions, and its operating principle is the same as that of a conventional hot cathode ionization gauge, but it is special in that it adopts a variable potential plate to overcome extreme noise. Using a variable potential, fast signal processing is required and the data is acquired from data reduction and averaging on Field Programmable Gate Array (FPGA). The KSTAR use APG as an in-vessel pressure gauge. In 2017 operation, 1 gauge on the P-port upper divertor and 2 gauges on the P-port lower divertor are installed. However, only 1 gauge installed on the upper is successfully operated. Depend upon KSTAR plasma operation scenario, the gauge shows different signal pattern and that is compared with those of plasma density, plasma current, heating powers, vacuum gauge, and D_α line. In particular, when entering the h-mode the gauge value saturates to a specific value, and it is necessary to study the physical interpretation and new application. Also to overcome this phenomenon it is necessary to study the new position of gauge.

Nuclear fusion(C)/0746 G11.02

Rejection of stray light in Thomson scattering measurements using polarization switched multiple roundtrip scheme for the incident optical pulse

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Abstract :

Background noise caused by stray light, the biggest noise in Thomson scattering measurements, is rejected by using a specially designed multiple roundtrip scheme for the incident optical pulse, which rotates the plane of polarization by a 90^{o} in each consecutive roundtrip. The Thomson scatting signal which is contaminated by background noise is measured when the polarization of the incident laser pulse is perpendicular to the plane containing the incident laser pulse and the optical axis of the detector, while the background is measured when the polarization is contained in the plane. It will be shown that better than 95% of background noise can be rejected by using our multiple roundtrip scheme.

National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2014M1A7A1A01029956).

Nuclear fusion(C)/0473 G11.03

Electromagnetic enhancement of residual stress with the parity change of the global ITG mode

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Abstract :

The impact of and electromagnetic (EM) fluctuations impact on residual stress is investigated by using linear global simulations. Five-field model is employed and solved in the BOUT++ framework to describe EM ion temperature gradient mode. Analyses in the context of the quasi-linear theory show that not only the conventional parallel residual stress but also the additional stress due to EM fluctuations strongly increase with plasma beta_e (=electron thermal energy/magnetic energy). As beta_e increases, the mode parity changes from even to odd for electric potential and vice versa for parallel velocity. However, the changing rate of electric potential is faster than that of parallel velocity. Thus, we identify that this discrepancy in parity change rate can lead to the strong enhancement of residual stress at high beta_e regime.

Nuclear fusion(C)/0276 G11.04

A mechanism for the generation of secondary bursts after an edge localized mode crash

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Abstract :

A recent nonlinear reduced magnetohydrodynamic (MHD) simulation shows that dynamics of geodesic acoustic modes (GAM) may play an important role in edge pedestal collapse, in particular, when the critical alpha (=normalized pressure gradient) is reduced near/below the ideal threshold value [H Jhang et. al, Nucl. Fusion **57** (2017) 022006]. Bursts of GAM activity is observed near the end of the crash and leads to secondary crashes. This phenomenon was attributed to the onset of a tertiary instability driven by the excitation of strong zonal flows. This raises a question of a dynamical mechanism which could generate such a strong zonal flow during the pedestal collapse. To address this question, we perform an analytic study of coupled zonal flow-ballooning modes. In this study, we assume that Reynolds and Maxwell stress drivers for the zonal mode are exactly cancelled (in line with observations in the simulation) and consider only the contribution from the geodesic curvature coupling drive. A simple analysis shows that a new nonlinear instability can arise due to the strong poloidal convection of the zonal flow, leading to the classical nonlinear Duffing oscillations. Implications of this analysis are discussed.

Nuclear fusion(C)/0876 G11.05

Critical roles of perpendicular plasma transports in ohmic breakdown in a tokamak

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Abstract :

The physical mechanism of the ohmic breakdown in the tokamak has not been clearly revealed due to a lack of experimental data and complex electromagnetic structures in the device. Over the past 50 years, many previous researches have assumed that the electron avalanche proceeds along the magnetic field lines and its growth rate is determined by the traditional Townsend avalanche theory. However, we found that this simple avalanche model cannot explain the mysterious experimental results of slow plasma formation and homogeneous plasma structures along the magnetic field lines. We realized that the space-charges in the plasma and related transports, which have been ignored in the previous researches, are essential to understand the physical mechanism of the ohmic breakdown properly. A toroidally symmetric plasma model and a particle simulation code BREAK [1] have been developed to elucidate the ohmic breakdown physics systematically. As a result, a new systematic avalanche model including space-charge effects is well established and it successfully explains the mysterious experimental results. Especially, significant roles of the perpendicular plasma transports via ExB drifts are newly identified that prevent additional secondary avalanches and mix the plasma density along the magnetic field lines.

[1] Min-Gu Yoo, Jeongwon Lee, Young-Gi Kim and Yong-Su Na, “Development of 2D Implicit Particle Simulation Code for Ohmic Breakdown Physics in a Tokamak”, *Computational Physics Communications* (2017) (http://dx.doi.org/10.1016/j.cpc.2017.08.009)

Plasma instruments, processing & applications(E)/0262 G11.07

Self-consistent global model for plasma chemistry of surface microdischarge considering the effects of joule heating and gas flow

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[1] 국가핵융합연구소, 플라즈마기술연구센터

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Abstract :

A global model was developed for surface microdischarges in flowing humid air of atmospheric pressure, including the effects of the gas flow and joule heating of gases by discharge. The developed model calculated the densities of neutral species and temperature of gases as time dependent variables in a self-consistent way using simplified thermal configuration. The calculated density trends of various RONS showed reasonable agreement with the experimental result of Fourier transformed infrared absorption spectroscopy, but the calculated density trends without joule heating of gases by discharge showed considerable disagreement. These results indicate that local joule heating of gases by discharge increased the temperature of gases considerable, and the increased amount of temperature was large enough to alter the rate of the temperature dependent chemical reactions. Thus, in order to properly calculate the densities of reactive neutral species in surface microdischarges, the models should consider the effect of joule heating of gases by discharge.

* This study was supported by R&D Program of 'Plasma Advanced Technology for Agriculture and Food (Plasma Farming)' through the National Fusion Research Institute of Korea (NFRI) funded by the Government funds.

Plasma instruments, processing & applications(E)/0973 G11.08

Developments of Gas Monitor Detector for Intensity Measurement of XFEL

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Abstract :

Pohang Accelerator Laboratory X-ray Free Electron Laser (PAL-XFEL) is designed to generate extremely intense and ultra-short pulsed X-rays, and is being operated. The photon diagnostic in PAL-XFEL is an indispensable device to check the XFEL's status such as flux and position. As one of the beam diagnostic devices, we have developed Gas Monitor Detector (GMD) using Xenon gas. It can measure the intensity of the XFEL. We have confirmed that charge state spectrum of photoionized Xenon ions using time of flight (TOF) and linearity between other beam flux diagnostics devices and the detector, and more detailed analysis is being performed to understand the behavior of the detector. Characterization of the detector and various test results including flux monitoring availability will be presented.

Nanomaterials and nanodevices(A)/0153 G12.01

Electromagnetically-induced transparency-like effect, based on phase coupling in bending structures

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Abstract :

Over the last few years, the classical analog of electromagnetically-induced-transparency (EIT) phenomenon has attracted a great deal of attention due to the wide variety of applications such as slow-light phenomenon, nonlinear enhancement, and quantum optical memory. The EIT is an effect generally induced by a laser, which is based on the destructive interference between atomic energy levels. This phenomenon requires special conditions such as a cryogenic laser. In recent years, however, metamaterials can be used to achieve EIT-like effects at room temperature without special equipment.

In this work, we investigated the EIT-like effects at microwave frequencies using structures of cut-wire resonators (CWR)/ring resonators (RR). The sample shows the effect, which results in the enhanced transmission at 5.69 GHz. By combining two types of resonators (CWR and RR) on the top and the bottom layers, it was possible to make them have different phases for the incident wave. This allowed us to have a classical analog to the EIT-like effect due to the phase coupling between CWR and RR. Besides, we also use a flexible substrate to illustrate the bending effect, and the transmission is manipulated by adjusting the bending parameters. In particular, additional transmission peaks and broadband transmission were observed in the bent state. Our approach provides significant advances in tuning electromagnetic responses that are useful for potential switching sensors.

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIT) (No. 2013-0-00375) and by the NRF funded by MSIT, Korea (No. 2017R1A2B4003916).

Devices and application(F)/0847 G12.02

An ideal material system to study the effect of Au tip on ReRAM switching: epitaxial brownmillerite oxide thin film

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Abstract :

A novel ReRAM was discovered very recently in brownmillarite $SrCoO_x$. The conducting filament was supposed to be vertical and straight and thus these shapes should give very reliable switching if this film can be grown with atomically uniform thickness. Unfortunately, the film could not be grown with layer by layer mode. Thus the initial vertical and straight filament should end up with many local minima paths near the one electrode, leading to non-reproducible switching. Here, we tried to reduce the number of local minimum paths using simple Au-probe tip. Since the vertical and straight shaper for most part of the conducing filament in a device based on brownmillarite $SrCoO_x$ epitaxial thin film should be an ideal target to study the effect of nano-size tip on ReRAM switching

Nanomaterials and nanodevices(A)/0977 G12.03

Graphene Based Nanoelectromechanical Mass Sensor

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Abstract :

Nanoelectromechanical (NEM) technology has attracted a lot of attention since electrical and mechanical degrees of freedom in NEM devices provide great potential for utilizing the devices as sensors and actuators in electronic, mechanic, and photonic applications. In addition, the exceptionally low mass of low-dimensional nanomaterials leads the NEM device performance to the operation speed of terahertz range and the sensitivity of single-atom mass. In the NEM deivce, surface condition of the nanomaterials is one of the most important factors to determine the device performance. Residual materials on the device surface prevent the NEM devices from exhibiting their excellent inherent physical properties. In the present work, we studied high temperature annealing effects on the resonance behaviour of ribbon-shaped graphene resonators at a temperature exceeding 2000 K induced by Joule heating. We also evaluated mass-sensing performance and reliability of the graphene resonator after high temperature annealing by observing the change in resonance behaviour after controlled deposition of chromium.

Nanomaterials and nanodevices(A)/0109 G12.05

Graphene on self-ordered nanostructure porous anodic aluminum oxide

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Abstract :

다공성 양극 산화 알루미늄(porous anodic aluminum oxide)을 이용해 그래핀(graphene)의 전기적 특성 변화를 연구하였다. 산성 용액에서 양극 산화를 통해서 성장되는 다공성 양극 산화 알루미늄은 자연적으로 규칙적인 나노구조(self-ordered nanostructure)를 형성하는 것이 특징이다. 이 나노구조의 크기는 산성 용액의 종류, 전압, 전류, 성장 온도 등의 요인에 따라서 작게는 수십 나노미터에서 크게는 수백 나노미터까지 형성될 수 있다. 본 연구에서는 수십 나노에서 작게는 10-20 나노미터까지의 다공성 양극 산화 알루미늄을 사용해서 그래핀과의 접합 소자를 제작하여 특성을 조사하였다. 특히 알루미나, 즉 산화 알루미늄은 고유전율 물질(high-kappa material)로서 평면구조를 가진 그래핀과 접합했을 때 그래핀의 전기적인 특성에 큰 영향을 미치게 된다. 따라서 다공성 양극 산화 알루미늄이 갖는 파라미터를 조절하여 그래핀의 전기적인 특성이 어떻게 변화하는 지를 중점적으로 조사하였다. 더 나아가 닫힌 그래핀의 밴드구조를 다공성 양극 산화 알루미늄을 이용해 주기적인 에너지 장벽(potential barrier)을 만들어 그래핀 밴드구조를 변화시킬 수 있는 지에 대한 가능성에 대해서 연구하였다.

Nanomaterials and nanodevices(A)/0722 G12.06

Extrinsic disorder-induced magnetoresistance of monolayer graphene in contact with $BiFeO_3$ nano-island Array

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Abstract :

단일층 그래핀은 넓은 표면적, 높은 전하 이동도, 높은 영률(Young's modulus), long-distance spin communication, linear dispersion relation 등의 탁월한 특성 때문에 많은 주목을 받고 있다. 또한, 이러한 특성에 의해서 nano-electronics, micro- and nano-mechanical systems, sensors, optoelectronics, photonics 같은 분야에서 응용 가능성이 지속적으로 증가하고 있는 추세이다. 그러나 이러한 우수한 특성에도 불구하고, 그래핀은 여전히 약한 반/강자성, 약한 spin-obit coupling, 상온에서 약한 자기저항 특성 때문에 spin field effect transistors, magnetic sensors, and magnetic random access memory 와 같은 분야에서는 응용에 한계를 보여주고 있다.

최근에, 그래핀의 성질을 제어하고 조절하는 많은 연구들이 발표되고 있다. 그 중에서도 그래핀에 disorder 를 유도하는 방법은 그래핀의 전자기적 특성을 제어하는 가장 중요하고 효과적인 방법 중에 하나이다. 예를 들어, mosaic-like bilayer graphene[1]와 nitrogen-doped graphene[2] 은 넓은 온도 범위에서 선형적인 자기저항 특성을 보여준다. 기적 특성을 조절하기 위해서는 extrinsic disorder 을 이용하는 방법이 연구되어야 한다.

본 연구에서는 단일층 그래핀과 $BiFeO_3$ nano-island Array 의 접합 소자를 제작하여 그래핀에 extrinsic disorder 를 유도하였으며, 온도에 따라 hall 측정을 수행하여 그래핀의 전자기적 특성을 분석하였다. 우리가 제작한 그래핀 / $BiFeO_3$ nano-island Array 의 접합 소자는 상온에서 250% 정도의 자기저항 특성을 보여주었다. 또한 본 연구에서는 AFM 을 이용하여 $BiFeO_3$ nano-island Array 와 접합한 그래핀의 표면 상태를 확인하였으며, Raman 을 이용하여 strain 과 도핑 상태를 확인하였다.

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Nanomaterials and nanodevices(A)/0546 G12.07

Analysis of Room Temperature Photoluminescence from V_2O_5 Micro-Nanospheres

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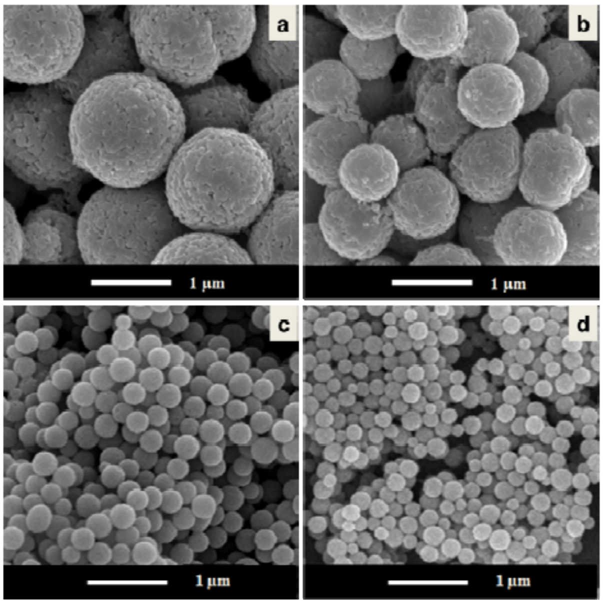
Abstract :

V_2O_5 micro-nanospheres with different diameters from 100-1000 nm were prepared by chemical reaction. The morphology, structure and composition of the V_2O_5 micro-nanospheres were investigated by SEM, XRD, Raman and XPS measurement. Photoluminescence (PL) from all the sizes of V_2O_5 micro-nanospheres at room temperature reveals high intensity with three peaks located at around 400–410 nm, 520-530 nm, and 700-710 nm. The physics and chemical mechanisms of PL and the effect of micro-nanospheres to PL intensity at room temperature were discussed.



2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Condensed-matter computational physics(G)/0631 G13.01

Origin of distorted 1T-ReS_2 and quasi-1D phase transition in $W_xRe_{1-x}S_2$

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Abstract :

Using first-principles calculations, we study the structural transition of group VIIB transition metal dichalcogenides (TMDCs) ReS_2 monolayer. These materials are known to be stabilized in a distorted 1T phase termed as 1T″ phase. These group VIIB TMDCs are characterized by large gap and anisotropic transport properties compared with group VIB TMDCs in 1T′, another distorted 1T phase. We find one dimensional Peierls-like instability as the origin for 1T′-1T″ phase transition of ReS_2. Two half-filled bands in the 1T′-ReS_2 make robust peak in the Lindhard function and lead to cell doubling with large gap opening. The transition from the 1T′ to the 1T″ phase is clearly shown in $W_xRe_{1-x}S_2$ alloy by virtual crystal approximation and the critical point is x = 0.45. At this point, only one half-filled band occurs the Peierls-like instability and after this point, the other band is shifted lower and modifies the instability. The total energy curve near the critical point shows the first order Landau transition behavior, indicating local bonding character plays an important role in the transition. This study shows the relation between the 1T′ and the 1T″ phase and possible phase transition in $W_xRe_{1-x}S_2$ alloy.

Condensed-matter computational physics(G)/0086 G13.02

Atomic-scale control of the magnetism in hydrogenated graphene

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Abstract :

Partial hydrogenation of graphene has profound effects on its material properties. For example, graphene undergoes a metal-insulator transition upon dosing with small amounts of atomic hydrogen in the low-coverage monomer regime. The spin-orbit interaction of graphene also becomes significantly enhanced for weakly hydrogenated graphene. Recently, it was experimentally demonstrated that the adsorption of atomic hydrogens on graphene induces local magnetic moments around the adsorption sites. However, a ferromagnetic spin-spin interaction in hydrogenated graphene is possible only when the H adatoms sit on a same sublattice of graphene. In this presentation, we present our first-principles spin-polarized calculations of hydrogenated graphene and discuss how to obtain a ferromagnetic phase through atomic-scale control of the H adsorption or desorption processes. We propose a new method to make the hydrogenation occur preferentially on one of the two equivalent sublattices of graphene, paving the way for transition-metal-free magnetism in graphene.

*This work was supported by the DGIST R&D Programs of the Ministry of Science, ICT and Future Planning (Grant No. 17-BT-02).

Condensed-matter computational physics(G)/0772 G13.03

Polaronic Behavior in Ca-doped $BiFeO_3$ as Origin of Electrochromism: A First-Principles Study

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Abstract :

Bismuth ferrite ($BiFeO_3$) has attracted attention as multiferroic material, which simultaneously exhibits both ferroelectric and antiferromagnetic properties [1]. Cation doping has been used in several experimental studies to improve fundamental properties such as the electronic, magnetic and ferroelectric properties of multiferroic oxides [2]. In particular, it has been reported that Ca-doped $BiFeO_3$ exhibits a prominent electrochromic effect [3]. Moreover, the electronic conductivity of Ca-doped $BiFeO_3$ can be reversely controlled by changing the concentration of oxygen vacancy via the applied electric field [4].

In this study, we performed first-principles hybrid functional calculations to understand the underlying mechanism of electrochromism phenomena in Ca-doped $BiFeO_3$. Based on the defect study of calcium substitutional at the bismuth site (Ca_{Bi}) and oxygen vacancy defect (V_O), we investigated electronic structures of V_O defects and Ca-doped $BiFeO_3$ under thermodynamic stability. We found that the isolated V_O undergoes deep-to-shallow electronic transition from (0)-charge state to (2+)-charge state, similar to the other DFT study [5]. Moreover, the isolated neutral charged ((+)-charged) Ca_{Bi} dopant induces a deep state in the band gap, indicating that the hole-induced trap state can be regarded as a small polaron (bipolaron) associated with the Bi and O atoms near the Ca dopant. These polaron states are considered as an origin of the electrochromism in Ca-doped $BiFeO_3$. We found that our calculated absorption coefficient in wide energy range agree with previous experimental result. Our theoretical results from Ca dopant and oxygen vacancy in Ca-doped $BiFeO_3$ can provide an explanation for recent experimental observations and a correlation between hole polaron and electrochromism.

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(2016)

Condensed-matter computational physics(G)/0608 G13.04

Atomic oxygen binding to a Pt/Mn surface: ab initio investigation

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Abstract :

Using density functional theory calculations, we examine atomic oxygen absorbed on the Pt/Mn surfaces structure. In this study, we compare the Pt single layer (1Pt) and Pt double layers (2Pt) on the Mn slab. To describe the interaction between the electrons and ions, we used the generalized gradient approximation (GGA) with a functional form proposed by Perdew, Burke, and Ernzerhof within the projector-augmented wave method implemented in Vienna Ab Initio Package (VASP). Wave functions are expanded, using a plane wave basis set. An energy cutoff of 500 eV and a Γ-centered 30 30 1-point sampling are employed to calculate the total energy and to obtain fully relaxed geometries for primitive cell. We use a grid of 3 3 1 -points for a 3 3 unit cell. For a slab model, we consider Mn (111) for the bcc structure and Pt (111) for the fcc structure. Under the structure optimization, the lattice constant of 1Pt (2Pt) is 2.57 Å (2.62 Å), and the interlayer distance between the Pt and Mn layers is 2.22 Å (2.16 Å). For the lowest energy configuration, absorption energy of atomic oxygen to 1Pt (2Pt) is 1.22eV (2.74eV). According to our computational simulation, Pt double layers on the Mn surface may be more favorable for oxygen reduction reaction in experiment.

Combined DFT and STM studies of SnSe and $SnSe_{1-x}S_x$ alloys

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Abstract :

Recently, SnSe single crystal has been found to exhibit excellent thermoelectric performance with an extremely high ZT (figure of merit) value of 2.6. Although this high ZT value has attracted considerable attention, the microscopic origin of p-type character of SnSe has yet to be clearly understood. Here, by combining scanning tunneling microscopy (STM) and density functional theory (DFT) calculations, we find that the most dominant Sn vacancies move the Fermi energy inside the dispersive valence band and produce extra holes throughout the system. On the other hand, other intrinsic vacancies create a nondispersive donor level and generate immobile electrons localized near the vacancy site. In addition, it has been known that $SnSe_{1-x}S_x$ alloys can be potential candidates for further enhancing the thermoelectric properties of SnSe because phonon scattering from foreign S atoms can further lower the thermal conductivity. Here, we first directly probed the microscopic structures of $SnSe_{1-x}S_x$ alloys and their structural evolution at the atomic level by combining STM experiments with DFT calculations. We expect that our combined STM/DFT studies provide important information for the development of highly efficient SnSe-based thermoelectric devices.

Condensed-matter computational physics(G)/1123 G13.06

Electronic Structure of the Substitutional W in GaSe Monolayer

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Abstract :

Since the discovery of graphene with high mobility and linear dispersion, graphene-like two-dimensional materials have been studied extensively. For example, transition metal dichalcogenides have been investigated by their high current on/off ratio and recently, metal monochalcogenides (MMCs) have attracted researches due to their large nonlinear optical coefficient. MMCs are compounds of group-III metal atoms (*e.g.*, Ga and In) and group-VI chalcogen atoms (*e.g.*, S, Se, and Te), and the basic structural building block is a tetralayer (TL) (*e.g.*, Se-Ga-Ga-Se). Within the TL atoms are bonded covalently, and the interaction between TLs are known to be the van der Waals attraction [1]. In previous study, 3*d* transition metal substitutional defects were investigated by L. Ao *et al*. [2] for the GaSe 1TL, and found that magnetism is induced except for the substitutional Sc and Cu and the magnetic moment is contributed from the *d* orbital of the defects and *p* orbital of neighboring Se atoms for defects with a partially filled *d* orbital. In this work, we studied the effect of substitutional 5*d* transition metal atoms to 1TL-GaSe by replacing a Ga atom by a W atom (W-GaSe). We performed density functional theory calculations by using Vienna *ab initio* simulation package. We used generalized gradient approximation for the exchange-correlation functional and a 4x4 supercell to simulate the isolated defect. The substitutional W atom relaxes towards the neighboring Se atoms, resulting in the reduced W-Se bond length (7% shorter than Ga-Se bond length) and the dilated W-Ga bond length (4% longer than Ga-Ga bond length). Such structural modifications induce a distortion in the $GaSe_3$ tetrahedron surrounding the W atom: the originally elongated $GaSe_3$ tetrahedron becomes an almost regular tetrahedron, which changes the crystal field around the W substitutional defect. Regarding the electronic structure, we found 5 spin-split defect states located within the fundamental band gap and the defect states are contributed by 5*d* orbitals of W atom. The spin-split defect states produce a magnetic moment of $3\mu_B$.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2015R1A2A2A01005564).

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Reliability and applicability of magnetic force linear response theory: Numerical parameters, predictability, and orbital resolution

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Abstract :

We investigated the reliability and applicability of so-called magnetic force response theory (MFT)[1-3] to calculate spin-spin interaction strengths from first-principles. We examined the dependence on the non-orthogonal LCPAO (linear combination of pseudo-atomic orbitals) parameters such as cut-off radii and basis orbitals. The results show that the parameter dependence and the ambiguity caused by these choices are small enough compared to other computational methods and experiments. We further explored the applicability of MFT. We showed that MFT could provide the reasonable estimation especially for the case of strongly localized moments even when the ground state configuration is unknown or the total energy value is not accessible. The formalism is also extended to carry the orbital resolution from which the matrix form of the magnetic coupling constant is calculated. By applying it to Fe-based superconductors including LaFeAsO, NaFeAs, $BaFe_2As_2$, and FeTe, a distinctive characteristic is clearly noticed in between single-stripe pnictides and double-stripe chalcogenides.

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Pioneer: Sterile neutrino searches and the JSNS2 experiment/1176 H1.01

Status of the JSNS2 Project

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Abstract :

The JSNS2 experiment aims to search for the existence of neutrino oscillations with Delta m2 near 1eV2 at the J-PARC Materials and Life Science Experimental Facility (MLF). With the 1 MW of 3 GeV proton beam created by Rapid Cycling Synchrotron (RCS) and spallation neutron target, an intense neutrino beam from muon decay at rest is available. Neutrinos come predominantly from mu+ decay : mu+ --> e+ + numubar + nue. The oscillation to be searched for is numubar to nuebar which is detected by the inverse beta decay interaction nuebar + p --> e+ + n, followed by gammas from neutron capture of Gd. The two detectors with a fiducial volume of 50 tons are located 24 meters away from the mercury target.

Additional physics programs include the cross section measurements with neutrinos with a few 10 MeV from muon decay at rest and with monochromatic 236MeV from kaon decay at rest.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/0409 H1.02

JSNS2 Detector Construction

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Abstract :

The JSNS2 (J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source) experiment is to search sterile neutrino at ~24m short baseline with17 tons of Gd loaded liquid scintillator detector as a neutrino target and aimed to start data taking at late 2018 or early of 2019. In this talk, we will present details of detector construction including detector vessel, production of both Gd loaded and unloaded liquid scintillator, PMT installation, and so on. Current status and tentative schedule will be followed.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/0158 H1.03

Sterile neutrino study by new schemes for low-energy neutrino sources by accelerator and non-accelerator

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Abstract :

We present new ideas for producing low-energy neutrino sources. Low-energy neutrino reaction turns out to be important for understanding supernova explosion as well as sterile neutrino. In this talk, we present new schemes for producing low-energy neutrino sources and show effects due to sterile neutrinos by exploiting those neutrino sources through detailed simulation.

For the neutrino sources, we suggest two different sources. One way is to use a low-energy proton accelerator which can produce 27Si emitting a few MeV neutrinos from 27Al target. Another type is to exploit 13C beam for scattering off 9Be target, which reactions may produce many kinds of isotopes emitting neutrinos. We simulate the neutrinos flux and applied to search for sterile neutrinos. Finally, we also present a method by non-accelerator method, which uses 252Cf as a neutron emitter to 7Li material. 8Li produced by the neutron absorption is shown to emit very effective low-energy neutrino flux around 10 MeV and be used as interesting neutrino sources for extracting sterile neutrinos from active neutrinos.

Pioneer: Sterile neutrino searches and the JSNS2 experiment/1177 H1.04

Liquid Scintillator Detectors and Sensitivity to DSNB

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Abstract :

We report the estimations of anti-electron neutrino flux density of diffuse supernovae neutrino background (DSNB) to have been emmited from core collapsing supernovae, so called type-II, taking into account the neutrinos released from supernovae at the early stage of the Universe. In these estimations, we include the effects of neutrino oscillation phenomena based on standard three neutrino flavors and standard flavors plus a type of sterile neutrinos. These two way estimations could lead us to new ideas to probe the existence of sterile neutrinos.

From the fact that a gadolinium loaded liquid scintillator, Gd-LS is believed to be an ideal detector material of anti-electron neutrinos through inverse beta decay process without any ambiguity, we also examine the detection sensitivity of anti-electron neutrinos using Gd-LS neutrino detectors varying those design parameters.

Particle physics theory(A)/0386 H2.01

Thermally averaged Sommerfeld factor for heavy quarks in Quark-Gluon Plasma

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Abstract :

Annihilation of slowly moving heavy quark and heavy anti-quark experiences multiple exchanges of gluons. Thus, the matrix elements for annihilation process receive considerable corrections, known as Sommerfeld effect, when compared to a naive expectation from a perturbation theory. In thermal environment, these Sommerfeld effect gets averaged since the velocity of heavy quarks follows Boltzmann distribution. Using lattice Non-Relativistic Quantum ChromoDynamics, we compute the thermally averaged Sommerfeld factors for S-wave and P-wave in Quark-Gluon Plasma. In addition to our previous calculations of S-wave case, we report the result from P-wave calculation.

Particle physics theory(A)/0832 H2.02

Identification of zero modes of QCD Dirac operator using improved staggered fermions

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Abstract :

We suggest a new approach identifying zero modes of QCD Dirac operator using improved staggered fermions on lattice QCD. Low eigenstates of Dirac operator are calculated by an improved Lanczos algorithm. We measure the chiralities of those eigenstates and examine their leakage patterns. In the end, we identify zero modes among them and determine their chiralities. We compare the topological charges calculated based on our observation with those are calculated field-theoretically.

Field and string theory(B)/0355 H2.03

One-loop perturbative calculation of Z_q and Z_m in RI-MOM scheme using improved staggered quark

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Abstract :

We present results of matching factors for Z_q and Z_m calculated perturbatively at the one loop level with improved staggered quarks. We use RI-MOM scheme for the renormalization condition. We calculate Z_q and Z_m with HYP-smeared staggered quarks. Final results of Z_q and Z_m at mu=2 GeV and 3 GeV in the MS-bar scheme are given in tables.

Particle physics theory(A)/0829 H2.04

Improvement of heavy-heavy current for calculation of the $bar{B}to D^{(*)}ell bar{nu}$ semi-leptonic form factors using Oktay-Kronfeld action

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Abstract :

It is necessary to improve flavor-exchanging vector and axial-vector currents for calculating $bar{B}to D^{(*)}ell bar{nu}$ semi-leptonic form factors using Oktay-Kronfeld (OK) action. The OK action is improved up to $mathcal{O}(lambda^3)$ in the HQET power counting. Thus, we need to improve the flavor-exchanging currents up to the same level as well, to get a full advantage of the action. We report the recent progress on the current improvment.

Particle physics theory(A)/0738 H2.05

Calculation of $bar{B} rightarrow D^ast ell bar{nu}$ zero-recoil form factor using the Oktay-Kronfeld action

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Abstract :

We present preliminary results of the calculation of $bar{B} rightarrow D^ast ell bar{nu}$ semileptonic form factor at zero recoil. We use $N_f=2+1+1$ MILC HISQ ensembles. The charm and bottom quarks are implemented using the Oktay-Kronfeld (OK) action. For the light spectator quark, we use the HISQ action. We also report a recent progress in determining the critical hopping parameter $kappa_text{crit}$ in a completely non-perturbative way.

Particle physics theory(A)/0522 H2.06

Quenched spectrum in Sp(4) gauge theory

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Abstract :

We present numerical results for the meson and glueball spectra of Sp(4) gauge theory in the quenched limit using lattice gauge theories. Aiming to realize the global symmetry breaking SU(4)->Sp(4), which is phenomenologically relevant to Higgs compositeness, we consider two-flavor Dirac fermions at two different lattice spacings. We utilize the low energy effective theory to analyze the masses and decay constants of pseudoscalar, vector and axial vector mesons in the same framework. We also report the continuum extrapolated values of the string tension and the glueball masses.

Particle physics theory(A)/0230 H2.07

Lepton flavor non-universality from B-meson decays in a U(1)' model.

Ligong Bian[1], Soo-Min Choi[1], Yoo-Jin Kang[1], Hyun Min Lee[*1]

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Abstract :

We consider an anomaly-free U(1)' model for explaining the lepton flavor non-universality from B-meson decays observed at LHCb. The U(1)' gauge boson couples to heavy quarks, muon and tau leptons, enhancing the transition in b to s mu+ and mu-. We show some parameter space explaining B-meson anomalies, being consistent with the current experimental bounds such as LHC dimuon, tau decay, neutrino scattering, and so on.

Particle physics theory(A)/0226 H2.08

Vector SIMP dark matter

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Abstract :

Strongly Interacting Massive Particles (SIMPs) have recently been proposed as light thermal dark matter relics. Here we consider an explicit realization of the SIMP mechanism in the form of vector SIMPs arising from an SU(2)X hidden gauge theory, where the accidental custodial symmetry protects the stability of the dark matter. We propose several ways of equilibrating the dark and visible sectors in this setup. In particular, we show that a light dark Higgs portal can maintain thermal equilibrium between the two sectors, as can a massive dark vector portal with its generalized Chern-Simons couplings to the vector SIMPs, all while remaining consistent with experimental constraints.

Particle physics theory(A)/0759 H2.09

Light bending in a Coulomb gas

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Abstract :

Photons traveling in a background electromagnetic field can bend via vacuum polarization effect with the background field. The bending in a Coulomb field by a heavy nucleus, as might be expected, is small even at a large atomic number, rendering it difficult to detect experimentally. As an amplifying mechanism of the effect we consider the bending of light traveling in a chamber of Coulomb gas. The Gaussian nature of the bendings by each nuclei in the gas increases the total bending angle in proportion to the square root of the number of nuclei in the gas. In a dense, cold Coulomb gas the enhancement can be orders of magnitude over the bending by a single nucleus at small impact parameter, which may help experimental observation of the Coulombic bending.

Astrophysics experiments/observations (B)/0149 H3.01

Probing the Dark Sector of the Universe through Gravitational Weak Lensing

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Abstract :

The most well-accepted scenario for the structure formation of the Universe today is the so-called Lambda Cold Dark Matter (LCDM) paradigm. However, the success of the LCDM paradigm is in stark contrast with our ignorance on the nature of dark matter and dark energy. Gravitational weak lensing is a powerful tool to probe the dark sector of the Universe through precision measurement of spacetime distortions by the large scale structure. In this talk, 1) an introduction to gravitational weak lensing is presented, 2) the current state-of-the-art results are reviewed, and 3) future gravitational weak lensing projects are discussed.

Astrophysics experiments/observations (B)/0150 H3.02

The Status of the GroundBIRD Experiment

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Abstract :

Our understanding of physics at very eary Universe, as eary as 10^-35 s after the Big Bang, relies on the scenario known as the inflationary cosmology. Inflation predicts a particular polarization pattern in the cosmic microwave background, known as the B-mode yet the strength of such polarization pattern is extermely weak. To search for the B mode of the polarization in the comic microwave background, we are constructing an off-axis rotating telescope to minigate systematic effects as well as to maximize the sky coverage of the observation. We will discuss the present status of the GroundBIRD telescope.

Nuclear structure(A)/0737 H4.01

Parameterization of Deformed Wood-Saxon Potential

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Abstract :

Until now, most of Woods-Saxon potential parameter sets have been adjusted by empirical stable nuclei, such as ^{16}O, ^{40}Ca and ^{208}Pb in doubly magic nuclei. Standard Woods-Saxon potential for the shell model calculation provide a good expectation for single particle energies which are relevant to stable nuclei. Most of the Woods-Saxon potential and there's parameters and adjusted to those for stable nuclei, but these parameter sets are not proper to describe the single particle energies of deformed nuclei. Therefore, one needs the modified Woods-Saxon parameter sets to apply for nuclei far from the stability line. In this work, we are searching a Woods-Saxon parameter set for unstable nuclei and deformed nuclei. Furthermore, it can be also useful for applying to a deformed BCS and QRPA approach in deformed nuclei.

Nuclear matter with intruder baryons

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Abstract :

We study a possibility to have an intruder baryon in conventional cold nuclear matter. The onset density of the presence of the intruder baryon in nuclear matter is calculated in the mean field approximations. We discuss if such kind of matter is within the reach of RAON. We also present some preliminary results of nuclear structure study in a parity doublet model.

Nuclear astrophysics(E)/0879 H4.03

Role of the light mass nuclear reactions to the r-process nucleosynthesis

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Abstract :

We investigate the sensitivity of the r-process nucleosynthesis to light mass nuclear reactions. In the core-collapsed supernova, one of the promising r-process site, the light mass nuclear reactions play important roles. We study the role of the light mass nuclides near the neutron drip-line in the reaction network for the r-process. We use the Meyer's code for the reaction network calculation and include additional reactions rates near drip-line and update some reaction rates using recent experimental data. Then, we calculate the r-process nucleosynthesis in the core-collapsed supernovae for two different scenarios, neutrino-driven wind model and magnetohydrodynamic (MHD) jet model, and compare r-abundances between cases with and without additional reactions. The sensitivity of the r-abundances to these reactions are estimated using the empirical power-law relations. When there is artificial increase of thermonuclear reaction rates, we observe the change of r-abundances. We discuss reaction network flows under the various conditions and importance of light mass nuclear reactions to understand the r-process nucleosynthesis.

Nuclear astrophysics(E)/0375 H4.04

Equation of State for Nuclear Matter within a Skyrme Interaction by Systematic Treatmant of Hyperon Interactions

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Abstract :

We investigated equation of state (EoS) of dense matter within the Skyrme interaction by systematically including hyperon interactions. The hyperon interaction is comprised of Λ, Σ and Ξ. we take into account the nucleon-nucleon (NN), hyperon-hyperon (YY) and their three-body interactions. All of these hyperon interactions are parameterized by following the Brueckner-Bethe-Goldston (BBG) expansion. Finally this EoS is applied to the EoS and mass-radius relation of neutron stars.

Nuclear astrophysics(E)/0184 H4.05

Spectroscopic study of radionuclide ^{21}Na for the astrophysical ^{17}F(a,p)^{20}Ne reaction rate

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Abstract :

The ^{24}Mg(p,α)^{21}Na reaction was measured at the Holifield Radioactive Ion Beam Facility of the Oak Ridge National Laboratory to study the spectroscopy of the radionuclide ^{21}Na. A 31-MeV proton beam from the 25 MV tandem accelerator bombarded isotopically-enriched ^{24}Mg targets. Recoiling ^{4}He particles were identified by an annular silicon strip detector array. Two energy levels at E_x = 6.594- and 7.132-MeV were observed for the first time. By comparing the experimentally-obtained angular distributions and distorted wave Born approximation (DWBA) calculations, the spins and parities of ^{21}Na energy levels were constrained. The astrophysically important ^{17}F(α,p)^{20}Ne reaction rate was also calculated for the first time using resonance parameters for 12 energy levels. Details of the experiment will be presented.

Semiconductor devices(G)/0966 H6.01

Fabrication and analysis of Cr-doped ZnTe intermediate band solar cell with high power conversion efficiency

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Abstract :

Low-cost, high efficiency next generation solar cells are tremendous interests for the realization of a renewable and clean energy source. Among next generation solar cells, intermediate band solar cells (IBSCs) have been extensively studied as a potential approach to achieve high power conversion efficiency (PCE). In this work, we fabricated the Cr-doped ZnTe (ZnTe:Cr) IBSC by pulsed laser deposition (PLD) and then studied also the dependence of laser power during ZnTe:Cr deposition on PCE. At first, a 100-nm-thick Al thin film was deposited on the rear surface of the p-Si substrate by using thermal evaporation, and then the Si substrate was annealed in furnace at 500 °C for 30 min. The annealed substrate was loaded into PLD chamber, and the vacuum system was evacuated to $1x10^{-6}$ Torr. The growth temperature was maintained at 250 °C during deposition. A pulsed (10 Hz) Nd:YAG laser operating at a wavelength of 266 nm was used for ablating the ZnTe:Cr and ZnO:Al targets, and the laser energy was varied from 10 to 7 J/cm^2. Finally, grid patterns of Ti/Au (50/100 nm) were deposited on front of the solar cells by using thermal evaporation. For ZnTe:Cr IBSCs, the optical properties were measured by photo-reflectance and time-resolved photoluminescence at room temperature, and its external quantum efficiency were studied also in the wavelength ranges from 300 to 1100 nm. The solar cell parameters were analyzed under Air Mass 1.5 Global solar simulator with an irradiation intensity of 100 mW cm^{-2}, and then open circuit voltage, short circuit current, fill factor, and PCE of ZnTe:Cr IBSC were obtained 0.38V, 35 mA, 0.56, and 7.5 %, respectively.

Semiconductor devices(G)/0951 H6.02

Sputter growth of oxygenated amorphous carbon for resistive random-access memory application

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Abstract :

ReRAM is one of the next generation of non-volatile memory that is undergoing much research. In a recent paper, confirming the characteristics of a-CO_x based ReRAM with a high speed and a large on-off ratio has been published for the first time. However, when a-COx is reactive sputtered, it is difficult to fabricate devices due to oxidation plasma etching. So, we tried various methods to solve the problem. And Through these methods a-COx films were deposited, Fundamental characteristics of the film is confirmed by XPS, XRD, AFM while increasing the oxygen partial pressure from 0 to 28%.. As a result, we observed that oxygen- carbon bond ratios and film resistivity is increasing with oxygen partial pressure. Also we confimed the characteristics of a-COx ReRAM with bipolar switching feature . However, since a clear mechanism for the current a-Cox ReRAM has not been clarified, much research is needed to nucover it.

Semiconductor devices(G)/0931 H6.03

The First-principles Study of Microscopic and Electronic Structure of $CsBi_3I_{10}$

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Abstract :

The hybrid organic-inorganic perovskite materials have received a lot of attention in the fields of solar cell applications due to their excellent electrical and optical properties with simple solution process ability and low cost. But, the highly-toxic lead (Pb) is mainly used as light absorber in the most of the high efficient solar cell materials. Due to the issues on the environmental concerns, other materials such as Sn, Ge, Bi are suggested as lead replacement. Among lead-free materials, Sn-based ones have the highest efficiency, but easy and rapid oxidations from Sn^{2+} to Sn^{4+} lead to the structural instabilities in air. Ge-based ones are expansive and are difficult to make due to tricky process while they have appropriate band gaps for the solar cell applications. In this view, Bi-based perovskite materials are emerged as good candidates because they are low-toxic and are stable in air. Recently, Johnasson *et al.* experimentally reported high efficient Bi-based material of $CsBi_3I_{10}$, but no detailed theoretical studies have been investigated yet. Therefore, it is crucial to understand the reason why $CsBi_3I_{10}$ shows the high efficiency as compared to other Bi-based materials for the development of the next generation solar cells. In this presentation, we will study about the microscopic and electronic structure of $CsBi_3I_{10}$ using the first-principles pseudopotential total energy calculations based on the density functional theory (DFT).

Semiconductor devices(G)/0837 H6.04

Spin orbit torque-based electronic synapse

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Abstract :

Recently, neuromorphic systems inspired by human brain has garnered great interest to overcome a limitation in the conventional computing paradigm based on binary logic and Von Neumann structure. In particular, the memristor characteristic devices is known to mimic the behavior of biological synapses. Recently, magnetic devices utilizing spin orbit torque through magnetic manipulation by in-plane current injection have become one candidate of alternatives to conventional memristor devices due to lower power consumption and faster magnetization switching. Therefore, we report a novel nanoscale electronic synapse based on SOT effect observed in modified magnetic tunnel junction (MTJ) structures. First, we observed domain wall motion (DWM) driven by SOT applying in-plane current pulse injection. Furthermore, we also confirmed that domain wall motion driven by SOT, which is confirmed by Magneto-Optic Kerr Effect (MOKE) measurement, induces resistance change using MTJ behavior. Through these resistance change behaviors, the various synaptic features such as short-term potentiation (STP), long-term potentiation (LTP), spike-timing dependent plasticity (SDTP) are confirmed to be realized in the suggested SOT-based synaptic device, which establishes a foundation in the implementation of a synaptic learning rule.

Semiconductor devices(G)/0835 H6.05

Control of spin-orbit-torque behaviors by various [Ta/W]n multi-stacked buffer layer in Heavy metal / Ferromagnet / Oxide trilayer

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Abstract :

Recently, in many reports, magnetization switching induced by in-plane current in Heavy metal (HM) / Ferromagnet (FM) / Oxide trilayer shows great efficiency in device application owing to possibility of higher tunneling magentoresistance (TMR) by using thick MgO layer and lower threshold current density compared to that of STT-based switching. In general, previous SOT studies deal with HM / FM bilayer, where spin hall effect mostly occurs in HM. It indicates that microscopic states in HM is critical for generation of SOT. Therefore, in this study, we investigated various multi-stacked buffer layer of $[Ta(t_{Ta})/W(t_{W})]_5$ for the role in SOT and also in perpendicular magnetic anisotropy (PMA). We observed quite different magnitudes in SOT even in magnetically identical samples for various buffer layer systems, which presents that critical role for SOT is related to detailed atomic properties such as lattice constant, chemical bonding states or interface quality. In addition, another origin of SOT regarding additional spin scattering by different material properties can be suggested by changing thickness ratio of multi-stacked layer.

Semiconductor devices(G)/0826 H6.06

Analysis of threshold switching characteristics of ZnTe.

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Abstract :

Crossbar array based on resistive random access memory(ReRAM) requires selector for reliable operation. Several selector mechanisms have been investigated. some of chalcogenide called Ovonic threshold switching(OTS) materials are noticeable properties such as high non-linearity, fast switching speed and endurance. We studied threshold switching characteristics of ZnTe based on OTS mechanism. Electric field dependence of ZnTe was confirmed varying thickness of ZnTe layer. Current density along ZnTe device implies conduction after forming is rather filamentary type. Switching time and endurance check by time-resolved measurement is validated as OTS selector

Semiconductor devices(G)/0686 H6.07

Silicon membrane 온도/임피던스 센서의 제작 및 특성 분석

유태균 [1], 김은섭 [1], 황신애 [1], 이지승 [2], 박찬흠 [2], 장문규 [*1,3]

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Abstract :

본 연구에서는 반도체 및 MEMS 공정을 이용하여 SOI 기판상에 온도/임피던스가 적층된 구조로 구성된 바이오 센서를 제작하였다. 슬라이드 글라스에 제작된 경우와 비교하여 실리콘 멤브레인에 제작된 경우에서 온도센서의 감도와 반응속도가 크게 향상되었다. 열 반응 특성은 Fick's second law 모델링을 통하여 해석하였으며 슬라이드 글라스와 비교하여 반응속도는 약 5 배, 민감도는 약 3 배 개선됨을 확인하였다. 제작된 센서에 HeLa 세포를 배양하고 항암제 투여에 따른 임피던스 변화와 온도 변화 특성을 시간별로 측정하였다.

Semiconductor devices(G)/0395 H6.08

Suppressed Coulomb scattering and effective Schottky barrier reduction on MoS_2/*h*-BN heterostructure

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Abstract :

Layered hexagonal boron nitride (*h*-BN) thin film has been reported as an exceptional dielectric substrate that prevails silicon oxide (SiO_2) for diverse optoelectronic applications in conjunction with other two-dimensional layered materials such as graphene and transition metal dichalcogenides. However, the underlying mechanism of *h*-BN effect on suppressed Coulomb scattering and Schottky barrier is little known. Herein, we present a four times enhanced field-effect mobility and reduced effective Schottky barrier height (SBH) by a factor of three in monolayer molybdenum disulfide (MoS_2) on *h*-BN substrate compared to those of MoS_2/SiO_2. The inserted *h*-BN enables carriers in MoS_2 to mask the effects of fixed oxide charges in SiO_2 and reduce interface trap density. The reduction of effective SBH in MoS_2/*h*-BN is ascribed to a higher energy band bending and dipole alignment effects compared to MoS_2/SiO_2. As a consequence, the advantageous role of the inserted *h*-BN dielectrics allows us to observe metal-insulator electronic phase transition at a much lower charge density of ~1.0 x 10^{12} cm^{-2} (T = 25K).

Dielectrics/Functional oxides(H)/0190 H7.01

VO_2 Phase Transition Dynamics through Designed Heterostructures

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Abstract :

Phase transitions in correlated materials promise emerging physical phenomena and functions, and usually show couplings between multiple order parameters. These coupled phase transitions can exhibit an exotic and technologically beneficial phenomenon, distinct from that in conventional materials. However, it still remains elusive to explore and control such exotic phase transitions, especially in real time and at the nano-/atomic scale. Here, I present a couple of breakthrough findings on the exotic phase transitions in an archetypal correlated material vanadium dioxide (VO_2). (1) Through a combination of phase-field modeling, template-controlled thin-film epitaxy, and *in situ* transmission electron microscopy, we reveal a protected phase transition of VO_2 that persists undisturbed by preexisting structural domain boundaries. This originates from a large interfacial energy at the coupled structural and electronic phase boundaries, and allows much enhanced metal-insulator transitions in template-controlled VO_2films. (2) I also design and demonstrate an isostructural, purely electronically-driven metal-insulator transition in artificial heterostructures of VO_2, whose metal-insulator transition should otherwise be coupled to a large structural distortion in bulks. These findings offer new insight for understanding and utilizing the phase transitions in correlated materials.

Dielectrics/Functional oxides(H)/0237 H7.02

Strain-mediated manipulating of photocatalytic property in $BiVO_4$

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Abstract :

Recently, $BiVO_4$ has attractive attention for photocatalytic application to produce hydrogen fuel via water splitting into H_2 and O_2 thanks to good stability and the moderate band gap (2.4 eV) absorbing visible light. However, $BiVO_4$ is known to be not good H_2 production material but excellent O_2 production material, resulting from the lower position of conduction-band edge relative to the $H+/H_2$ level. As a result, this material is utilized for water splitting practically by combining with another oxide (e.g., $SrTiO_3$) or semiconductor (e.g., MoS_2) to complement it. In this work, we propose the possibility of band edge tuning via strain through first-principles hybrid functional calculation.

Dielectrics/Functional oxides(H)/0736 H7.03

Realization of room-temperature ferroelectricity in brownmillerite thin film

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Abstract :

Engineering of oxygen concentration in multivalent transition metal oxides has been investigated owing to its promising potential to realize attractive and functional properties, such as colossal ionic conduction and metal-insulator transition. In particular, brownmillerite $ABO_{2.5}$ structure can be induced by reducing one-sixth of the oxygen in perovskite oxide, and alternating oxygen-deficient BO_4 tetrahedra and BO_6 octahedra layers along b-axis form, without losing the crystalline symmetry. Ferroelectricity in the brownmillerite oxide thin film has never been revealed even though rotation and tilting of tetrahedra could induce the centrosymmetry breaking.

Epitaxial $SrFeO_{2.5}$ thin films possessing tetrahedral layers perpendicular to the surface of the SrTiO3 (001) substrate have been grown by using pulsed laser epitaxy (PLE). The piezoresponse force microscopy method obviously figure out that $SrFeO_{2.5}$ thin films have a ferroelectric nature (~8μC/cm^2) at room temperature. This resultant value is well-matched with theoretical expectation (7.7μC/cm^2) from the first principle calculation and survival of second-order-harmonic signals further suggest that the as-grown $SrFeO_{2.5}$ thin film has non-polar system.

Dielectrics/Functional oxides(H)/0691 H7.04

Ferroelectricity in epitaxial Y doped HfO_2 thin film integrated on Si substrate

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Abstract :

Since the discovery of ferroelectricity in HfO_2, HfO_2 has attracted attention due to the possible application for ferroelectric memory device instead of perovskite materials because HfO_2 has simple binary structure and Si compatibility. Although these interests for ferroelectric HfO_2 has been paid to many researchers, the underlying mechanism govern the ferroelectricity of the HfO_2 such as the role of mechanical strain or oxygen vacancies has been little reported because ferroelectric HfO_2 were studied using poly-crystalline film in most researches. So, the epitaxial growth of ferroelectric HfO_2 on Si platform will enlarge our understanding on the underlying mechanism govern the ferroelectric. In this presentation, epitaxial Y-doped HfO_2 film was fabricated on yttria stabilized zirconia (YSZ) buffered Si (001) substrate by using pulsed laser deposition. The structural properties of the film were investigated by conventional X-ray diffraction and transmission electron microscopy. The ferroelectric properties of the film were investigated by conventional polarization-electric field measurement, piezo force microscopy and capacitance-voltage measurement.

Dielectrics/Functional oxides(H)/0659 H7.05

Effect of oxygen vacancies on physical properties of Moo_{3-x}

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Abstract :

Molybdenum oxides are a promising material for smart window, electrodes for batteries and gas sensors, and component in solar cells. But, due to drastic change of activation energy of MoO_3 at about 650^{o}C, it forms elongated shape crystal with few μm of width. In previous research, we have grown large MoO_3 single crystals successfully by modified Bridgman method. In this work, we report effect of oxygen vacancies on physical properties of MoO_{3-x} single crystals. We annealed MoO_3 single crystal in reducing condition with different temperatures. Structure, composition, physical properties and surfaces were investigated with various characterization tools. The results were compared and discussed with those of as grown MoO_3 single crystals.

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korea government (MSIP) through GCRC-SOP (No.2011-0030013). Also, this research was supported by Basic Science Research Program through the NRF funded by the Ministry of Education (NRF-2015R1D1A1A02062175).

Dielectrics/Functional oxides(H)/0615 H7.06

Configurable topological textures in strain graded ferroelectric nanoplates

Kwang-Eun Kim[1], Seuri Jeong[1], Kanghyun Chu[1], Jin Hong Lee[1], Gi-Yeop Kim[2,3], Tae Yeong Koo[4], Si-Young Choi[2], Ramamoorthy Ramesh[5,6,7], Chan-Ho Yang[*1,8]

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Abstract :

The topological defects in ferroic materials have been have received considerable attentions because of their potential applications for high density non-volatile information storage. Recently, there has been a lot of efforts to make racetrack memory using movement of domain wall or skyrmions by short pulses of spin-polarized current in ferromagnetic materials. However, creation of stable isolate ferroelectric vortex states and electric configuration of the topological invariant in dielectrics are experimentally still veiled. Here, we show an epitaxial ferroelectric square nanoplate of bismuth ferrite subject to a large strain gradient associated with misfit strain relaxation enables five discrete levels for the ferroelectric topological invariant of the entire system as a consequence of the peculiar radial strain relaxation and the domain wall chirality. The piezoresponse vector of the nanoplate was defined by using position-sensitive angle-resolved piezoresponse force microscopy, and the existence of vortices was confirmed by winding number calculation. Our finding offers useful concept to stabilization and control the ferroelectric vortex.

Dielectrics/Functional oxides(H)/0971 H7.07

Sulfurization of Ferroelectric Perovskite Oxides

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Abstract :

Anion doping to oxide materials is of great interest for synthesizing new multi-functional materials and realizing unusual physical properties which do not exist in nature. While halogen and pnictogen elements have been widely employed for such anion doping to oxide materials, a chalcogen group (e.g. S, Se, Te) has attracted lots of attention as another candidate due to the larger ionic size than an oxygen and the similar valency nature as the oxygen atom. However, in oxide materials, the anion doping of chalcogen elements has been rarely reported due to the difficulty/limitation in the synthetic method which is easily applicable in a small laboratory.

In this work, we developed a feasible route for the doping of the chalcogen elements, in particular, sulfur (S) doping to perovskite oxides. A thiourea (CH_4N_2S) solution is spin-coated to ferroelectric PZT compounds and then, the coated layer is thermally annealed to assist a sulfur substitution to cation or anion by atomic diffusion. We note that perovskite PZT is suitable to assess the sulfur-doping effect, because its ferroelectric properties (e.g. remnant polarization) are susceptible to the cation or anion substitution. It is interesting that an S-doped PZT with a particular mole ratio of the sulfur content exhibits higher polarization than a pure PZT with larger tetragonality. On the other hand, the band gap becomes narrower with the increasing sulfur doping concentration with an increase in electrical leakage. Potentially, our synthetic technique of sulfur doping can be utilized for designing novel ferroelectric photovoltaic materials with a high performance.

Dielectrics/Functional oxides(H)/0429 H7.08

The effect of Acceptor and Donor Doping on Defects and charge transports in Mn-modified $0.67Bi_{1.05}FeO_3$ - $0.33BaTiO_3$ ceramics

D. J. KIM[1], M. H. Lee[1], T. K. Song[*1], M.-H. Kim[1], W.-J. Kim[2], D. Do[3]

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Abstract :

Manganese ions have diverse valence states, such Mn^{2+}, Mn^{3+}, and Mn^{4+}. Mn-modified lead-free ceramics have a significant influence on their electrical properties and sintering behavior due to different defects with oxygen vacancies. One of lead-free piezoceramics in $BiFeO_3$ - $BaTiO_3$ system, there is mainly focused on their relevant piezoelectric and electromechanical properties as well as their relatively high Curie temperature. Most published reports depend on the reduction of defects in dopant-modified $BiFeO_3$ - $BaTiO_3$ ceramics. We investigated on the formation of the defects are in acceptor-doped (hard) and donor-doped (soft) Mn-modified $0.67Bi_{1.05}FeO_3$ - $0.33BaTiO_3$ ceramics sintered in the furnace-cooling and water-quenching process. As a result, $0.67Bi_{1.05}Fe_{0.99}Mn_{0.01}O_3$ - $0.33BaTiO_3$ (WQ BF33BT-1MnO) ceramic have high performance piezoelectric constant (d_{33} = 331 pC/N, d_{33}^* = 257 pm/V) and total strain (S_{max} + S_{neg} = S_{total}) is 0.36%.

Dielectrics/Functional oxides(H)/0428 H7.09

Stabilization of hexagonal structure in $(Lu,In)FeO_3$

CHO Kwanghee[1], KIM Hakbeom[1], PARK Soonyong[*1]

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Abstract :

Hexagonal $LuFeO_3$ has attracted much attention in materials research due to its room-temperature multiferroicity. Due to the instability of hexagonal phase in the bulk crystals, most studies focused on $LuFeO_3$ thin film which can be stabilized by strain using substrates [1]. Recently, there have been reports showing that the bulk crystals with a polar hexagonal $P6_3cm$ structure formed through Sc or Mn substitution in A-site or B-site of $LuFeO_3$, respectively [2]. In order to investigate the stabilization of hexagonal structure and its influence on ferroelectricity and magnetism in $LuFeO_3$, we studied the structural, magnetic, and electrical properties of In doped $LuFeO_3$. Non-polar hexagonal $P6_3/mmc$ structure in single phase for the In doping range of $0.4 \leq x \leq 0.8$ in $Lu_{1-x}In_xFeO_3$ was confirmed. Our study will provide a useful information for the stabilization of distinct hexagonal structures in $LuFeO_3$ related systems.

[1] W. Wang et al. Phys. Rev. Lett. 110, 237601 (2013).

[2] S. M. Disseler et al. Phys. Rev. B, 92, 054435 (2015).

Superconductivity(C)/0396 H8.01

Synthesis and superconductivity in oxysulfate-based cuprates

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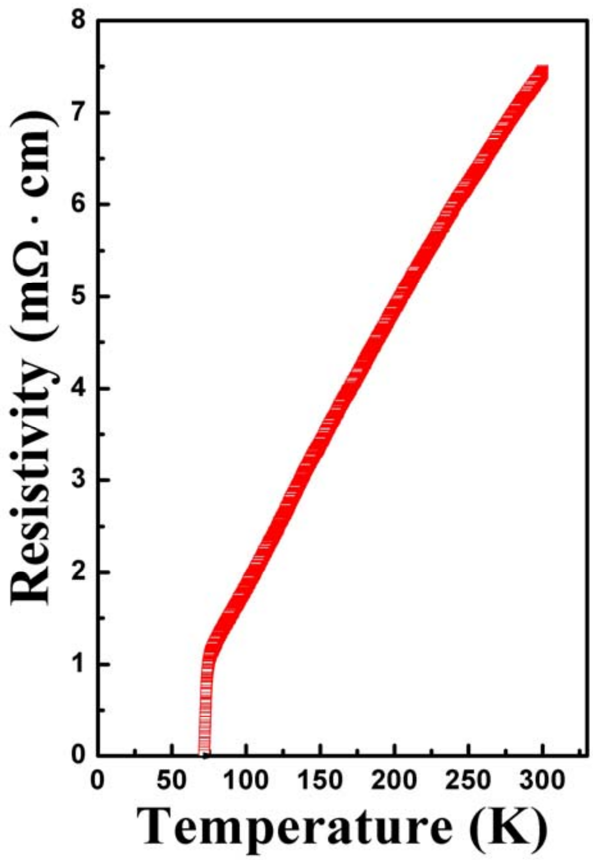
Abstract :

After the discovery of possibility to replace copper by carbonate groups in the perovskite structure, a profusion of new superconducting cuprates were discovered. In this work we report that the oxysulfate-based cuprates, $TlSr_4Cu_2SO_4O_z$ and related compounds found to exhibit superconductivity with T_c (zero) above 72 K. They crystallize in tetragonal system.



Superconductivity(C)/0195 H8.02

Analysis of Pairing Symmetry for Flux Quantization Measured in the YBCO-Pb Corner Junction, DC SQUIDs, and the Tricrystal Superconducting Ring of YBCO

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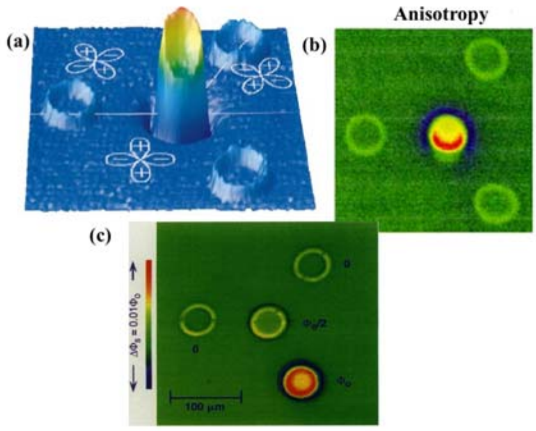
Abstract :



For cuprate high-T_c superconductors, the pairing symmetry of Cooper pair is still controversial and remains unsolved. This is a central issue for the mechanism of high-T_c superconductor. For the measurements of flux quantization obtained in the YBCO-Pb corner junction [1], DC- SQUIDS [2,3,4] and in the tricrystal superconducting ring of YBCO [5,6], the results had suggested that the measured half fluxes are strong evidence of the dx^2-y^2 (or d) pairing symmetry. This has still an influence on the superconductor mechanism research. At this time, we feel reanalysis of the measured half-flux-quantum data, because of the unclear analysis on flux trap in the papers. The authors [1] analyzed that the Fraunhofer diffraction pattern is symmetry, and the authors [2-6] also suggested that the measured half-flux quantum comes from supercurrent induced by the superconducting ring. However, we found anisotropy of the Fraunhofer diffraction pattern, an anomalous large supercurrent, anisotropy in the half-flux quantum SQUID image (see below). These are evidence coming from a superconductor with trapped flux trap denying the *d*-wave symmetry. We suggest the s-wave pairing symmetry [7]. [1] PRL 74(1995)797, [2] PRL 71(1993)2134, [3] PRL 74(1995)4523, [4] IEEE Trans. Appl. Super. 7(1997)2331, [5] PRL 73(1994)593, [6] Rev. Mod. Phys.. 72(2000)969. [7] J. Phys. Soc. Jpn. 71 (2002) 2106. Figures (a-c) show anisotropy in flux in the tricrystal rings measured at YBCO [6] & $Ti_2Ba_2CuO_{6+d}$ (Fig. c, Tsuei *et al*., Science 271(1996)5249), which indicates absence of *d*-wave supercurrent. Moreover, red ring in Fig. (c) showing symmetry is evidence of the s-wave symmetry.

Superconductivity(C)/0199 H8.03

Reconciliation of STS and ARPES in Fe-based Superconductors

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Abstract :

In studying high-Tc superconductors such as cuprates and Fe-based, proposed superconducting gaps by STS and ARPES are always different in a meaningful scale. I show that this discripancy is resolved by extracting sample density of states (DOS) from the STS data which are usually ill-known as sample DOS. I show that one may extract the DOS by considering entangled state tunneling which takes into account both coherent couplings to the tip and the sample. I show that the extracted sample DOS comprises multiple parts which reflect multiple Fermi surfaces of Fe-based superconductiors.

Superconductivity(C)/1106 H8.04

Spin polarized STM study on strongly underdoped cuprate superconductor La-Bi2201

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Abstract :

Direct real-space investigation on the spin degrees of freedom of doped Mott insulators have been anticipated to reveal fundamental physics of high T_c cuprate superconductors. Using variable magnetic-field spin-polarized STM, we have studied two potential candidates for spin degrees of freedoms in cuprates: (a) the checkerboard state of underdoped UD10 La-Bi2201 and (b) the spin glass state of extremely underdoped EUD La-Bi2201 with no superconducting transition. Variable magnetic field spin-polarized topographic studies show that the well-known checkerboard state of UD10 La-Bi2201 contains no spin textures in it, while the variable magnetic field spin-polarized spectroscopic-imaging STM measurements on EUD La-Bi2201 show signatures of fluctuating spin glass state.

Superconductivity(C)/0729 H8.05

Interplay between magnetism and superconductivity in $Pr_{1-x}LaCe_xCuO_{4-\delta}$

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Abstract :

We present zero-field (ZF) and transverse-field (TF) muon spin relaxation (μSR) measurements of the electron-doped cuprates $Pr_{1-x}LaCe_xCuO_{4-\delta}$ (x=0.05-0.2) towards drawing a phase diagram and understanding an interplay between magnetism and superconductivity. The ZF- and TF-μSR data show that short-range antiferromagnetic correlations persist to the superconducting phase. The TF-μSR data allow determining the temperature dependence of the superfluid density ($\sigma_{sc} \sim 1/\lambda^2 \sim n_s/m^*$). The power-law dependence of σ_{sc}(T) is described by the *s*+*s*-wave model for the underdoped samples and is approximated by the dirty-limit *d*-wave model, $1-(T/T_c)^2$, for the optimally doped samples. Noticeably, we find deviation from the power-law at low temperatures due to the development of the magnetic correlations.

Superconductivity(C)/0194 H8.06

T_c enhancement on fully strained superconducting $BaPb_{1-x}Bi_xO_3$ thin film

Jinkwon Kim[1,2], Han-Gyeol Lee[1,2], Bongju Kim[1,2], Daesu Lee[1,2], Tae Heon Kim[3], Shinbuhm Lee[4], Seohyoung Chang[5], Tae Won Noh[*1,2]

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Abstract :

The perovskite oxide superconductor $BaPb_{1-x}Bi_xO_3$(BPBO, T_c=12K in bulk), which has monumental position in history of high T_c superconductor, is re-highlighted recently because of structural phase separation and its related physics [1],[2]. However, there is few research on BPBO thin film because of BPBO's large lattice constant(a=4.30 Å) compared to commercially available substrate, like $SrTiO_3$(a=3.905 Å). The large lattice mismatch between the BPBO and substrates make it difficult to synthesize fully strained BPBO thin film.

In this research, we tried to prepare fully strained BPBO thin film by using pulsed laser deposition system with buffer layer templates [3]. By using $BaZrO_3$/$BaCeO_3$ buffer layer, we succeed to achieve fully strained epitaxial BPBO thin film while maintaining the quality. The detail characterization was done by using X-ray diffraction, atomic force microscopy, and physical property measurement system. Interestingly, we observed the T_c enhancement on tensile strained BPBO thin film. We checked the T_c of the BPBO thin film with various strain and thickness, and found the systematic change of T_c. Subsequently, we acquired high quality BPBO thin films, and confirmed the strain and thickness dependency on T_c of BPBO thin films.

[1] E. Climent-Pascual *et al.*, *Physical Review B*, **83**, 174512 (2011).

[2] P. Giraldo-Gallo *et al., Nature Communications*, **6**, 8231 (2015)

[3] H. G. Lee *et al*., *APL Matter,* **4**, 126106 (2016).

Superconductivity(C)/0525 H8.07

Switching Magnetism and Superconductivity with Spin-Polarized Current in an Iron-Based Superconductor

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Abstract :

We have explored a new mechanism for switching magnetism and superconductivity in a magnetically frustrated iron-based superconductor using spin-polarized scanning tunneling microscopy (SPSTM). Our SPSTM study on single crystal Sr_2VO_3FeAs shows that a spin-polarized tunneling current can switch the Fe-layer magnetism into a non-trivial C_4 (2×2) order, which cannot be achieved by thermal excitation with unpolarized current. Our tunneling spectroscopy study shows that the induced C_4 (2×2) order has characteristics of plaquette antiferromagnetic order in the Fe layer and strongly suppresses superconductivity. Also, thermal agitation beyond the bulk Fe spin ordering temperature erases the C_4 state. These results suggest a new possibility of switching local superconductivity by changing the symmetry of magnetic order with spin-polarized and unpolarized tunneling currents in iron-based superconductors.

Superconductivity(C)/0721 H8.08

Thermal activation energy of 3D vortex matter in $NaFe_{1-x}Co_xAs$ (x=0.01, 0.03 and 0.07) single crystals

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Abstract :

We report on the thermally activated flux flow dependency on the doping dependent mixed state in $NaFe_{1-x}Co_xAs$ (x=0.01, 0.03, and 0.07) crystals using the magnetoresistivity in the case of *B*//c-axis and *B*//ab-plane. It was found clearly that irrespective of the doping ratio, magnetoresistivity showed a distinct tail just above the $T_{c,offset}$ associated with the thermally activated flux flow (TAFF) in our crystals. Furthermore, in TAFF region the temperature dependence of the activation energy follows the relation $U(T,B)=U_0(B)(1-T/T_c)^q$ with q=1.5 in all studied crystals. The magnetic field dependence of the activation energy follows a power law of $U_0(B)\sim B^{-\alpha}$ where the exponent α is changed from a low value to a high value at a crossover field of B=~2T, indicating the transition from collective to plastic pinning in the crystals. Finally, it is suggested that the 3D vortex phase is the dominant phase in the low temperature region as compared to the TAFF region in our series samples.

Superconductivity(C)/0724 H8.09

Optical Properties due to the competition between superconducting states and Kondo states in $(Ca_{1-x}La_x)_{10}(Pt_3As_8)(Fe_2As_2)_5$ (x=0, 0.032, 0.082)

서유일 [1], 최우재 [1], Shin-ichi Kimura[2], 권용성[*1]

[1]DGIST, 신물질과학, [2]Osaka University, FBS and Department of Physics

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Abstract :

We have measured the reflectivity spectra from 20 to 11000 cm^{-1} at several temperatures from 8 to 300 K for superconducting single crystals $(Ca_{1-x}La_x)_{10}(Pt_3As_8)(Fe_2As_2)_5$ (x=0, 0.032, 0.082). The optical conductivity spectra derived from the reflectivity data in the normal state were fitted by two Drude terms, indicating the presentation of multiple bands at Fermi energy, two or three Lorentz oscillator terms in infrared frequency region, which indicates the presentation a few bands in the proximity of fermi energy. The scattering rate increases as –log T until ~10 K at x=0 with decreasing temperature, which is caused by the scattering of a part of conduction electrons with the localized magnetic band located at about 600 cm^{-1} below E_F. Below ~10 K, the scattering becomes coherent and the conduction electrons become heavy, which is confirmed by the specific heat. Other conduction electrons remaining in the narrow hole band induce the superconductivity.

Strongly correlated systems(B)/1048 H9.01

Critical vortex shedding in a strongly interacting Fermi gas

Jee Woo Park*[1,2], Bumsuk Ko[1,2], Yong-il Shin[1,2]

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Abstract :

In a 2D superfluid, quantized vortices are topological point defects whose creation and dynamics reveal the underlying thermodynamic and transport properties of the superfluid. In this presentation, we report on the experimental study of critical vortex shedding in a strongly interacting Fermi gas. A highly oblate fermionic condensate consisting of 10^6 ^{6}Li atoms (per spin state) is prepared at nK temperatures (T/T_F<0.15), and a magnetic Feshbach resonance is used to precisely tune the interspin interaction strength, allowing access to the crossover between a BEC of tightly bound molecules and a BCS superfluid of weakly bound pairs. Using a moving repulsive optical obstacle, we locally drag the condensate and observe spontaneous creation of vortex-antivortex pairs above a certain critical speed. The critical speed for vortex dipole shedding, together with the superfluid speed of sound, is explored throughout the BEC-BCS crossover, and the ensuing vortex pair dynamics is also examined. These measurements provide an experimental benchmark for theories on static and dynamical properties of strongly interacting Fermi gases.

Strongly correlated systems(B)/1033 H9.02

Critical spin superflow in a spinor Bose-Einstein condensate

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Abstract :

We investigate the dynamics of spin superflow in a spin-1 antiferromagnetic spinor Bose-Einstein condensate (BEC). We induce the spin superflow by applying a linear magnetic field gradient to a BEC in easy-plane polar phase, and observe the rapid increase of dissipation rate with the field gradient above a certain critical value. The dissipation of spin superflow is found to be associated with two critical phenomena: 1) generation of dark-bright solitons due to the modulation instability of the counterflowing spin components, which finally provokes the emergence of spin turbulence, and 2) generation of transverse magnon excitations via spin-exchange collisions, which leads to the transient formation axial polar spin domains.

Strongly correlated systems(B)/0989 H9.03

Insulator-metal transition through applied pressure in 2D hexagonal antiferromagnet $FePS_3$

COAK Matthew John[*1,2], HAINES, Charles Robert Sebastian[2,3], LIU, Cheng[2,3], SAXENA, Siddharth Shankar[2]

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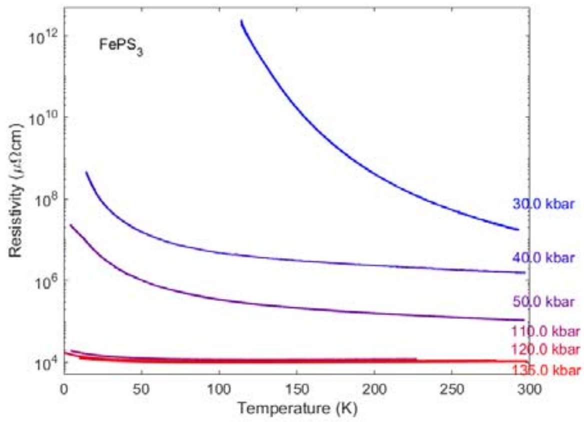
Abstract :



$FePS_3$ is structurally and magnetically two-dimensional, with a magnetic ground state in which spins are ordered as ferromagnetic chains coupled antiferromagnetically. At ambient pressure, it is an insulator with a direct gap of approximately 0.5 eV and a room temperature resistivity of approximately 104 Ωcm. We present the results of magnetisation and resistivity measurements under applied pressures up to 120 kbar (12 GPa) in piston-cylinder clamp cells, sintered diamond Bridgman anvil cells and diamond anvil cells using a cryogenic argon pressure medium. Pressure was seen to increase the antiferromagnetic ordering temperature as the crystal planes are pushed together. The electrical band gap is seen to close and the sample becomes metallic at around 100 kbar, but with an additional upturn in the resistivity at low temperature that remains to be fully explained.

Strongly correlated systems(B)/0416 H9.04

Search for the low-temperature highly correlated phase in the charge-density-wave 1T-TaS_2 compound

Kratochvilova Marie[1,2], Hillier Adrian[3], Wildes Andrew[4], Wang Lihai[5], Cheong Sang-Wook[5], Yu Yunjie[6], Li Shiyan[6], Park Je-Geun[*1,2]

[1]Seoul National University, Seoul 08826, Korea, Department of Physics & Astronomy, [2]Institute for Basic Science, Seoul 08826, Korea, Center for Correlated Electron Systems, [3]Rutherford Appleton Laboratory, Didcot OX11 0QX, United Kingdom, ISIS, STFC, [4]Institute Laue-Langevin, 6 Rue Jules Horowitz, 38042 Grenoble, France, Science Department, [5]Rutgers University, Piscataway, USA, Rutgers Center for Emergent Materials, Department of Physics & Astronomy, [6]Fudan University, Shanghai 200433, China, State Key Laboratory of Surface Physics, Department of Physics, and Laboratory of Advanced Materials

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Abstract :

1T-TaS_2 is a prototypical quasi-2D metallic compound which has been under extensive studies due to its intricate interplay of a Mott-insulating ground state and a peculiar charge density-wave (CDW) order. Moreover, it has been proposed as a quantum spin liquid (QSL) candidate recently. The compound reveals strong electron-phonon coupling responsible for a series of CDW transitions; first, an incommensurate CDW phase below 540 K is established, then a nearly commensurate CDW phase forms at 350 K and finally, a commensurate phase is observed below ~160 K. In this phase, 12 out of 13 Ta^{4+} 5*d*-electrons form some kind of molecular orbitals in hexagonal star-of-David patterns, leaving one 5*d*-electron with S = ½ spin free. This orphan quantum spin with a large spin-orbit interaction may form a highly correlated phase of its own. In order to investigate the low-temperature magnetic properties, we performed a series of measurements including diffuse neutron scattering and low-temperature thermal conductivity. The obtained data indicate the presence of a short ranged phase and suggest the upper bound for the size of the magnetic moment expected from such an orphan-spin scenario. Also, the results put strict contraints on the ground state theories of the possible QSL type, practically excluding the gapless scenarios.

Strongly correlated systems(B)/0106 H9.05

Unconventional charge ordering in 3D metallic single crystal of $Na_{2.7}Ru_4O_9$

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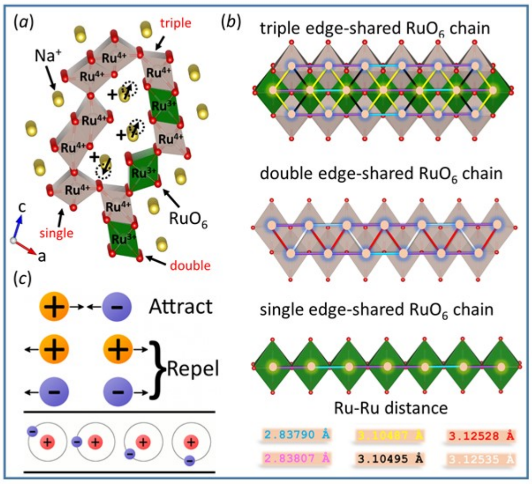
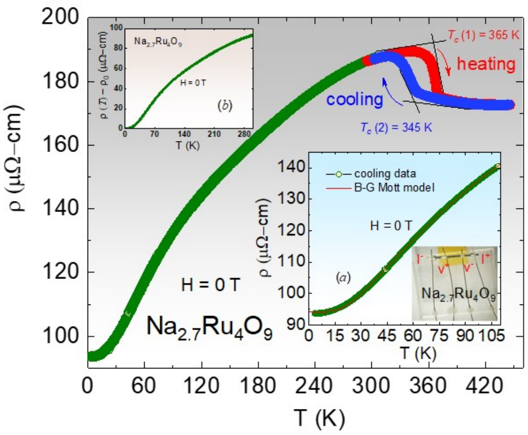
Abstract :





We report a comprehensive investigations of the structural, electric transport, magnetic, and thermodynamic properties of $Na_{2.7}Ru_4O_9$ single crystals. $Na_{2.7}Ru_4O_9$ crystalize in monoclinic structure with P 2_1/ m space group. We observed a first-order phase transition in the electrical resistivity with two consecutive transitions at T_c (1) = 365 K and T_c (2) = 345 K for $Na_{2.7}Ru_4O_9$ which supports well by magnetization and heat-capacity results. The electron–phonon mediated scattering mechanism is involved in the resistivity of Ru-based metallic system. The evidence of metal-like electronic contribution in the low-temperature heat capacity was also observed. The electronic contribution to the specific heat (*g*) for $Na_{2.7}Ru_4O_9$ was determined to be 26.91 mJ/mol K^2. Magnetic susceptibility *c(T) = M/H* curve shows a broad hump near the first order phase transition for $Na_{2.7}Ru_4O_9$, indicating coexistence of short range correlations. The temperature dependent SC-XRD results shows super-lattice peaks $q1(0,12,0)$ and $q2(13,13,0)$, which substantially suppressed at higher temperatures. The suppression of super-lattice peaks is viewed as a Na^+ ion motion in the $Na_{2.7}Ru_4O_9$ lattice which is responsible to increase localized 4d Ru^{4+} (S = 0) $t2g\uparrow 2t2g\downarrow 2$ "ultralow" spin state without the loss of metallicity. These results provide an unprecedented ionic motion driven charge ordering (CO) in $Na_{2.7}Ru_4O_9$ single crystals.

Strongly correlated systems(B)/0524 H9.06

Anisotropy of magnetic interactions and symmetry of the order parameter in unconventional superconductor Sr_2RuO_4

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Abstract :

We present a density-functional based analysis of magnetic interactions in Sr2RuO4: Our goal is twofold. First, we access the possibility of the order parameter rotation in an external magnetic field of 200 Oe, and conclude that the spin-orbit interaction in this material is several order of magnitude stronger than this hypothesis implies. Thus, the observed invariance of the Knight shift across Tc has no plausible explanation, and casts doubt on using the Knight shift as an ultimate litmus paper for the pairing symmetry. Second, we propose a quantitative double-exchange-like model for combining itinerant fermions with magnetic interaction, which is complementary to the Hubbard-model-based calculations published so far, and forms an alternative framework for exploring superconducting symmetry in Sr2RuO4: As an example, we use this model to analyze the degeneracy between various p−triplet states in the simplest mean-field approximation, and show that it splits into a single and two doublets with the ground state defined by the competition between the so-called “Ising” and “compass” terms.

Bongjae Kim, Sergii Khmelevskyi, I. I. Mazin, D. F. Agterberg, and Cesare Franchini, npj Quantum Materials **2** 37 (2017).

Strongly correlated systems(B)/0592 H9.07

Correlated electronic structure of Sr_2RuO_4: A DFT+DMFT study

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Abstract :

We investigate the layered perovskite oxide Sr_2RuO_4 by means of density functional theory plus dynamical mean-field theory (DFT+DMFT), in which the exact diagonalization method is employed as an impurity solver. Ruthenates compounds are known to have strong mutual electronic interactions with moderate spin-orbit coupling, while their explicit role in metal-insulator transitions has not been completely clarified. We discuss the transition nature in the ground state of Sr_2RuO_4, focusing on spectral properties induced by the interplay between the Coulomb interaction and the spin-orbit coupling. We also compare the results to earlier DFT+DMFT studies combined with the quantum Monte Carlo solver, considering the role of finite temperatures.

Strongly correlated systems(B)/0943 H9.08

Role of Coulomb interaction in the multi-fractality of Anderson transition

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Abstract :

In Anderson insulators the Coulomb interactions between localized electrons remain essentially unscreened and give rise to a strongly correlated low temperature state, the so-called electron or Coulomb glass. This state of matter is expected to occur in strongly doped, but insulating semiconductors, in granular metals, as well as in dirty thin metal films. Such systems were long ago predicted to exhibit glassy properties due to their inability to reach the ground state on experimental time scales. The latter leads to experimentally observable out-of-equilibrium phenomena such as the slow relaxation of conductivity and compressibility, aging as well as memory effects.

We study the interaction-driven localization transition of the disordered, Coulomb-interacting spinless fermions focusing on the multifractality and the Coulomb anomaly (pseudo-gap) exhibited in the tunneling density of states. The long-range Coulomb interactions is numerically treated within the Hartree-Fock/Ewald method, with which we can demonstrate that the shape of the pseudo-gap evolves from the quantum (Altshuler and Aronov correction) to the classical behavior (Efros-Shklovskii pseudo-gap) across the metal-insulator transition.

A scaling analysis of wave-functions and inverse participation ratio is performed to demonstrate the multifractality at two separate mobility edges: the long-range Coulomb interaction induces an additional mobility edge around the Fermi level besides the one in the vicinity of the UV cut-off. The multifractality sustains Coulomb interaction although there is considerable degradation. The multi-fractal spectrum at the two mobility edges turns out to be identical. We discuss the effect of the Coulomb interaction on critical, multifractal electronic states, which has been observed in the recent tunneling experiments on Ga_1-xMn_xAs by Richardella et al [1].

[1] Richardella A et al 2010 Science **327**, 665

Focus: 2D Material photonics/0515 H10.01

나노카본물질과의 소멸장 상호작용을 통해 *Q*-스위칭 된 Yb:KYW 고체 평면도파로 레이저

Yb:KYW solid-state planar waveguide lasers *Q*-switched by evanescent field interaction with nanocarbons

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Abstract :

고체 도파로 펄스 레이저는 작고 간단한 공진기 구조, 효율적인 동작특성, 높은 가격경쟁력 등으로 널리 연구되어 왔다. 이러한 고체 도파로 펄스 레이저의 동작을 위해서는 작고 간단한 구조에 적합한 포화흡수체가 필수적으로 요구되나, 도파로 크기에 대응되는 작은 빔크기로 인해 포화흡수체가 쉽게 손상문제에 노출된다는 단점이 있다. 이를 극복하기 위해 소멸장 상호작용관련 연구가 활발히 이루어져 왔다. 소멸장 상호작용은 약한 소멸장 세기를 긴 상호작용거리를 통해 극복한 형태로서 기본적으로 포화흡수체가 약한 빔세기에 노출되기 때문에 포화흡수체의 손상 문제를 효과적으로 피할 수 있다. 이러한 소멸장 상호작용을 적용하기 위해서는 도파로 위에 포화흡수체가 위치해야 하기 때문에, 그 위치를 자유롭게 할 수 있으며 우수한 광특성을 지닌 포화흡수체가 요구된다.

본 연구에서는 탄소나노튜브 및 그래핀과 같은 나노카본 물질을 포화흡수체로 활용하여 Yb:KYW 고체 평면도파로 레이저의 Q-스위칭 동작을 유도하고 그 특성분석을 수행하였다. 탄소나노튜브와 그래핀은 overcladding 이 없는 Yb:KYW 평면도파로 상에 위치시켰으며 이는 소멸장 상호작용을 통해 안정적인 Q-스위칭 동작에 기여하였다. 이어서 소멸장 상호작용에 대한 정량화를 위해 직접상호작용에 해당하는 위치에 탄소나노튜브를 위치시켜 각각의 경우에 대해 Q-스위칭 동작을 유도하고 그 특성을 비교분석하였다. 이로부터 본 연구에 사용한 Yb:KYW 고체 평면도파로 레이저의 경우 소멸장 상호작용시의 최대 첨두세기가 직접상호작용에 비해 약 1,000 배 작은 것을 확인하였다.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Quantum electronics(D)/0197 H10.02

펨토초 레이저의 효율적인 2 차 조화파 생성을 위한 NLO 결정의 조건 최적화

김동준 [1,2], 이병학 [2], 허두창 [2], 김광훈 [2], 김지원[*1]

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Abstract :

가시 파장 영역의 고출력 극초단 레이저는 미세 기계 가공, 안구 수술, 통신, 분광기 등 수많은 응용 분야를 가지고 있다. 고출력 극초단 가시광 레이저 빔을 생성하기 위하여 근적외선 레이저 빔을 비선형 광학 결정에 통과시켜 파장변환을 하는 기술이 가장 표준적인 기술로 알려져 있으나, 극초단 레이저의 넓은 파장 선폭으로 인해 효율적인 파장 변환을 위해서 ns 펄스 레이저 시스템이나 연속발진 레이저 시스템과 같이 무조건 긴 길이의 비선형 광학 물질을 사용하는 것은 바람직하지 않다. 즉 위상정합 조건이 파장에 의존하고 비선형 물질의 복굴절로 인한 워크-오프(walk-off) 효과 때문에 넓은 선폭의 펨토초 레이저빔의 효율적 파장 변환에는 많은 제한 조건이 있는데, 특히 비선형 광학 결정 길이의 최적화는 효율적 파장 변환을 위해 매우 중요하다. 지금까지 극초단 레이저의 효율적인 파장변환에 대한 많은 연구들이 보고되어 왔지만 펄스 폭, 선폭 및 변환 효율과 같은 파장 변환 과정에서의 결정 길이의 영향에 대한 많은 연구는 부족한 형편이다.

본 연구에서는 비선형 광학 결정의 조건을 최적화하여 1 μm 펨토초 Yb 레이저의 효율적인 파장 변환에 대한 결과를 보고한다. 우선 펨토초 레이저 펄스의 파장 변환을 수치적으로 계산할 수 있는 모델링 프로그램을 자체적으로 만들고, 이 결과를 선행 실험결과와 비교하여 잘 일치함을 확인하였다. 그 후 계산된 최적화된 결과를 바탕으로 효율적 파장 변환 시스템을 구축하고 고효율 파장변환 펨토초 레이저를 얻는 연구에 대해 보고할 것이다.

Quantum electronics(D)/0611 H10.03

고출력 고효율 피코초 MOPA 시스템

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Abstract :

높은 평균 출력 및 첨두 출력을 가지는 좋은 빔질의 피코초 레이저는 나노초 레이저에 비해 열문제를 크게 줄일 수 있어 정밀 가공시 가공 성능을 크게 향상시킬 수 있고, 펨토초 레이저에 비해 높은 생산성을 얻을 수 있어 많은 산업현장에서 요구되고 있다. 하지만 높은 첨두 출력으로 인한 광소자들의 광손상, 열 문제, 비선형 효과 등으로 인해 단일 공진기 구조에서 얻을 수 있는 레이저 출력은 한계가 있으므로, 이를 해결하기 위해 MOPA(Master Oscillator Power Amplifier) 시스템을 구축하여 출력을 높이는 것이 일반적이다. 이를 위해 최근 증폭단으로 많이 보고되고 사용되는 레이저 구조는 slab, thin disk, PCF 등을 사용한 것으로, 높은 출력 및 효율, 좋은 빔질의 피코초 레이저빔을 얻을 수 있다고 알려져 있으나, 구조가 복잡하고 고비용, 특허권 등의 문제가 있다. 본 연구에서는 일반적인 rod-type 레이저 결정들을 사용하여 최적화된 증폭단을 구축하여 고출력 고효율 피코초 레이저를 얻는 방법을 보고한다.

본 연구에서는 피코초 광섬유 레이저를 주공진기로 사용하고, 여기서 나온 저출력 피코초 신호를 두 개의 Nd:YVO4 결정을 사용한 1 단 증폭기와 한 개의 Nd:YAG 결정을 사용한 2 단 증폭기를 통하여 증폭하였다. 펌프빔 사이즈와 시그널빔 사이즈, 각 증폭단에서의 증폭률을 최적화하여 펄스폭 ~8.5 ps 를 가지고 최대 ~60 uJ 의 펄스 에너지를 가지는 고출력 레이저빔을 생성하는데 성공하였다. 최종 출력 레이저빔의 빔질은 <1.2 로 측정되었고 증폭단의 광-광 전환 효율은 약 ~20%로 우수한 효율을 가지고 있음을 확인하였다.

4 PW 레이저 빔의 회절 한계 집속을 통한 초강력 레이저 생성

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Abstract :

본 연구를 통해 4 페타와트(1 PW=10^{15} W) 레이저 빔을 회절 한계에 가깝게 집속함으로써 10^{22} W/cm^2 이상의 광세기를 갖는 초강력 레이저를 구현하였다. 초점 크기를 최소화하기 위해 f 수 1.5 의 대구경 비축 포물면 거울을 이용하여 레이저 빔을 강하게 집속하였고, 초점 품질 개선을 위해 적응 광학계를 이용해 파면 왜곡을 보상하였다. 이를 통해 4 PW 레이저 빔을 회절 한계에 가깝게 집속할 수 있었고, 2 마이크론 이하의 집속 빔 크기, 10^{22} W/cm^2 이상의 광세기를 구현하였다.

Quantum electronics(D)/0687 H10.05

Analysis of output pulse energy and remained energy change according to input pulse length in double pass laser amplifier

이중통과 레이저 증폭기에서 입력펄스의 길이에 따른 출력펄스에너지 및 매질 저장에너지 변화 분석

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Abstract :

기존의 Frantz Nodvik 공식에서는 펌프펄스 대비 입력펄스의 길이가 매우 짧기 때문에, 펌프펄스로 인해 매질에 저장되어 있는 에너지를 고정값으로 보고 입력펄스가 증폭되는 방식으로 계산을 해왔다. 그러나, 입력펄스가 펌프펄스 수준으로 길어지는 경우, 더이상 펌프펄스로 인해 매질에 저장되어 있는 에너지를 일정한 값으로 볼 수 없고, 펌프펄스 또한 고정값이 아닌 변수로 고려해야 한다. 본 발표에서는 기존의 이중통과 레이저 증폭기에서 펄스의 중첩효과를 고려하는 동시에, 펌프펄스를 일정한 값이아닌 변수로 고려하여 입력펄스의 길이에 따른 출력펄스에너지 및 매질 저장에너지 변화를 계산하는 방법에 대하여 소개하였다.

Optical technology(B)/0957 H10.06

Single cycle pulse generation with a cascade spectral broadening and its characterization using a tunneling ionization method

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Abstract :

We demonstrate the generation of a single cycle laser pulse with a cascade spectral broadening and its characterization using a tunneling ionization method. The cascade spectral broadening is achieved using a gas-filled hollow core fiber, and subsequently using thin solid plates. The optimum pressure of the hollow core fiber, which gives short duration of the pulse without developing very high third order dispersion, is found. The waveform of the laser pulse is measured the technique called Tunneling Ionization with a Perturbation for Time domain Observation of the Electric field (TIPTOE). We achieved a single cycle pulse whose duration is only 2.4 fs while the Fourier Transform Limited pulse duration is 2.2 fs. It is also shown that the continuum high harmonic spectra can be obtained without having a temporal gating technique.

Basic plasma phenomena(D)/0072 H11.01

Dynamics of water-ice grains spontaneously generated in a plasma where gravitational force is compensated by thermophoretic force.

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Abstract :

A capacitively-coupled plasma source equipped with liquid nitrogen cooling system has been developed to study the growth and dynamics of water-ice grains formed in a plasma environment at Korea Atomic Energy Research Institute. We found that the gravitational force exerted on 5 μm water-ice grains is nearly compensated by the thermophoretic force when the top electrode is cooler than the bottom electrode by 10-15 K and observed two axisymmetric vortex flows are formed in the upper and lower plasma regions. The numerical calculation solving a set of equations including the vorticity equation confirms that the observed axisymmetric vortex flows are caused by the non-conservative ion drag force.

Basic plasma phenomena(D)/0319 H11.02

Effects of Surface Tension Decrease in Plasma Treated Water on the Characteristics of the Pin-to-Water Plasma

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Abstract :

The atmospheric pressure plasmas are widely used for various environmental and biomedical applications. Most cases, the plasma treatment targets including or included in the liquid. Bruggeman *et. al.*, [1] reported that the electric field from the electrode deforms the water surface into Taylor-cone shape in the pin-to-liquid discharge. The major factors for the height of deformed liquid surface are electric field on the liquid surface and surface tension coefficient of the liquid. Because the pin-to-liquid discharge produces the nitric ions in the liquid, the ions decrease the surface tension coefficient of the liquid. We demonstrated the pin-to-water discharge by applying the ac-driven voltage on the pin on the plasma treated water. For the plasma treated time, the plasma treated water shows high electrical conductivity due to high density of nitric ions. We estimated the corresponding surface tension coefficients by fitting the deformed liquid surface profiles to the simulated results. Thus, we found that the decreased surface tension coefficient by the plasma increases the height of Taylor cone and the increased plasma current enhances the decrease of the surface tension coefficient. Also, these results can be a basic physical data to establish the physical properties of plasma treated water.

Acknowledgement – This study was supported by the R&D Program of “Plasma Advanced Technology for Agriculture and Food (Plasma Farming)” through the National Fusion Research Institute of Korea (NFRI) funded by government funds.

[1] Bruggeman *et. al.*, “Water Surface Deformation in Strong Electrical Fields and Its Influence on Electrical Breakdown in a Metal Pin–water Electrode System.” Journal of Physics D: Applied Physics 40 (2007): 4779–86.

Accelerator & beam physics(A)/1042 H11.03

레이저 펄스 재이용을 통한 효과적인 이온 가속 연구

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Abstract :

지난 20 년간 초강력 레이저를 이용한 이온가속은 많은 연구를 거쳐왔으며 수~수십 MeV/u 에너지의 이온 빔이 다양한 연구소에서 만들어지고 있다. 주어진 레이저설비에서 더 강한 가속장을 만들기 위해서는 레이저 흡수율이 좋아야 하며 단순하면서 효과적인 방법이 타겟을 특수하게 가공하는 것이다. 기존 연구들은 메인 타겟 표면을 코팅하는 방법을 주로 사용하였는데 우리는 반사된 레이저펄스를 재이용할 수 있는 구조를 제시하였다. 우리가 제시하는 타겟은 2 차원 파티클-인-셀 시뮬레이션을 통해 이온빔의 에너지를 45%, 챠지량을 250% 증가시킴을 확인하였다. 또한 타겟 사이의 각도를 조절하여 레이저의 재입사 위치를 조절할 수 있으며 추가적인 레이저 설비 없이도 빔의 방향성을 조절하는 이중펄스 가속의 특징을 가진다. 이 타겟구조는 이해하기 쉬우며 실험에 적용할 수 있는 가능성이 높을 것으로 생각된다.

Accelerator & beam applications(B)/1134 H11.04

Ultrafast charge dynamics: proton imaging/deflectometry

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Abstract :

In many experiments, laser driven proton beams have been successfully implemented to study the transient dynamics of electromagnetic fields in laser produced plasmas. The key to this application is that the proton beam is sensitive to electric and magnetic fields and the deflection caused by them generates local modulations in the proton density across the beam. The ultra-short burst duration ensures high temporal resolution (~ps), while the extreme laminarity, and small source size lead to a high spatial resolution (~μm) in the determination of the field evolution.
This point projection imaging technique has been used to study the interaction of fs laser pulses of intensities (I>10^20 W/cm^2) with solid targets flat foils, wires). A novel proton imaging technique was applied by placing a mesh downstream of the target to investigate laminarity of fs laser driven proton beam. A 3D ray-tracing technique was developed to determine the "virtual source" position and size by tracing the proton trajectories back from the mesh images on RCF stuck detector.

The phenomena of ultrafast charge up of the target due to the loss of hot electrons, which draws a neutralization current was investigated by proton probing technique. A flow of kilo-Ampere charge away from laser focus with velocity close to speed of light and discharging of laser irradiated region in a few 10's of picoseconds was measured. Numerical simulation confirmed the propagation of an electromagnetic pulse through the wire without decay and hence corresponded to the expansion of charge.

Accelerator & beam physics(A)/0125 H11.05

Relativistic electron beams produced by an ultra-intense circularly polarized Laguerre-Gaussian laser pulse

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Abstract :

As a scheme for producing relativistic ultrashort electron bunches, we theoretically studied the acceleration of plasma electrons by ultraintense laser pulses having spin and orbital angular momenta. A laser pulse has a spin angular momentum when it is circularly polarized, and it has an orbital angular momentum when it is in a Laguerre-Gaussian mode. From three-dimensional particle-in-cell simulations, we found that a relativistic electron bunch train is produced from an underdense plasma slab when the spin and orbital angular momenta of the driving laser pulse cancel each other out. In such case, the laser pulse exerts on the plasma electrons not only the inward ponderomotive force, a characteristic of Laguerre-Gaussian modes, but also alternating electric force along the laser propagation axis. As a result, relativistic femtosecond electron bunch train is generated with bunch spacing equal to the laser wavelength and small beam divergence. Such a relativistic electron bunch train may be useful for many applications in material science.

Accelerator & beam applications(B)/0110 H11.06

High-power microwave generation experiments using relativistic electron beam accelerators and millimeter-terahertz(THz) wave source research and biomedical application

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Abstract :

A high power microwave (HPM) based on a research on a vacuum element called a back-wave oscillator that electron beams and microwaves interact with each other in electron relativistic regions ($\gamma \approx 2$, $\beta = 0.87$) generation experiments were performed. This study was conducted to analyze the effects of exposure to electromagnetic pulses in the microwave frequency band and to study the effects of transient pulsed radiation effects of electronic devices. In addition, a high-power terahertz wave source is being studied in the millimeter-terahertz frequency band. The structure of the vacuum element and the cathode is a large cross-section diameter type of relativistic backward wave oscillator (Overmoded Relativistic Backward Wave Oscillator) Vacuum element research and induction in vacuum associated with accelerating electron beam acceleration in a plasma wakefield accelerator - This is a high power electromagnetic emission technique using Cherenkov radiation using a plasma accelerated metamaterial. When a vacuum device is developed through these studies, it is possible to apply electromagnetic waves in the range of 0.1 THz to 1 THz, and to apply biological effects analysis experiments under the condition of Larmor resonance. This is due to the fact that under non-thermal conditions, the interferometry frequency band (10 GHz to 1 THz, γ -dispersion) can cause interference, excitation, dipolarity, oscillation, and resonance. This is suitable for the study of biomolecule movement effect of proteins composed of polypeptide bonds of amino acids, and can be applied to development of calcium-protein regulatory control diagnosis and treatment system based on genome research.

Accelerator & beam physics(A)/0509 H11.07

Enhancement of proton fraction by controlling electron temperature using transverse magnetic field in pulse-operated PIG hydrogen ion source

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Abstract :

The high proton fraction plays an important role in the performance of the hydrogen ion source in the beam-using facilities such as accelerators. It is known that the proton fraction goes up, as the electron temperature and the operating pressure decrease and the plasma density increases. However, the behavior of the operating pressure and the electron temperature is coupled together in low temperature plasma; if operating pressure goes down, the electron temperature increase, and vice versa. So the operating pressure and the electron temperature cannot be lowered at the same time to improve the proton fraction. The transverse magnetic field in the extraction region affects the transport of the electrons and works to lower the electron temperature. This allows the electron temperature to be adjusted independently regardless of the operating pressure. Using this principle, a method to enhancing the proton fraction is presented in this study. A cold cathode PIG (Penning Ionization Gauge) ion source is constructed, and operated in a pulsed arc mode. A transverse magnetic field is applied to the extraction region to control the electron temperature. The behavior of the proton fraction is observed through changing magnetic field structure. A time-of-flight mass analyzer is used to measure the ion species fraction of the pulsed hydrogen ion beam. To measure the plasma parameters such as the plasma density and the electron temperature, a triple Langmuir probe, suitable for pulse plasma, is used.

Accelerator & beam physics(A)/0318 H11.08

Study of ESASE scheme for generating terawatt attosecond X-ray pulse in XFELs

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Abstract :

X-ray free-electron lasers have been successfully operated or will be operated to supply femtosecond X-ray pulses with a few tens of gigawatt power. However, an attosecond X-ray pulse is required to investigate the phenomena such as the dynamics of electrons in atoms, molecules and nanoscopic systems in their real time. The power of an attosecond X-ray pulse also have to be increased to the level of terawatt to deliver a sufficient number of photons. Such terawatt attosecond X-ray pulse in XFELs can be generated by the high and narrow current spike in the electron beam and such current spike can be obtained by using ESASE (enhanced self-amplified spontaneous emission) scheme. In this presentaion, it is discussed how to utilize this scheme to obtain the high and narrow current spike in the electron beam by manipulating the electron beam.

Nanomaterials and nanodevices(A)/0447 H12.01

The study of synaptic plasticity in two-dimensional chromium thiophosphate ($CrPS_4$) CBRAM

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Abstract :

Two-dimensional (2D) van der Waals (vdW) materials have attracted much attention due to their excellent electrical and mechanical properties. $TmPS_x$ (Tm = transition metal) is an emerging 2D vdW material which is expected to show various physical phenomena depending on Tm. Here we report unprecedented synaptic behavior of a vertical Ag/$CrPS_4$/Au capacitor structure where $CrPS_4$ is a single-crystalline 2D vdW layer. Multi-stable resistive states are obtained by external voltage less than 0.3 V. Both short-term plasticity and long-term potentiation are observed by controlling the interval of external voltage pulse. Simple mechanical exfoliation enables the implementation of a synaptic device based on a very thin $CrPS_4$ layer with thickness of ~17 nm. Therefore, the vertical Ag/$CrPS_4$/Au capacitor offers a promising inorganic synaptic device compatible with next-generation flexible neuromorphic technology.

Nanomaterials and nanodevices(A)/0337 H12.02

Synaptic Plasticity Selectively Activated by Polarization-Dependent Energy-Efficient Ion Migration in an Ultrathin Ferroelectric Tunnel Junction

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Abstract :

Selectively activated inorganic synaptic devices, showing a high on/off ratio, ultrasmall dimensions, low power consumption, and short programming time, are required to emulate the functions of high-capacity and energy-efficient reconfigurable human neural systems combining information storage and processing. Here, we demonstrate that such a synaptic device is realized using a $Ag/PbZr_{0.52}Ti_{0.48}O_3$ (PZT)/$La_{0.8}Sr_{0.2}MnO_3$ (LSMO) ferroelectric tunnel junction (FTJ) with ultrathin PZT (thickness of ~4 nm). Ag ion migration through the very thin FTJ enables a large on/off ratio (10^7) and low energy consumption (potentiation energy consumption = ~22 aJ and depression energy consumption = ~2.5 pJ). In addition, the simple alignment of the downward polarization in PZT selectively activates the synaptic plasticity of the FTJ and the transition from short-term plasticity to long-term potentiation.

Nanomaterials and nanodevices(A)/0336 H12.03

The study of Al layer effect on black phosphorus field effect transistors

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Abstract :

Two-dimensional (2D)-layered materials have emerged as a new class of materials applicable to next-generation electronic devices due to their excellent electrical performances. Graphene has been tried as a channel because of its high carrier mobility. However, its zero band gap has limited application for electronic devices with high on/off ratio. For high on/off ratio, semiconducting 2D materials with considerable band gaps, such as MoS_2 and black phosphorus (BP), have been alternatively used. Especially, BP is considered to be a promising candidate for next-generation 2D electrical and optical devices due to its high carrier mobility of ～1000 cm^2/V·s at room temperature and band gap of ～0.3 eV in bulk. Additionally, an exfoliated few-layer BP with direct band gap of ~1.2 eV exhibits mobility of 200−1000 cm^2/V·s and on/off ratio of 10^4−10^5 in a field effect transistor. However, its instability in air is of paramount concern for practical applications. Recently, encapsulation, passivation, and chemical functionalization methods are reported for enhanced air stability of BP device. Here, we suggested a new method for reduction and encapsulation of BP devices. Reduction and encapsulation are demonstrated via Al metal deposition with high oxidation Gibbs free enery for oxidized BP channel field effect transistor (FET).

Nanomaterials and nanodevices(A)/0283 H12.04

Epitaxial growth of AuCN Nanowires on graphene for Hybrid Phototransistors

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Abstract :

We present a facile method to fabricate epitaxially-grown semiconducting AuCN nanowires on graphene and investigate the evolution of nanowire morphology depending on growth conditions. The nanowire morphology and its directional alignment relative to graphene substrate are studied in detail with transmission electron microscopy, which clearly reveals the effect of diffusion kinetics during the nanowire formation process. We also investigate the electrical properties of AuCN/graphene heterostructures and their phototransistor behaviors. We find that the AuCN-sensitized hybrid device strongly responses to photons with energy above 2.6 eV, which is consistent with the bandgap of semiconducting AuCN. The device show a large UV response with responsivity ~ 10^4 A/W under the illumination of 3.1 eV (400 nm) photon.

Spin and magnetism(C)/1122 H12.05

Observation of tilting domain wall motion due to the interfacial Dzyaloshinskii-Moriya interaction in perpendicularly magnetized junction

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Abstract :

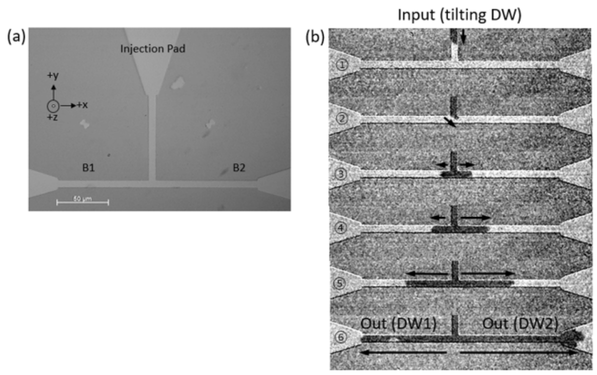

Fig. 1: (a) Microscopy image of a T-shaped device, which has a wire width, 5μm. (b) ① - ⑥ Kerr microscopy images for DW dynamics in the structure as DW has a creep motion by field pulse. DW tilting angle has been oriented due to the propagation directions from an input wire to two outputs. Black arrows indicate the propagation direction of DW.

Magnetic domain wall (DW) manipulation in a complex structure is an crucial for realizing the spin-based logic or memristor devices.[1,2] The Dzyaloshinskii-Moriya interaction (DMI) in the inversion symmetry breaking structure induces a non-equal DW motion with respect to the direction of in-plane field.[3,4] The dynamics of field-driven DW motion in perpendicular magnetic anisotropy (PMA) influenced by DW tilt due to DMI effect and topological defects in T-shaped structure. Thin film stacks $Si/SiO_2/Ta/Pt/[Co/Pt]_{x4}$ with Pt capping were used for T-shape device fabrication. Images from Kerr microscopy reveal that the DMI effective field contributes a tilting and an evolution of DW configuration along its propagation direction. DMI constant has been estimated by measuring circular DW expansion on the film utilizing Kerr microscopy technique.[5] Due to the DW tilt angle orientation changes in T-shape structure, the DW velocity increases along its propagation direction. In addition to, micromagnetic simulation result support the details for dynamics of a DW configuration in the structure.

Spin and magnetism(C)/0302 H12.06

Ultrafast giant magnetic cooling effect in ferromagnetic Co/Pt multilayers

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Abstract :

The magnetic cooling effect originates from a large change in entropy by the forced magnetization alignment, particularly around the magnetic phase transition at the Curie temperature. Here, we report, for the first time, that a giant magnetic cooling (up to 200K) phenomenon exists, even on a femtosecond time scale, during the photoinduced demagnetization and remagnetization. An analysis of the time-resolved hysteresis curves based on a 3-temperature model indicates that giant magnetic cooling exists in the Co/Pt multilayers for the initial tens of picoseconds of photoinduced demagnetization and remagnetization, and is proportional to the external magnetic field strength via modification of the lattice-spin interaction. The giant magnetic cooling observed in the present study on a subpicosecond timescale can enable a new avenue to the realization of ultrafast magnetic and spintronic devices.

Spin-orbit coupling in strongly correlated systems

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Abstract :

Strongly correlated systems, named due to the presence of strong electron-electron correlation, are the hosts of variety of interesting phenomena such as metal-insulator transition, magnetism including quantum spin liquid, spin-charge separation and unconventional superconductivity. This variety comes from the fact that all possible interactions played by all degree of freedoms (DOFs) in solid - lattice, charge, orbital and spin DOF are equally important in the fundamental level, enhanced by strong correlation.

Among many interactions in solids, spin-orbit coupling is highlighted recently due to its key role on the formation of topological state. When spin-orbit coupling is combined with correlation flavor, it can manifest many interesting results such as relativisitic Mott insulating phase driven by melting of orbital angular momentum quenching against the crystal field forced by spin-orbit coupling. In this tutorial, staring from basics of spin-orbit coupling and correlation effect in solid, recent examples from the presence of spin-orbit coupling and the correlation will be introduced.

Tutorial: Machine learning in search for new physics beyond the standard model/1008 T2.01

Machine Learning Algorithms for High Energy Physics

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Abstract :

심층신경망(deep neural networks)을 통한 학습기법의 비약적인 발전으로 인하여, 복잡한 데이터속에 담겨져있는 모델을 추출해내는 기계의 성능이 매우 빠른 속도로 향상되고 있으며, 이러한 기계학습알고리즘(machine learning algorithm)의 발전은 인간만이 할 수 있었던 작업들을 효율적으로 대체하는 수준을 넘어, 인간이 하지 못했던 모델링을 가능하게 한다. 고에너지의 진공으로부터, 최종 탐지기에 남겨지는 복잡한 전기신호까지, 광범위한 유효 시스템에서의 모델들과 데이터들의 거대 집합으로서의 고에너지 입자물리학은, 기계학습의 발전이 자연과학의 발전에 기여할 수 있는 매우 좋은 테스트베드가 되고 있으며, 이는 인공지능과 함께 할 과학의 미래를 예견해볼 수 있는 좋은 사례가 된다. 본 튜토리얼 세션에서는 기계학습을 통한 모델링의 의미와 여러가지 기계학습 알고리즘들을 예제와 더불어 상세히 설명하고, 고에너지 물리학에의 최신 응용 사례들을 소개하고자 한다.

Tutorial: Machine learning in search for new physics beyond the standard model/0617 T2.02

포스트 힉스 시대의 딥 러닝

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Abstract :

2012 년 힉스 입자가 발견되고 5 년이 지난 지금 힉스 입자의 질량을 자연스럽게 설명하거나 암흑물질의 후보가 되는 새로운 입자의 존재가 아직 확인되지 않고 있다. 그 동안 거대 양성자 충돌에서 충돌에너지는 높아지고 데이터의 양은 점점 쌓여 앞으로는 100 배가 넘는 데이터의 양이 더 쌓일 것으로 예상한다. 이런 포스트 힉스 시대에 딥 러닝의 필요성과 역할에 대해서 소개하고자 한다.

Tutorial: Super-resolution imaging/0420 T3.01

초고해상도 광학 이미징

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Abstract :

광학 이미징 기기의 해상도는 가시광선의 회절로 인하여 제한되기 때문에, 높은 개구수의 고분해능 광학 현미경도 약 250 nm 의 해상도를 가진다. 이러한 분해능의 한계 때문에 나노미터 규모에서 일어나는 생명현상의 생체 내 실시간 이미징이 불가능하였으나, 최근에 수십나노미터 분해능을 가진 광학 현미경이 개발되어 기존에 볼 수 없었던 나노미터 세계를 생체 내에서 직접 관찰할 수 있게 되었다. 본 튜토리얼에서는 해상도 한계를 극복하는 다양한 물리/화학적 원리를 소개한다. 그 중 STED(Stimulated Emission Depletion), SIM(Structured Illumination Microscopy)과 단분자 중심위치 측정을 이용하는 방식(PALM/STORM/GSDIM 등 여러 이름으로 통칭됨)의 세 가지 방식에 촛점을 맞추어, 이들의 작동원리, 장점, 단점 및 차이점을 논의한다. 또한, 각 방법을 어떠한 생명현상에 응용할 수 있는지 예제를 중심으로 소개하고자 한다. 덧붙여 최근 2-3 년 사이에 소개된 방법들 중, 샘플 자체의 부피를 팽창시키는 방법(expansion microscopy)과 기존의 초고해상도 광학이미징의 해상도를 뛰어넘는 방법(MINFLUX 등) 등의 이 분야의 최신동향을 살펴본다. 이를 통하여 분자 단위의 물리적 현상을 직접 세포 내에서 연구하는 생명물리연구의 방향을 제시하고자 한다.

Tutorial: Quantum entanglement and gravity/0047 T4.01

양자얽힘과 중력의 기초

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Abstract :

최근 양자정보, 특히 양자얽힘과 중력, 더 나아가 시공간의 기원의 연관성에 대한 관심이 높아지고 있다. 본 강의에선 비국소적 양자 상관관계의 하나인 양자얽힘의 정의, 물리적 의미, 기초적인 계산법을 살펴본다. 그리고 양자얽힘과 중력, 블랙홀, AdS/CFT, 그리고 양자장론의 관련성에 대한 그간의 연구결과와 양자중력 및 우주론등에서 앞으로의 활용에 대해 간략히 알아본다.

Tutorial: Quantum entanglement and gravity/0169 T4.02

홀로그래픽 양자얽힘 엔트로피와 중력

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Abstract :

최근 다양한 물리계의 양자적 성질들을 이해하기 위해 양자얽힘에 대한 많은 연구들이 수행되고 있다. 하지만 아쉽게도 강하게 상호작용하는 물리계의 경우, 양자얽힘을 계산하는 것은 매우 어려운 일이다. 이 튜터리얼 세션에서는 홀로그래피를 이용하여 한차원 높은 중력이론에서 강하게 상호작용하는 양자얽힘을 이해하는 새로운 방법론에 대해 논의한다.

Tutorial: Quantum entanglement and gravity/0314 T4.03

얽힘으로부터 시공간 이해하기

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Abstract :

홀로그래픽 얽힘 엔트로피의 연구 이후에 이를 이용하여 시공간을 이해하려는 시도가 많은 사람들의 관심을 끌게 되었다. 그래서 본 강의에서는 이러한 시도들을 나열하고 그것들이 왜 의미가 있는 지 살펴보겠다. 특히 블랙홀이나 다른 시공간이 형성되는데 어떻게 얽힘이 작용하는지 설명하고 시공간을 기술하는 아인슈타인의 장 방정식이 어떻게 얽힘 엔트로피가 만족하는 방정식으로부터 나오는지에 대해 알아볼 것이다. 또 중력의 안정성과 얽힘 엔트로피가 어떤 관계가 있는지 간단히 다룰 것이다. 이 외에도 여러 가지 관련된 최근의 해석과 결과들에 대해 소개할 것이다.

Tutorial: Introduction to Dirac and Weyl semimetals/0526 T5.01

Introduction to Dirac and Weyl semimetals

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Abstract :

Topological semimetals describe the state of matters in which the energy gap between the conduction and valence bands is closed at several points or along lines in the momentum space. Recently discovered Dirac and Weyl semimetals are such examples. Topological semimetals can be generated either via a band inversion or due to the symmetry protected band degeneracy at a high symmetry point in the Brillouin zone. In many cases, such a band contact point or line is protected by some topological invariants, which indicates the nontrivial topological properties of the relevant semimetal state. In this talk, I am going to give a pedagogical introduction to topological semimetals including Dirac and Weyl semimetals. I'll explain the general mechanism creating various topological semimetals and describe their topological properties. Also I'll discuss how to classify possible topological semimetals based on space group symmetry. Finally, I'll describe possible unconventional topological phase transitions mediated by semimetals carrying point or line nodes.

Special Sessions(A)/0776 W1.01

아인슈타인과 우주 - 100 년의 신화

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Abstract :

1917 년 아인슈타인은 자신이 완성한 새로운 중력인론인 일반상대성 이론을 우주에 적용하는 시도를 했다. 그는 우주원리를 도입하여 영원불변한 우주를 얻기 원했지만 그의 이론은 팽창하는 우주를 내놓았고, 허블에 의해 팽창의 증가거 발견됨으로써 현대 우주론이 시작되었다. 이 강연은 지난 100 년간 이루어진 우주에 대한 놀라운 발견들과 이것을 성취해낸 인류의 도전에 대한 이야기이다. 우주의 팽창, 우주마이크로파배경의 발견에서 암흑 물질과 암흑 에너지의 존재를 밝히기 까지의 과정과 시공간과 물질의 틀에서 어떻게 관측된 우주를 이해하고 있는가와 시공간과 물질의 궁극적 기원을 밝히려는 도전을 다룬다.

Special Sessions(A)/0632 W1.02

많음, 다름, 그리고 양자역학 (More, Different, and Quantum)

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Abstract :

“전체는 부분의 합보다 크다 (The whole is greater than the sum of its parts)”라는 유명한 명제는 노벨물리학상 수상자인 필립 W. 앤더슨(Philip W. Anderson)에 의해서 “많음은 다르다 (More is different)”라는 조금 더 시적인 명제로 압축되었다. 현대 응집물질 물리에서 가장 중요한 연구 분야 중의 하나인 다체 물리(Many-body physics)는 여기에 양자역학이 개입될 때 어떠한 일이 일어나는가에 대해서 관심을 갖는 분야이다. 본 강연에서 연사는 다체 물리에서 다루어지는 다양한 연구 주제들을 하나로 묶을 수 있는 개념인 “새로운 물질 상태의 창발(Emergence)”이라는 관점에서 다체 물리를 얘기하고자 한다.

Special Sessions(A)/1221 Y1.01

Quantum Black Holes and the Structure of Space and Time

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Abstract :

Theories of strings and D-branes can be used to describe objects that may be regarded as black holes or candidates thereof, but leave some properties of horizons and space-time structure underdeveloped. Yet one can also start off with black hole models using not much more than standard quantum field theory in combination with perturbative gravity. Then also, one can take gravitational back reaction into account, and find out where information is stored and how out-going particles are entangled. This yields a remarkably clear picture of the non-trivial space-time structure of black holes.

Special Sessions(A)/1222 Y2.01

The Quantum Properties of Magnetic Atoms on Surfaces

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Abstract :

The scanning tunneling microscope is an amazing tool because of its atomic-scale spatial resolution. This can be combined with the use of low temperatures, culminating in precise atom manipulation and spectroscopy with microvolt energy resolution. In this talk we will apply these techniques to the investigation of the quantum spin properties of magnetic atoms sitting on a thin film of magnesium oxide (MgO). In such a situation, the thin insulating film serves two important purposes: first, it provides a strong ligand field which is crucial to understanding the low-energy (magnetic) states of the metal atoms (adsorbate). Second, the insulating film electronically decouples the atom from the underlying conduction electrons, which in turn preserve the quantumness of the adsorbate.

In a first set of experiments, we will investigate the tunneling spectroscopy of 3d transition metal atoms at low temperature and in high magnetic fields. We find that the tunneling electrons can interact with the magnetic states of the adsorbate by exchanging energy and quanta of angular momentum. This leads to clear selection rules in this inelastic tunneling spectroscopy, which we coined ‘spin excitation spectroscopy’ (*Science* 2004). Due to the strong ligand field of the polar MgO surface, we find that adsorbates with spin larger than ½ show strong magnetic anisotropy, giving rise to non-trivial magnetic states (*Science* 2014, *PRL* 2015).

On our quest towards more quantumness we will then investigate the lifetimes of excited states. After a tunneling electron excites the adsorbate, it can be left behind in an excited state. Often this lifetime is far shorter than the time resolution of traditional STM, which is in the range of millisecond. We therefore developed an all-electrical pump and probe measurement technique that allows lifetime measurements down to nanoseconds (*Science* 2010). Surprisingly, we find lifetimes that vary from nanoseconds to hours, a truly amazing consequence of the quantum states of the different adsorbates.

Finally, we will explore the superposition of quantum states which is inherent to spin resonance techniques. We recently demonstrated the use of electron spin resonance on single Fe atoms on MgO (*Science* 2015). This technique combines the power of STM of atomic-scale spectroscopy with the unprecedented energy resolution of spin resonance techniques, which is about 10,000 times better than normal spectroscopy.

포스터발표논문

Poster session abstracts

Organic electronics and photonics(E)/0058 P1-ap.101

고굴절 박막을 활용한 실크 단백질 유기레이저 발진

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Abstract :

실크 단백질은 최근 바이오 광학분야에 적용 가능한 광학 소재로 많은 관심을 받고 있다. 여기서는 실크 단백질 박막과 유기 염료와의 결합을 통해 가시광선에서 발진하는 다양한 유기 레이저 구현에 대한 보고와 새로운 개념의 레이저 구현 및 이들의 응용에 대하여 논하고자 한다.

Organic electronics and photonics(E)/0361 P1-ap.102

Morphology-dependent Switching Property of Organolead Halide Perovskite Memory Device

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Abstract :

Recently, diverse organolead halide perovskite (OHP) materials have been highlighted as a new organic component in two-terminal organic resistive memory due to low-operating voltage, multibit capability, simple solution process, and flexible device application [1,2]. In this study, we fabricated the two-terminal OHP memory device using a $CH_3NH_3PbI_3$ film confined between Ag and ITO electrode, and we controlled two different types of its morphologies in terms of the grain size, the existence of pinhole, and uniformity of the film thickness: (i) good and (ii) poor morphology. For the good morphology, the precursor solution was prepared by adding a 1:1:1 molar ratio for PbI_2, CH_3NH_3I, and DMSO, respectively. And then, the diethly ether (DME) was dropped on top of the ITO substrate during the spin coating process of the precursor solution, resulting in the rapid crystallization of $CH_3NH_3PbI_3$ film [3]. On the other hand, for poor morphology, it was simply prepared without adding DMSO and DME. As compared with poor morphology, the device fabricated with relatively good morphology of the film exhibited the enhanced switching characteristics such as lower-operating voltage as low as 0.2 V (0.5 V for poor morphology), good endurance cycle (> 500 cycles), On/Off ratio of 10^2 (~50 for poor morphology), and good retention time of 10^3 s. We will discuss the origin of morphology-dependent switching property of the OHP memory device.

[1] Choi, J. *et al.* Organolead Halide Perovskites for Low Operating Voltage Multilevel Resistive Switching. *Adv. Mater.* 6562–6567 (2016).

[2] Gu, C. & Lee, J. S. Flexible Hybrid Organic-Inorganic Perovskite Memory. *ACS Nano* **10,** 5413–5418 (2016).

[3] Namyoung, A *et al. Highly Reproducible Perovskite Solar Cells with Average Efficiency of 18.3% and Best Effi*ciency of 19.7% Fabricated via Lewis Base Adduct of Lead(II) Iodide. *J.Am.Chem.Soc.*. **137**, 8696-8699 (2015).

Organic electronics and photonics(E)/0431 P1-ap.103

Development of an artificial synapse based on ferroelectric organic field-effect transistor for wearable neuromorphic applications

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Abstract :

Recently, the field of neuromorphic electronic system for mimicking diverse functionalities of biological synapse and massively parallel neural network found in human brain has been emerging as a promising approach toward energy-efficient computing technology.[1] Here, we introduce a new class of artificial synapse as a basic unit for flexible and wearable intelligent device applications. We fabricated a large scale of ferroelectric organic field-effect transistor memory (~ 500 nm total thickness) in a free-standing form using a pentacene and a ferroelectric copolymer, PVDF-TrFE, and utilized it as a free-standing artificial synapse. The device exhibits the reliable switching properties even in free-standing form, and it can be also properly operated on various corrugated surfaces such as a thermal-shrink plastic film, a jelly, a textile, a candy, a teeth brush, and a brain mold. By applying diverse electrical pulses with modulated relative timing between pre-synaptic (gate electrode) and post-synaptic neuron (drain electrode), diverse synaptic activities such as STP, LTP, LTD, and STDP have been implemented. Furthermore, it features sustainable synaptic functions for more than 6,000 times of input signals under extreme conditions such as transferred on the corrugated brain-like mold and completely folded with very small banding radius (R = 50 μm).

Organic electronics and photonics(E)/0434 P1-ap.104

Alcohol based solvent vapor annealing of the poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) layer for improving the performance of inverted perovskite solar cells

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Abstract :

Since first reported by Kojima and co-workers in 2009, organic–inorganic methylammonium lead halide-based perovskite solar cells (PSCs) have been very rapidly developed because of their high performance and simple fabrication process. In addition to finding new materials, morphology control of each layer is also very important for device performance. In this study, we developed alcohol based solvent vapor annealing (SVA) of the poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) layer for improving the performance inverted PSCs. We observed an enhanced phase separation of PEDOT and PSS after using the alcohol based SVA, which leads to an improved conductivity of the PEDOT:PSS layer. The atomic force microscopy and atomistic theoretical simulations indicated that the phase separation was highly related with the dielectric constant and polarity of the alcohols. By using methanol based SVA, the short circuit current density of the PSCs was improved from 20.7 to 21.6 mA cm^{-2}, yielding the enhanced power conversion efficiency (PCE) from 16.1 to 17.3%. While using ethanol or isopropanol based SVAs lead to less performance improvements. The PCEs of best sample in this study under forward and reverse scans were 17.7–18.0%, indicating the small hysteresis of the PSC. Our results suggest that using methanol based SVA to treat PEDOT:PSS layer is a simple and effective way for developing high performance inverted PSCs.

Organic electronics and photonics(E)/0443 P1-ap.105

A novel structure for Planer Lead Halide Perovskite Solar Cells with better stability, performance and flexibility

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Abstract :

Nowadays, perovskite solar cells (PSCs) have been a hot topic all over the world due to the high performance and low cost. The photoelectric conversion efficiency gets a huge boost, reaching around 22% within a few years. It is shown to be a promising substitute for present traditional photoelectric products. In this work, we use a low temperature processed, solution processed, metal-oxide free method to deposit a flexible anode to replace the traditional ITO layer. By this way, we can avoid the erosion of perovskite owing to the acetic property of poly(3,4-ethylenedioxylenethiophene):poly(styrene sulfonate) (PEDOT:PSS) by inserting a poly(bis(4-phenyl)(2,4,6-trimethylphenyl)amine) (PTAA) layer between PEDOT:PSS and perovskite as a hole transfer layer. Furthermore, PTAA has a more balanced work function alignment. As a result, this novel device structure will bring a good stability as well as an excellent performance. In our work, the highest efficiency of perovskite solar cells is up to 15.6% on a glass substrate and 12.7% on a flexible substrate. In the meantime, the device with new structure has a better stability and longer lifetime. This essentially offers more means to future industrialization.

Organic electronics and photonics(E)/0448 P1-ap.106

Improving the performance of lead acetate based perovskite solar cells by using dimethylsulfoxide

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Abstract :

During past few years, perovskite solar cells (PSCs) have become very popular because of their excellent performance, such as low cost, easy fabrication, and high efficiency. As first reported by Kojima and coworkers in 2009, the power conversion efficiency (PCE) of PSCs has increased very rapidly from 3.8% to 22.1% within just a few years. Usually lead halides (PbI_2, $PbCl_2$, and $PbBr_2$) are used as lead source for preparing perovskite solutions. In addition to lead halides, lead acetate is another promising material to provide lead element for perovskite. In this work we talked about the mix solvent effect on the performance of lead acetate based PSCs by adding dimethylsulfoxide (DMSO) in to the perovskite precursors. We respectively added 0vt.% ,2.5vt.%,5vt.% and 7.5vt.% DMSO into the perovskite precursors and found that using 5vt.% DMSO resulted in the best performance of PSCs with PCE largely improved from 13.4% to 17.03%. This is mainly caused by the improvements in fill factor (0.63 - 075) and current density (20.90 - 22.31 mA cm^{-2}). The scanning electron microscopy and X-ray diffraction results indicated the improved crystallinity of perovskite by using DMSO. Our results indicate that using DMSO for perovskite precursor preparation is a simple and effective way for fabricating high performance and low hysteresis PSCs.

A label-free electrochemical impedimetric DNA biosensor for fast-response detection of mutation

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Abstract :

Recently, a lot of attentions have been paid to developing DNA biosensors for fast, low cost detection of mutation. Due to the unique mechanical, thermal and electronic properties, muti-wall carbon nanotube (MWCNT) shows excellent electrochemical reactivity and promoting electron-transfer reactions. Considering the advantages of MWCNT, in our work, we fabricated MWCNT/polydimethylsiloxane electrode and built sensitive impedimetric DNA detection system for distinguishing one base mismatched target DNA (T2) from complementary target DNA (T1) and non-complementary target DNA (T3). The sensitivity of T2 is calculated to be 43.28%. The detection process of each target DNA can be completed within 30 minutes by using electrochemical impedance spectroscopy. The linear range of the complementary target DNA (T1) was 10-0.05 nM. The limit of detection of our system is calculated to be 24.5 pM. Our results indicate that MWCNT is very useful for fast and sensitive DNA detections.

Biophysics and bioengineering(H)/0597 P1-ap.202

Monitoring bacterial growth using aptamer-functionalized capacitive sensor.

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Abstract :

We have developed vertical capacitive sensor to monitor bacterial growth in blood. Bacteria may be regarded as dielectric particles, so bacterial growth is expected to be monitored in real-time by measuring the capacitance change. While *E. coli* and *S. aureus* were cultured, the capacitance increased over time, and apparent bacterial growth curves were observed even when 10 CFU/mL bacteria was inoculated. Because of the selectivity of aptamers, bacteria could be identified within 1 hour using the capacitance sensor array functionalized with aptamers. Thus our experiment demonstrates that the aptamer-functionalized capacitive sensor array could be applied for monitoring bacterial growth.

Biophysics and bioengineering(H)/0604 P1-ap.203

Neuronal signal analysis in using polypyrrole coated multi-wall carbon nanotube multi-electrode array

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Abstract :

We have investigated neuronal signals with multi-electrode arrays (MEAs) *in vitro*. To enhance a signal-to-noise ratio, we have fabricated polypyrrole coated multi-walled carbon nanotube (PPy-CNT) electrodes and characterized them by measuring the *C-V* curves. Compared to conventional metal electrodes, PPy-CNT electrodes provide a lower contact impedance to neurons, leading to an increase in signal-to-noise ratio. To investigate the spatial propagation of neural signal, we have patterned neurons on the MEA using poly-L-lysine (PLL) that can guide cell body attachment and neurite outgrowth. Spatial and temporal distributions of neural signals along the patterned neurons will be discussed.

Biophysics and bioengineering(H)/0938 P1-ap.204

방사광 X-선 마이크로 단층촬영을 이용한 쥐 눈의 3 차원 구조 분석

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Abstract :

광학기술의 발달로 인해 마이크로 단층촬영(micro-computed tomography; micro-CT)을 이용하여 세포 또는 조직 구조의 절단, 변형 등과 같은 손상없이 3D 이미징이 가능하게 되었다. 이 연구에서는 이를 이용하여 PAL(포항가속기연구소)의 빔라인 6D 와 6C 에서 각각 Babl/C 와 rat 의 눈의 Micro-CT 를 촬영한 후 프로그램 영상처리를 통하여 2D 영상과 3D 영상으로 재구성하여 이미지를 획득하여 내부구조를 관찰하고 그 유용성을 확인하였다. 빔라인에서 Micro-CT 를 통해 Balb/C 와 rat 눈의 촬영을 통해 내부구조 관찰이 가능하였고, 조직 염색 후 얻은 이미지와 비교한 결과 눈을 구성하는 모든 구조들이 일치하였으며 3D 이미지를 통해 미세한 해부학적 구조와 병변의 발견이 가능함을 확인하였다. 그리고 빔라인 6C 에서 얻은 rat 의 micro-CT 이미지의 경우 6D 에서 얻은 이미지와 비교하였을 때, 6D 에서는 얻을 수 없는 세밀한 구조인 슐렘관, 섬유주 등과 같은 이미지를 획득할 수 있음을 발견하였다. 이는 눈 조직의 구조뿐만 아니라 슐렘관의 폐쇄 및 전방각으로 인해 질환이 발생되는 녹내장과 같은 질환의 연구에 유용하게 사용할 수 있을 것으로 생각되어진다.

Biophysics and bioengineering(H)/1088 P1-ap.205

집게형 맥진기로 측정한 수축기 시간으로 비가압 혈압 공식 도출 연구

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Abstract :

한방의료 진단기기인 집게형 맥진기로 측정한 요골 동맥파와 가압식 혈압기로 연속 측정한 상완 수축기 혈압(SBP)를 분석하여 맥파의 수축기 시간(S.time)과 혈압간의 상관관계를 조사하였다. 평소 혈압이 정상인 20 대 남성 2 명, 20 대 여성 1 명, 30 대 남성 1 명은 체질지수, 수축기 및 이완기 혈압, 수축기 및 이완기 시간, 맥파기의 상관관계에서 큰 변화가 없음을 알 수 있었다. 50 대 남성인 평소 고혈압인 임상실험대상자는 혈압에 따라 S.time 이 줄거나 늘어나는 변화가 있었다. SBP 가 낮으면 S.time 은 늘어남을 알 수 있으며, SBP 가 높으면 S.time 은 줄어드는 것을 알 수 있었다. 또한, 평상시 정상혈압을 유지하는 20 대의 남성과 여성을 과한 운동을 하게 하여 인위적으로 혈압을 상승시켜 혈압과 맥파를 측정한 결과, 혈압이 상승할 경우 맥파의 S.time 이 비례적으로 감소하는 것을 확인하였다. 따라서, 본 연구에서는 개인별로 홀소자 집게형 맥진기로 측정된 요골동맥파의 수축기의 변화에 따라 비가압 혈압을 추정식을 도출하였다.

Photonics and optoelectronics(D)/0343 P1-ap.206

Theoretical study on effect of polarization-dependent loss on degree of polarization in fiber-optic network with polarization mode dispersion and its compensator

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Abstract :

High-speed optical fiber transmission systems are impaired by polarization mode dispersion (PMD) to suffer system degradation, thus needing PMD compensation for performance enhancement. When polarization-dependent loss (PDL) coexists with PMD in the system, the coupling of PDL and PMD causes variation in relative magnitude and orthogonality between two principal states of polarization induced by PMD, thereby affecting PMD compensation. For investigation of such phenomena, the influence of PDL on degree of polarization (DOP) of an optical signal undergoing PMD and its compensation in fiber transmission systems is studied theoretically and via simulation. The simulation shows that DOP of the PMD-damaged and uncompensated optical signal changes depending on various states of PDL in fiber link, and in the presence of PMD compensator, DOP behavior of the output signal under PDL effect makes it difficult for the compensator to trace and compensate for PMD.

Photonics and optoelectronics(D)/0373 P1-ap.207

Measurement of OSNR based on analysis of RF noise and optical power in optical fiber communication system

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Abstract :

Optical fiber networks are expected to advance to allow dynamic reconfiguration, which may incur different optical signal-to-noise ratio (OSNR) for each channel that may traverse through different route, thus requiring OSNR measurement per channel. A novel method for monitoring OSNR inside signal band using RF noise, optical power analysis and separation of principal states of polarization (PSP) in optical fiber network is proposed and experimentally demonstrated. The proposed method uses difference of maximum and minimum RF noise powers along with optical power and PSP separation to obtain high measurement accuracy by removing various RF noises and effects of polarization mode dispersion (PMD) and non-flat amplified spontaneous emission noise. The operating principle was demonstrated with a measurement accuracy of less than 0.8 dB in both experiment using PMD emulator and experiment using 400-km single-mode fiber transmission.

Photonics and optoelectronics(D)/0867 P1-ap.208

Spin-orbit engineered resonant second harmonic generation of artificially stacked Van der Waals multilayer

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Abstract :

Due to broken inversion symmetry, monolayer transitional metal dichalcogenides (TMDCs) are great platform for nonlinear optical study, especially second harmonic generation (SHG). Previously, we found that the resonantly enhanced SHG of monolayer MoS_2 can be spectrally tuned by Se doping. In this study, we artificially produced different well-aligned vertical stacking of monolayer MoS_2 and its alloy including hetero-bilayer, hetero-trilayer and homo-bilayer using polymetyl metaacrylate assisted method. Photoluminescence analysis on vertical hetero-structure reveals two intra-layer *A*- and *B*-excitons for each individual layers mainly contributed to luminescence spectra with excellent optical properties. Broadband wavelength-dependent SHG were measured using a pico-second pulsed laser in a wide spectral range of fundamental wavelength

Advanced materials syntheses and charcterizations(B)/0090 P1-ap.301

Tunable Conductive Nanomesh-based Pressure Sensors with High Sensitivity and Wide Operation Range for Wearable Health Monitoring Applications

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Abstract :

Wearable pressure sensors that can detect pressure changes induced by human body have been attracting drastically increasing interest in various applications such as wearable health condition monitoring systems, human-machine interfaces, and artificial intelligence. In particular, for the health monitoring applications, the wide pressure range produced by human body needs to be considered. For example, the pressure range of arterial pulse is ~ 10 kPa and the range by body weight and accordingly by walking can exceed ~ 90 kPa. A variety of pressure sensors employing different materials systems have been proposed to show ultrasensitive response and/or tunable operation ranges. However, an approach to tune the operation range of flexible pressures covering from sub kPa to hundreds of kPa by tuning materials properties has been elusive. Here we report that a biologically assembled conductive nanomesh of single-walled carbon nanotubes can be successfully employed for the fabrication of wearable pressure sensors with high sensitivity and wide operation range. We show that the tunable electrical properties and the nanostructures of the conductive nanomesh synergistically change the operation range of the pressure sensors. The device resistance changed by about five orders in the pressure ranges from 0.1 kPa to 100 kPa. Furthermore, the device shows excellent cycle stability at 100 kPa and consumes a relatively low power, < 12 uW. We envision that out approach would not only enable the development of high-performance wearable health-monitoring devices but also benefit other fields involving human-machine interface.

Advanced materials syntheses and charcterizations(B)/0188 P1-ap.302

Direct molecular-scale observation of C_{70} amorphous structure and single-molecule dynamics on graphene

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Abstract :

Disordered states of materials, such as glassy materials, have been intensely investigated over the past decades owing to their peculiar thermodynamics properties as well as direct implication to various material processing. However, due to limitation in the application of imaging tools to the complex structures, there are only a limited number of real-space imaging studies on the atomic and molecular disordered systems. Here we investigate disordered C_{70} molecular structure and single-molecule dynamics using aberration-corrected transmission electron microscopy (acTEM). C_{70} molecule on graphene serves as a model molecular system, exhibiting pronounced molecular movement on atomically flat graphene substrate and enhanced molecular robustness to electron beam. Our precise, automatic procedure to identify molecular positions in the disordered state allows us to obtain pair and triplet distribution functions of C_{70} molecules, which clearly shows the short-range molecular ordering. The detailed correlation analysis indicates that the molecular position in the upper layer is off-centered from the close-packed stacking position. Interestingly, the single molecule monitoring further shows e-beam induced heterogeneous diffusive behaviors near a pore in C_{70} packing, which is a liquid-like property of a normal amorphous material above its glass transition temperature.

Advanced materials syntheses and charcterizations(B)/0268 P1-ap.303

An ultraviolet converting blue $Ca_3Y_2(SiO_4)_3:Ce^{3+}$ phosphors for white light emitting diodes

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Abstract :

Recently, white light emitting diodes (WLEDs) have attracted much attention because of the low energy consumption, long lifetime, high efficiency, high brightness and environment friendly characteristics. At present, commercially available WLEDs are mostly fabricated by combining a blue LED chip with a yellow light-emitting phosphor. However, WLEDs show a low color rendering index. A new approach to obtain white light has been suggested, which utilizes blue, green and red phosphors excited by UV LED or near UV LED, due to their emission efficiency, color temperature and high color rendering index. Production of the various red or green phosphors has been considerably developed, but stable blue phosphors are very few.

In this research, $Ca_3Y_2(SiO_4)_3:Ce^{3+}$ phosphors were synthesized by a simple solid state reaction with different sintering temperatures from 1300 to 1600 °C. The structural, morphological and optical properties were investigated by X-ray diffraction, field emission scanning electron microscopy and PTI fluorimeter using a Xe-arc lamp. $Ca_3Y_2(SiO_4)_3:Ce^{3+}$ phosphors have orthorhombic structure and irregular shape. The excitation spectra of samples showed at 348 nm and emission spectra exhibited at 420 nm (5d→$^2F_{7/2}$ and $^2F_{5/2}$, blue color). The CIE coordinates is calculated to (0.165, 0.127) for 1600°C.

Advanced materials syntheses and charcterizations(B)/0270 P1-ap.304

Homogeneous sphere, square prism and hexagonal rod $Gd_2O_3:Eu^{3+}$ for improving efficiency of photoluminescence and photocatalysis

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Abstract :

The cubic structure $Gd_2O_3:Eu^{3+}$ particles with homogeneous multiform morphologies (pH 6: sphere, pH 10: square prism and pH 12: hexagonal rod) were prepared by pH modifiers: nitric acid- and ammonium hydroxide-assisted solvothermal reaction. The effect of synthesis conditions (reaction time and pH value) on the morphology and the particle growth mechanisms were researched. The photoluminescence (PL) and photocatalytic studies of $Gd_2O_3:Eu^{3+}$ showed strong dependence of luminescent and photocatalytic properties on the morphology alteration. $Gd_2O_3:Eu^{3+}$ samples showed the efficient photocatalytic activity on congo red (CR). The high luminescence (red color) efficiency and photocatalytic activity of $Gd_2O_3:Eu^{3+}$ make them a potential material. We consider that such multifunctional materials based on multiform $Gd_2O_3:Eu^{3+}$ will be of interest for various advanced applications.

Advanced materials syntheses and charcterizations(B)/0287 P1-ap.305

열처리 분위기에 따른 ZnO Nanowire/Nano Cellulose 복합체의 I-V 특성 비교

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Abstract :

본 연구에서는 일상생활에서 이용되는 물리적 에너지를 전기에너지로 변환하여 사용하기 위하여 압전효과가 우수하고 인체에 무해한 비납성의 화합물 반도체인 ZnO 나노와이어를 제조하였다. 그리고 친환경적이고 다양한 응용 분야로의 활용성 증대를 위하여 flexible 한 특성을 갖는 나노 셀룰로오스와 ZnO 나노와이어를 복합화하였다. 이 복합체의 압전특성을 이용하여 에너지 하베스팅 응용 연구를 수행하였다.

ZnO 는 격자상수가 a = 3.25 Å , c = 5.2 Å 인 hexagonal wurtzite 구조를 되어 있다. 그리고 high exciton binding energy(60 meV), high breakdown strength, exciton stability 이며 환경친화적이다.[1-3] 온도와 가스 분위기를 달리하여 Annealing 을 하였으며 XRD, SEM 분석을 통해 ZnO 나노와이어의 결정성과 표면을 확인하였다. 잘 생성된 ZnO 나노와이어는 나노 셀룰로오스와 복합화 공정을 수행하여 복합체를 제조하였으며 I-V 특성을 확인하였다.

본 연구에서는 Sol-Gel 법을 이용하여 ZnO 나노와이어 제조용 졸을 제조하였으며, 제조된 ZnO 용액은 18kv, 0.7ml/h 의 조건으로 전기방사법(electrospinning)을 이용하여 나노와이어 형태로 FTO(fluorine-doped tin oxide) substrate 상에 도포하였다. 도포된 ZnO 나노와이어를 120℃에서 건조 공정을 수행한 후 ZnO 나노와이어의 결정성을 확인하기 위하여 Air 및 Ar 열처리 분위기에서 300℃, 400℃, 500℃, 600℃ 및 700℃ 온도에서 열처리 공정을 수행한 후 XRD 회절 분석을 수행하였다. SEM 분석을 통하여 ZnO 나노와이어의 미세구조 특성을 확인하여 길이/지름의 비를 최적화하였다. Ar 분위기에 따른 Annealing 에서 ZnO 나노와이어의 특성은 oxygen-deficient 되며 공기 중에서는 oxygen-rich 가 됨이 보고된 바 있다. ZnO 내에서 oxygen vacancies 는 charge carrier 농도를 증가시켜 전기전도성을 상대적으로 증가 효과를 기대할 수 있어 향우 본 연구에서 기대하는 에너지 하베스팅의 효과에 지대한 영향을 끼치리라 판단된다.[4] 전통적인 종이 제조법을 활용하여 ZnO 나노와이어와 나노 셀롤로오스와의 복합화 공정을 수행하였으며, 지름 8cm, 두께 수 마이크로미터의 2 차원 복합체를 제조하였다. 제조된 복합체의 전기발생량을 확인하기 위하여 멀티미터, 오실로스코프를 이용하여 I-V 특성을 확인하였다. 그 결과 Ar 분위기에서 열처리한 ZnO 나노와이어에서 더 우수한 특성의 전기발생량을 확인하였다.

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Advanced materials syntheses and charcterizations(B)/0322 P1-ap.306

Oriental Epitaxy of AgCN Microwires on Various Hexagonal Two-Dimensional Crystals

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Abstract :

The epitaxy process is often utilized to obtain high-quality thin-film crystals as well as nanostructures on various substrates. However, the epitaxial process is strongly influenced by the growth substrate because the atom-substrate interaction as well as the degree of lattice parameter matching are substrate-specific. Here, we show that micro-sized crystals of linear silver cyanide (AgCN) polymer adapt oriental epitaxial growth on various hexagonal two-dimensional crystals (graphene, h-BN, MoS_2, $MoSe_2$, $MoTe_2$, WS_2, and WSe_2). The universal tri-axial epitaxial behavior of AgCN crystals, where the polymer chains are aligned along the zigzag lattice direction of various two-dimensional crystals, is demonstrated regardless of different lattice parameters and chemical surface properties of substrates. By performing the DFT calculations, we find that the AgCN polymer chains are energetically stable at the various hexagonal two-dimensional material's zigzag direction and which is consistent with the experimentally-observed results. Our study clearly demonstrates that it is possible to obtain the universal oriental epitaxial behavior of nanocrystals over different substrates.

-We acknowledge support from Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2016R1D1A1B03934008).

실리카 나노 입자의 선택적 패턴 성장

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Abstract :

TiO2, ZrO2 등과 같은 무기물의 패턴 성장에 관한 연구가 많이 이루어졌다[1]. 미시적 크기의 선택적 패턴 성장은 광학표면, 발광 다이오드, 자기정보 저장매체, 광정보 저장매체 등 여러 분야에 응용될 수 있다[2]. 선택적 패턴 성장을 위한 기술로서 Top-down process 를 대표적으로 들 수 있다. 하지만 Top-down process 는 정밀하게 패턴을 만들 수 있다는 장점을 가지고 있지만 많은 비용이 든다는 단점도 가지고 있다. 이러한 단점을 보완하기 위하여 본 연구에서는 PDMS 패턴을 이용하여 실리카 나노 입자를 선택적으로 성장시키는 연구를 수행하였다. 실리카 나노 입자는 NH3OH, H2O, TEOS(Tetraethyl orthosilicate), Ethanol 을 이용하는 Stöber 방법으로 합성하였다. 다양한 크기의 구형 실리카를 합성하기 위하여 반응 온도, 반응물의 농도, Water-Ethanol 의 비를 조절하여 20~500 nm 의 크기를 갖는 실리카를 합성하였다. 또한 주름진 표면 구조를 갖는 메조포러스 실리카 나노입자를 합성하기 위하여 물-계면활성제-오일의 혼합비율과 다양한 보조 용매를 추가하여 실리카 나노 입자의 표면 구조를 조절하였다[3]. 크기가 다른 구형 실리카와 다공성 메조포러스 실리카의 선택적 성장을 위하여, 소수성 성질을 지닌 OTS solution 을 PDMS 에 묻혀 기판 위를 선택적으로 기능화 시키고, OTS 로 기능화 되지 않은 영역에서만 실리카 나노 입자가 성장되도록 하였다. 성장된 실리카의 크기와 표면구조, 선택적으로 성장된 형태 등은 주사전자현미경(SEM, Scanning Electron Microscope)으로 분석하였다. 또한 패턴 형상 및 실리카 나노입자에 의한 광학적 특성은 UV-visible spectrophotometer 로 평가하였다.

Quantitative analysis of Na^+ ion current emitted from beta-eucryptite like material.

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Abstract :

By ordinary method, it is difficult to extract alkali atoms from solid to vacuum. Beta-eucryptite is known as a good Li^+ ion emitting material. In this study, we fabricated the Na^+ ion emitting material by substituting Li atoms in the beta-eucryptite for Na atoms and we investigated the Na ion emission properties of this material as the function of ion source temperature and potential. The Na^+ ion beam current density J obey the Richardson equation and proportional to $V^{3/2}$ where V is the source potential. Finally, we listed the Na^+ ion beam current J as the function of source temperature T and source potential V. This function can be used for determining the half life time for the various physical conditions of the Na^+ ion emitting material.

Photoluminescence studies on $Zn_{0.5}Mn_{0.5}Te$ single crystal grown by Bridgman technique

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Abstract :

Polycrystalline compound of $Zn_{0.5}Mn_{0.5}Te$ have been synthesized by melt oscillation method. Phase purity of the synthesized compounds was analyzed by powder X-ray diffraction technique and all the (h k l) planes were well indexed. Single crystal has been grown from melt by using a vertical Bridgman method. The crystalline perfection of the grown crystal was analyzed by high resolution X-ray diffraction (HRXRD) measurements. The HRXRD result clearly reveals a single peak and indicates that the grown crystal is free from structural grain boundaries. The cut off wavelength of the grown crystal was observed around 605 nm from UV–Vis–NIR spectroscopy. The Raman spectra were carried out at room temperature in a back scattering geometry. Spectra exhibit high intensity first-order Raman bands. Temperature dependent photoluminescence studies were carried out for the grown crystal in the range of 10 – 300 K.

Advanced materials syntheses and charcterizations(B)/0883 P1-ap.310

Cu_2ZnSnS_4/TiO_2 이종접합 나노선 제조 및 광전기화학 특성

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Abstract :

Cu_2ZnSnS_4 (CZTS)는 밴드갭이 1.3~1.5 eV 인 p-type 반도체로서 가시광선 흡수에 적절할 뿐만 아니라 원재료가 친환경적이고 저렴하기에 차세대 에너지재료로 각광받고 있다. CZTS 는 비교적 짧은 연구기간에도 불구하고 10% 이상의 전기변환 효율을 보이고 있어 그 동안의 연구는 광기전력 태양전지에 집중되어 왔으나, 최근 광전기화학반응을 통한 수소 에너지 방향으로도 가능성이 타진되고 있다. 본 연구에서는 n-type 반도체인 TiO_2 나노선에 p-type CZTS 를 성장시켜 p-n 이종접합구조를 형성하여 광전기화학 반응을 극대화 하고자 하였다. TiO_2 나노선은 수열합성법으로 성장하였고, 이후 화학용액 직접성장법으로 CZTS 를 코팅하였다. 수열합성법에서는 Ti precursor 의 농도와 성장시간에 따라 TiO_2 나노선의 형상과 크기를 조절할 수 있었고 CZTS 는 합성 시간이나 반응물의 농도를 변화시킴에 따라 두께와, 성장형태를 조절하였다. TiO_2 나노선의 형상과 크기, CZTS 두께에 따른 광전기화학 반응도를 논의하고자 한다.

망막질환 치료를 위한 Alginate- Ferrogel 약물이식체의 기공사이즈에 따른 물성 비교

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Abstract :

망막은 해부학적으로 눈 안쪽 깊숙이 위치하고 있어, 질병에 대하여 치료하기가 어렵다. 신생혈관이 동반되는 노인성황반변성 등 망박질환을 치료하기 위해서는 일반적으로 약물전달의 침습적인 방법인 안내주사법이 쓰인다. 현재, 이와 같은 만성적 망막질환을 효과적으로 치료하기 위해 여러 번의 안내주사가 필요하다. 주사에 대한 합병증으로 안내염증, 망막박리, 백내장 ,유리체 출혈이 발생할 수 있는데, 이것은 약물의 반복전달과 함께 증가된다. 이러한 합병증에 대한 대체 방법으로서 지속적으로 약물이 방출되는 시스템이 필요로 하게 된다〔1〕. 추가적으로 이것에 근거하여 우리는 생분해성을 갖는 Alginate 를 골격으로 Ferrogel 을 만들어, 후의 제거과정이 없고 필요로 할 때 마다 더 많은 양의 약물을 방출할 수 있는 자기성 on-demand 시스템을 고안하였다. Ferrogel 의 약물 로딩/방출에 관련된 기공 크기를 조절하기 위해, Alginate 의 gel 형성 시 자연적으로 nano size 기공이 형성되는 특성을 이용하여, 시료에 손상을 주지 않고 형태를 유지하며 건조 할 수 있는 CO2 초임계 건조 장치(Critical Point Dryer)를 사용하여 nanoporous ferrogel 을 제작하여 기공사이즈를 조절할 수 있었다. Sodium alginate 와 세포부착 RGD- peptide 를 합성하기 위해, Alginate 0.1 g 에 MES buffer 5 ml,EDC 5 mg, sulfo-NHS 2.8 mg, RGD-peptide 100μg 를 균질하게 섞고, 동결건조 시켰다. Macro/nano porous Ferrogel 을 제작하기 위해 MES buffer(pH 6)에 RGD-peptide 가 결합된 Sodium Alginate 1wt%와 가교 결합제인 Adipic acid dihydrazide 5mM, Fe_3o_4 nano –particle 13wt%, HOBt hydrate, EDC 를 균질하게 섞어주었다. 그 후, 즉시 틀에 넣고 2 시간 동안 굳혔다. 굳혀진 Gel 의 잔류시약을 제거하기 위해 대용량의 삼차증류수에 2 일 동안 넣어 두었다. 그런 다음, macro–porous 의 기공을 만들기 위해 –20℃에 얼린 후, 동결건조 시켰고, nano- porous 의 기공을 만들기 위해, 잔류시약 제거 후, 초임계 건조 장치(Leica,EM CPD300, DGIST)를 이용해 말렸다. Alginate - RGD peptide 를 합성한 뒤, Ninhydrin assay 로 평가하여 RGD-peptide 양이 10ug, 100ug 중에 100ug 일 때 흡광도가 가장 높게 나타났고, H-NMR 에서 Alginate 에 부착된 NH_2-resonance(6.8~7.2ppm picks)를 확인할 수 있었다. Alginate-RGD 의 세포부착성에서 합성하지 않은 Alginate 보다 약 11 배 더 부착이 된 것을 확인 할 수 있었다. 또한 macro-기공의 평균 장축 사이즈는 510 ㎛, nano-기공의 평균장축 사이즈는 44.8nm 로 나타났다.

Advanced materials syntheses and charcterizations(B)/0993 P1-ap.312

The tetravalent manganese activated in $SrLaMgTaO_6$ for warm LED applications

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Abstract :

The new Mg^{2+},Mn^{4+}co-doped red-emitting $SrLaMgTaO_6$ phosphor for solid state lighting are reported. The phosphor can be efficiently excited in the wavelength range of 250-500 nm, which matches well with the emission wavelengths of blue or NUV chips. The photo-luminescence spectra exhibit the highest emission peak at 692 nm from $^2E_g \rightarrow {}^4A_2$ spin forbidden transition of Mn^{4+} under NUV excitation. The Mg^{2+} co-dopant for charge compensation plays a key role in enhancing the luminescence intensity by a factor of 2.8. The incorporation of Mg^{2+} ion in the host could not only suppress the energy migration among Mn^{4+} ions but also eliminates the charge imbalance in Mn^{4+}-Mg^{2+} pairs. W-LED fabrication with different mass ratios of yellow emitting YAG:Ce^{3+} and red emitting $SrLaMgTaO_6$:Mn^{4+}/Mg^{2+} phosphors is designed to explore its possible application in warm w-LEDs with high CRI. The w-LEDs fabricated with the integration of $SrLaMgTaO_6$:Mn^{4+}/Mg^{2+} red phosphor show changing trends toward warm white light with lower color temperature and higher CRI than that based on single yellow emitting YAG:Ce^{3+} phosphors. The results suggest that $SrLaMgTaO_6$:Mn^{4+}/Mg^{2+} phosphor has great potential for the warm w-LEDs application as a suitable red light component.

Advanced materials syntheses and charcterizations(B)/1005 P1-ap.313

Crystal Structure, Electronic Structure, and Photoluminescence Properties of KLaMgWO6:Eu3+as Red Phosphors for Light-emitting Diode Applications

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Abstract :

The attributes of strong absorption, high quantum efficiency, high quenching temperature and high color purity are very important for phosphors to be used in light emitting diode (LED). In this paper, the KLaMgWO6:Eu3+ phosphors which were synthesized by solid-state reaction method possess all of the mentioned properties. The structural properties including the phase purity and structural parameters were analyzed through Rietveld analysis for the first time. Meanwhile, the energy band structure of KLaMgWO6 was measured with an ultraviolet-visible diffuse reflection spectroscopy (UV-visDRS), the electronic structures were calculated using the plane-wave density functional theory (DFT). The charge transfer band (CTB) of KLaMgWO6:Eu3+ phosphors is situated at ultraviolet and near-ultraviolet region from 250-410 nm. The phosphors show intense absorption in near ultraviolet-blue region and exhibit intense red emissions with CIE coordinates of (0.6499,0.3497) under 394 nm excitation. The excellent luminescent properties and good color saturation make it be potentially useful in the fabrication of white light-emitting diodes (LEDs).

Enhanced luminescence Properties of Zn2P2O7:Eu3+ Phosphors through different methods

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Abstract :

Eu3+-activated Zn2P2O7 red-emitting phosphors were successfully prepared and characterized. The X-ray diffraction (XRD), photoluminescence excitation, emission spectra, fluorescent decay curves and concentration quenching were applied to characterize the samples. There are two different types of Eu3+ ions in the zinc pyrophosphate, the first type was a relatively few symmetric 5-coordinated Zn sites, while the second was a symmetric 6-coordinated Zn sites. A broadband in the region of 200–300 nm has been attributed to the O2–- Eu3+charge transfer band (CTB), which is caused by the electron transfer from 2p orbits of O2- ions to 4f shells of Eu3+ ions. The sharp lines in 300–500 nm is attributed to intra-configurational 4f – 4f transition of Eu3+ in host lattice. The peaks seen at 394 and 465 nm were assigned to electronic transitions of 7F0–5L6 and 5D2, respectively. The emission spectra consist of series of peaks in the range of 560–720 nm corresponding to the characteristic transition of Eu3+, from the excited 5D0 state to7FJ (J=0–4) levels. Upon excitation at 394 nm, the emission spectrum exclusively contains the strong bands of 5D0–7F1, 5D0–7F2, 5D0–7F3 and 5D0–7F4. Co-doping alkaline ions (Li, Na and K) can enhance the red emission of Eu3+in Zn2P2O7. Red emission was realized in this single-phase phosphor with exposure to 394 nm near-UV light, suggesting that this material is competitive as a promising red component for possible applications in solid state lighting.

Effect of doping La^{3+} ions on the performance and characteristics of Eu^{2+} ions in novel $Sr_3CeNa(PO_4)_2SiO_4$ phosphors

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Abstract :

In recent years, the global issues of environmental protection and power saving have motivated the substitution of traditional incandescent and fluorescent lamps with white light–emitting diodes (w–LEDs) due to the extraordinary advantages of w–LEDs, such as high electro–optical conversion efficiency, long lifetime, good stability properties and environmental friendliness.
In this study, we have synthesized and investigated the effect of doping La^{3+} ions in novel phosphor–silicate apatite $Sr_{2.99}CeNa(PO_4)_2SiO_4$:0.01$Eu^{2+}$ phosphor, which shows the regulation of luminescence intensity in different luminescent centers. X–ray diffraction, GSAS Rietveld refinement, X–ray photoelectron spectroscopy, luminescent spectra, decay curves and thermal quenching were applied to investigate the phase, structure, luminescent and thermal stability properties. Interestingly, by the incorporation of La^{3+} ions in $Sr_{2.99}CeNa(PO_4)_2SiO_4$:0.01$Eu^{2+}$, the regulation of Eu^{2+} luminescence intensities in two centers were achieved in two methods: one is varied the La^{3+} substitution concentration, the other is adjusted the excitation wavelength, at the meantime, a significant blue–shift appeared since the band gap shows a widening trend from 5.548 to 5.621 eV and a continuous red–shift was also observed due to the reabsorption. The orderly changes of Eu^{2+} emission intensities over the two Eu^{2+} luminescent centers suggested that the La^{3+} ions incorporation in SCNPS:0.01Eu^{2+} can affect the performance and characteristics of Eu^{2+} ions. Furthermore, our work also encourages research on the luminous effect of site occupancy and the local environment of luminescence centers.

Nanomaterials and nanodevices(A)/0348 P1-ap.318

가스 센서용 SnO_2 나노구조물의 직접 성장

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Abstract :

Tin Dioxide(이하 SnO_2)는 rutile 구조를 가지는 반도체 물질로써, Oxygen-deficient n-type semiconductor 로 알려져 있다. SnO_2 는 일반적인 결함(defect) 중 산소원자가 부족한 Oxygen vacancy 형태이며, vacancy 의 전자가 carrier 로 작용을 하기에 n-type 반도체의 특성을 나타낸다[1]. 이러한 성질 때문에 SnO_2 는 반도체 가스 센서에 응용 될 수 있다. 반도체 가스센서는 세라믹 반도체의 표면에 가스가 접촉되었을 때 전기전도도가 변화하는 현상을 이용하며, 대기 중에서 가열하여 사용되는 일이 많아서 고온에서 안정한 산화물이 주로 사용된다[2-4]. 나노구조물은 bulk 상태일때보다 그 표면적이 넓어 가스를 고감도로 감지할 수 있다. 본 연구에서는 SnO Nanoplatelets 를 다양한 기판 위에 dense 하게 성장을 시켰던 기존의 연구결과를 응용하여 진행되었다. SnO_2 나노구조물을 Thermal CVD 를 이용하여 Si wafer 조각 위에 직접 성장 시켰으며, Heater 를 2 개 이용하는 2-zone method 를 채택하였다. 각각의 Heater 는 1097°C, 424°C 로 가열되었다. Quartz Tube 안에 precursor 인 SnO_2 Powder(99.9%, Sigma Aldrich)를 Alumina boat 에 장착한 후 1097 °C 에서 기상화 시켰으며, 424 °C 로 가열된 2nd Heater 영역에 초음파 세척된 SiO_2/Si wafer 조각을 위치시켰다. 기상화 된 SnO_2 Vapor 는 Carrier Gas(Ar, 99.999%, 990 SCCM, O_2, 99.999%, 10 SCCM)로 기판 위로 이송되었다. 성장된 SnO_2 나노구조물의 Morphology 를 FE-SEM 으로 관찰하였고, Raman Spectroscopy 와 XRD 분석으로 결정학적 특성을 조사하였다. 그 결과 424 °C 영역에서 nanodots 모양의 SnO_2 나노구조물이 dense 하게 성장되었음을 확인하였다.

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Nanomaterials and nanodevices(A)/0444 P1-ap.319

물 분산이 용이한 자성 나노입자(Magnetite)의 합성

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Abstract :

Magnetite(Fe_3O_4)는 독특한 자기적 특성과 생체적합성으로 약물전달(target-drug delivery), 바이오물질 분리(biomaterials separation), MRI(magnetic resonance imaging) 신호강화, 자기발열치료(magnetic hyperthermia), 임상 진단(clinical diagnosis) 등에 폭넓게 활용되고 있다[1,2]. 의료분야에 적용되는 자성 나노입자는 혈액 중에서 안정적으로 분산되어야 한다[3]. 하지만 Magnetite 는 유기용매 중에서 대부분 합성되고, 물 속에서 잘 분산되지 않는 문제점이 있다. 이러한 문제점을 해결하기 위하여 Core-Shell 구조의 Magnetite/Au 나노입자를 고분자 물질(PANi–PSSA)로 기능화하여 수용액 중에서 자성나노입자(Magnetite)가 분산이 용이하도록 합성하였다. Magnetite 나노입자(MNPs)는 $FeCl_3$, $FeCl_2$, citric acid 을 이용해 co-precipitation method 으로 합성하였고, Magnetite/Au 나노입자에서 Au 는 MNPs 을 seeds 로 하여 $HAuCl_4$ 의 환원 과정으로 합성하였다. 표면 기능화의 고분자는 Polyaniline-poly(styrene-sulfonic acid)(PANi–PSSA)를 leucoemeraldine(완전환원형태) 반응을 기반으로 하여 나노입자에 부착하였다. 합성된 기능성 Magnetite/Au/PANi-PSSA 나노입자의 모양과 결정학적 특성은 FE-TEM, FE-SEM, XRD 등으로 분석하였으며, 기능성 고분자에 의한 표면 기능화는 UV-visible spectrophotometer 와 Cyclic Voltammetry(CV)를 통하여 확인하였다.

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Surface, interface and thin films(G)/0306 P1-ap.401

수중 에탄올 함량에 의한 다공성 실리콘 간섭색 변화

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Abstract :

본 연구에서는 500nm 내외의 간섭색을 나타내는 다공성 실리콘을 이용하여 수중의 에탄올 함량에 따른 간섭색의 파장과 강도 변화를 측정하였다. 이를 위해 광섬유와 분광기를 사용하여 수중에 놓인 다공성 실리콘 표면의 반사 스펙트럼 측정 장치를 구성하였다.

그 결과 에탄올 함량에 따라 반사 스펙트럼 안에서 봉우리 파장 이동과 강도 증감현상이 관찰되었다. 이를 이용해 파장과 강도 변화량이 에탄올 함량과 어떤 관계를 갖는지 분석하였다. 본 연구로 다공성 실리콘을 기반으로 하는 광학식 액체센서 개발이 가능함을 알았다.

Surface, interface and thin films(G)/0309 P1-ap.402

진동하는 알루미늄 평행판의 진동수 응답특성

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Abstract :

콘덴서 마이크 헤드 앞에 평행한 3 개의 알루미늄 판을 두고, 양 끝 판에 함수발생기를 이용하여 동일한 전압과 진동수를 갖는 AC 신호를 인가하였다. 다만 양 끝의 두 판중 한 판에 인가되는 AC 신호는 인버터를 경유하여 연결함으로써 신호의 위상이 반대가 되도록 하였다. 또한 중간에 배치된 알루미늄 판에는 DC 전압을 인가하였다. 이를 통해 마이크 앞의 전면판에 인가된 AC 신호에 의한 전기장 유도신호와 양 끝판의 진동에 의한 음파 신호가 콘덴서 마이크로 동시에 측정된다. 그러므로 두 신호는 서로 간섭되어 합성신호가 마이크에서 출력되고 이 출력실호를 분석함으로써 진동하는 알루미늄 판의 진동수 응답특성을 도출하였다. 이 과정에서 알루미늄 판의 형태, 알루미늄 판에 인가된 AC 전압, 전면판과 마이크와의 거리 등을 체계적으로 측정하고 해석하였다.

Gamma-ray irradiation effects on ferroelectric domain switching dynamics in epitaxial $Pb(Zr_{0.52}Ti_{0.48})O_3$ thin films

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Abstract :

Ferroelectric thin films have attracted considerable attention because they are used for non-volatile ferroelectric random access memories (FERAM) actuators and transducers. In particular, as the development of the aerospace industries, investigation on ferroelectric domain behavior of memory devices in exposed to high-energy radiation such as in space is required. In previous study, the ferroelectric thin films has been reported degradation behavior of polarization and dielectric properties by gamma-ray irradiation. Therefore, we investigated a change in the ferroelectric domain structure of epitaxial $Pb(Zr_{0.52}Ti_{0.48})O_3$ (PZT) thin films by gamma-ray irradiation. Epitaxial PZT thin films were prepared on the $SrRuO_3/SrTiO_3$ (001) substrates by using a sol–gel method with a spin-coating process. The x-ray diffraction analysis show that fully *c*-axis oriented epitaxial PZT films were grown. The prepared epitaxial PZT thin films were subjected to gamma-ray radiation with various total doses from 0 MGy to 3 MGy. However, there were no noticeable morphological and structural changes in PZT films before and after irradiation. Piezoelectric force microscopy (PFM) is employed to study the ferroelectric domain structure in epitaxial PZT thin films. We have prepared 3 μm x 3 μm square patterns in PZT films, which areas were formed through the electrical poling with the cantilever by applying a + 5 V dc bias. By combining the perpendicular and in-plane piezoresponse data, we found that the ferroelectric domain structure is mainly described by one polarization directions. There patterns were investigated a change in the ferroelectric domain structure by repeated PFM measurements with various irradiation total doses. Based on these results, gamma-ray irradiation effects on ferroelectric domain structure and ferroelectric properties in epitaxial PZT thin films will be discussed.

Surface, interface and thin films(G)/0470 P1-ap.404

RF magnetron sputtering 에 의한 산화아연 박막의 성장 및 표면형상

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Abstract :

1. 서론

산화아연(ZnO) 박막은 광전소자, 나노레이저, 태양전지 및 디스플레이의 투명전극 등의 핵심소재로 널리 이용될 뿐만 아니라, 압전 특성을 이용한 압전소자, 압력센서, 바이오센서 응용 소재로서 유망하며 광촉매 특성을 이용하여 항균필름으로도 사용되고 있다. 그러나, ZnO 박막의 다양한 표면형상과 구조에 따른 물성의 체계적인 연구는 미흡한 실정이다. 본 연구에서는 전자기기 터치스크린 패널의 오염방지를 목적으로, 표면형상 및 구조에 따른 ZnO 박막의 자기세정 작용 및 항균작용에 대하여 연구하고자 한다.

2. 실험 방법

RF magnetron sputtering 을 이용하여 Si 및 Glass 기판 위에 ZnO 박막을 증착하여, sputter 조건에 따른 결정의 배향성과 표면형상의 변화를 조사하였다. Sputter 조건은 chamber 내 분위기 가스 압력을 10 mTorr 로 하였고, 가스의 전체 유량을 10 sccm 으로 고정시키고 Ar 과 O_2 가스의 유량 비율은 상대적으로 변화시켜 가면서 성막하였다. 기판 온도는 상온 및 200°C, RF power 는 70 W 에서 실험하였다. 제작된 ZnO 박막은 X-선 회절법(XRD)에 의해 결정구조 및 방향성, 주사전자현미경(SEM) 및 원자간력현미경(AFM)에 의하여 표면형상을 측정하였다.

3. 결과 및 고찰

분위기 가스의 전체 유량을 10 sccm 으로 고정시키고 Ar 과 O_2 가스의 유량 비율을 상대적으로 변화시켰을 때 ZnO 박막의 증착 속도를 조사하였다. Ar/(Ar+O_2) 이 1 일 때 ZnO 박막의 증착속도가 가장 크며, Ar/(Ar+O_2)이 작아질 수록 ZnO 박막의 증착속도는 점차 감소하는 경향을 나타내었다. SEM 에 의해 ZnO 박막의 표면형상을 관찰한 결과, Ar/(Ar+O_2)이 1 일 때 ZnO 박막의 결정립(grain)이 가장 크며, Ar/(Ar+O_2)이 작아질 수록 ZnO 박막의 결정립은 점차 작아지는 경향을 나타내었다. 분위기 가스 중 Ar 과 O_2 가스의 상대적 비율의 변화에 따른 ZnO 박막의 물방울과의 접촉각(contact angle)을 측정한 결과, Ar/(Ar+O_2) 가스의 상대적 비율이 작아질수록, 즉 ZnO 박막 표면의 결정립이 작아질수록 접촉각이 커지는 경향을 나타내었다. 즉 ZnO 박막의 친수성 여부는 박막의 표면 구조보다는 표면원자의 화학결합 상태에 더 좌우되는 것으로 보인다.

Surface, interface and thin films(G)/0471 P1-ap.405

Ferroelectric polarization effect for graphene/PMN-PT hybrid structure

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Abstract :

Recently, many graphene-ferroelectric hybrid structures have been studied to investigate the possibility of candidate for a potential memory device. However, it is found out that the fundamental understanding of interface between graphene and ferroelectric and the effect of the polarization switching on graphene are critical issues for the future development of this system. In addition, depolarization field induced by insufficient compensation charges in graphene can lead to reduction of remanent polarization in ferroelectric substrate. Therefore, we try to elucidate the role of the amount of induced charges and interface on device operation through two approaches, where we use PMN-PT ($(1-x)Pb(Mg_{1/3}Nb_{2/3})O_3$ $PbTiO_3$) single crystal as a ferroelectric material. The first is that the shape of electrodes and the size of graphene vary, for example, interdigitated electrode pattern and large CVD-grown graphene, respectively. Secondly, by additional fabrication of gate electrode on top of graphene, the initial number of charges can be controlled. In this device structure, it is expected to have the deep understanding on the operation mechanism of the grapheme/ferroelectric non-volatile memory device

Surface, interface and thin films(G)/0497 P1-ap.406

The study of surface Characterization in TiO_2 Films Prepared by Ammonia Added anodizing about Titanium alloy.

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Abstract :

The anodization method is attractive for the formation of ordered nanochannel or nanotubular films onto the surface of valve metals. In the last few decades this method has been successfully applied for fabrication of self-ordered porous templates of titanium oxide for subsequent production arrays of various nanostructured materials. Al plate was anodized in an acid electrolyte with Pt counter electrodes. The anodization temperature was 8 ℃ for sulfuric acid (2.5 M) and 15 ℃ for Ammonia water (0.7 M), respectively. The anodization voltage and time were 5 ~ 15 V and 0.5 h. In this study, we investigated the roughness and optical properties of films produced by anodizing of Ti surface in ammonia water –containing Etg solutions.

Surface, interface and thin films(G)/0668 P1-ap.407

MgF_2 기판 위에 제작된 VO_2 박막의 결정 방향에 따른 금속-부도체 전이 특성

안승휘 [1], 산토스 기미르 [1], 이영진 [1], 도중회 [*1]

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Abstract :

바나듐 이산화물 VO_2(Vanadium dioxide)는 상온에서 ~0.7 eV 의 광 밴드 갭(Optical band gap)을 가지며, 약 T_c = 340 K 근처에서 저항이 크게 변하는 금속-부도체 전이(Metal-Insulator Transition) 특성을 보인다. VO_2 는 금속-부도체 전이 온도(T_c)보다 낮은 온도에서 단사정계(Monoclinic system) 구조와 부도체성을 띠며, T_c 보다 높은 온도에서는 정방정계(Tetragonal system) 구조와 금속성을 띤다. 또한 VO_2 는 금속-부도체 전이와 함께 적외선 영역에서 광 스위칭 효과(Optical switching behavior)를 보이기 때문에 광전자 소자의 개발에 활용될 수 있다. 지금까지 에피탁시 VO_2 박막은 TiO_2 기판과 MgF_2 기판 위에서 두께에 따른 전이 특성 연구가 진행되었고 격자 변형에 따라 T_c 의 변화가 관측되었다 [1-3]. 하지만 (111) MgF_2 기판 위에서 VO_2 박막의 두께에 따른 특성은 연구되었으나 결정 방향에 따른 특성은 연구되지 않았다. 이번 연구에서는 먼저 (0001) Al_2O_3 기판 위에 헤테로 에피탁시 VO_2 박막을 다양한 조건에서 레이저 증착법으로 제작하고 증착 조건에 따른 특성을 분석하여 최적의 제작 조건을 찾았다. VO_2 박막은 레이저 에너지가 증가할수록 표면 거칠기가 커졌으나 전이 특성은 좋아졌으며, 또한 약 5 ~ 15 mTorr 산소분압 영역에서 금속-부도체 전이 특성이 관측되었다. 이러한 결과를 바탕으로 VO_2 박막을 (100), (001), (110), (111) 방향의 단결정 MgF_2 기판 위에 증착하였고 표면 특성, 결정성, 전이 특성 등을 분석하였다. VO_2 박막은 결정방향에 따라 뚜렷한 금속-부도체 전이 온도의 차이가 관측되었는데, 이는 기판 방향에 따른 격자불일치와 격자변형의 차이에 기인된 것으로 생각된다.

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Surface, interface and thin films(G)/0677 P1-ap.408

Thermochromic properties of VO_2 film on transparent conductive oxide glass depending on sputtering conditions

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Abstract :

Theromochromic glass is one of smart window application that transmittance of light can be automatically modulated from a transparent state to an opaque state at the critical temperature. Vanadium oxide is the typical material having thermochromic property. VO_2/FTO glass was fabricated using sputtering system controlling oxygen partial pressure. Optical properties were checked with optical transmittance by a UV/VIS/NIR spectrophotometer equipped with a heating unit and Raman spectroscopy of VO_2 film depending on various O_2 pressure. We verified the best condition of deposited VO_2 film in Sputtering process.

Surface, interface and thin films(G)/0702 P1-ap.409

Study on physical properties of Fe-oxides α-Fe_2O_3 and γ-Fe_2O_3 films

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Abstract :

Transition metal oxides have fascinating electrical and magnetic properties owing to various charge, spin and orbital orderings. Among them, Fe-oxides have various phases depending on the valence state of Fe and crystal structure, since they have potential applications such as photoelectrochemical cells in the form of Fe_2O_3 and spintronic devices in the form of Fe_3O_4. For developing to device, growth of single-phase Fe-oxide films is required. In this study, the structural, magnetic and chemical properties of various phases of Fe-oxide (i.e., α-Fe_2O_3 and γ-Fe_2O_3) films grown by RF-magnetron sputtering were investigated. Fe-oxide films deposited for 5 min showed α-Fe_2O_3 structure whereas spinel structure was measured for the films deposited for 10 min. Magnetization measurements confirmed the spinel structure was γ-Fe_2O_3 (not Fe_3O_4). Interestingly, multiphase (i.e., both α-Fe_2O_3 and γ-Fe_2O_3) was observed for the film deposited for 15 min. The chemical states of the Fe-oxide films were examined to explain the physical origin of the different phase formation depending on the growth time.

This research is supported in part by NRF Korea (NRF-2015R1D1A1A01058672), Korea Basic Science Institute (E35800) and Korea Atomic Energy Research Institute. Also, J. W. Kim is supported by Global PhD Fellowship Program through the NRF Korea funded by the Ministry of Education (2015H1A2A1034200).

Surface, interface and thin films(G)/0762 P1-ap.410

AZ91D 에서 플라즈마 표면처리에 관한 표면 물성 연구

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Abstract :

The effect of plasma electrolytic oxidation (PEO) process for AZ91 Mg alloy was investigated. The coating layer on AZ91 Mg alloy coated from the “A” Bath containing 0.10 mol/L of sodium phosphate for 360 s exhibited considerably dense structure and contained 15% ~ 20% (mass fraction) of phosphorous. The higher content of phosphorous of coating layer coated from “A” Bath could be detected at the bottom of oxide layer, which strongly implied that the phosphorous ion might be concentrated at the barrier layer. Consequently, The effect of sodium phosphate in electrolyte on PEO process for AZ91 Mg alloy was investigated. The pore size on the surface of coating layer increased with increasing concentration of the sodium phosphate in the electrolyte.

Surface, interface and thin films(G)/0769 P1-ap.411

플라즈마 표면처리 된 AZ91D 합금의 Annealing 효과 연구

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Abstract :

Plasma electrolytic oxidation (PEO), environmental friendly and cost effective, is gaining increased attentions as a novel technique to produce ceramic coatings with unique properties on valve metals such as Al, Mg, Ti, etc., and their alloys. The wear resistance, mechanical strength and electrical insulation of the metals and their alloys can be improved after PEO process. However, it has also been reported that coatings produced by PEO are porous on the top layer, which is a disadvantage for their tribological properties and corrosion resistance. In this work, the annealing performance of the coatings were investigated.

Surface, interface and thin films(G)/0770 P1-ap.412

Enhanced NO_2 gas sensitivity in hydrogenated graphene gas sensor

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Abstract :

We have investigated enhanced performance NO_2 sensing in graphene based gas sensor. Graphene has significant importance due to its unique properties, such as room temperature working condition, atomically thin structure and high conductivity. Howerver, the pristine graphene gas sensor exhibited the poor sensitivity. We doped graphene with hydrogen to generate defects in graphene for improving the gas response sensitivity. So the NO_2 gas sensitivity of the hydrogenated graphene was enhanced at room temperature.

Surface, interface and thin films(G)/0838 P1-ap.413

RBS 측정을 이용한 다층박막의 두께 및 조성 분석법

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Abstract :

Rutherford Backscattering Spectrometry(RBS)는 단일 에너지의 알파입자를 시료에 조사하고, 이때 후방산란 되는 알파입자의 에너지를 측정하여 시료의 두께와 조성을 알아내는 측정법이다. RBS 측정은 비파괴 분석이고, 빠른 시간 내에 측정이 끝난다는 장점이 있다. 이 실험은 한국원자력연구원의 양성자가속기연구센터(경주)에 있는 1.7MV tandem 가속기를 이용하여 수행했다. 이 가속기는 정전형 가속기로서 이온조사 빔라인, RBS, PIXE 측정 빔라인, 표준중성자 빔라인을 갖추고 있다. 이중 RBS 빔라인을 이용하여 실험하였다.

준비된 시료는 SiO2/Si substrate, Co/Pt/SiO2/Si substrate 의 두종류 이다. RBS 를 측정하기에 앞서 알파입자의 정확한 에너지 보정을 위하여 16O(alpha, alpha) 16O resonant scattering 측정(SiO2/Si substrate 시료)을 하였다. 이는 알파 입자가 특정 에너지를 가질 때, 알파입자와 산소원자의 scattering cross-section 이 증가하는 것을 이용한 방법이다. 이 방법을 이용하면, 일반적인 RBS 측정법으로는 분석이 난해한 미량의 가벼운 원소(ex. C, N, O) 분석이 가능하다. 이 방법을 이용하여 위의 단일 산화막 시료와 다층박막 내에서의 산소 분석을 수행하였다. 이번 추계물리학회에서 일반적인 RBS 분석법과 resonant scattering 측정법에 대하여 발표하고자한다.

Acknowledgement
This work has been supported through KOMAC (Korea Multi-purpose Accelerator Complex) operation fund of KAERI by MSIT (Ministry of Science and ICT).

Surface, interface and thin films(G)/0913 P1-ap.414

Tunable dielectric properties of $SrMnO_3$ thin films via in-situ strain engineering

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Abstract :

A multi-state device based on materials with various dielectric constants has been a subject of interest in development of memory devices with a high storage capacity. $SrMnO_3$ epitaxial thin films has been predicted to exhibit various dielectric constants because of the phase transition at the various epitaxial strain.[1] For instance, weak ferroelectric $SrMnO_3$ can be transformed to ferroelectrics along with an increased dielectric constant under approximately 2% epitaxial strain. Previously, various substrates with different lattice constants have been used to apply various misfit strain on upper $SrMnO_3$ films.[2] However, this method is hard to tune the misfit strain of films diversely as well as to observe the change of dielectric constant in real time. In case of piezoelectric substrate, we can continuously modulate the lattice parameter through applying electric field. Thus, we can tune the dielectric constant via controlling the misfit strain of films. The $0.72Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.28PbTiO_3$ (PMN-PT) piezoelectric substrate possesses a high piezoelectric coefficient of around 1500 pm/V. Here, we report a strategy to manipulate the dielectric constant of $SrMnO_3$ thin film via applying voltage directly to PMN-PT substrates.

The $SrMnO_3$ films were deposited onto $La_{0.7}S_{r0.3}MnO_3$ (LSMO) / (001)-oriented PMN-PT substrate under oxygen pressure in a range from 10 to 150 mTorr using pulsed laser deposition (PLD). Pt top electrodes were deposited using an e-beam evaporator. The crystallinity of film was investigated using X-ray diffraction. The polarization and dielectric constant will be investigated through P-E loop and C-V curve, respectively.

[1] J. Lee and K. Rabe, Physical Review Letter, 2010, **104**, 207204

[2] P. Agrawal *et al*., Physical Review B, 2016, **94**, 104101

Surface, interface and thin films(G)/0921 P1-ap.415

Effect of Annealing Process on the Interface of Organic Light Emitting Diodes

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Abstract :

Solution processing is expected to next generation fabrication technology for OLEDs because it has many advantages over the vacuum deposition process such as possibility of high resolution and low process cost. However, many previous research have reported that solution processed OLEDs show lower device performance and shorter lifetime than conventional OLEDs. To investigate origin of these problems, we have studied the interface properties of solution-processed devices, particularly, between the emission layer (EML) and hole transport layer (HTL) by using Ar gas cluster ion beam sputtering, photoelectron spectroscopy, and time-of-flight secondary ion mass spectrometry. Our results show that the vacuum deposited devices have well defined discrete interface, while the solution processed devices suffer severe interlayer mixing over wide range of HTL thickness. We also investigate effect of annealing process on interlayer mixing problem. We found that an annealing process that proceeds after HTL layer formation accelerates interlayer mixing in the solution processed OLEDs. In the vacuum deposition processed OLEDs, however, additional annealing does not result in a significant change of interface characteristics.

Surface, interface and thin films(G)/0948 P1-ap.416

Physical Characterizations of Al-doped $Zn_{1-x}Li_xO$ Thin Films by using the Sol-gel Spin Coating Methods

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Abstract :

Al-doped $Zn_{1-x}Li_xO$ (ZLO:Al, x = 0.0001 ~ 0.10, Al 5.0 at.%) thin films were deposited on SiO_2/p-Si(100) substrate with the ZLO:Al precursor solutions by applying the spin coating method. The ZLO:Al precursor solutions were prepared by using the sol-gel routes with ethanol / monoethanol amine mixed solvents. Surface morphology of the ZLO:Al thin films were characterized by using the scanning probe microscopy (SPM). Structural, optical, and electrical properties were investigated by using the X-ray diffraction (XRD), the diffused refection spectroscopy (DRS), and the four-point probe (FPP) surface resistance. The SPM images of ZLO:Al thin films showed that a root meansquare roughness were estimated as R_{RMS} = 4.0 nm ~ 20. nm. XRD data of ZLO:Al thin films showed that a (002) diffraction peak was much dominat than others, such as (100) and (101) peaks. By fitting the DRS spectra, the optical band gap (Eg) and the thickness (d) were estimated to be about Eg = 3.3 eV and d = 250 nm ~ 300 nm, respectively. The surface resistance of the ZLO:Al thin films was increased from $1.0x10^6$ ohm ~ $4.6x10^6$ ohm as the Li content was increased from x = 0.0001 to 0.05 at room temperature.

Surface, interface and thin films(G)/1034 P1-ap.417

Photoluminescence property of $SrLaMgTaO_6$ double perovskite bulk and thin film

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Abstract :

We investigated the photoluminescence property of the $SrLaMgTaO_6$ double perovskite bulk and thin film. X-ray diffraction shows that the $SrLaMgTaO_6$ compound belongs to the monoclinic symmetry with $P2_1/n$ space group. Photoluminescence (PL) spectra indicated that the strong red emission in bulk sample sintered at 1400 ^oC is observed. X-ray absorption spectroscopy (XAS) and resonant inelastic x-ray scattering (RIXS) confirmed that the oxygen vacancy in octahedral TaO_6 was not affected to the red emission. We deposited the $SrLaMgTaO_6$ thin film on the Quartz and $SrTiO_3$ (001) substrates by using a pulsed laser deposition to investigate the PL property depending on the substrate. We found that the $SrLaMgTaO_6$ were well aligned with $SrTiO_3$ (001) substrate. The red emission was not observed in the PL spectra of the two samples, and the Mg^{2+} ions were found to be deficient by XPS analysis. We expected that the MgO substrate was able to supply the octahedral MgO_6 lacking in the $SrLaMgTaO_6$ thin film, the red emission was observed in the thin film deposited on the MgO substrate.

Corresponding author : JEONG Junghyun, CHANG Seohyoung

Surface, interface and thin films(G)/1051 P1-ap.418

Graphene-based supercapacitor performance was improved with a simple process involving water

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Abstract :

Reduced graphene oxide (RGO) can be used in optoelectronics, electronics, and supercapacitors. For the RGO-based supercapacitors, there is an issue for increasing the energy storage capacity. Here we report a simple process using deionized (DI) water to achieve an enhancement in the energy storage capacity for the RGO supercapacitor. For the supercapacitors containing the PVDF mass ratio of 10% and 20%, we observed that the specific capacitance increased by 10-200% after the DI water treatment. This increase was more prominent as the PVDF content increased or the measurement speed increased. The investigation results of the DI water effect on the RGO-based supercapacitors will be presents. For the large-scale production of RGO supercapacitors, this process may be useful because it is environmentally friendly, low cost, and very simple.

Surface, interface and thin films(G)/1089 P1-ap.419

Atomically flat $LaAlO_3$ surfaces through deionized water etching

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Abstract :

$LaAlO_3$ single crystal has widely been used for the growth of various perovskite oxide thin films. For the preparation of atomically flat $LaAlO_3$ surfaces, HCl treatment has often been used. We report that deionized water etching can also be used for the preparation of atomically flat $LaAlO_3$ surfaces. After annealing $LaAlO_3$ in high temperature, the surface characterized by tapping mode Atomic Force Microscopy shows flat, but mixed terminated surfaces. The mixed terminated surface can be prepared to be singly terminated through the agitation in deionized water. Depending on etching time, the surfaces could either be stable or unstable in the condition for thin film growth and we further provide a guideline to set proper etching time. $CaTiO_3$ film grown by Pulsed Laser Deposition on the prepared $LaAlO_3$ substrate shows smooth surface topography and sharp $CaTiO_3/LaAlO_3$ interface seen by Transmission Electron Microscopy.

Atomic and molecular structure and properties(A)/0860 P1-at.001

Attosecond counter rotating wave effect in a highly excited atom driven by strong fields

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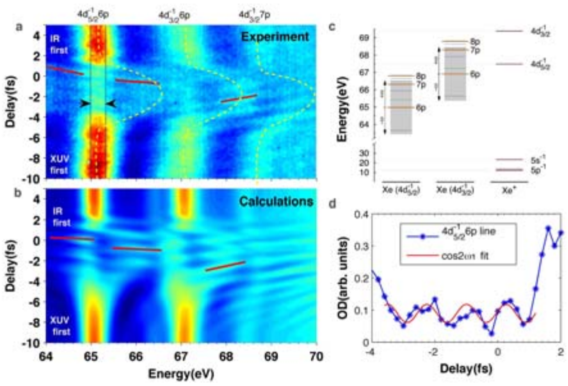
Abstract :



In analysis of light-matter interaction, the rotating wave approximation (RWA) has been widely used, which holds as long as the Rabi frequency. But for strong field-matter interaction, the rotating wave approximation breaks down and new effects appear, originating from the counter-rotating wave (CRW) terms in the Hamiltonian. With ultrashort pulses and the development of attosecond metrology, it is now possible to study CRW effects on a sub-femtosecond time scale.

In this work, we report the real time observation of ultrafast sub-cycle CRW feature with optical frequencies. We study the CRW effect in highly excited $4d^{-1}np$ states in atomic xenon, which are dressed by an intense near infrared few cycle pulse using attosecond transient absorption spectroscopy (ATAS). Time-dependent many-body theory confirms the observation and explains the various features of the absorption spectrum seen in experiment.

The ATAS experiment is carried out by measuring the transmitted spectrum (I_{gas}) through the gas target (Xe) as a function of delay (τ) between IR and XUV pulses from delays of -10 fs to 6 fs (negative delays correspond to xuv pulse arriving first) with a step of 200 as. Fig. (a) shows the optical density measured from xenon in the spectral region of 64 to 70 eV as a function of delay between the NIR and XUV pulse. The absorption lines correspond to the core-electron excited states $4d_{5/2}^{-1}6p$, $4d_{3/2}^{-1}6p$ and $4d_{3/2}^{-1}7p$ as shown in Fig. (c). The three main features noted in the region of overlap between the pulses are (1) the splitting of the absorption lines, (2) the asymmetry in the splitting (dotted yellow line) and (3) the oscillating substructures within them. The oscillating sub-structures have a frequency of about twice the NIR frequency. This is seen more clearly in Fig. (d) (blue line), where the optical density integrated over a bandwidth of 200 meV centered at the 65eV (area between the black vertical lines in Fig 2a) absorption line ($4d_{5/2}^{-1}6p$) is shown as a function of delay between the IR and XUV pulse.

With attosecond transient absorption spectroscopy we can time-resolve this fast dynamics, which has not been seen so far in the optical regime. The shortness of the IR and the attosecond pulse allows for characterizing highly excited electronic states that are challenging to access with direct spectroscopic approaches due to their short lifetimes.

Precision measurements(E)/0104 P1-at.002

Progress of atom spin gyroscope in ADD

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Abstract :

We present recent progress of atom spin gyroscope in ADD. Xe-Rb vapor cell is heated up to 120 degree and 4-layer magnetic field shield is employed to protect external manetic field. Larmor frequency of ^{87}Rb is measured and characterized as magnetic field is tuned. We designed 2-layer heater with counter-propagated wire to reduce the residual B-field. We will discuss current issue in developing atom spin gyrosopce in detail.

Gold Coating Method on an Aluminum-Based Surface Ion Trap Chip to Suppress Accumulation of Laser-Induced Stray Charges

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Abstract :

In ion trap experiments, stray charges on the dielectric materials near trapped ions are one of the noise sources distorting electric fields. For reducing the effects of the stray charges, the dielectric surfaces can be coated by conducting layers to prevent the exposure to the ions. This paper presents gold coating method on an aluminum-based surface ion trap chip to suppress accumulation of laser-induced stray charges. Note that Al can form thin native oxide layers, and Au is preferred for an electrode material of surface ion trap chips since it does not oxidize. However, Au cannot be used to fabricate complex electrode structures, since the use of gold is rarely allowed in conventional microfabrication processes. In the proposed method, a surface ion trap chip with Al electrodes is fabricated firstly, and an additional Au layer is deposited on the chip surface by using a shadow mask. The fabrication results show that the Au layer is successfully deposited on the RF, the outer DC, and the inner DC electrodes, without any electrical short between isolated electrodes. Also, the experimental results indicate that the Au coating on the Al electrodes can reduce the stray fields induced by built-up charges.

Acknowledgement: This work was partly supported by the ITRC (Information Technology Research Center) support program of MSIT/IITP [IITP-2017-2015-0-00385] and ICT R&D program of MSIT/IITP [10043464, Development of quantum repeater technology for the application to communication systems].

Quantum optics and quantum information(C)/0998 P1-at.004

Theoretical analysis of high-order harmonic generation in solid under inhomogeneous laser fields

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Abstract :

아토초펄스를 만들기 위한 방법으로 최근에는 비교적 파장이 긴 레이저를 이용하여 고체에서 만들어지는 plasmon 을 이용한 고차조화파발생이 연구되고 있다. 최근에 Han[1] 은 금으로 감싼 SiO 팁에 레이저를 입사시켜 HHG 가 발생함을 실험적으로 보이는 등의 많은 실험이 이루어지는 반면 이론적인 연구는 아직 많이 부족한 실정이다. Plasmon 에 의해 발생되는 전기장의 모델링뿐만 아니라 파동함수의 경계조건조차 명확하게 결정되지 못하고 있다. 이번 연구는 Han 이 시행한 실험의 설명을 위해 1 차원 모형을 만들어 plasmon 에 의해 만들어지는 균일하지 않는 전기장을 모델링하고, 여러 경계조건을 사용하여 계산한 결과를 실험과 비교해 보고자 한다.

1. Nat. Commun 7, 13105(2016)

Quantum optics and quantum information(C)/0850 P1-at.005

Ultrafast control of single-atom qubit in tweezer trap array

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Abstract :

Ultrafast laser pulses have been an indispensable tool in coherent quantum control since their broad spectral bandwidth and short time duration provide large degree of freedom to manipulate quantum interference by pulse shaping, even for vulnerable systems of short coherence time such as atomic fine-structure qubit of ns order lifetime. Meanwhile, single-atom tweezer trap array has become a rising new platform for quantum information science, utilizing the lately developed techniques to form defect-free array through atom reconfiguration. In order to achieve the combination of these two methods, we demonstrate fundamental qubit gates: Rabi oscillation (X-gate) and dynamic Stark shift (Z-gate), of a single-atom fine-structure qubit driven in ultrafast time-scale. The experimental procedures to prepare an initial state, to apply ultrafast pulses, and to detect the resultant qubit state will be presented. Also, we suggest a method to implement hyperfine qubit gates by controlling fine-structure states with shaped ultrafast pulses.

Quantum optics and quantum information(C)/0797 P1-at.006

Rapid and robust qubit probability inversion using hybrid adiabatic-nonadiabatic interaction

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Abstract :

When a broadband pulse is highly chirped, it induces adiabatic evolution of a qubit system and robust probability inversion occurs. However, because this adiabatic method requires large chirp, the operation time becomes longer than 1 ps even for a pulse with spectral bandwidth of several THz. Here, we report a new method to make rapid and robust probability inversion of a qubit system which utilizes hybrid adiabatic-nonadiabatic interaction. When we only manipulate the temporal envelope of a chirped pulse, it induces qubit evolution which always can be expressed by a combination of Y and Z rotations in adiabatic basis. Thus, for a pulse with a temporal symmetry with respect to t=0, a reflection about YZ plane at t=0 causes complete cancel out between t>0 and t<0 parts, which results in the qubit probability inversion. Our numerical simulation shows that probability inversion of >99.9% fidelity occurs in the 0.5 pi pulse-area range, with 3 times shorter operation time than the adiabatic method.

Quantum optics and quantum information(C)/0665 P1-at.007

Storage and retrieval of entanglement states in Rydberg atom chains

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Abstract :

Long-living atomic storage qubit states are used to store and retrieve the entanglement states of Rydberg atom chains. The atoms (Rb) are initially prepared in an array configuration by the holographic atom rearrangement method [1] and entangled with the Rydberg dipole blockade through the two-photon transition pathway [2]. Then the atoms are simultaneously de-excited to map the as-prepared entanglement states in the ground hyperfine states. The preliminary result obtained using the release-and-recapture method shows the coherent four-photon transition between the ground hyperfine states is successfully implemented.

[1] W. Lee, H. Kim, and J. Ahn, "Defect-free atomic array formation using the Hungarian matching algorithm," Phys. Rev. A 95, 053424 (2017).
[2] H. Kim, K. Kim, W. Lee, and J. Ahn, "Quantum simulation with N=19 Rydberg atoms for quantum Ising dynamics," JTh5C.1, 14-19 May, CLEO 2017.

Quantum optics and quantum information(C)/0131 P1-at.008

광자 포집 효율 증대를 위한 다이아몬드 나노 기둥 안테나 제작

전승우[1], 한상욱[1], 김용수[1], 조영욱[1], 이상윤[*1], 문성욱[1]

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Abstract :

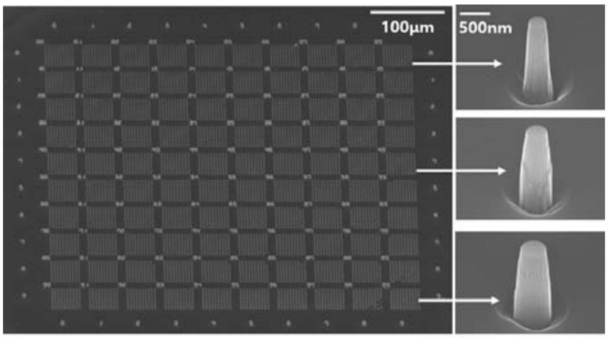

그림1 다이아몬드 기둥구조의 SEM사진

다이아몬드의 점결함은 스핀 큐빗 소자로 사용할 수 있으면서 동시에 단일양자광원으로 사용이 가능하다. 이 점결함으로부터 방출되는 광자들의 양자간섭을 통해 다수의 스핀 큐빗 사이의 양자 네트워크를 구현하여 양자 정보 처리 소자를 실현할 수 있다. 광자를 통해 다수의 점결함을 얽히게 하는 것을 광자-원자 양자 인터페이스라고 한다. 하지만 다이아몬드 점결함의 광자방출효율이 자연방출속도에 의해 제한되고, 방출된 광자는 표면 굴절률 차이에 의해 대부분 반사되어 포집 할 수 없기 때문에 효율이 낮다는 문제점이 있다. 따라서 다이아몬드 점결함을 이용한 광자-원자 양자인터페이스의 효율을 높이기 위해서는 나노포토닉스 기반 양자 인터페이스 연구가 반드시 필요하다. 안테나와 공진기와 같은 다이아몬드 광구조물을 제작함으로써 점결함의 단일광자 방출효율과 포집효율을 효과적으로 개선할 수 있다. 특히 그림 1 과 같은 나노 기둥 구조는 비교적 간단하게 제작할 수 있으면서, 광자를 효과적으로 포집 할 수 있게 하기 때문에 안테나로써 널리 연구되고 있는 구조이다. 본 연구에서는 점결함 광원으로부터 방출되는 광자의 포집효율을 높이기 위해 다이아몬드 나노 기둥 안테나를 설계하고 제작하는 과정을 소개하고자 한다.

Quantum optics and quantum information(C)/0045 P1-at.009

Polarization dependence in velocity selective optical pumping spectroscopy for ^{85}Rb atoms

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Abstract :

We investigate velocity selective optical pumping spectroscopy for the $F_g=3 \rightarrow F_e=2$, 3, and 4 transitions of ^{85}Rb atoms for various coupling beam polarization configurations. The experimental results are compared with the results calculated from accurate density matrix equations. We find good agreement between experimental and calculated results. We also study the effects of laser linewidths and frequency-mixing between the coupling and probe beams.

Methods in biological physics(B)/0159 P1-bp.001

Superresolution fluorescence microscopy for 3D reconstruction of thick samples

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Abstract :

Three-dimensional (3D) reconstruction of thick samples using superresolution fluorescence microscopy remains challenging due to high level of background noise and fast photobleaching of fluorescence probes. We develop superresolution fluorescence microscopy that can reconstruct 3D structures of thick samples with both high localization accuracy and no photobleaching problem. The background noise is reduced by optically sectioning the sample using line-scan confocal microscopy, and the photobleaching problem is overcome by using the DNA-PAINT (Point Accumulation for Imaging in Nanoscale Topography). As demonstrations, we take 3D superresolution images of microtubules of a whole cell, and two-color 3D images of microtubules and mitochondria. We also present superresolution images of chemical synapse of a mouse brain section at different z-positions ranging from 0 μm to 100 μm.

Methods in biological physics(B)/0606 P1-bp.002

Super-resolved Expansion Microscopy

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Abstract :

Super-resolution fluorescence microscopy is a powerful imaging technique that overcome the diffraction limit by means of optics and spectroscopy. Expansion microscopy has also recently emerged as a novel technique improving resolution, but dependent on physically expanded sample linked to swellable polymer matrix. The enlarged sample allows for going over the resolution limit under conventional diffraction-limited fluorescence microscopy. Combining the two methods (i.e. super-resolution imaging of expanded samples) may result in sub-10-nm resolution. However, the enlarged sample volume reduces labeling density and it makes difficult to apply expanded samples to super-resolution microscopy. To overcome the challenge, we first designed the biotin-avidin complex to amplify fluorescence intensity in expanded sample. The densely labeled fluorophores can boost the signal intensity. And then we observed subcellular structures with DNA points accumulation for imaging in nanoscale topography (DNA-PAINT), which is a method that utilizes transient hybridization of two short complementary DNA strands as a modality of localized-based super-resolution microscopy. In this study, we demonstrate the efficiency of amplified signals quantitatively and enhanced the spatial resolution from the combination of super-resolution microscopy and expansion microscopy.

Methods in biological physics(B)/0624 P1-bp.003

A New Photoswitchable Fluorescence Protein for Long-term Live-cell Super-resolution Imaging of Various Subcellular Structure

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Abstract :

Here we report a new way to image subcellular structures with sub-diffraction limit resolution by introducing a fluorogen inducible fluorescent protein, UnaG, whose fluorescence arise only when the protein binds to bilirubin (BR), a nonfluorescent metabolite. UnaG showed an efficient photoswitching property due to the nonfluorescent nature of free BR, in addition to simple switching kinetics and equilibrium that are controllable by light intensity and the concentration of BR. We found that UnaG has a strong resistance to photobleaching; more than 50 % of UnaG moelcules can survive after >300 switching cycles. These characteristics are suitable for single-molecule localization based super-resolution techniques, especially for long-term live-cell imaging. We demonstrated long time-lapse imaging of UnaG labeled subcellular structures in live Cos7 cells, resulted in >10 times increment of the number of super-resolved snapshots compared to conventional fluorescent probes (except lipophilic dyes that have limited applications).

Methods in biological physics(B)/0678 P1-bp.004

HybTrack: A hybrid single-particle tracking software using manual and automatic detection of dim signals

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Abstract :

Single particle tracking is a compelling technique for investigating the dynamics of nanoparticles and biological molecules in a broad range of research fields. In particular, recent advances in fluorescence microscopy have made single molecule tracking as a prevalent method for studying biomolecules with a high spatial and temporal precision. Particle tracking algorithms have matured over the past three decades into more easily accessible platforms. However, there is an inherent difficulty in tracing particles that have low signal-to-noise ratio, various sizes, and different microenvironment. Here, we present a new MATLAB based tracking program which combines the benefits of manual and automatic tracking methods. The program prompts the user to manually locate a particle when an ambiguous situation occurs during automatic tracking. We demonstrate the utility of this program by tracking the movement of β-actin mRNA in dendrites of cultured hippocampal neurons. Because neuronal mRNA granules have various subpopulations with different characteristics, it is particularly difficult to detect them with the same tracking parameters. Applying this program to β-actin mRNA in dendrites, we show that the diffusion coefficient of mRNA decreases upon KCl depolarization. This tracking method allows a more efficient dissection of the dynamic regulation of biological molecules in highly complex intracellular environments.

Methods in biological physics(B)/0915 P1-bp.005

polarization-selective interferometric detection of nano objects

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Abstract :

Single particle tracking is a powerful technique to reveal an underlying principle of microscopic phenomena. Here we report an optical microscopy technique, polarization-selective interferometric detection for optical scattering nanoscopy, that enables us to capture rotational as well as positional information of nano-scale objects. This technique grants all the merits of interferometric scattering microscopy and provides a further advantage of the capability of determining the orientation of single nanoscopic objects in a straightforward and facile way. We anticipate that this technique would be of critical use in rotational tracking of a single anisotropic particle or biological system in the nanoscopic world

The Use of Single Molecule FRET to Identify the Mechanism of Rho-dependent termination

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Abstract :

Identifying how Rho factor terminates RNA transcription is a fundamental problem in Rho-dependent termination, involved in 20% *E. coli* transcription. Two models are suggested for this problem, Hybrid-shearing and Hyper-translocation. In Hybrid-shearing model, factor Rho changes base paring or generate mismatches in the RNA-DNA hybrid. On the other hand, Hyper-translocation model argues that forward translocation of RNAP(RNA polymerase) without concomitant nucleotide addition, moving single-strand DNA into the main channel of RNAP plays role. We hypothesized that temporal sequence of RNA dissociation and RNAP dissociation can be an evidence, as sole dissociation of RNA might support Hybrid-shearing model, while simultaneous dissociation of RNA and RNAP can be thought as a result of Hyper-translocation model. We try to test this hypothesis by observing the FRET(Fluorescence Resonance Energy Transfer) change and PIFE(Protein Induced Fluorescence Enhancement) during the termination process. We design the DNA sample with dye based on λTR1 region. In this assay, we observed Rho-dependent termination and some cases of simultaneous dissociation of RNA and RNAP. We will do further study to make evidence for explaining the concrete mechanism of Rho-dependent termination.

Molecular & cellular biological physics(A)/0218 P1-bp.007

Single Molecule FRET studies on Difference between monomeric/dimeric state of Chd1 on nucleosome

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Abstract :

Nucleosome is packaging unit of eukaryotic dna, and key player of transcription regulation. These functions are achieved by forming, sliding, removing activity of a set of enzymes, chromatin remodelers. In previous study, we observed that yChd1 slides nucleosome stepwisely 4bp or 7bp using an ATP, with characteristic DNA unwrapping phenomenon in initiation of remodeling process. In other structural studies, nucleosome can bind two related enzymes due to its symmetric structure. Here, we observed different behavior of monomeric state and dimeric state of Chd1-nucleosome complex by single-molecule FRET.

Molecular & cellular biological physics(A)/0222 P1-bp.008

Single-molecule observation of co-transcriptional folding in TPP riboswitch regulation

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Abstract :

A riboswitch is a non-coding region of an mRNA which recognizes a specific metabolite and regulates the expression of the mRNA itself. Recently, the fact that RNA folds sequentially as it is being transcribed is carefully considered for RNA structure prediction and dynamics study. It has been shown that this co-transcriptional effect strongly influences RNA folding pathway suggesting that the formation of transient conformations serves as a guideline for the following co-transcriptional folding.
We used fluorescence resonance energy transfer (FRET) to study conformational dynamics of the Escherichia coli thiM TPP (thiamine pyrophosphate) riboswitch. Previously, we found that the open form and the closed form of the riboswitch recognize the ligand with similar preference and the final conformational transition of it is induced by the ligand. Using RNA polymerase elongation complex system, we now found that TPP riboswitch folding process including ligand bindings are strongly related to the transcription process such as elongation and pause.

Molecular & cellular biological physics(A)/0224 P1-bp.009

Replication fork regression by Rad5

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Abstract :

DNA lesions in the template strand block the replication process. If the damage is on the lagging strand template, the gap can be filled by synthesis from the adjacent Okajaki fragment. However, if the lesion is on the leading strand template, the gap cannot be repaired by fill-in synthesis using DNA polymerases. One method to bypass the leading strand lesions is to use the fork reveral, a postreplicational pathway. In the yeast Saccharomyces cerevisiae, this postreplicational repair is dependent on Rad5 protein which has a helicase activity that is specialized for replication fork regression. In this study, we characterize the fork regression mechanism of Rad5 at the single molecule level, using single molecule fluorescence technique.

Molecular & cellular biological physics(A)/0231 P1-bp.010

Single Molecule Study on Formation and Regulation of R-loop

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Abstract :

R-loop is a three-stranded nucleic acid structure formed co-transcriptionally in both prokaryote and eukaryote. It constitutes of two components : one double strand made of DNA:RNA hybrid, and remnant ssDNA. Generally, almost r-loops are harmful if they cannot be removed adequately, because their exposed ssDNA is fragile so that it can be easily damaged, causing many genetic diseases. At some regions like TSS, TTS, and telomere, they, however, have some functions like transcription activation, transcription termination and chromatin modification. So proper regulation is very important and actually many enzymes are related with it. First aim of our study is basically to observe the formation of R-loop and test some enzymes known for eliminating and preventing the R-loop. Of course, there are some ways used to detect the formation of R-loop with extracted gDNA like DRIP-seq and bisulfite method. But theses methods have limited resolution and are not the realtime observation. Therefore with these methods we can not see some issue like r-loop formation models. Our second aim of the study is see what sequences are prone to form R-loop and how.

Molecular & cellular biological physics(A)/0247 P1-bp.011

Single-molecule Mechanistic Studies on DNA Proofreading by DNA Polymerase

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Abstract :

Escherichia coli DNA polymerase III (Pol III), consisting of the polymerase a subunit and the 3' to 5' proofreading exonuclease e, associates with the b_2-sliding clamp to processively synthesize DNA and remove misincorporated nucleotides. In contrast to the polymerase activity of Pol III, dynamic features of proofreading are poorly understood. We used single-molecule flow-stretching and fluorescence imaging methods to determine the excision rate and processivity of the b_2-associated Pol III core and to visualize the transient conformation in the proofreading mode, and observed that both properties are enhanced by mutational strengthening of the interaction between e and b_2. Thus, the e–b_2 contact is maintained in both the synthesis and proofreading modes. Remarkably, single-molecule real-time fluorescence imaging revealed the dynamics of transfer of primer–template DNA between the polymerase and proofreading sites, showing that it does not involve breaking of the physical interaction between e and b_2.

Molecular & cellular biological physics(A)/0317 P1-bp.013

Microscopic mechanism of R-loop expansion for Cas9 nuclease activation

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Abstract :

Cas9 nuclease targets and cleaves foreign DNA with the help of guide RNAs for adaptive immunity in prokaryotes. Since its wide application to genome editing, structural studies for the CRISPR/Cas9 system have been extensively reported. However, the detailed mechanism upon R-loop expansion, followed by the nuclease activation, is still elusive. Here, we investigate the real-time dynamics during the formation of the R-loop between guide RNA and target DNA. Using single-molecule FRET assays, the RNA-DNA heteroduplex is revealed to have repetitive transitions between two distinct sub-conformations (PAM-distal 'open' and 'zipped' conformations), which regulate the nuclease activation of Cas9. Upon the transition, non-target strand of DNA is found to move in a highly coupled manner, which further provides structural detail for the microscopic mechanism of the R-loop expansion and thereby mechanistic basis for the target specificity of CRISPR/Cas9.

Molecular & cellular biological physics(A)/0368 P1-bp.014

Diffusion analysis of PCNA interacting with p15^{PAF} on DNA

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Abstract :

UV-damage to DNA can arrest DNA replication, which results in cell death. Human cells have a translesion synthesis(TLS) system that resumes the stalled DNA replication process. And the interaction between p15^{PAF} and PCNA (proliferating cell nuclear antigen) plays an important role in the beginning of the TLS process. The intrinsically disordered protein p15^{PAF} regulates the DNA polymerase switching of PCNA by directly interacting with the PCNA sliding clamp for TLS process. A recent crystal structure of the human p15^{PAF}–PCNA complex suggests that p15^{PAF} drags or stops PCNA sliding along the DNA to regulate freely diffusing PCNA to facilitate the switch from replicative to translesion synthesis polymerase binding [1].

To investigate the dynamic features of PCNA in the presence of p15^{PAF}, we directly examined the thermal fluctuation-driven motion of a single PCNA and p15^{PAF} molecule fluorescently labeled with Cy5 and Cy3 on extended DNA and examined FRET changes at the DNA junction.

Molecular & cellular biological physics(A)/0383 P1-bp.015

A single-molecule dissection of DNA recognition and cleavage by CRISPR-Cas12a (Cpf1) endonuclease

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Abstract :

Cpf1 is a key enzyme of CRISPR-mediated immunity in prokaryotes such as the well-known Cas9 protein. As part of its essential cellular functions, the enzyme recognizes and cleaves DNA with a single guide RNA. However the regulation mechanism of this RNA-guided nuclease activity for genome editing like Cas9 is not well understood. Here, we study single molecule fluorescence assays that monitor several critical steps during DNA cleavage by Cpf1-guide RNA complex, including transient binding, stable binding, and sequential cleavages of target DNA double strands. Our results suggest that stable binding of Cpf1-guide RNA complex plays an important role for target recognition and cleavage, and the stable binding is efficiently established only when the seed matches up to 17 base pairs. Furthermore, we found that cleavage of two DNA strands occur in a defined sequential order, which is consistent with recent structural studies of type V CRISPR-Cas endonucleases that strong support the conclusion that cleavage of target and non-target DNA strands is catalyzed by the same RuvC active site.

Molecular & cellular biological physics(A)/0415 P1-bp.016

Single molecule study on the crosstalk between H2B ubiquitylation and H3K79 methylations by Dot1

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Abstract :

Ubiquitylation of histone H2B at lysine 120 (H2B-Ub) linked to a diverse nuclear processes including the regulation of chromatin conformation, transcriptional elongation as well as specific methylations of histone H3. Particularly, H3K4 and H3K79 methylations are directly regulated by H2B-Ub in *trans*-crosstalk, however, the mechanistic principles underlying the enhanced methylations remain poorly understood. Herein, we use a single-molecule observation to explore how ubiquitylation of H2B stimulates methylation of H3K79 by dot1p, using chemically ubiquitylated H2B. The kinetic analysis implies that ubiquitin increases the binding stability of dot1p to the nucleosome, and facilitates productive binding of dot1p on the nucleosome. Interestingly, the N-terminal region of dot1p displayed specificity for the ubiquitylated nucleosome.

Molecular & cellular biological physics(A)/0441 P1-bp.017

Dynamics of transcription and transport of labeled-endogenous Arc mRNA in live neurons

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Abstract :

Spatially and temporally controlled gene expression is crucial for the formation of memory. Especially, an immediate early gene Arc is known to be deeply involved in the modulation of synaptic plasticity. Upon stimulation, transcription of Arc mRNA occurs in a selected group of neurons. After transcription, Arc mRNA is transported to the desired destinations including distal parts of dendrites for local translation. These two biological phenomena, transcription and transport of Arc mRNA undoubtedly have significant roles in the memory formation. We developed Arc-PBS KI mouse for single mRNA imaging in live cells by knocking in 24 tandem arrays of PP7 binding site (PBS) in the 3′ untranslated region (3′ UTR) of the Arc gene. Using the Arc-PBS KI mouse, we investigated the dynamics of transcription and the transport of Arc mRNAs in live primary neuron cultures. First, we simultaneously imaged somatic Ca^{2+} activity and Arc mRNA transcription after stimulation by bicuculline. Whereas synchronized bursts of Ca^{2+} activity was induced in 100% of neurons, Arc transcription was induced only in a subpopulation of neurons during 30 min of observation after stimulation. To determine the factor governing this selection of Arc transcribing neurons, we performed immunostaining of Ser-133 residue phosphorylated transcription factor CREB and single molecule FISH of Arc mRNA together. We found that neurons with higher level of CREB phosphorylation (Ser-133) have indeed higher probability of Arc transcription. We also investigated transport of Arc mRNAs along the dendrites after stimulation. Most of the Arc mRNAs were in rest phase (~88%) during one-minute observation time, and even the directed motions of Arc mRNAs were frequently interrupted by rests, similar to the previously reported behavior of β-actin mRNAs. The active movements of Arc mRNAs were bidirectional but slightly biased toward anterograde direction. Also contrary to the known neural activity dependent localization of Arc mRNA, inhibiting neural activity for 20 min didn't alter the moving fraction of Arc mRNA. In summary, this study presents new perspectives about the dynamics of transcription and transport of endogenous Arc mRNA, which plays important roles in synaptic plasticity at the molecular level.

Molecular & cellular biological physics(A)/0642 P1-bp.018

Revealing the Role of Histone Tails in Controlling Nucleosome Assembly and Chromatin Compaction

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Abstract :

Histone proteins are essential to the construction of chromatin fiber and controlling its conformational state for the regulation of gene expression. DNA wrapping over histone octamer forms a nucleosome as the basic unit of chromatin fiber and understanding how the nucleosome wrapping/positioning and the compaction of nucleosome arrays are controlled is the key to understanding epigenetic gene regulation. Each histone protein subunit has unstructured tail region, which is known as multiplexed target of epigenetic modification. But we still lack knowledge about the role of the tail regions and the effect of each epigenetic modification on the chromatin structure and dynamics. We developed magnetic tweezers combined with single molecule fluorescence imaging to measure the mechanical properties and dynamics of nucleosomes and chromatin fibers. By using histone proteins with deleted tail regions or with epigenetic modification at specific residues, we try to figure out their role in controlling chromatin structure and dynamics. We present preliminary results from the measurement of the chromatin compaction and nucleosome unwrapping dynamics.

Molecular & cellular biological physics(A)/0693 P1-bp.019

Synapse-specific localization of beta-actin mRNA studied by two-photon uncaging

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Abstract :

The purpose of this research is to investigate the physiological role of beta-actin mRNA localization in stimulated dendritic spines on long-term potentiation (LTP). LTP is the most important procedure in learning and storage of information in the brain where interacting neuronal cells undergo continuous stimulation and sustain structural changes in the synapse. In order to understand the role of beta-actin mRNA localization in neurons, we hypothesized that local translation of beta-actin mRNA plays a key role in structural remodeling of dendritic spines during LTP. We employed two-photon glutamate uncaging to stimulate single dendrite spines with or without beta-actin mRNA localization. Hippocampal primary neuron cultures from a transgenic mouse in which all beta-actin mRNAs are fluorescently labeled were used for RNA detection in live cells. Then, the activity of all neurons was blocked by applying tetrodotoxin(TTX), which is an inhibitor of sodium channels. Two-photon uncaging of glutamate was carried out to stimulate only a confined area near a single dendritic spine with a specific stimulation frequency. The structural LTP was assessed by measuring the changes in the volume of dendritic spines using a numerical fitting program. Our results suggest that localization of beta-actin mRNA has a strong correlation with the structural LTP process. This study sheds a light on the implication of beta-actin mRNA localization and local translation for LTP in neurons and their role in long-term memory formation.

Molecular & cellular biological physics(A)/0751 P1-bp.020

Disordered dynamics of bivalent protein Pin1 on its peptide substrate

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Abstract :

Pin1, Peptidyl-prolyl *cis-trans* isomerase NIMA-interacting 1, contains two functional domains, WW domain for the recognition of the peptide substrate and PPIase domain for *cis-trans* isomerization, linked by a flexible, intrinsically disordered region (IDR). Recent evidences from NMR studies suggest the inter-domain migration in this bivalent protein, the mechanism of which remains puzzling. Therefore, we characterized the inter-domain dynamics of Pin1 from multi-color single molecule fluorescence resonance energy transfer measurements. We measured the dynamics of Pin1 directly tethered to the surface or co-encapsulated in a lipid vesicle with the peptide substrate in order to observe its transient interaction with the substrate. We visualized the structural dynamics between the Pin1 domains as well as their interaction with the peptide substrate in real time to reveal the temporal correlation between the domain recognition and isomerization dynamics. This approach will provide new understanding of the role of the intrinsically disordered regions in coordinating multi-domain protein functions.

Molecular & cellular biological physics(A)/0949 P1-bp.021

Binding mode and degradation activity of ribonuclease H on the RNA/DNA hybrid substrate by single molecule FRET

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Abstract :

RNase H catalyzes a series of reactions digesting an RNA moiety in a DNA/RNA hybrid, and its mutations lead to the Aicardi-Goutieres syndrome in human. During DNA replication, RNase H is responsible for removing a short piece of RNA (~11 nucleotides) from ~1 or 2 kilobase-long Okazaki fragments in prokaryote, implying its unique recognition mechanism. Here, we used single molecule FRET to elucidate/examine the recognition mechanism via binding modes and time-trajectory rate analysis, and discovered that RNase H binds to, not only a 3' overhang DNA/RNA junction but also a chimeric strand junction. The binding and dissociation analysis revealed two characteristic distributions, e.g., a Poisson distribution at the 3'-overhang junction and a single-exponential distribution at the chimeric junction, suggesting different binding mechanisms. The kinetic analysis also indicated that a creation of a nick by catalysis at the chimeric junction may dictates how long RNase H stays and triggers to dissociate from the chimeric junction. Overall, our study recapitulates how RNase H orchestrates the maturation process of Okazaki fragments by means of different binding capabilities along with structural variations on its substrates.

Molecular & cellular biological physics(A)/0963 P1-bp.022

The Characterization of Cooperative Unwinding by SARS-CoV nsp13 Helicase

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Abstract :

SARS-CoV and MERS-CoV were epidemic in 2003 and 2015 in ASIA. SARS-CoV helicase plays critical roles in viral replication, and has been proposed to be a potential target for anti-SARS-CoV therapy. Thus, the characterization of enzymatic activity might be critical for drug development. We utilize single molecule FRET to examine the unwinding and rewinding mechanism of nsP13 helicase on partial DNA duplexes as a function of protein, ATP concentration, and tail length. Our results unravel that the tail length of the substrates governs the total amount of DNA unwound by increasing the number of proteins loaded. In contrast, unwinding rate and step size depend on protein and ATP concentrations with a long tail partial duplex (45nts long), but is independent of protein concentration for a short tail partial duplex (30nts long). We also observed a repetitive unwinding displaying multiple rounds of re-unwinding and re-zipping events where re-unwinding becomes favorable at higher protein concentration. We also found that the relative extent of constitutive unwinding and repetitive fluctuation is defined by the enzyme oligomerization formed in the presence of ATP concentration. The relative ratio between unwinding and re-zipping determines the processivity of the cooperative helicases.

Molecular & cellular biological physics(A)/0979 P1-bp.024

Mechanism of mismatch recognition of phi29 DNA polymerase revealed by single-molecule FRET

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Abstract :

Phi29 DNA polymerase performs a functional interplay between its 3'-5' exonuclease and polymerization, which plays essential role in proofreading activity to prevent DNA mismatch incorporation. Its proofreading process requires the mismatch recognition to transfer the 3'end of primer from polymerase active site to exonuclease active site. We report the single-molecule study that monitors the dynamics of phi29 DNAP with different mismatch positions DNA. The results obtained allow us to propose: (1) the mismatch recognition spectrum of phi29 DNAP is from 3' end to 7 nucleotides upstream of primer, (2) the polymerase/exonuclease activity of enzyme depends on the mismatch positions, in which the mismatch at 3rd and 4th position can keep phi29 DNAP the most stable at exo-binding mode.

Molecular & cellular biological physics(A)/0986 P1-bp.025

Topoisomerase II selects its target sites by using enzyme induced flexibility of DNA

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Abstract :

Topoisomerase II plays the essential role of resolving topological issue of double strand DNA, Although Topoisomerase II has different cleavage efficiencies for DNA sequences, its cleavage site selection mechanism is not well understood. Here, using single-molecule fluorescence FRET assays, we observed the fundamental steps of DNA cleavage reaction by topoisomerase II and found that cleavage site is selected during the bending step. Although it occurs during bending step, the cleavage efficiency is determined by DNA-protein interaction instead of the intrinsic flexibility of DNA.

Study of cytotoxicity of graphene nanosheets to blood-coagulation protein using molecular dynamics simulation of

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Abstract :

Graphene is a nanomaterial that is widely used in electronics, biomedicine, and drug delivery systems. Although it has many industrial applications, the cytotoxicity of graphene has not been sufficiently studied. In this study, we used molecular dynamics simulation to investigate how a graphene nanosheet affect a blood-coagulation protein, namely a TF/FVIIa binary complex bound to a lipid bilayer membrane, in a 4:11-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine/1-palmitoyl-2-oleoyl-sn-glycero-3-phospho-l- serine lipid bilayer mixture. Based on the results, we suggest a mechanism for the cytotoxicity of graphene nanosheets to blood-coagulation protein at the molecular level.

Other biological physics(D)/0645 P1-bp.027

Stimulus-dependent transcriptional bursts in hippocampal neurons revealed by long-term live-cell imaging

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Abstract :

Mammalian transcription often occurs discontinuously and stochastically, consisting of short bursts of RNA synthesis followed by longer silent periods. However, how these burst frequency and sizes are modulated is poorly understood especially in neurons. Here, we studied the transcriptional responses of the endogenous beta-actin mRNA in neurons upon physiological stimuli by using bicuculline which blocks the inhibitory action of GABA receptors to mimic epilepsy. We quantified the transcriptional events using long-term live-cell imaging and stochastic modeling of the time traces. Our study thus provides valuable insights into how physiological stimuli can trigger kinetically distinct transcriptional responses in neurons.

Other biological physics(D)/0672 P1-bp.028

A Simulation Study for the Feasibility of the usage of Heavier Ions in Charged Particle Therapy

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Abstract :

Proton therapy is a kind of advanced radiotherapy that applies the high energy proton beam to kill the target cells by using the special physical properties of protons. Beside of proton beam, in some institute, carbon ion beam is also utilized due to its more ideal physical properties compare to proton. According to the interaction principle of ion and matters, the heavy ion, such as oxygen ion or heavier ions, could show sharper Bragg peak. In another world, they may show more advantages in dose distribution compare to with proton or carbon ion. In order to confirm this, we use Monte Carlo method to simulate the radiotherapy using the various heavy ions, and we calculated the dose in target volume and surround normal volumes. The result showed that the heavier ion would deposit less dose into the normal volumes, in the case of same dose deposition in the target volume. In conclusion, in particle radiotherapy, the heavier ion could show the more ideal physical dose distribution compare to proton and carbon.

Theoretical & computational biological physics(C)/0123 P1-bp.029

Obstructed diffusion in a fractal globule and in other random geometries

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Abstract :

The fractal globule is a recently highlighted model of chromatin structure in the interphase cell nucleus. The compact nature of the fractal globule geometry makes itself an effective random obstacle that hinders diffusion of living molecules which would, otherwise, undergo normal diffusion. Here we perform a computational study for the anomalous transport dynamics inside a fractal globule, and gain an insight into molecular diffusion within an interphase chromatin structure. Especially, we compare the diffusion characteristics for the following three distinct geometries: (1) Fractal globule, (2) Equilibrium globule, and (3) Random percolation geometry. Various dynamic observables obtained from simulation are presented.

Theoretical & computational biological physics(C)/0449 P1-bp.030

Geometrical Analysis for non-stereotactic image co-registration with ImageMerge^{TM} in LGP

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Abstract :

The phantom study was performed to assess the geomeric accuracy of co-geristered PET image with stereotactic reference image. To assess the spatial accuracy of co-registered PET images, the geometric distortion phantom was designed. The local displacement was determined as difference between the lattice point coordinates for reference and non-stereotactic images. To identify factors related to an imaging quality of non-stereotactic image, the imaging distortion phantom was also designed. The coodinate values for indicators of phantoms was measured in Leksell GammaPlan (LGP). This study suggests that while PET images co-registered with stereotactic images provide sufficient precision in Gamma knife treatment plan, its metabolic volume should be weighted differently depending on the size and location of the tumor.

Theoretical & computational biological physics(C)/0562 P1-bp.032

First passage dynamics of fractional Brownian motion with stochastic resetting: a computational study

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Abstract :

We study anomalous diffusion where a diffusive searcher performs a strongly correlated diffusion modeled by fractional Brownian motion (FBM) and stochastically resets to its initial position at a constant rate r in a finite domain. In biological systems strong correlation often occurs in a diffusion process and the diffusive searcher explores in a finite space. As an example, the mutS protein has to signal to the mutH protein by diffusion in the mismatch repair process. Our simulation shows that the stochastic resetting enhances the efficiency of target search if the distance between the target and reset site is less than a critical value, which turns out to depend on the Hurst exponent and the domain size. In this case, there exists an optimal resetting rate r* that minimizes the mean first passage time (e.g., the mean search time). Beyond this distance, the resetting is no longer effective to find a target. Seemingly counterintuitively, resetting significantly enhances the target search when the random walk searcher moves subdiffusively with the anti-correlation memory.

Theoretical & computational biological physics(C)/0571 P1-bp.033

Roadblock elimination by 1D Diffusion of DNA sliding clamps on DNA

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Abstract :

To maintain cellular DNA in life processes, the orchestration of proteins involved in the reaction is required. DNA sliding clamp that encircles DNA and diffuses along DNA serves as a processive-enhancing factor in DNA replication and a signal-transmission factor in DNA repair. Due to the extraordinary stability of DNA sliding clamps, they can be accumulated on DNA. However, chromatin blocks or nonspecific DNA binding proteins may inhibit the diffusion of the sliding clamps for the protein-protein interaction along DNA. We hypothesize that multiple DNA sliding clamps on DNA move like one- dimensionally diffusing hard spheres. Sliding clamps, at the extraordinary condition, may generate sufficient pressure to remove the roadblocks on DNA. Here we propose a single-molecule experiment to measure the force by sliding clamps on DNA, based on the analytical calculation of the repulsive force that is the result of the diffusion of multiple sliding clamps on DNA.

Theoretical & computational biological physics(C)/0586 P1-bp.034

분자동력학 시뮬레이션을 이용한 세포 침투성 펩타이드 연구

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Abstract :

세포 침투성 펩타이드(Cell-Penetrating Peptides, CPPs)는 양의 전하를 띤 40 개 이내의 아미노산으로 이루어진 펩타이드로, 세포막에 손상을 주지 않으면서 세포 내로 이동하는 것이 가능하고 세포막을 통과하지 못하는 DNA 나 분자량이 큰 단백질도 세포 내로 전달시킬 수 있는 획기적인 역할을 한다. CPP 를 이용하여 단백질, 핵산, 약물 등을 원하는 세포 내로 수송하는데 관심이 모아지고 있지만, 이들이 세포 안으로 들어가는 메커니즘은 아직 정확히 밝혀지지 않은 부분이 많다. 분자동력학 시뮬레이션을 이용하여 다양한 CPP 들이 물 분자 내에서, 그리고 생체막 환경에서 어떤 특성을 보여주는지 관찰하고 기존의 실험결과와 비교한다. 생체막 환경의 경우 생체막을 이루고 있는 지질의 성분변화에 따른 CPP 와의 상호작용을 이해하고, 시간에 따른 생체막의 곡률 변화를 구한다.

Bio/Soft-condensed/Organic materials(D)/0490 P1-co.101

Angle-resolved light-scattering spectroscopy on single-crystalline lysozyme

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Abstract :

In proteins, the underdamped collective modes in THz range are considered to be essential for the conformational dynamics, which are necessary for protein function. We propose a spectroscopic approach to measure the polarization-angle-dependence of the Raman intensity of a single-crystalline protein to observe the low-frequency modes obscured by a broad and large central peak. The mode symmetry and its degree of anisotropy can be deduced from the polarization-angle-resolved measurements because the Raman intensity is determined by the corresponding Raman tensor and the employed scattering geometry [1].

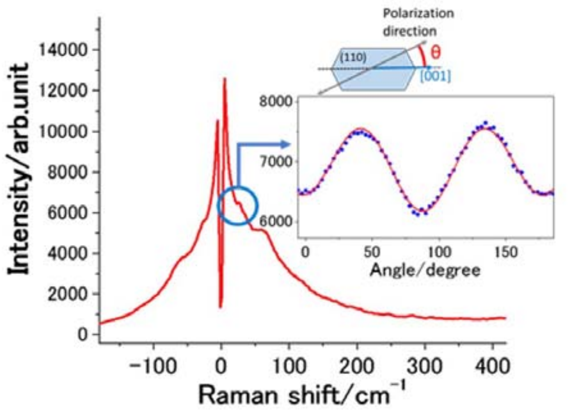

Fig.1. Raman spectrum of a tetragonal lysozyme observed in a parallel nicol setup.

We investigated tetragonal lysozyme crystals grown by the batch method. Figure 1 shows the Raman spectrum of a tetragonal lysozyme obtained in a parallel nicol geometry with the incident polarization direction parallel to [001], while the inset shows the angular dependence of the Raman intensity of the mode at . We examined the low-frequency modes below by decomposing the angle-resolved spectra into the spectral components of several underdamped vibrational modes and a central peak.

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Bio/Soft-condensed/Organic materials(D)/0303 P1-co.102

Large enhancement of refractive index by iodine doping in a small molecule organic semiconductor Tetramethyltetraselenafulvalene

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Abstract :

Among the various optical properties of organic semiconductors, how electromagnetic wave propagate through the medium depending on wavelength below absorption edge is an important issues but has been seldom studied. The dispersion of refractive index, essentially linked by absorption spectrum through Kramers-Kronig relation, can provide the fundamental information on the energy band structure. Moreover, the effective design and precise fabrication of optoelectronic devices and elements require precise knowledge of the dispersion of refractive index.

Refractive index, depending on its state of polarization and the direction of propagation, has been commonly measured with ellipsometry, interferometry, and prism or grating coupling technique. In this report, the dispersion of the refractive index and its temperature dependences of an organic single crystal tetramethyltetraselenafulvalene (TMTSF) are systematically studied from the broadband interference modulation of photoluminescence (PL) spectra, which are essentially the emission spectra coupled to the longitudinal cavity multimode formed between a pair of the parallel crystal facets. With doping of iodine in the amount of less than 1 percent of the volume fraction, the group refractive index of TMTSF ($C_{10}H_{12}Se_4$) is largely enhanced from 1.67 to 2.06 ($\Delta n \sim 0.4$) at long wavelength limit ($\lambda \to \infty$). Data also suggest that the interference modulation analysis is a promising strategy to monitor wide range of refractive indices and their temperature dependence for molecular organic semiconductors.

Condensed-matter computational physics(G)/1081 P1-co.201

Magnetic interactions in organic electrides : A first-principles study

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Abstract :

Electride is a ionic crystal which has the trapped electrons in cavity playing a role as anion. The organic electrides have skeleton structure made of big molecules such as cryptands or crown ethers. Most of these organic electrides have been known as anti-ferromagnets [1-3] and contain the large number of atoms in the unit cell due to these big organic molecules. Therefore, the theoretical investigations have been limited to the nearest neighboring coupling [4]. In this paper, we apply our newly developed computation method to three different organic electrides, namely Rb^+(cryptand-2.2.2)e^-, Li^+(cryptand-2.1.1)e^- and [Cs^+(15C5)(18C6)e^-]$_6$(18C6). Our method is based on magnetic force linear response theory [5-7] where does not require the supercell calculations even for the long-range interactions. In order to describe the trapped electrons, also we used maximally localized wannier function (MLWF) technique [8] as well as so-called empty potential technique [9]. Our results show that there are non-negligible interactions, which could not be estimated in a previous theoretical study [4] and are neglected in previous experimental studies [1-3]. It is also show explicitly that the source of measured magnetic character really comes out from the localized electron.

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Atomic neural network potentials for aluminum clusters and bulk phases

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Abstract :

Aluminum clusters (Al_N) have a variety of different shapes depending on the cluster sizes around N = 50 [1]. Interestingly, low-coordination surface atoms of Al clusters can be stabilized through the hybridization between the s and p orbitals of the Al atoms. For example, the tetrahedral-like Al_{55} cluster is 4.8 eV more stable than the spherical icosahedral Al_{55} in density-functional theory calculations. Several empirical potentials have been developed to describe the nontrivial interatomic interactions in the Al clusters, but none of them succeeded yet. In this work, using the generalized neural network (NN) scheme proposed by Behler and Parrinello [2], we develop *ab initio* quality, many-body atomic potentials for Al nanoclusters and bulk phases. NN atomic potentials trained for Al clusters and bulk phases will be compared to address how the interatomic metallic bonds are affected in the presence of the surfaces. This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2016R1C1B2016046).

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Condensed-matter computational physics(G)/0456 P1-co.204

Topological and Transport properties of three dimensional Dirac semimetals

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Abstract :

For last decade years, topological matters are one of the hot issues in condensed matter physics. Various types of topological insulators (Tis) have been proposed and realized. In addition to Tis, the three-dimensional topological semimetals (SMs), classified by three groups of Dirac, Weyl, and nodal-line SM, have been taken extreme attention due to its interesting properties, which imply a new way of electronics and spintronics applications.

We have been investigated topological and transport properties of perovskite-like novel three-dimensional semimetals, using density functional theory based calculations. In this presentation, we will address its topological characters. Also, its thermal and optical properties will be discussed.

[Acknowledgements] The research was supported by NRF of Korea under Grant. No. NRF-2016R1A2B4009579.

Condensed-matter computational physics(G)/1096 P1-co.205

Accurate Quantum Monte Carlo study for a Single Pt Atom on a Benzene Molecule

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Abstract :

Pt clusters adsorbed on the graphene surface are known to possess good catalytic properties when compared to the unsupported ones. To understand this, one needs to make an accurate description of the Pt-graphene interaction including many-body effects. Here we investigate adsorption of a single Pt atom on the center of a benzene molecule, which can be regarded as the simplest fragment of the Pt/graphene system, by using quantum Monte Carlo (QMC) method. Since a Pt atom in the system could form multiple bonds that cannot be described only by a single Slater determinant in its many-body wave function, we use multi-determinant expansions obtained from the CIPSI (Configuration Interaction using a Perturbative Selection made Iteratively) calculations. This allows us to investigate how much the multi-determinant trial wave functions affect binding properties of the system in QMC calculations.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Condensed-matter computational physics(G)/1130 P1-co.207

Electronic and Transport Properties of Vertical Heterostrucrure of h-BN and Black Phosphorus

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Abstract :

Recently, the air-stable hexagonal boron nitride (h-BN) encapsulated black phosphorous (BP) devices have been suggested and demonstrated. However, many details about the electric and thermoelectric transport properties of semiconductor heterostructure consisting of h-BN and BP are still lacking. In this work, based on the density functional theory (DFT) calculation, we investigate the electronic structure and transport properties of vertical heterostructure of 2D h-BN and BP.

Condensed-matter computational physics(G)/1028 P1-co.208

First principle calculation on Electronic structure and Polar properties in Ga_2O_3

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Abstract :

Recently, wide bandgap semiconductor materials such as SiC and GaN have been attracting considerable attentions because they can be operated at higher voltages, frequencies and temperatures than conventional semiconductors, Si or GaAs. One of main research discovery of wide bandgap semiconductor for power devices is Ga_2O_3. However, the detailed physical properties of Ga_2O_3 are far from perfections. The main complication of understanding Ga_2O_3 is that several phases with small energy difference could be stabilized under ambient growth condition. The well-known polymorphic structures of $Ga_2O_3$are considered five. Recent experimental reports indicate that the twins of κ-Ga_2O_3 have been revealed as ε-Ga_2O_3. Therefore, the detailed understanding of different polymorphic structures as well as their physical properties is needed.

In this presentation, we have studied the electronic structure and polar properties of (ε, κ)-Ga_2O_3 phase using DFT. We have calculated the bandgap of materials by hybrid functional method and the polarization value by two independent methods. Our layer-by-layer analysis shows the ferroelectric alignment of polarization in the different layers. Finally we propose the relationship between crystal structures of two polymorphs and physical properties of (ε, κ)-Ga_2O_3.

Condensed-matter computational physics(G)/1013 P1-co.209

The critical effect of metal atoms in mechanically interlocked supramolecular devices and the prevention using graphene

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Abstract :

As a good candidate of molecular electronics, bistable rotaxanes have great deal for the application of molecular-switching devices regardless of many obstacles which simply reproduce results from varying testbed architectures. Considering the fact that gold adatoms can easily be detached from electrode which may result in failure in device, we find that even a single metal atom penetrated into this molecular system can destroy the switching nature. We analyze the changes of electronic and transmission properties of Au-rotaxane-Au system with and without the penetrated atom by using the first-principles calculations with density functional theory and non-equilibrium Green's function (NEGF). Finally, we suggest that a layer of graphene attached on the metal electrode can prevent the penetration of metal particles without effecting the switching nature. This result will give the definitive insight for the rotaxane-based molecular-switch.

Condensed-matter computational physics(G)/0372 P1-co.210

입방형 페롭스카이트 $BaOsO_3$의 격자 구조 안전성

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Abstract :

다양한 Os 이온의 산화 상태를 보이는 Os 산화물은 스핀-궤도 결합과 상관 효과의 상호 작용에 의해서 발현된 독특한 자성과 도체-부도체 전이 현상을 연구할 수 있는 흥미로운 물질군이다. 최근에 고온・고압 기술로 합성된 입방형 페롭스카이트 $BaOsO_3$는 $5d^4$ 상태를 갖고 있으며, 이 때문에 van Vleck 상자성 발현 가능성에 대해서 높은 관심을 받고 있는 물질이다.

본 연구에서는 기존에 포논 계산을 통해서 제안된 정방형 구조의 불안정성을 제일원리 계산에 기반한 탄성 상수 계산을 통해서 조사하였다. 계산 결과, [110] 방향의 탄성파가 허수 음속을 갖게 되어 구조적인 불안정성을 입증할 수 있었다. 본 발표에서는 이에 대한 물리적 의미에 대해서 좀더 논의할 예정이다.

[사사의 글] 김서진은 현재 동대학원 석사과정에 진학하여 재학 중입니다. 본 연구는 고려대학교 “인공지능 디스플레반도체 융합디바이스 창의인재사업단”의 CK 프로그램에 의해서 지원되었습니다.

Condensed-matter computational physics(G)/0742 P1-co.211

Electrical and optical properties of amorphous $CaAlO_x$ thin films

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Abstract :

Functional oxide thin films have been actively studied owing to its promising potential in opto-electronic and energy devices. Usually, the fabrication of thin films with structurally well-defined lattice is a prerequisite for a the fundamental understanding of the physical behavior. However, applications such as high-performance flexible electronics beyond the organic devices and multifunctional solar-cell-glasses require active investigation in amorphous oxide thin films as well.

In this presentation, we introduce the growth and characterization of an atomically flat, amorphous $CaAlO_x$ (CAO) thin films. Using pulsed laser epitaxy, we fabricated the amorphous CAO thin films with different oxygen concentration (x). The atomically flat surface was confirmed by sharp step-and-terrace structure in topography obtained using atomic force microscopy, and significant Fresnel fringes in x-ray reflectivity. By annealing under oxygen atmosphere, CAO thin films became completely transparent, indicating an insulating behavior. Measuring optical absorption via ellipsometry, we could characterize huge band gap of ~5 eV, for the transparent CAO thin films. Indeed, highly insulating behavior was further confirmed from the in-plane transport measurements. On the other hand, by annealing in the vacuum of 1.0×10^{-5} Torr, CAO thin films had dark bluish color with a high conductivity despite of the thin thickness (~30 nm). Due to the thin thickness, the transmittance of this highly conducting films reached to a value of 80%, which gives rise to the potential to be a very cheap substitute for the indium tin oxide (ITO), the most popular transparent conducting oxide.

Dielectrics/Functional oxides(H)/1030 P1-co.301

X-ray micro-diffraction study of structural changes in (1-x)$(Bi_{0.5}Na_{0.5})TiO_3$ –$xBaTiO_3$ (x = 0, 2, 4 mol%)

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Abstract :

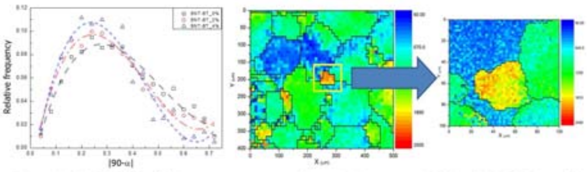

Fig 1. (a) BNT-BT |90-α| histogram (b) von Mises stress (MPa) of BNT-BT 2 mol%

$Bi_{0.5}Na_{0.5}TiO_3$ 에 $BaTiO_3$(BT)를 doping 한 (1-x)$(Bi_{0.5}Na_{0.5})TiO_3$–$xBaTiO_3$(BNT-BT)는 압전성이 우수하다고 보고되었는데, BT 의 함량이 증가함에 따라 rhombohedral 에서 tetragonal 로 구조적 변화를 거친다. Ceramic 형태의 BNT-BT 는 다결정 형태이며 grain boundary 와 lattice distortion 이 물리적 성질의 변화에 중요한 역할을 한다. Grain 별 구조 변화를 측정하기 위하여 작은 크기로 집속된 X-선을 이용하여 구조를 분석하는 X-선 미세회절을 이용하였다.

본 연구에서는 BNT-BT 다결정 시료의 BT 함량 변화, grain 의 변화, grain 내부에서 위치의 변화에 따른 distortion angle |90-α| 값의 변화를 관측하고, 전체적인 구조변화와의 상관관계를 찾아내고자 시도하였다.

대략 |90-α|=0.37°를 기준으로 low distortion angle(tetragonal-like)와 high distortion angle(rhombohedral-like)로 나누었을 때, BT 의 함량이 증가하면서 tetragonal-like 한 부분이 증가함을 아래 histogram 을 통하여 알 수 있다. 또한 BNT-BT 2mol% 시료에서는 size 가 큰 grain 들로 둘러싸인 작은 grain 은 von Mises stress 가 특히 높게 관측되었으며, 이런 grain 내부에는 sub-grain 이 존재하는 것을 관측할 수 있었다. 대체적으로 grain 내에서의 stress 변화보다는 grain 별 stress 의 변화가 훨씬 더 크게 관측되었다. 본 연구의 측정은 포항가속기연구소 4B 의 X-선미세회절 장치에서 이루어졌다.

Dielectrics/Functional oxides(H)/1019 P1-co.302

Structural and Electronic Properties of $LaNiO_{3-x}$ Films on $SrTiO_3$ (001) Substrates by Pulsed Laser Deposition

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Abstract :

Correlated transition metal oxides have attracted great attention due to its intriguing physical properties as well as potential applications, e.g., electrocatalysts for water splitting [1]. $LaNiO_3$ is a metallic system and one of highest active materials having Ni^{3+} state. The activity is closely related with the valence state of Ni. However, understanding the detailed electronic structure of nonstoichiometric $LaNiO_{3-x}$ is far from satisfactory. Here, we investigate the structural and electronic properties of epitaxial $LaNiO_{3-x}$ films on $SrTiO_3$ (001) substrates by using pulsed laser deposition. We systematically changed the oxygen partial pressure and growth temperature for controlling the amount of oxygen vacancies in the films. By using x-ray scattering and x-ray photoemission studies, we found that the out-of-plane lattice parameters and the stoichiometric Ni^{3+} states are very sensitive to the change of the oxygen partial pressure during the growth. We will also discuss the conductivity and the activity of non-stoichiometric $LaNiO_{3-x}$ films.

[1] Jie Yu, Jaka Sunarso, Yinlong Zhu, Xiaomin Xu, Ran Ran, Wei Zhou, and Zongping Shao, Chem. Eur. J. 2016, **22**, 2719 – 2727

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Dielectrics/Functional oxides(H)/0976 P1-co.304

$Li_2B_4O_7$-$Sr_{0.25}Ba_{0.75}Nb_2O_6$ 유리의 결정화기구 및 유전특성 연구

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Abstract :

$Sr_xBa_{1-x}Nb_2O_6$ (SBN)은 거대 유전율 물질과 유사한 수준의 유전특성 (단결정; $\varepsilon \sim 10^4$)을 나타내고 상온에서는 tetragonal 구조이며 Sr/Ba 의 비에 따라 전기특성이 변한다. $0.25 \le x \le 0.75$ 의 넓은 조성 영역에서 강유전체이고 Sr 의 양이 많아질수록 큐리 온도가 낮아진다. x=0.25 부근에서 tetragonal 과 orthorhombic 구조가 공존하는 상경계가 존재하여 유전 및 압전 특성이 다른 성분에 비해 우수하다. 최근 SBN 에 유리형성제를 첨가하여 제조한 다기능성 유리-세라믹에 대한 연구가 활발하다. 비강유전체 $Li_2B_4O_7$ (LBO)는 표면탄성파, 비선형광학 특성이 있다. Borate 를 함유한 LBO 는 유리형성 능력이 있으므로 SBN 과 함께 유리-나노세라믹 제조가 가능하고 이 복합체에서 전기특성 상승효과를 기대할 수 있다.

본 연구에서는 LBO-$Sr_{0.25}Ba_{0.75}Nb_2O_6$ (LBO-SBN25) 유리를 용융 급냉법으로 제조하고 결정화기구 및 유리상태의 유전특성을 분석하였다. DTA 를 이용한 열분석으로 상온 ~ 800 ℃의 범위에서 유리의 결정화에 따른 두 개의 발열봉우리를 확인하였다. 온도구간을 나누어 열처리 후, XRD 측정을 수행한 결과, 각 봉우리는 LBO, SBN25 각각의 결정형성에 기인하고, 두 결정이 복합체로 존재함을 알 수 있었다. Kissinger model, isoconversional 방법을 이용하여 결정화 매개변수 및 활성화에너지를 구하여 결정화 기구를 설명하였다. 임피던스 분석기로 측정한 결과분석에 Cole-Cole 모델 및 지수법칙을 적용함으로써 LBO-SBN25 유리의 dc, ac 전도에 따른 유전완화 현상을 해석하였다.

Dielectrics/Functional oxides(H)/0975 P1-co.305

비정질 Li_2O-B_2O_3-Ta_2O_5의 유전특성 연구.

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Abstract :

나노복합체 및 유리-세라믹에 대한 연구가 기초과학과 응용 차원에서 활발하다. 비정질을 이용하면 이러한 영역 접근이 용이한 장점이 있다. 특히 비정질은 성분 조성 시 당량-비당량의 제약이 없기 때문에 물질 종류의 다양성이 매우 넓다. 상온에서 강유전체인 $LiTaO_3$ (LT)의 큐리온도와 용융점은 607 ^oC, 1650 ^oC 이다. 최근 LTO 의 초전 (pyroelectricity) 현상을 이용한 저온 핵융합과 고온 결빙메커니즘이 Nature (2005)와 Science (2010)에 발표된 이후 더욱 많은 연구가 진행되고 있다. 비강유전체 $Li_2B_4O_7$ (LBO)는 용융점이 917 ^oC 이고 압전, 표면탄성파, 비선형광학 특성이 있다.

본 연구에서는 용융점이 높은 LTO 를 고상반응법으로 합성하고 상대적으로 낮은 온도에서 녹는 LBO 와 1:1 의 몰비로 혼합한 후 용융급랭법을 이용하여 비정질 Li_2O-B_2O_3-Ta_2O_5를 제조하였다. 연구목적은 산소이온 속에서 3 가지 +이온들이 미치는 유전특성이며, 온도와 주파수 의존성을 분석하는 것이다. 전기측정 결과를 Cole-Cole 모델을 이용하여 해석함으로써, 비정질 내 이온전도 메커니즘과 완화현상을 해석하였다.

Dielectrics/Functional oxides(H)/0786 P1-co.306

Ferroelectric switching dynamics of polycrystalline orthorhombic HfO_2 thin films

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Abstract :

Ferroelectric hafnium oxide thin film is well known for its ferroelectricity. It has good compatibility with the complementary metal oxide semiconductor process, large remnant polarization and large coercive field compared with general perovskite ferroelectric materials such as $SrBi_2Ta_2O_9$ and $BaTiO_3$. In addition, the robustness of ferroelectricity of doped HfO_2 has been known in the ultrathin film (~5nm). These advantages of ferroelectric HfO_2 make it a strong candidate for ferroelectric random access memories (FRAM). However, understanding the polarization switching kinetics in ferroelectric hafnium oxide thin is not enough although it is important with regard to application.

Here, we report the polarization switching dynamics of ferroelectric hafnium oxide thin films. We measured write pulse-width dependences of switched polarization under various applied electric fields. In addition, we investigated the conventional ferroelectric properties such as polarization-electric field loop, retention property and endurance characteristic.

Dielectrics/Functional oxides(H)/0663 P1-co.307

High Strain of Na and K Deficient $Bi_{0.5}(Na_{0.78}K_{0.22})_{0.5-x}TiO_3$ Piezoelectric Ceramics

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Abstract :

$Bi_{0.5}(Na_{0.78}K_{0.22})_{0.5-x}TiO_3$ (BNKT) ceramics exhibited tetragonal structure without any secondary phase confirmed by XRD. SEM images indicate that the shape of grains changed from round to stick type with increasing Na and K deficient ratio. The dielectric constant of BNKT ceramics were 1030~1500 and Curie temperature (T_c) exist around 280 ℃ ~ 320 ℃. The $P-E$ hysteresis loop of BNKT ceramics changed from normal ferroelectric to pinched shape with increasing Na and K deficient ratio. As a result, BNKT ceramics showed high strain (S = 0.4%) corresponding to a large normalized strain ($d_{33}^* = S_{max}/E_{max}$ = 680 pm/V) at x = 0.015. The observed large d_{33}^* value suggest that Na and K deficient BNKT ceramics can be considered as a potential candidate for lead-free actuator applications.

Dielectrics/Functional oxides(H)/0641 P1-co.308

Enhancement of Switchable Ferroelectric Photovoltaic Effects in *h*-$RFeO_3$ Thin Films via Strain Engineering

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Abstract :

Ferroelectric photovoltaics (FPVs) have drawn much attention owing to their high stability, environmental safety, anomalously high photovoltages of 10^4 V, coupled with reversibly switchable photovoltaic responses. However, FPVs suffer from extremely low photocurrents, which is primarily due to their wide band gaps. Here, we present a new class of FPVs by demonstrating switchable ferroelectric photovoltaic effects using hexagonal ferrite (*h*-$RFeO_3$) thin films having narrow band gaps of ~2 eV, where R denotes rare-earth ions. Moreover, we demonstrate enhanced FPV effects by suitably exploiting the substrate-induced film strain in these *h*-RFO based photovoltaics. We have shown that the enhanced photovoltaic efficiency mainly stems from the enhanced photon absorption over a wide range of the photon energy, coupled with the enhanced polarization under a compressive strain. Density-functional theory studies indicate that the compressive strain reduces E_g substantially and enhances the strength of *d*-*d* transitions. This study will set a new standard for determining substrates towards thin-film photovoltaics and optoelectronic devices.

Dielectrics/Functional oxides(H)/0638 P1-co.309

Strong Coupling between Strain and *in situ* Exsolution in Epitaxial Perovskite Thin Films

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Abstract :

Catalytically dispersed nanoparticles on surfaces play a key role in many fields such as renewable energy conversion, energy storage, catalysis and photocatalysis. In general, these nanoparticles are fabricated by deposition techniques. However, these approaches show limited control over size, distribution, thermally unstability, and hydrocarbon cocking problems. Recently, exsolution of B-site cations from perovskites oxides (ABO_3) under reduction has been extensively studied due to their possibility of *in situ* growth of catalyst, time-cost effective and resilience to agglomeration or cocking. Up to date, the exsolved particles can be controlled by tuning deviation from the ideal stoichiometry in bulk-form. i.e., defect engineering of non-stoichiometry. Herein, we demonstrate strong coupling between strain and exsolution in epitaxial perovskite thin films. We impose a variety of strain in (La, Sr)(Ti, Ni)$O_{3-\delta}$ thin films, and then investigate the role of strain on Ni particle growth by redox exsolution. This study opens up new way to optimize catalytic thin film structures such as micro-fabricated solid oxide cells (micro-SOCs).

Dielectrics/Functional oxides(H)/0554 P1-co.310

Dependence of deposition temperature of Nd-doped $Bi_4Ti_3O_{12}$ thin films Prepared by Pulsed Laser Deposition.

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Abstract :

Recently, the deleterious environmental impact of the lead used in many ferroelectric and piezoelectric materials has stimulated research into lead-free alternatives with comparable properties. We investigated the lead-free perovskite $Bi_{3.1}Nd_{0.9}Ti_3O_{12}$ (BNdT) as thin films fabricated by Pulsed Laser Deposition (PLD), which is a relatively easy method for fabrication of thin films. The samples were grown on $Pt/SiO_2/Si$ substrates using a KrF laser (248nm). We varied the PLD deposition temperature. The BNdT thin films were measured by X-ray diffraction (XRD), Atomic Field Microscope (AFM), and T-F analyzer respectively for observing those structure and electrical properties. As the films were deposited at different temperature up to 560℃, the ratio of the main peak (117) is the highest value at 500℃ using (117)/{(117)+(006)+200}} which are the three highest value of BNdT. The grain size has growing trend when the temperature is increasing. Also, at 459℃, dielectric constant is 178 at 100 kHz with enough low value of dielectric loss, and then $2P_r$ value is $9uC/cm^2$ which is thought quite smaller. As we compared fatigue property of this sample, there is no significant change before and after 10^8 switching cycle.

Dielectrics/Functional oxides(H)/0474 P1-co.311

Physical understanding of electrocatalytic activity in epitaxial $CaRuO_3$ thin films

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Abstract :

Perovskite oxides show strong coupling among the charge, spin, lattice, and orbital degrees of freedom, which strongly influences their structural, electrical, magnetic, and chemical properties. Elemental vacancies in oxides which can be tailored using defect engineering play a major role in modifying the crystal and electronic structures. Recently, perovskite oxide catalyst $SrRuO_3$ (SRO) has been studied in the context of its noticeable electrochemical activity and structural and electronic phase transition. Here, we present catalytic activity in epitaxial $CaRuO_3$ (CRO) thin films in relation to the electronic structure. High quality epitaxial CRO thin films have been prepared using Pulsed Laser Epitaxy (PLE), by systematically controlling the elemental vacancies via changing of oxygen partial pressure during the growth ($P(O_2)$). At $P(O_2)$ = 10 mTorr, stoichiometric CRO thin film could be obtained. Epitaxial CRO thin films with Ru and oxygen vacancies were obtained with a lower $P(O_2)$. X-ray photoemission spectroscopy and temperature dependent resistivity manifested the systematic change in the stoichiometry. To investigate the electronic structure, we performed spectroscopic ellipsometry and obtained optical conductivity spectra with a clear Drude peak indicating the metallic behavior. In addition, the optical transition peaks A ($O_{2p} \rightarrow$Ru t_{2g}), and β (Ru $t_{2g} \rightarrow e_g$) changed dramatically and systematically with the change in $P(O_2)$. Due to the change in the electronic structure, the electrocatalytic activity could be modulated. Moreover, decreased orbital hybridization between Ru_{4d} and O_{2p} state by vacancies induce the lower overpotential for catalytic activity. Our results give us crucial perception for the fundamental understanding of strong correlation between the electronic structure and the catalytic reaction.

Dielectrics/Functional oxides(H)/0430 P1-co.312

Colossal permittivity of single-crystalline (In+Nb) co-doped TiO_2

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Abstract :

Colossal permittivity (CP) materials, which have large permittivity ($>10^4$) and sufficiently low dielectric loss have been searched for the high-density energy-storage application as well as their physical importance. Recently, (In+Nb) co-doped TiO_2 was proposed as one of the promising CP materials, in which the CP may arise from the In-Nb related defect dipole formation [1]. On the other hand, there have been reports claiming that CP in such materials is due to extrinsic contributions such as grain boundary effects. In order to investigate the intrinsic dielectric property of (In+Nb) co-doped TiO_2, we have successfully grown high-quality single crystals which show large dielectric permittivities and low dielectric losses as reported earlier in polycrystalline samples. Analyses of dielectric relaxation and thermally stimulated depolarization currents will be discussed during the presentation.

[1] Hu *et al*. Nature Mater. **12**, 821-826 (2013)

Dielectrics/Functional oxides(H)/0384 P1-co.313

Acoustic and Dielectric Properties of Lead-Free ($Na_{1/2}Bi_{1/2}TiO_3$) -$BaTiO_3$ Single Crystals

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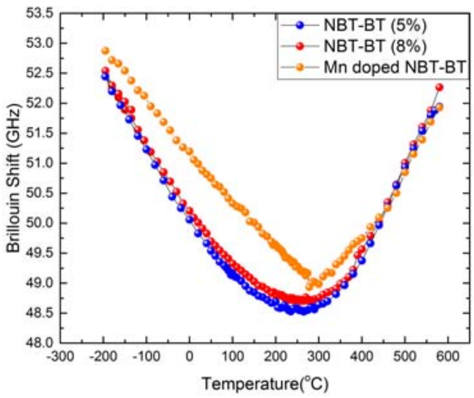
Abstract :



비납계 압전 소자는 $Pb(Zr_{1-x}Ti_x)O_3$ 와 같은 납 기반의 압전소자보다 압전 성능이 일반적으로 낮음에도 불구하고 환경 친화적인 특성으로 인해 주목을 끌고있다. 특히 Top-Seeded Solution Method(TSSG)방식으로 성장된 $Na_{0.5}Bi_{0.5}TiO_3$-$BaTiO_3$(NBT-BT) 단결정은 morphotropic phase boundary(MPB)근처에서 높은 압전 특성과 강유전성 특징이 발견되었다. Mn 이 도핑된 NBT-BT 는 전기 비저항, 유전 상수 및 압전 특성이 현저하게 향상되는 것으로 밝혀졌다. 이 연구에서는 브릴루앙 분광법을 이용하여 NBT-BT(5%), NBT-BT(8%)과 망간이 도핑된 NBT-BT(5%)단결정의 음향특성을 조사하고 비교하였다. NBT-BT(5%)에 대해서는 각각 다른 조건으로 전기장을 인계하여 연구되었다. 이 조건에서 특정 인계조건에서는 음향 특성이 불연속적인 변화를 나타내었고, 특정 임계 전기장 이상에서는 강유전 상전이가 발생하였다. 또한 단결정들의 유전상수를 전기장 인가 전과 후로 나누어 연구하였다.

Dielectrics/Functional oxides(H)/0328 P1-co.314

EPR and Optical Absorption Investigation of Cu^{2+} ions in Li_2O-B_2O_3-CuO Glasses

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Abstract :

xLi_2O-B_2O_3-yCuO (x=Li_2Omol%/B_2O_3mol% and y=CuOmol%/B_2O_3mol%) with x=0.01～0.20 and y=0.02 were prepared by the melt-quenching technique. EPR and optical absorption measurements were carried out to understand the role of Li_2O content in the glass structure. The observed values of spin Hamiltonian parameters for all the samples show that the ground state of Cu^{2+} ions is orbital ($^2B_{1g}$) and Cu^{2+} ions are located in tetragonally distorted octahedral sites. The optical absorption spectra exhibited a broad band corresponding to the $^2B_{1g} \rightarrow {}^2B_{2g}$ transition (ΔE_{xy}). The bonding parameters of Cu^{2+} ions can be estimated using the EPR and optical absorption data and show that the σ-bond between copper ion and its ligands are partial covalent and in-plane π-bonding is also partially covalent in nature.

Dielectrics/Functional oxides(H)/0320 P1-co.315

Exotic magnetic behavior in $SrRuO_3/SrTiO_3$ artificial superlattices

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Abstract :

Magnetic properties of the heterostructure composed of ABO_3 perovskites can be modified by the introduction of artificial structural periodicity through the fabrication of superlattice structure. Oxide superlattices are attractive model systems, in which the coupling of various interface effects (*e.g*. chemical intermixing, structural distortion, epitaxial strain effect) can be investigated. Hence, by deliberately controlling the thickness of the constituent layers of oxide superlattices, the modified *B*-O bonding geometry near the interface and the effect of the enlarged periodicity can be studied in the context of the magnetic behaviors. In this presentation, we have modified magnetic properties of the oxide superlattice composed of ferromagnetic metal $SrRuO_3$ (SRO) and paramagnetic insulator $SrTiO_3$ (STO). The thickness of each layer has been precisely determined down to the atomic-level, by automized control of the number of laser pulses during pulsed laser epitaxy. The overlap of Ru t_{2g} orbitals with the O *2p* orbitals causes the itinerant ferromagnetic nature in SRO with a ferromagnetic T_C of ~150 K, which can be tailored by changing the periodicity of the superlattices. Octahedral rotation and tilt, thickness effect, and magnetic interaction across the nonmagnetic STO layer will be discussed in the course of understanding the exotic magnetic ground state of the superlattices.

Dielectrics/Functional oxides(H)/0253 P1-co.316

Phase transformations and polymorphism in Tl_2SO_4

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Abstract :

Thallium selenate Tl_2SeO_4 undergoes an improper ferroelastic phase transition at 388 °C, and has spontaneous strain $a_s = (e_{22}-e_{33})/2 = 1.97 \times 10^{-2}$ at room temperature. Tl_2SeO_4 shows domain structures composed of three kinds of orientations with two types of domain boundaries. The crystal belongs to the space group with the hexagonal unit cell parameters of $a_h = 6.295(6)$ Å and $c_h = 8.189(5)$ Å at 410°C. Moreover, Tl_2SeO_4 undergoes phase transitions at 74 K and at 97 K. Thus Tl_2SeO_4 has four phases. On the other hand, less is known about the physical properties of thallium sulfate (Tl_2SO_4). It has been reported to crystallize as orthorhombic. According to Diot, Lachenal and Vignalou, Tl_2SO_4 shows a complex suite of phase transitions not reported in the published Tl_2SeO_4 phase diagram. By means of heat treatment, it has been found to evolve successively from a γ–monoclinic phase, through four (β_1, β_2, β_3, β_4) orthorhombic phases to an α-trigonal phase. According to the preparation method at room temperature, Tl_2SO_4 can be obtained in γ or β_1 or β_2 form or in a mixture of these three phases. The predominance of one of these three forms and the reversibility of some modifications are strongly influenced by crystal size. The melting point of Tl_2SO_4 is known as 632 °C, but the substance tends to decompose on heating producing highly toxic fumes including thallium and sulfur oxides. In the present paper, we report the thermal property using differential scanning calorimetry and impedance measurements in Tl_2SO_4 for studying phase stability and polymorphism.

Dielectrics/Functional oxides(H)/0075 P1-co.317

Development of direct electrocaloric effect measurement system

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Abstract :

The electrocaloric (EC) effect is a phenomenon where a material shows an electric-field-induced temperature change under adiabatic conditions. Because of its tiny effect, the temperature change has been calculated from the conventional ferroelectric hysteresis loops at various temperatures.

Here, we will introduce a direct EC measurement system using a heat flux sensor. The system is equipped in PPMS, which enable us to measure EC in the temperature ranges of 2 ~ 400 K and in the magnetic field ranges of -9 ~ 9 T. A comparison between direct and indirect EC measurements is shown for BaTiO3 ceramics.

Instrumentation and big facilities(I)/1080 P1-co.401

Spontaneous phase separation of In-doped beta-Ga2O3 thin films grown by radio frequency powder sputtering

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Abstract :

We investigate the spontaneous phase separation of In-doped β-Ga2O3 thin films deposited on sapphire substrate using radio frequency powder sputtering. Evolution of the surface morphology with increasing film thickness is studied. The initial thin film is non-stoichiometric gallium oxide (Ga2O3-x) that is in an oxygen deficient state due to the oxygen deficient atmosphere during sputter growth. Then, Ga2O3-x is transformed into a stoichiometric Ga2O3 by receiving oxygen from In2O3. Some of In2O3 are transformed spontaneously into a self-assembled In cluster as the film thickness increases. Consequently, a spontaneous phase separation from In-doped Ga2O3-x to Ga2O3 and In occurred at an intermediate stage. The metallic In cluster acts as liquid seeds, providing nucleation sites for the growth of In-doped β-Ga2O3 nanowires initiated on surface islands via a self-catalyzing vapor-liquid-solid growth mechanism.

Fabrication of nano-porous ZnO nanowires using a process combining laser-induced hydrothermal growth followed by a post annealing process

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Abstract :

We report the fabrication of nano-porous ZnO nanowires (NWs) using a process combining laser-induced hydrothermal growth followed by a post annealing process. Initially, the ZnO nanowires are grown by laser-induced hydrothermal process. Seeds such as ZnO nanoparticles or Au thin films are used to initiate the growth of ZnO NWs on substrates such as sapphire(0001) and SiN/Si(001) wafers. As-prepared ZnO NWs show typical hexagonal basal planes with varying 50~200 nm in diameter and epitaxial characteristic with respect to the sapphire substrate. Post annealing process is carried out under argon, nitrogen, oxygen, and vacuum atmosphere. The nano-porous NWs are formed under vacuum ambient, while no significant morphological changes are observed in the samples annealed under the gas atmosphere. The formation of nano-porous NWs might be attributed to the release of the trapped gas molecules during annealing process.

Instrumentation and big facilities(I)/1071 P1-co.403

Synthesize and characterization of SnO and SnO2 NWs synthesized By thermal-CVD under hydrogen reduction condition

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Abstract :

We fabricate the SnO and SnO2 nanowires (NWs) on Au/Si3N4/Si(001) substrates using thermal chemical vapor deposition (thermal CVD) process. Different from typical thermal CVD process, a mixture of hydrogen (H2) and Ar gases is used as carrier gases. The hydrogen gases maintain a reducing atmosphere and break the bonding of SnO2 powder without catalysts to provide the vapor source such as Sn and O. This induces the Vapor-Liquid-Solid growth of SnO2 NWs at relatively low reaction temperatures below 700 C. We observed that the resulting NWs consisted of SnO and SnO2 determined by performing XRD and TEM analysis. Both SnO and SnO2 NWs have the tetragonal structure. The formation of SnO NWs can be explained by the hydrogen reduction of SnO2.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 – 2017.10.27, 경주 화백컨벤션센터

ZnO nano-structures synthesized by x-ray induced hydrothermal process

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Abstract :

We report synchrotron x-ray induced synthesis (x-ray radiolytic process) of ZnO nano-structures. Seed layers such as Au thin films or ZnO nano-particles are coated on SiO2/Si(001) substrates. Then, the samples are irradiated with x-rays in an aqueous solution containing zinc acetate dihydrate (Zn(CH3COO)2•2H2O) and ammonium hydroxide (NH4OH) at room temperature (RT). A ZnO nano-wall network forming a sponge structure is fabricated. In particular, ZnO crystals are also observed in aqueous solution and their size ranged from several hundred nanometers to several microns. In contrast to the laser induced hydrothermal process, ZnO nanowires aligned perpendicular to the substrates are not observed. This might be attributed to radiolytic growth performed at RT. Laser-induced hydrothermal growth is a thermal process inducing that the temperature of the growth surface typically rises above 1000 °C. Transmission electron microscopy investigations reveal that ZnO is polycrystalline and disordered. It is demonstrated that the x-ray radiolysis is an effective method for producing ZnO nano-structures at RT.

Instrumentation and big facilities(I)/0936 P1-co.405

Efficient characterization of the beam by nanoparticle diffraction in XFEL

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Abstract :

The development of X-ray Free Electron Lasers (XFELs) is promoting advancement in diverse fields on science. The properties of light source, such as the pulse energy and the coherence of the beam, are essential parameters for successful experiment in XFELs. However, it demands much resources and efforts to characterize those properties due to the high intensity of the XFELs. We tried to estimate the flux of incident photons of the beam effectively with diffraction patterns of gold nanoparticles and achieved reliable outcome in comparison with previous measurements. Also, the spatial and temporal coherence of the beam were determined in the analysis of the single-particle diffraction.

Instrumentation and big facilities(I)/0873 P1-co.406

자성박막측정을 위한 하나로 편극 중성자 반사율측정장치 개선

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[1] 한국원자력연구원, 중성자과학연구센터

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Abstract :

편극 중성자 반사율(Polarized Neutron Reflectometry; PNR)은 자기박막의 다층 및 자기구조에 대해 나노미터 아래의 분해능으로 깊이에 따른 자화 크기와 방향 분포에 대한 정량적 해석이 가능한 분석법이다. 연구용 원자로 하나로(HANARO)의 냉중성자시설에는 국내 유일의 편극 중성자 반사율 장치가 운영되고 있으며, 최근 장비개선을 통해 성능 향상이 기대된다. 편극 중성자 반사율 측정을 위해서 기존의 장치에 고효율 초거울 편극기, 해석기, 중성자 스핀 반전기를 교체하고, 빔패스에 백그라운드 및 중성자 감소를 줄이기 위한 장치를 추가로 설치하였다. 다양한 시료측정을 위해 저온(~4K), 자기장(~1T)를 인가할 수 시료환경장치를 제작하고, X-선 반사율측정을 시설내에서 할 수 있는 환경도 구축하였다. 또한, McStas 몬테카를로 시뮬레이션 분석결과, 최적 장치구성에서 2 배이상의 중성자속의 증가가 예상되며, 기존에 측정이 어려웠던 소형 박막 시료에 대한 측정이 가능해질 전망이다.

Demonstrations of ptychographic imagings in PAL-II

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Abstract :

Lensless imaging based on diffraction provides a means of observing objects with high resolution even with relatively simple experimental setups. The diffraction pattern produced by coherent light provides a clue that the sample can reconstruct its structure even if it is not a crystal. The coherent diffraction imaging (CDI) technique has attracted attention as a way to observe the structure of various samples since the first demonstration in 1999.

Ptychography is a branch of the CDI, which has the advantage that the probe beam scans a region of interest to obtain a wider FOV and also obtains the profile of the probe beam used for the measurement. The field of view of the ptychography helps to measure broadly distributed samples, such as film-type samples. Measuring a well-defined reference sample using ptychography also provides the possibility to measure the beam profile of a light source.

Here, examples of ptychography imaging using visible light or soft x-ray will be reported. These will show that the probe beam can also be measured along with the structural and morphological analysis of various samples using coherent light with the ptychography technique.

Instrumentation and big facilities(I)/0564 P1-co.408

Systematic investigation on resolution in X-ray free electron laser single-pulse imaging

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[1]POSTECH, Physics, [2]POSTECH, Pohang Accelerator Laboratory, [3]Gwangju Institute of Science and Technology, Department of Physics and Photon Science

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Abstract :

In coherent diffraction imaging, the image resolution is determined by the incident X-ray wavelength, the angle of diffracted signals, and the radiation damage. After the advent of X-ray free-electron laser (XFEL), it has opened up an opportunity to acquire high-resolution images without considering the radiation damage to specimens using ‘diffraction before destruction’ method. The maximum diffracted intensity with good signal-to-noise ratio (SNR) is key to determine image resolution. The diffracted signal from multi-particle can show distinct interference patterns due to interference effect by large coherent volume of X-rays. In this talk, we show systematic investigation of interference effect in XFEL single-shot imaging.

Instrumentation and big facilities(I)/0478 P1-co.409

Three dimensional visualization core-shell structure of oxidized nickel nano particles by using coherence x-ray diffraction imaging.

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[1]Gwangju Institute of Science and Technology, Department of Photonics and Applied Physics, [2]European XFEL, Single Particles, Clusters, and Biomolecules and Serial Femtosecond Crystallography

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Abstract :

We performed a three dimensional (3D) visualization of core-shell structure in oxidized nickel (Ni) nano particles using coherence x-ray diffraction imaging (CDI). The samples were prepared on silicon nitride membrane substrates for transmission geometry CDI using electron beam lithography and evaporation. Deposited samples were annealed in a furnace at 800℃ for 12 hours in vacuum to fabricate nano sized Ni particles through dewetting, which were subsequently oxidized at 300℃ for 60 min under air ambient. The oxidation and core-shell structure were clearly observed in 2D images reconstructed from the diffraction pattern which were compared with SEM images taken after oxidation. To apply equally sloped tomography (EST) technique for 3D images, diffraction patterns were obtained at an inclination of 25 specific angles. Reconstructed 3D image clearly showed morphology and distribution of core-shell structure of oxidized nickel nano particles.

Instrumentation and big facilities(I)/0299 P1-co.410

스퀴드 자력계에서 발견되는 오류와 수정 방법

엄태운[1], 이년종[1], 조영훈[1], 박승영[*1]

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Abstract :

일반적으로 자기적 특성을 분석하기 위한 자력계 가운데 SQUID 자력계는 가장 높은 정밀도를 보이는 것이다. 그러나 통상의 SQUID 자력계는 자기장 발생 장치로써 초전도자석을 포함하고 있으며 이에 따른 오류가 내재되어 있다. 따라서 본 연구에서는 SQUID 자력계를 사용함에 있어 간과되고 있거나 빈번히 발생 가능한 오차를 제시하였다. 그리고 그 오차의 발생 원인을 분석하여 이를 극복할 수 있는 방법을 조사하였다. 이를 위해 Quantum Design, Inc. 사의 Magnetic Property Measurement System (MPMS) XL 기기와 MPMS SQUID VSM 기기를 이용하였다. 그리고 Palladium, Indium, Nickel, Silicon 등의 시료를 사용하여 분석과 비교를 수행하였다. 발생되는 오류는 시료의 실제 온도와 시스템 제어 온도의 간극, 초전도자석의 잔류 자기장, Gradiometer 의 구조적 한계, 시료 고정용 홀더의 형태 및 재질, 시료의 고정 방법에 따른 오차 등에서 기인한다. 이러한 오류 요소를 극복하는 방법을 통해 SQUID 자력계를 이용한 자기모멘트 측정에 있어서 높은 정밀도 달성을 위한 방법을 제시한다.

Instrumentation and big facilities(I)/0206 P1-co.411

Performance test of new ambient pressure XPS at GIST

임호준[1], 문봉진[*1], 유영석[1], 고유빈[1], 김건화[1], 정문정[1]

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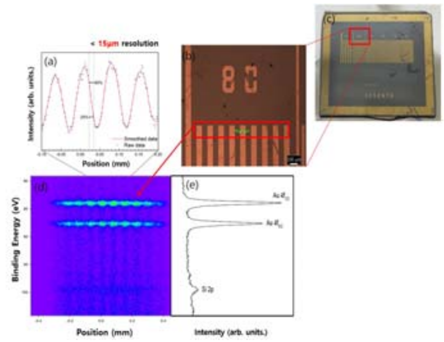
Abstract :



The performance test of newly installed Ambient Pressure X-ray Photoelectron Spectroscopy (AP-XPS) system at GIST is carried out. The system is equipped with the Scienta R4000 HiPP-3 electron with monochromated Al Kα X-ray source (MX650, VG Scienta). A polyimide Al window is used to isolate the X-ray source from back-filled type high pressure chamber.

Two modes of XPS operations are tested, a transmission mode and an imaging mode. In the case of the transmission mode, the lens voltage of analyzer is optimized for maximum detection of photo-excited electrons under elevated pressure condition i.e. a typical standard lens operation mode. On the other hand, in the case of imaging mode, a spatial information of outgoing electrons is conserved to generate one-dimensional image of measured surface.

With superb design of differential pumping and electron transfer optics, a good intensity-to-signal ratio of XPS core-level spectra are obtained up to 500 mTorr of Ar, O_2, and N_2 gases pressure. Also, the test of imaging mode on Au/Si reference sample shows a spatial resolution of ~15 μm under 500 mTorr of N_2 gas pressure.

Magnetism(A)/0358 P1-co.501

Inertia-driven switching of antiferromagnet via electrically induced Dzyaloshinskii-Moriya torque

KIM Tae Heon[1,2], Gruenberg Peter[2], Han Song Hee[3], CHO Beong Ki[*1,2]

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Abstract :

Ultrafast precession or switching of antiferromagnetic oxide has attracted much interest to many researchers developing spintronics and information processing technologies. For this reason, many studies on these antiferromagnets have been archived through various means such as magnetic field or spin current. In this work, we report electrical switching of antiferromagnet with a center of inversion symmetry. When an electric field breaks interfacial mirror inversion symmetry of thin film, Dzyaloshinskii-Moriya interaction (DMI), one of the strongest magnetic interaction, is generated. While deriving the pendulum equation of motion of the antiferromagnet driven by DM torque, d|*D*|/dt, we demonstrated that appropriate controls (e.g. direction, magnitude and pulse shape) of induced DMI realize the deterministic switching of antiferromagnet. In addition, the magnetic state of collinear antiferromagnet is enable of detection through weak magnetization produced by DMI. Our findings open up the promising potential to electrical applications based on magnetic storage.

Magnetism(A)/0912 P1-co.502

Comparison of Dzyaloshinskii-Moriya interaction energy by using asymmetric spin-waves propagation and domain wall motion speed measurement

Dae-Yun Kim[1], Nam-Hui Kim[2], Yune-Seok Nam[1], Joo-Sung Kim[1], Hyeok-Cheol Choi[1], Min-ho Park[1], Yong-Keun Park[1], Sug-Bong Choe[*1], Chun-Yeol You[2]

[1]Seoul National University, Department of Physics and Institute of Applied Physics, [2]DGIST, Department of Emerging Materials Science

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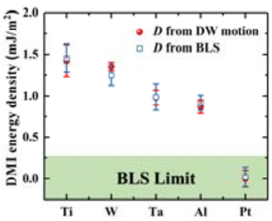
Abstract :



The Dzyaloshinskii-Moriya interaction (DMI) has been highly interest because it has a crucial role for creating new-type spin texture such as skyrmion. Especially, Brillouin light scattering (BLS) and asymmetric domain wall (DW) speed measurement are powerful methods to investigate the DMI energy. However, relatively BLS can observe larger DMI, while the DW speed method can observe rather smaller DMI region. Recently it has been reported that the additional asymmetric contribution influences the DMI energy based on the DW speed measurement. This asymmetric contribution removes a large portion of experimental inaccuracy in the DMI measurement. In this report, the DMI energy (*D*) is experimentally compared BLS with DW speed methods considering with additional antisymmetric contribution. We prepared the sample which is deposited with a Pt(2.5 nm)/Co(0.9 nm)/X(2.5 nm)/Pt(1.5 nm), X = (Ti, W, Ta, Al, Pt). From two different measurement methods, we obtained quite well matched DMI energy densities in both BLS and DW speed measurements as shown Figure 1. This fact shows that the existence of antisymmetric contribution such as chiral damping in the DW speed method. With the consideration of the antisymmetric contribution, DW speed and BLS methods show more consistence results.

Magnetism(A)/0307 P1-co.503

Spin-orbit torque in an antiferromagnet in weakly noncollinear spin configuration

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Abstract :

An antiferromagnet is a promising material for spin-orbit torque generation. Earlier studies of the spin-orbit torque in an antiferromagnet are limited to collinear spin configurations. In this poster, we show theoretically that deviation from perfect collinearity can significantly modify properties of the spin- orbit torque since noncollinearity generates extra Berry phase contributions to the spin-orbit torque, which are forbidden for collinear spin configurations. In clean antiferromagnets, in particular, this effect can be significant even for weak noncollinearity. Considering that spin configurations are noncollinear in many antiferromagnets and also that noncollinearity develops during magnetization dynamics even for antiferromagnets with collinear spin configurations in equilibrium, this effect is important for spintronic devices based on antiferromagnets.

Magnetism(A)/0916 P1-co.504

Probing of time-dependent magnetization switching due to domain wall creep motion in multiple hall bar structure

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Abstract :

Due to the limitation of classic von Neumann architecture, the study about memristor which imitates functionality of brain is actively discussed. Its resistance changes depending on applied current or field. This property makes memristor to stand out clearly from other conventional electronic devices. Here, we show that resistance change when domain wall(DW) moves in the multiple hall bar structure. Multiple hall bars are fabricated Si/SiO2/Ta(4 nm)/Pt(3 nm)[Co(0.6 nm)/Pt(0.6 nm)]$_3$/Co(0.6 nm)/Pt(2 nm) stack. The wire width is varied from 9 um to 5 um. Anomalous Hall resistance has been measured with a 250 Oe field pulse and its duration time 0.2s. By the DW creep motion, a DW passes through each Hall cross and AHE signal shows a clear step. It shows memristive behavior with DW creep motion and reveal possibility for spintronic based neuromorphic device.

Magnetism(A)/0376 P1-co.505

위상 콘도 절연체 CeRhSb 의 방사광 분광 연구

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Abstract :

Ce 계 화합물 (Ce-based compound) 은 종종 콘도 효과 (Kondo effect) 로 인한 독특한 물성을 보이는데, 그 이유는 Ce 4f 전자가 고온에서 단일 자기 불순물처럼 행동하는 반면 콘도 온도 (Kondo Temperature: T_K) 온도 이하에서 전도 전자와 결합된 국소 단일항 (local singlet) 을 형성하기 때문으로 알려져 있다. [1] 최근 한 이론 연구에서 non-symmorphic symmetry 를 가지는 CeNiSn, CeRhSb, CeIrSb 등의 콘도 절연체 (Kondo insulator) 화합물이 위상 콘도 절연체 (Topological Kondo insulators : TKIs) 가 될 가능성이 제안된 바 있으나, [2] 이에 대한 실험적 검증은 아직 부족한 실정이다. 본 연구에서는 방사광을 이용한 연 X 선 흡수 분광법 (soft X-ray absorption spectroscopy: XAS), 연 X 선 자기원편광 이색성 (soft X-ray magnetic circular dichroism: XMCD), 각분해 광전자 분광법 (angle-resolved photoemission spectroscopy: ARPES) 실험을 수행하여 CeRhSb 의 전자구조를 연구하였다. 이 연구 결과에 의하면, Ce 이온의 원자가는 약 3+이며, CeRhSb 는 거의 금속상태임을 알 수 있었다. Ce 이온의 XMCD 신호는 Ce3+ peak 에서 관찰되었으며, 반면 Rh 이온의 XMCD 신호는 거의 0 이었다. ARPES 를 이용하여 CeRhSb 의 페르미 면 (Fermi Surface)과 띠구조를 측정하였으며, CeRhSb 의 ARPES 실험 결과를 띠 구조 계산 (band structure calculations) 결과와 비교하여 위상 콘도 절연체의 가능성 여부를 연구하였다.

[1] P. S. Riseborough, Adv. Phys. **49**, 257 (2000).

[2] Po-Yao Chang, et al., Nature Physics, **13**, 794, 30318 (2017).

Condensed matter physics(D)/1062 P1-co.506

Effects of metal-insulator-transition of V_2O_3 on magnetic properties of ferromagnetic layer

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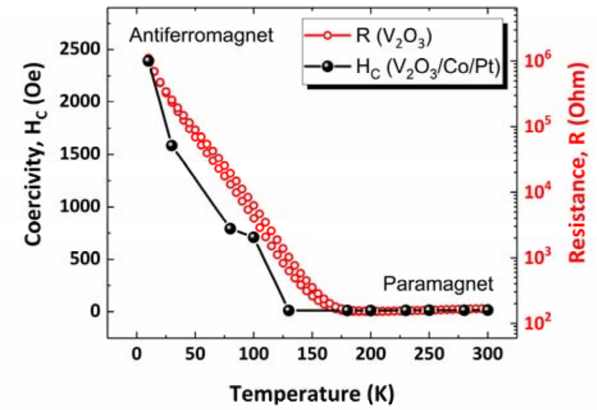
Abstract :



Vanadium oxide (V_2O_3) exhibits a first-order metal-insulator-transition (MIT) at a certain transition temperature from a low-temperature monoclinic structure (antiferromagnetic insulating phase) to a high-temperature rhombohedral structure (paramagnetic metallic phase) [1]. In this work, we investigate magnetic properties of ferromagnetic layer grown on V_2O_3 layers by the MIT. We used single crystal Al_2O_3 (0001) substrate and V_2O_3 (50 nm)/ layer is prepared using pulsed laser deposition system. Successively, Co (0.9 nm)/Pt (2 nm) is deposited on V_2O_3 film using DC magnetron sputtering system, which is connected with pulsed laser deposition chamber. We confirmed that Co/Pt layer shows perpendicular magnetic anisotropy. To confirm the MIT, temperature dependence of electric resistance of V_2O_3 film is obtained using Physical Property Measurement System (PPMS) without magnetic layer. And magnetic properties (coercivity, saturation magnetization) of Co/Pt layer is obtained using Magnetic Property Measurement System (MPMS). Figure 1 shows that relation between the coercivity, H_C and the electric resistance, R controlled by temperature (T). Both H_C and R show similar tendency with decreasing T as expected. It indicates that the phase transition of V_2O_3 affects to magnetic properties of ferromagnetic (FM) layer. The details will be further discussed.

Magnetism(A)/0350 P1-co.507

Compensated Half-metal in Cr-based Inverse-Heusler Compounds

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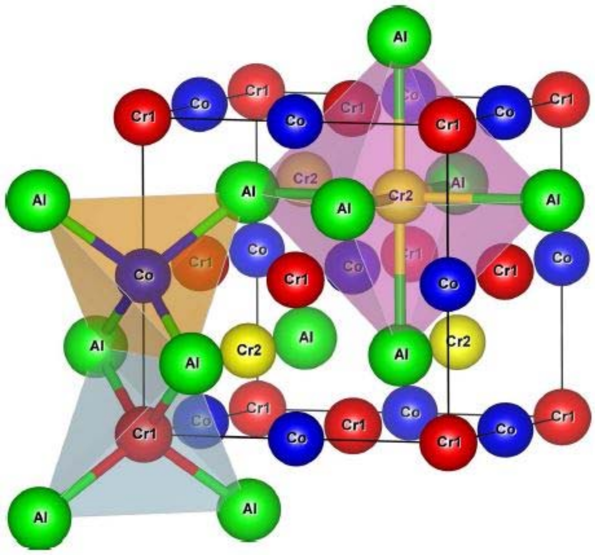
Abstract :

The compensated half-metal (CHM), also called the half-metal antiferromagnet, is a half-metal, which has one conducting and the other insulating spin channels, with the precise zero net moment. CHM has been anticipated as a promising candidate with many advantages for spintronics applications, although realization of CHM is very limited so far.



We have been investigated CHM in Cr-based inverse-Heusler compounds, showing a high Curie temperature T_C, using three correlated band theory approaches of DFT+U, the modified Becke-Johnson functional (mBJ), and the hybrid functional. Inclusion of correlation effects through three approaches leads to an exact compensated moment in Cr_2CoAl with T_C ~ 750 K, although conventional DFT calculations show a tiny moment. Additionally, in this presentation, we will address its interesting electronic structures in correlated regime. Our results are expected to provide a promising way of room temperature CHMs.

[Acknowledgements] This research was supported by NRF Grants No. NRF-2016R1A2B4009579.

Magnetism(A)/0540 P1-co.508

Understanding the spin glass behavior in ultrathin van der Waals spin glass $Mn_{0.5}Fe_{0.5}S_3$

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Abstract :

Conventionally, van der Waals or layered magnetic material have been supposed as useful candidates for the study of low dimensional magnetic system. Transition metal phosphorus trisulfide, $TMPS_3$, is one such example, and it is very attractive aspect because $TMPS_3$ can host several transition metal elements at the TM sites, Mn, Fe, Ni and so on. More interestingly, each material presents a different principal spin Hamiltonian, two-dimensional (2D) Ising system ($FePS_3$), 2D XY system ($NiPS_3$), and 2D Heisenberg system ($MnPS_3$). This diversity of different physical properties in these materials will not only present a huge advantage when it comes to actual application but also arise scientific interest if they are mixed. The competing anisotropies are likely to lead to interesting magnetic behavior; one of them is spin glass phenomenon. Spin glasses are disordered magnetic materials by limiting isotropic and/or anisotropic interaction and controlling site- and bond-randomness, a promising candidate of complexity studies. A specific composition $Mn_{0.5}Fe_{0.5}PS_3$ shows spin glass characteristics and others appear only glassy properties. However, it has not yet fully understand why these various phenomena develop in mixed $TMPS_3$ system and the mechanism for it. In this research, we present the magnetic properties of $Mn_{0.5}Fe_{0.5}PS_3$ single crystal and try to account for the spin glass mechanism in $Mn_{0.5}Fe_{0.5}PS_3$ system by decreasing the thickness.

Magnetism(A)/0730 P1-co.509

Improvement of spin wave transmission in magnetic nanowire system

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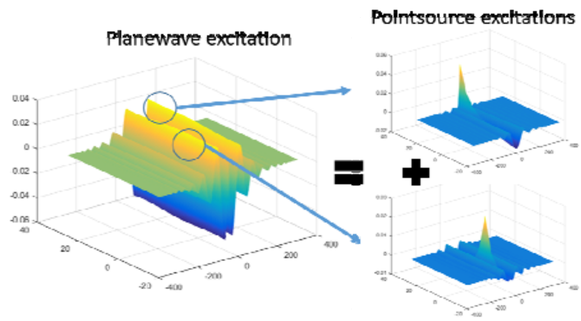
Abstract :



The field of magnonics have recently made a huge progress in order to realize the use of spin waves for data processing [1,2]. In this work, we report on a general method to optimize the input spin wave (SW) so as to obtain the maximum output signals at any observation point. First, the method assumes that an input plane wave is a sum of point sources across the width of the nanowire. Secondly, the output waves that are generated by these point sources are further separated into several 'point-outputs' at the observation point. In this way, the waves at the point-outputs (*Y(t)*) and the point sources (*X(t)*), are related by: . In this equation, *Y(t)* and *X(t)* are both matrices with components that correspond to each of the point-output and point source, respectively. Meanwhile, $F(x,y,z,\omega)$ is a $N\times M$ dimensional matrix that correlates the waves of the point-outputs and the waves of the point sources, with N and M being the number of point-outputs and point sources, respectively. By knowing *F*, it is then possible for us to obtain the eigenvectors a.k.a. the optimum input signal that can be generated to obtain the strongest signal at the observation point. By using this method, our results show that the best input signal in this SW experiment corresponds to a wave that is strong at the edges of the nanowires and yet weak at the center of the nanowire. Such input signal can be created by patterning an input line that is thicker at the center to reduce the current distribution at the center of the nanowire.

1) A. V. Chumak. A. A. Serga, B. Hillebrands, Nature Commun. 5, 4700 (2014).

2) K. Vogt, et al. Nature Commun. 5, 3727 (2014).

Figure 1. A schematic of the spin wave analysis method. Both the input signals and the output signals are broken into point observations.

Magnetism(A)/0698 P1-co.510

Magnetic Excitations in bulk (Lu,Sc)FeO_3

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Abstract :

Non-collinear two-dimensional triangular antiferromagnets (2D TLAF) are currently an area of much active research due to their unique magnetic properties, which lead to non-trivial quantum effects that experimentally manifest themselves in the spin excitation spectra. Recent examples of such insulating 2D TLAF include (Y,Lu)MnO_3 and $CuCrO_2$. $LuFeO_3$ is a recently discovered multiferroic material, which is isostructural to $LuMnO_3$ and contains one more electron in the e_g manifold. Characterization of the AFM ground state (T_N=155 K) in $LuFeO_3$ thin films with magnetometry and neutron diffraction has been previously reported. We present the first report of the spin dynamics in a bulk single crystal of ($Lu_{0.6}$ $Sc_{0.4}$)FeO_3 measured via time-of-flight inelastic neutron scattering, and compare and contrast these results with those found in $LuMnO_3$.

Magnetism(A)/0653 P1-co.511

Epitaxy of Fe thin films and effect of Mo capping

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Abstract :

Fe based magnetic materials such as $Fe_{16}N_2$ is strong candidate for permanent magnet to replace the rare-earth magnet. For a long time, it has been studied to improve saturation magnetization and coercivity of Fe or Fe based material. However, it is difficult to make Fe thin films due to their thermal and structural instability while thin film is great tools which can study about extremely ordered magnetic domain of Fe. Furthermore, it is also the biggest issue changing their own properties including structure and magnetism. In this work, we stabilized (110) Fe thin films on (0001) Al_2O_3 substrates using RF magnetron sputtering and added 10-nm-thick non-magnetic molybdenum as capping layer to prevent oxidation of Fe. The only diffraction peaks of (110) Fe imply epitaxial growth of thin films. For observing the effect of Mo capping, we prepared three samples with no capping and Mo capping. We still observed (110) Fe diffraction peaks. So, we believe there is negligible effect of intermixing. The magnetic hysteresis loop obtained by vibrating sample magnetometer at room temperature. First, we studied the influence of shape anisotropy of Fe via thickness control. The saturation magnetization and coercivity show clear differences relevant to thickness of Fe layer. Coercivity tends to rise with increase of thickness due to shape anisotropy. That of 10-nm-thick Fe is two times bigger than that of 20-nm-thick Fe film. Also, clear enhancement of coercivity is observed on the sample with nitrogen annealing. We also discuss the obstruction from oxygen and separation with other material using Mo layer is significant key to enhance coercivity of Fe films. This work was supported by the Industrial Strategic Technology Development Program (10062130, Theory-driven R&D for non-centrosymmetric structured rare-earth free Fe-based permanent magnet materials) funded by the Ministry of Trade, Industry & Energy (MI, Korea)

Magnetism(A)/0099 P1-co.512

Investigation of the effect of composition of FeCo magnetic material on magnetic properties using high-throughput process

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Abstract :

High-throughput method of synthesis and analysis of magnetic materials was developed to search for new magnetic materials. This method was applied to the FeCo magnetic material. High-throughput synthesis of thin film was carried out in the vacuum chamber with the components of Quartz Crystal Microbalance (QCM) to measure the deposition rate of each source, heater to increase the temperature of large area substrate, and thermal evaporators. We could obtain continuous composition spread of Fe and Co elements on the substrate by means of the disposition of evaporation boats and the distances between substrate and boats. The samples with composition spread were used to investigate the effect of composition ratios of magnetic materials on magnetic properties, microstructure, and preferred orientation. High-throughput analysis system is composed of the permanent magnets with surface magnetic intensity of 1.3 T, a continuous reel to reel tape moving device, and a three-axis Hall sensor. The system can measure the hysteresis loop in each position of tape using a permanent magnet while the tape moves at regular intervals. The advantages that can be obtained in this high throughput experiment are as follows. 1) We can obtain compounds having different composition ratios. The magnetic properties of them can be quickly determined through the continuous measurement results. 2) The reliability of results of the composition ratio dependency is high because all the compounds on the substrate experience the same deposition conditions except for the composition ratio. By virtue of this process, we could obtain the result of the effect of composition of FeCo magnetic material on magnetic properties with quickness and high reliability. The high-throughput methodology offer rapid and efficient magnetic materials screening, optimization and discovery.

Magnetism(A)/0463 P1-co.513

Electron paramagnetic resonance study of Y-doped ZnO

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Abstract :

Yttrium doping effects on sol–gel prepared ZnO systems have been studied by means of electron paramagnetic resonance (EPR) measurements. Samples with various Y-doping degrees have been synthesized with no structural defects as revealed by x-ray diffraction. Our results of the EPR intensities obtained as a function of temperature indicate that yttrium doping modifies the hydrogen donor concentration as well as their activation energies.

Hadron physics(C)/1099 P1-nu.001

Exotic glueball within QCD sum rule

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Abstract :

Using the QCD sum rule, we discuss an exotic glueball state consisted of the gluons with the quantum numbers which are not expected in the conventional quark model for the hadrons. According to our analysis of the QCD sum rule up to the energy dimension 8 operators, the glueball state under the consideration has the mass around 6.3GeV and the decay constant around 67keV. We discuss also that this state can be a bound states of pure gluons.

Nuclear experimental method and instrumentation(F)/0955 P1-nu.003

An upgraded silicon PIN photodiode based radon detector for underground experiments environment: Status and comparison with RAD7

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Abstract :

It is very important to monitor the amount of radon (Rn-222) in the underground experiments such as rare decay and dark matter experiments with ultra low background requirements. The radioactivity from the radon can be a significant background source to the experiments and need to be monitored precisely. We have upgraded a radon detector with a volume of ~70 L which was used in the KIMS (Korean Invisible Matter Search) experiment by replacing with a Hamamatsu silicon PIN photodiode and a Hamamatsu pre-amplifier. The positively charged radon's daughter particles (Po-214 and Po-218 mostly) produced in the air of the detector chamber are collected by the photodiode in a negative high voltage. The energy resolutions of alpha particles emitted from the decays of the daughter particles are measured to be better than 0.6% with very clean signals to be be identified. We have installed a pump to refresh airs in the radon chamber for real-time measurements of radons in the atmosphere of a test room. The pump is being controlled by a relay device and compared the results with a commercial detector RAD7 (DURRIDGE). In this presentation, we will discuss the status of the radon detector and a comparison with the RAD7.

Nuclear experimental method and instrumentation(F)/0922 P1-nu.004

Development of Medical Plastic Scintillator Dosimeter Using Colorimetric Discrimination Method

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Abstract :

방사선 치료에서 높은 공간 분해능으로 정확하게 X선 선량을 측정하는 것은 매우 중요하다. 이를 위해 높은 공간 분해능을 가진 플라스틱 신틸레이터 검출기가 자주 활용된다. 그러나 플라스틱 신틸레이터를 활용한 검출기는 고 에너지 X선의 경우 광섬유에서 발생하는 체렌코프 빛으로 인해 신호가 오염된다. 체렌코프 빛과 플라스틱 신틸레이터에서 발생하는 빛을 분리하는 일반적인 방법 중 하나는 두 개의 동일한 광섬유를 묶어 그 중 한 가닥에만 플라스틱 신틸레이터를 부착해서 비교하는 방법이다. 두 가닥의 신호 세기의 차이는 플라스틱 신틸레이터에서 발생하는 빛으로 간주할 수 있다. 하지만 이 방법은 두 개의 가닥이 필요하며 동일한 양의 조사량에 정확하게 노출된다는 가정 하에서만 활용할 수 있다. 본 연구에서는 이런 어려움을 극복하기 위해 Colorimetric Discrimination Method를 활용한 검출기를 개발한다. 광섬유의 끝에 컬러 필터가 있는 CMOS 센서를 부착해 신호의 Red, Green, Blue 3가지 색상 요소를 활용한다. 플라스틱 신틸레이터에서 발생하는 빛과 체렌코프 빛의 스펙트럼 차이를 통해 3가지 색상 요소로 두 빛을 구분한다. CMOS 센서는 많은 픽셀을 갖고 있기 때문에 여러 개의 광섬유를 하나의 CMOS 센서에 동시에 부착할 수 있는 장점도 있다. 실험은 일산 백병원의 Varian Clinac IX에서 시행되었으며 9가닥의 검출기로 다른 위치에서 동시에 선량을 측정하고, 길이 1mm-지름 1mm의 작은 플라스틱 신틸레이터(BCF-60)를 사용하여 높은 공간 분해능을 얻었다.

Nuclear experimental method and instrumentation(F)/0806 P1-nu.005

Recovery of Molybdenum from Molybdenum-Based Crystal Waste

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Abstract :

Advanced Molybdenum-based Rare process Experiment (AMoRE), a research collaboration, uses molybdenum based crystals to search for neutrinoless double beta (0νββ) decay of ^{100}Mo. AMoRE is presently developing few molybdenum-based scintillator crystals like $^{48}Ca^{100}MoO_4$, $Li_2{}^{100}MoO_4$ and $Na_2{}^{100}Mo_2O_7$. A huge amount of economically expensive isotopically enriched ^{100}Mo as well as depleted ^{48}Ca also remain in the crystal wastes. Therefore, recovery of ^{100}Mo and ^{48}Ca from crystal waste cuttings, which is produced during the preparation of the crystal detectors, is of great importance. Objective of this study was to develop an efficient technique to recover molybdenum (Mo) and calcium (Ca) from the crystal wastes so that they could be reused in crystal growing. The final product of Mo recovery was polyammonium molybdate (PAM) and that of Ca was $CaCO_3$ from the crystal wastes. Recovery yield efficiencies of Mo and Ca were 90% and 96%, respectively for $CaMoO_4$ crystal waste whereas that of Mo for Li_2MoO_4 was 99%. Inductively coupled plasma mass spectrometry (ICP-MS) was used to determine the concentration of radioactive impurities present in the initial powder and in PAM as well as in $CaCO_3$ powder after recovery. Some of the radioactive elements like Pb, U and Th present in the initial powder were reduced by a factor of 10 during the recovery process. On the other hand, the elements like Ba, Pb, Sr, Th and U were reduced by a factor of 100 in $CaCO_3$ powder. Results of the present work revealed that considerably high yield efficiency of Mo and Ca could be recovered from the molybdenum-based crystal wastes with reduction of radioactive impurities.

Nuclear experimental method and instrumentation(F)/0791 P1-nu.006

Compton Suppression Spectrometer Monte Carlo Simulation

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Abstract :

Neutron Activation System (NAS) is being widely applied for various neutron diagnosis fields for the benefit of neutron induced nuclear reactions, and it is also used for the neutron diagnostics to evaluate the total fusion power from nuclear fusion device. NAS have been installed at Korea Superconducting Tokamak Advanced Research (KSTAR) for more accurate detection of neutron flux. In this method, the measurement error of NAS must affect the measurement of other diagnostic system, minimizing the error is very important. The Compton suppression system (CSS) is a device that suppresses the Compton continuum in the spectrum and can help to reduce the measurement error of NAS. However, CSS needs to be optimized because the efficiency changes depending on the geometry structure of high-purity germanium detector (HPGe) -NaI(TI).

In this study, to find out the geometry structure of high-purity germanium detector (HPGe) -NaI(TI) and to optimize the effect of movement, Monte Carlo simulation was used to grasp the behavioral characteristics of Compton suppression and compare several layout structures. Therefore, it can be applied to NAS through optimized structure.

Nuclear experimental method and instrumentation(F)/0733 P1-nu.007

Phonon-scintillation properties of molybdate crystals measured by a compact low temperatures measurement system

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Abstract :

A metallic magnetic calorimeter (MMC) is one of the most sensitive thermometer sensors used in low temperature detectors (LTDs). We developed a compact heat and light detection system using MMC sensors to compare the characteristics of various molybdate crystals.A series of R&Ds of molybdate crystals are in progress to improve the detector performance. We studied phonon-scintillation properties of several molybdate crystals ($CaMoO_4$, $Na_2Mo_2O_7$). The detector performances of the crystals are to be compared.

Nuclear experimental method and instrumentation(F)/0570 P1-nu.008

Molybdenum Based Crystal Growing at CUP

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Abstract :

The Center for Underground Physics (CUP) is performing the AMoRE experiment for neutrinoless double beta decay search. The AMoRE collaboration will use the ^{100}Mo based crystal such as $XMoO_4$ (X = Ca, Li, Zn etc.) and $Na_2Mo_2O_7$. Since the experiment aims to search for the extremely rare process, it is required the ultra-pure crystals to minimize internal background. Therefore, we have studied growth of $CaMoO_4$ and Li_2MoO_4 crystals, and then the purities of grown crystals were checked via ICP-MS and HPGe detector measurement. We also studied the XRD measurement to confirm the composition of grown crystals. Recently, we are trying to grow the $Na_2Mo_2O_7$ crystal. In this study, we will present crystal growing activity at CUP and the measurement results for the crystals.

Nuclear experimental method and instrumentation(F)/0568 P1-nu.009

NaI Crystal Growing and Facility at CUP

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Abstract :

The Center for Underground Physics (CUP) is performing the COSINE experiment to search for dark matter. This experiment requires the ultra-pure NaI(Tl) crystals, which are grown from the highly purified NaI powder, and the NaI(Tl) crystals should minimize concentration variation of Tl in all regions of the crystals. The COSINE group is going to use a large size NaI(Tl) scintillation crystals as detectors. For these purposes, we set up the test grower, and then has been performing the NaI crystal growing to optimize growing condition. In the near future, the full size crystal grower will be installed. In this poster, we are going to introduce the NaI crystal growing and facility related with the COSINE experiment.

100 MeV 양성자가속기를 이용한 반도체 소자의 방사선 조사효과 실험용 빔조사 조건 연구

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Abstract :

반도체 소자의 집적도가 증가함에 따라 이들 소자들의 방사선에 대한 민감도가 증가하는 경향을 보이고 있고 이러한 방사선 조사효과에 대한 연구와 내방사선 시험 수행의 필요성이 증가하고 있다.
한국원자력연구원 양성자가속기연구센터에서는 100 MeV 양성자가속기를 이용하여 반도체 소자를 포함한 광센서, 광학렌즈 등의 여러 형태의 소자들과 이들 물질을 구성하고 있는 재료들에 대한 내방사선 시험을 수행하고 있다. 반도체 소자의 내방사선 시험 및 방사선 조사효과 연구를 위해서는 에너지, 조사량, 조사면적, 균일도 등의 여러 가지 빔 조사 조건과 조사과정 중과 조사후에 발생할 수 있는 방사화 등에 대한 면밀한 검토가 선행되어야 한다. 이번 연구에서는 최적화된 빔 조사조건과 빔 조사조건 조절 시 발생할 수 있는 에너지의 퍼짐, 시료의 방사화 등을 여러 방법을 통해 계산하고 그 결과를 바탕으로 효과적인 최적화된 실험방법을 제시해보고자 한다.

Nuclear experimental method and instrumentation(F)/0359 P1-nu.011

Spin-exchange Optical Pumping of ^{129}Xe

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Abstract :

Spin-exchange optical pumping (SEOP) method is used to polarize ^{129}Xe which has a medical usage as MRI gas. SEOP is based on polarizing the valence electron of the alkali metal (in our case Rb) by the resonant absorption of the laser light, enhancing a single state of the ground level. The polarization of ^{129}Xe happens due to collisions with polarized Rb vapor. In this experiment, 60 W circularly polarized laser light with wavelength tuned to 794.7 nm is used for polarizing the Rb gas. We use 2 holding magnetic field in our set-up. One source is Helmholtz coils, which provide 30 Gauss uniformly, required for Rb optical pumping. The other source, permanent magnet, uniformly provides 217 G, which is used for measuring the polarization. To improve the efficiency of SEOP, N_2 and ^4He are used as buffer gases. Polarization measurements are performed by using upgraded nuclear magnetic resonance (NMR) system.

Nuclear experimental method and instrumentation(F)/0296 P1-nu.012

Scintillation Properties of K2LiCeBr6 Grown by Bridgman Technique.

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Abstract :

We developed a new elpasolite-halide scintillation crystal, K2LiCeBr6, grown by Bridgman method. The Luminescence and scintillation properties of grown crystal are measured. X-ray induced luminescence of K2LiCeBr6 showed and emission spectra in the range of 350 nm ~ 420 nm with a peak centered at 390 nm. The K2LiCeBr6 is a very hygroscopic material. Therefore a cylindrical sample of size Φ10 mm X 4 mm was polished in Ar filled glove box for measurement of scintillation propeties. The pulse height spectra, energy resolution and fluorescence of decay time were measured under γ-ray excitation with a 137Cs γ-ray source. The sample crystal showed three main decay time components of 45 ns(94%), 149 ns(5%), 1152 ns(1%).

Nuclear experimental method and instrumentation(F)/0245 P1-nu.013

Compton imaging acquisition based on DSSD and CZT detectors

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Abstract :

Based on the DSSD (double-sided silicon strip detector) and CdZnTe detectors, measurements were taken to obtain Compton imaging. An analog shaping amplifier was used for the P-side of the DSSD and a digital pulse processing for the signals from the amplifier on the N-side. As a preliminary step in the Compton imaging measurement, we confirmed the energy spectrum in the coincidence of the two detectors and reconstructed the Compton imaging with the events measured in DSSD 32 ch and CZT 16 ch.

Nuclear experimental method and instrumentation(F)/0244 P1-nu.014

위치 민감형 섬광 검출기의 위치 분해능 향상과 감마선 에너지 분해능 비교

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Abstract :

본 실험에서는 위치 민감형 섬광검출기의 위치 분해능 향상을 위해 채널수가 많은 다중전극 광증배관을 사용하여 감마선 에너지를 측정하였다. 64 채널 다중전극 광증배관(H8500)에서 256 채널 다중전극 광증배관(H9500)으로 교환하여 2 배 높은 위치 분해능을 얻을 수 있었고, 감마선 에너지의 분해능을 측정하였다. 섬광 물질로는 픽셀화 된 16x16 GAGG 를 사용하여 두 검출기를 비교하여 보았다. 두 검출기의 신호를 처리하기 위해서 4 채널 저항 네트워크를 각각 설계 제작하여 감마선 반응 위치를 판별하였고, 판별된 위치의 에너지를 확인하였다. 표준감마선원 Na-22(511keV, 1274keV), Cs-137(662keV), Ba-133(80keV, 356keV)를 사용하여 다양한 에너지의 감마선을 측정하였고, 에너지 분해능을 평가하였다.

Nuclear experimental method and instrumentation(F)/0051 P1-nu.015

Synthesis of Li-Ti-O ceramic materials for tritium production in nuclear fusion reactors

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Abstract :

Nuclear fusion has attracted much attention, in which the lithium bearing blanket plays a crucial role in determining the tritium production and release in nuclear fusion reactor. Lithium based ceramic materials such as $LiCoO_2$, $LiAlO_2$, $LiMnO_2$, $LiNiO_2$, Li_2TiO_3, Li_4SiO_4, $LiZrO_3$, etc. are used as a tritium production in the nuclear fusion reactor. These materials, which have good mobility and mass transfer of lithium ions, high thermal and chemical stability, and fast releasing quality of tritium are considered promising candidate for tritium breeding material. Among the materials, the Li_2TiO_3 is one of the most promising candidates for tritium breeders because of its mechanical and chemical stability and rapid tritium diffusion. In this study, we synthesized Li_2TiO_3 and Li-rich Li_2TiO_3 tritium breeders by simple ball milling process. The synthesized tritium breeders have been measured by XRD, SEM, and TEM. Ionic conductivity values according to the temperature were measured by impedance analysis in the Air, H_2 and Ar conditions. The prepared tritium breeders were determined diffusion test with SS316L for evaluation of reactivity between ceramic materials and blanket materials. Detailed discussion about tritium breeder will be given.

Analysis of Neutron Capture Yield Spectra of Dysprosium for MLF beam line of J-PARC

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Abstract :

We measured neutron spectra for isotopes enriched dysprosium (Dy) sample using the time-of-flight method in the energy range of 0.1 eV to 300 eV. The NaI(Tl) spectrometer of the ANNRI (Accurate Neutron-Nucleus Reaction Measurement Instrument) was used to detect gamma-rays from the neutron capture reaction. The neutron capture yield spectra corresponding to the time-of-flight bunching range were compared. In order to measure the scattered neutron background, a natural carbon sample was chosen because the elastic scattering cross-section is much larger than the capture cross-section. The detector response was calculated withe Monte Carol simulation precisely describing the geometry of the NaI(Tl) detector including the sample, neutron guide, and so on.

*This R&D was supported by the NRF grant funded by MEST (Center for Korean J-PARC Users, Grant No. NRF-2013K1A3A7A06056592).

*This work was supported by the National Research Foundation

of Korea(DIRAMS) grant funded by the Korea government(MSIP) (No. 50496-2016)

Nuclear reaction(B)/0871 P1-nu.017

Measurement of the Transmittance and Mass Attenuation Coefficient of Materials According to the Gamma-Ray Energy

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Abstract :

The gamma ray spectrum for the thickness of the shield was measured using a NaI(Tl) scintillation detector. The source were ^{22}Na (0.511 MeV, 1.274 MeV), ^{137}Cs (0.662 MeV) standard source, and Am-Be (4.439 MeV). To use only the gamma rays from the Am-Be source, the neutron was shielded with polyethylene and the lead collimator was used for the narrow beam. Samples of $_{13}Al$, $_{26}Fe$, $_{29}Cu$, $_{30}Zn$, $_{50}Sn$ and $_{82}Pb$ were used. The sample size is 7 x 7 cm for lead and 10 x 10 cm for other materials. The thickness of the samples is 0.6, 1.5, 2.3, 2.8 and 3.8 cm for lead and the other materials are 1.5, 3.0, 4.5, 5.0 and 6.5 cm. The mass attenuation coefficients of gamma rays were compared with those of other researchers. The measurement time was set to be within 5% of the statistical error.

Nuclear reaction(B)/0868 P1-nu.018

Measurement of Delayed Gamma-ray Energy Spectrum from Residual Nuclide for $^{nat}W(p,x)$ Reaction by 100-MeV Proton Accelerator

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Abstract :

The gamma ray energy spectrum was measured from natW(p,x) nuclear reaction. Irradiation experiment was performed at the high-intensity 100-MeV proton linac facility (the Korea Multi-Purpose Accelerator Complex, KOMAC). The HPGe detector was used to measure the gamma rays of the samples. In general, the kind of nuclear reaction and its probability vary depending on the energy of the proton. We measured the change in intensity of delayed gamma rays for several different proton energies. The beam energy degradation along the stack was determined using the computer program SRIM-2008. We compared the gamma-ray peak intensity to distinguish the decay series. This process is important to obtain proton nuclear reaction cross-section.

This work was supported by Dongseo University “Dongseo Frontier Project” Research Fund of 2015.

Nuclear reaction(B)/0643 P1-nu.019

Measurement of isomeric cross section ratios for the $^{nat}Co(p,x)^{58m,g}Co$ reaction

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Abstract :

The isomeric cross section ratio (ICR) for the $^{58m,g}Co$ were performed using the activation method at KIRAMS (Korea Institute of Radiological & Medical Sciences). The study of ICR in the formation of isomeric pairs in nuclear reactions give important information about the nuclear reaction mechanism, particularly the energy and angular momentum transfer during the reaction process as well as the progress of nuclear reactions. The aim of the present work is to measure the ICR of the $^{58m,g}Co$ with proton energy of 30- to 45-MeV with a step of ΔE = 5 MeV from natural Cobalt. An activation technique was used to measure induced gamma activities in the irradiated foils. A high-resolution γ-ray spectrometric system with a high-purity germanium (HpGe) detector was used to acquire the data. The measured cross section data were corrected for gamma-ray attenuations, pulse pile-up effects, dead time, variations in proton flux. The obtained ICRs are compared with the calculated values based on the statistical model code TALYS (TALYS 1.6 code), the experimental data available in the literature and the data obtained from TENDL.

Nuclear reaction(B)/0098 P1-nu.020

Zr 의 양성자방사화에 의한 방사성핵종의 생성단면적 측정

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Abstract :

경주 양성자가속기에서 69 MeV 양성자 에너지를 이용하여 Zr 의 양성자 유도 핵반응으로부터 생성되는 방사성핵종의 생성단면적을 측정하였다. 양성자방사화로 부터 생성되는 감마선은 고 분해능 감마선 검출기에 의해 측정되었으며, 적층호일 방법을 사용하여 양성자 에너지에 대한 단면적 값을 구하였다. 시료에 입사되는 양성자 빔 에너지는 SRIM 코드를 사용하여 계산하였으며, 빔 플럭스는 잘 알려진 모니터 핵반응을 사용하여 결정되었다. 이번 실험으로부터 얻어진 양성자 에너지 함수에 대한 방사성핵종의 생성단면적은 기존에 수행하였던 57 MeV 양성자를 이용한 결과와 문헌의 실험데이터 및 TENDL 라이브러리와 비교 수행되었다. 본 측정은 이전 실험의 검증과 양성자 에너지에 대한 단면적을 생산하여 핵반응 이론 모델의 개선뿐만 아니라 치료와 진단용으로 사용되는 핵종들에 대한 유용한 정보를 제공하기 위해 수행되었다.

Nuclear structure(A)/0462 P1-nu.021

핵융합로용 RAFM 강에서 Ti 및 Ta 첨가에 따른 미세조직 및 크리프 거동 특성 고찰

(Microstructure stability and creep behavior of RAFM steels with Ti and Ta addition)

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Abstract :

본 연구에서는 핵융합로 블랭킷(Blanket) 후보 소재로 고려되고 있는 저방사화강(RAFM, Reduced Activation Ferritic/Martensitic steel)에 있어 고온 안정성 및 기계적 특성에 영향을 미치는 MX 의 미세한 석출을 증가시키고자 하였다. 이에 따라 (Ti,W)C 석출을 증가시키기 위한 Ti 첨가 효과를 고찰하였고, 아울러 Ta 첨가 영향도 함께 고찰하고자 하였다. 따라서, Eurofer97 강과 Eurofer97 강의 MX 형성원소인 Ta 를 Ti 로 치환한 Ti-RAFM 강에 대하여 미세조직 및 기계적 특성을 비교·분석하고 고찰하였다. 인장시험 결과, 초기에는 (Ti,W)C 의 형성으로 석출강화 된 Ti-RAFM 강이 Eurofer97 강 대비 더 높은 항복 강도를 보였으나, 장시간 열 노출(600°C/1000h) 이후에는 Ti-RAFM 강 (336→273 MPa)이 Eurofer97 강 (304→284 MPa) 대비 더 급격한 항복 강도 감소를 보였다. 이는 Ti-RAFM 강이 Eurofer97 강 보다 열화속도가 빠르다는 것을 의미한다. 빠른 열화의 원인은 기지의 빠른 회복과 석출물의 조대화 등 미세조직 안정성이 열위하기 때문이다. 이로보아, 열위한 미세조직 안정성은 열간 노출 중 빠른 확산과 연관된다고 사료된다. 이러한 확산 문제를 해소하기 위해 크기가 크고, 방사화가 낮은 Ta 를 첨가한 Ta/Ti RAFM 강은 우수한 미세구조 안정성을 보였으며, 열 노출 이후 인장시험에서도 Ti-RAFM 강은 약 11%의 항복 강도 감소가 발생하는 반면, Ta/Ti RAFM 강은 오직 0.9% (316→313 MPa)만 감소하였다. 이 결과로부터 Ta/Ti RAFM 강이 가장 우수한 고온 기계적 특성을 보일 것으로 예상되었다. 크리프 시험 (550°C/200 MPa) 결과, Ta/Ti RAFM 강의 경우 기존 Eurofer97 강과 유사한 크리프 특성을 보였지만, MX 의 미세한 석출을 위한 Ti 의 첨가량이 증가할수록 빠른 확산 속도로 인해 미세조직 안정성이 열위되어 오히려 크리프 수명이 감소하는 것을 확인하였다.

Nuclear structure(A)/0291 P1-nu.022

The study about nuclear structural changes in the rare-earth isotopic chains

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Abstract :

We investigated the change of the nuclear structure along with nuclear shape transition from spherical to axially rotational shapes using the first version of interacting boson model. The interacting boson model is examined for rare-earth Nd/Sm/Gd/Dy isotopic chains by analyzing the parameter. In this region, a change from spherical to well-deformed nuclei is observed when moving from the lighter to heavier isotopes.

Relativistic heavy ion collisions(D)/1146 P1-nu.023

Energy loss dependence of Two particle correlation

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Abstract :

The ridge structure observed in the high-energy heavy-ion collision experiments such as Pb-Pb collisions is well explained by the hydrodynamical models assuming perfect fluid. This is the strong evidence of Quark-Gluon Plasma(QGP) formation. However, ridge phenomenon has been observed also in small systems such as pp collisions. In this case, QGP is rarely expected to be formed and the perfect fluid assumption is not suitable. In this study, we apply a kinematic model with the scattering between energetic jet particles and medium partons. In this kinematic model, the scattering cross section is calculated from the field theoretical method where the medium partons follow the Maxwell Boltzmann distribution depending on the medium temperature. The cross sections is calculated in terms of rapidity and angle differences between jet & medium partons. It commonly shows peaks but peak shapes are different depending on the energy loss and angles between initial and final jet particles. We set the initial jet energy at 10 GeV for all cases. When we set the angle between initial and final jet particle to 10 degree and varied the final jet energy from 9 GeV to 5 GeV, the peaks move from 115 degree to 162 degree away from the final jet toward initial jet. We also change the angles between initial jet and final jet particles from 1 degree to 90 degree while setting the final jet energy as 9 GeV, and then the peaks move 169 to 47 degree. These changes in position of peaks can be understandable from the conservation of 4-momentum. Usually the photons are coming to the direction of initial jet particle and then the direction of the final medium parton can be determined to satisfy the 4-momentum conservation. The amplitudes of peaks are increases as the angle of the final jet aligns to the initial jet. This change becomes dramatic as the alignment get perfect, which can cause the divergence problem. Also we calculate the cross sections while increasing the energy loss. The amplitude of peaks are also increasing as the energy loss get higher, but its change is not dramatic at all. This can be understood by that it is more possible to lose more energy.

Nuclear fusion(C)/0739 P1-pl.001

2-D/3-D visualization of MHD instabilities and turbulence on KSTAR and WEST

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Abstract :

Magnetohydrodynamic (MHD) instabilities and turbulence based trasport physics in tokamak plasma are essentially multi-dimensional, and imaging diagnostics with high temporal and spatial resolution are thus necessary for comprehensive understanding of the phenomena. The electron cyclotron emission imaging (ECEI) and microwave imaging reflectometry (MIR) diagnostics installed on KSTAR measure 2-D electron temperature and density fluctuations. Both imaging diagnostics provide invaluable understanding of the interesting phenomena, such as the edge-localized modes (ELMs) and their interaction with turbulent eddies generated by Resonant magnetic perturbation, modified sawtooth instability coexisting with higher harmonics (m/n=2/2, 3/3, 4/4, …) due to current perturbation. A new ECEI system for WEST device is in final development stage, and expected to be installed on WEST in early 2018. Comparative study of the 2-D ΔT_e images obtained from KSTAR and WEST devices would provide the role of tungsten impurity on the dynamics of MHD instabilities, which will be essential for successful operation of ITER. This work is supported by NRF of Korea under contract no. NRF-2014M1A7A1A03029865.

Nuclear fusion(C)/0614 P1-pl.002

KSTAR 가열 및 안정성을 위한 고출력 밀리미터파 빔 입사 제어 시스템 개발

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Abstract :

토카막 핵융합 플라즈마 가열 및 비유도성 전류구동은 토카막의 steady state 운전을 위하여 필수적이다. 또한 토카막 플라즈마 내에 국부적으로 발생되는 난류 및 불안정성은 steady state 운전을 방해하는 중요한 요소로 파악이 되고 있으며, 국부 가열과 전류구동 제어를 위하여 ECH 와 ECCD 밀리미터파 입사가 필수적이다. 하지만 고출력 밀리미터파는 자이로트론 특성상 내부적으로 제어하기가 어렵기 때문에 외부적으로 제어할 기술이 필요하다. 시간적으로 밀리미터파 빔을 제어하기 위해 플라즈마를 이용한 fast switching system 을 전송선 라인에 설치를 한다면 수 마이크로 초에서 수 밀리 초 단위로 빔을 제어 할 수 있게 된다. 고출력 밀리미터파를 제어하기 위해서는 10^{13} cm^{-3}~10^{14} cm^{-3} 정도의 플라즈마 밀도를 유지하는 플라즈마가 생성되어야 한다. 고밀도 플라즈마를 만들기 위하여 Inductive coupled plasma(ICP) 방식을 채택하였다. RF Generator 에서 Pulsing 을 사용하여 RF 파워를 고속 스위칭 방식으로 전달한다면 펄스 플라즈마를 만들어 밀리미터파를 제어할 수 있게 된다. 이 연구는 효율적인 고속 스위칭 밀리미터파 입사제어 연구 뿐만 아니라 RF 와 플라즈마 간의 상호관계도 연구 함으로써 핵융합 플라즈마에 대한 이해도에 기여를 할 것으로 예상한다.

*이 논문은 2017 년도 정부(미래창조과학부)의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구 사업임(No. 2014M1A7A1A03029874).

Nuclear fusion(C)/0541 P1-pl.004

핵융합로 유사조건 고성능 운전모드 구현 실험 연구

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Abstract :

핵융합 플라즈마의 성능은 핵융합로의 효율을 결정하는 주요 요소이며, 효율적인 에너지 생산을 위해서는 높은 플라즈마 베타와 높은 자발 전류비를 동시에 갖춘 고성능 플라즈마를 유지할 수 있어야 한다. 본 거점센터 연구의 최종 목표는 핵융합로에 적합한 고성능 운전 시나리오를 확보하는 것이며, 목표 달성을 위하여 서울대에 건설되어 운전 중인 VEST 장치에 대전력 중성입자빔을 이용하여 중심 가열 방식으로 연소플라즈마의 알파 가열 환경을 모사하는 실험을 수행하고자 한다. 중성입자빔 가열 시 플라즈마 커플링 효율을 증대시키기 위해 고밀도 목표 플라즈마 형성 연구가 진행되었다. 보론화를 통한 불순물 제거, 효율적인 플라즈마 시동법 및 제어 기술 확보로 고밀도 플라즈마 운전(I_p~100kA, elongation > 2, n_e ~$3\times10^{19}m^{-3}$, T_e~300eV)과 장시간 플라즈마 운전(I_p~100kA, 20ms)에 성공하였다. 저항 가열을 이용한 전류 밀도 분포 제어 연구를 통해 고성능 운전 시나리오 확보를 위한 기초 연구가 선행되었다. 또한 고밀도 플라즈마 진단을 위해 다양한 고성능 진단장치들이 개발되었다. 다채널 간섭계와 광진단을 이용한 플라즈마 밀도 진단법이 연구되었고, 전자 온도 및 밀도 분포 측정을 위한 고속 톰슨 산란 진단계와 이온 온도 및 회전속도 측정을 위한 높은 시간 분해능의 불순물 분광진단법이 개발되어 1 채널 측정이 수행되었다. 현재 대전력 중성입자빔 실험과 고속 톰슨 산란 진단계 및 분광진단법의 측정 채널 증설을 통한 공간분포 진단계 개발이 진행 중에 있으며 이를 바탕으로 고성능 운전 모드 실험을 수행할 예정이다.

이 논문은 2014 년도 정부(미래창조과학부)의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구 사업임(No. 2014M1A7A1A03045374)

Nuclear fusion(C)/1021 P1-pl.005

LightTools 를 이용한 VEST 톰슨 산란계의 stray light 감소용 부품 설계

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Abstract :

서울대학교에 설치된 핵융합 플라즈마 발생 장치 VEST 는 100kA 정도의 플라즈마 전류를 20ms 유지하는데 성공하였으며, 현재 ECH, NBI, LHFW 등의 가열 장치를 설치하여 다양한 가열 실험 및 고성능 운전 시나리오 확보를 준비 중이다. 이런 가열 실험의 효율 및 플라즈마의 상태를 확인할 수 있는 가장 중요한 정보는 전자의 온도 및 밀도의 공간 분포이다. VEST 에는 전자의 온도와 밀도를 측정하기 위한 톰슨 산란 진단계가 설치되어 있으며 공간분포 측정 및 고속 진단을 위한 진단계 개발을 진행 중이다. 그러나 LHFW 안테나 등의 새로운 장비가 진공 용기 내부에 설치되어 내벽의 기하학적 구조가 변화하였고, 이에 톰슨 산란 진단계에 stray light 이 증가하여 톰슨 산란 신호를 측정하는 것이 불가능해졌다. 신뢰할 수 있는 톰슨 산란 또는 레일레이 산란 광을 측정하기 위해서는 stray light 을 줄이기 위한 노력이 필요하다. 이를 위한 방법으로는 Baffle 또는 viewing dump 를 설치하는 것이 가장 일반적인데, stray light 을 감소시키는 부품을 설치하고 신호 측정을 반복하며 stray light 이 줄어든 효과를 확인하는 것은 시간이 오래 걸린다. Stray light 감소용 부품 설계 및 효과를 확인하는 것을 효율적으로 진행하기 위하여 광학 시뮬레이션 프로그램 LightTools 를 이용하여 VEST 의 톰슨 산란 진단계의 기하학적 구조 및 레이저 빔을 현실에 가깝게 구현하였다. 그리고 이를 통해 baffle 등의 부품이 디자인에 따라 stray light 을 줄이는데 얼마나 기여하는지를 정성적으로 예측하였으며, 설치 후의 측정을 통해 실제 성능을 확인하였다.

이 논문은 2014 년도 정부(미래창조과학부)의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구 사업임(No. 2014M1A7A1A03045374)

Nuclear fusion(C)/0576 P1-pl.006

Statistical Analysis of pedestal structure in KSTAR H-modes using Neural Network

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Abstract :

The high energy confinement mode (H-mode) is selected as the reference scenario of ITER and being widely studied in tokamak. In this H-mode, the plasma pressure forms a very steep edge (pedestal) profile, leading to periodic bursts of energy from the edge plasma, so-called ELM (Edge Localized Mode). Since the energy loss by ELM is strongly dependent on the edge pedestal structure, its understanding is very important. Many theory-based models are developed on this purpose, for example EPED [1]. But, their applications are limited due to non-linearity and complexity of the pedestal, ELM modelling requires heavy computational resources and long calculation times. Recently, with development of machine learning and deep learning, neural network is applied in many tokamak problems, including the real time control system [2], prediction of the onset of plasma disruptions [3], modelling of transport phenomena [4], and transport simulations [5]. In this work, Neural Network is applied for predicting the H-mode pedestal structure using the KSTAR H-mode database.

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[2] Seung Hun Lee et al., Review of Scientific Instruments 87, 11E533 (2016)

[3] Ding Yonghua et al., Plasma Science and Technology 15, 1154 (2016)

[4] O. Meneghini et al., Physics of Plasmas 21, 060702 (2014)

[5] O. Menenghini et al., Nucl. Fusion 57, 086034 (2017)

Nuclear fusion(C)/0932 P1-pl.007

Upgrade of Mesh Generator for Transport Analysis of Various Magnetic Configurations in Tokamak

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Abstract :

The mesh generator, VEctor-following Grid generator for Adaptive mesh, VEGA [1], is upgraded to VEGA2.0 for analysis of more general magnetic configurations including Disconnected Double Null (DDN) and snowflake divertor configurations. The DDN configuration is commonly occurred from the Connected Double Null (CDN) magnetic configuration because of the difficulty of yielding the same magnetic flux values at both X points [2]. On the other hand, for the purpose of reducing heat loads to the divertor target, the snowflake divertor configuration is considered [3]. To deal with these configurations, VEGA has been modified in many aspects such as the code structure, algorithm, and functions. This upgraded version of VEGA, VEGA2.0 is verified with the former VEGA for CDN configuration of the KSTAR plasma by the grid quality factors [1]. Then, the grids of DDN and snowflake divertor configurations are generated by VEGA2.0 and the results are discussed.

In addition, VEGA2.0 is coupled with the two-dimensional tokamak plasma transport code C2 [5] through a newly developed bridge code in order to conduct core-edge-SOL (Scrape Of Layer) plasma transport simulations. The coupled C2 and VEGA2.0 is tested by a plasma transport simulation of the KSTAR DDN configuration.

Perturbative studies of toroidal momentum transport in KSTAR H-mode and effect of ion temperature perturbation

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Abstract :

Using tangential Neutral Beam Injection (NBI) and Non Resonant Magnetic Perturbation (NRMP), the perturbative experiments have been carried out to analyze momentum transport properties in KSTAR H-modes. Although operating conditions and methodologies applied in two cases are similar, obtained momentum transport properties show clear differences between them. The estimated momentum diffusivity obtained in the NBI modulation experiments are much larger than that in the NRMP modulation experiments. Introducing the temperature gradient dependence on the momentum transport coefficients, the linearized equation shows that the perturbation evolves faster than the equilibrium transport rate if the temperature perturbation exists. This could explain the estimated higher momentum diffusivity in NBI than NRMP modulation experiments where the ion temperature perturbation is larger. Time dependent transport simulations also show that the temperature gradient dependence on the momentum transport coefficients could lead to overestimation of the momentum diffusivity. The residual stress driven by the ion temperature gradient is investigated as another possible reason for the difference between the NBI and the NRMP experiment. However, its effect to the momentum diffusivity is shown to be small.

Nuclear fusion(C)/0452 P1-pl.009

Status of the Lower Hybrid Fast Wave Research on VEST

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Abstract :

Efficient current drive scheme in central or off-axis region is required for the steady state operation of tokamak fusion reactors. The current drive by using the fast wave in frequency range higher than two times lower hybrid resonance (w>2wlh) could be such a scheme in high density, high temperature reactor-grade tokamak plasmas.[1] An experiment was planned to prove the LHFW H&CD concept on VEST at SNU and the LHFW RF system has been prepared through collaboration between KAERI, KWU, SNU and KAPRA. Currently, 10 kW 500 MHz RF power is developed by refurbishing an old broadcasting klystron system and a comb-line type LHFW antenna is successfully designed, fabricated, and tested. The installation of RF system including antenna is progressing on the VEST device and the commissioning and low power injection experiment are going to be carried out soon. The system development including the theory and initial experiment result will be presented in the symposium.

[1] S.H. Kim, H.W. Lee et al., Fusion Engineering and Design 109-111 (2016) 707.

Acknowledgments : This research was supported by National R&D Program through the National Research Foundation of Korea (NRF)funded by the Ministry of Science, ICT & Future Planning (NRF-2014M1A7A1A03045372).

Nuclear fusion(C)/0068 P1-pl.010

다양한 디버터 조건에서 KSTAR SOL 영역의 운동량, 파워 손실 및 디버터 분리 현상의 비대칭 분석

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Abstract :

디버터 분리 현상에 대한 물리적 이해를 도모하고자 SOLPS-ITER 코드를 활용하여 KSTAR 플라즈마에서 upstream 전자밀도 스캔을 진행하였다. 입자균형 분석에 따르면 높은 밀도에서는 전하교환, 전자충돌 이온화, 분자해리, 재결합 반응을 포함하는 EIRENE 코드에서의 플라즈마-중성종 반응에 의한 손실항들이 분리현상을 촉진시킨다. SOLPS-ITER 결과를 low-recycling, high-recycling, detached 의 세 가지 디버터 조건에서 각각 후처리하였다. 이 디버터 조건은 upstream 전자밀도 스캔에 따른 타겟으로 입사되는 이온 입자속의 크기 변화를 기준으로 선택하였다. 입자, 운동량, 파워 균형을 flux tube 와 나란한 방향과 수직인 방향에 대해 source 항들을 나눠서 분석하였다. Near-SOL 에서는 지름방향의 확산에 의한 열, 운동량, 입자 손실이 EIRENE 반응에 의한 source 항과 비슷한 크기를 가지며, basic two-point model (2PM)에서의 가정과는 달리 무시될 수 없다. Basic 2PM 은 낮은 upstream 밀도에서는 비교적 타겟 물리량을 잘 예측하나, 높은 upstream 밀도 조건에서는 잘 맞지 않게 되어 향후 다른 장치에서의 양상을 예측하기 위해 외삽하는데 쓰기에 어려움이 있다. Two-point formatting equation (2PMF)은 volumetric 반응들을 손실항으로 고려하는 모델로서 이를 SOLPS 와 비교하였다. 2PMF 에서 타겟 물리량들은 volumetric 손실항들에 의해 대부분 보정이 된다. 자속 팽창, 이온-전자 온도 불균형, Bohm 쉬스 조건 등에 의한 '기타' 손실항들이 세부적인 보정을 한다. SOLPS 에서 진행된 밀도스캔 결과에 따르면, outer 디버터가 inner 디버터보다 상대적으로 낮은 upstream 밀도조건에서 디버터 분리 현상을 보인다. 이러한 양상은 2017 년 KSTAR 디버터 분리 실험의 결과에서 관측한 것과 정성적으로 일치한다.

Nuclear fusion(C)/0091 P1-pl.011

극자외선 분광진단시스템을 활용한 KSTAR 플라즈마의 텅스텐 스펙트럼 모델링 연구 초기결과

송인우 [1,2], 권덕희 [3], 홍주환 [1,2], 선창래 [4], 안영화 [4], GUIRLET Remy[5], 최원호[*1,2,6]

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Abstract :

KSTAR 에서 금속 불순물 주입 시스템과 소형 첨단 EUV 분광진단시스템(CAES)을 활용하여 EUV 영역의 파장 대에서 공간 분해된 텅스텐(W) 스펙트럼을 관측하였다. 본 연구에서는 KSTAR 플라즈마에서의 텅스텐 분포 및 수송물리 현상을 분석하기 위해 측정 된 텅스텐 스펙트럼을 스펙트럼 모델링과 비교하였다. 본 스펙트럼 모델링에는 Flexible Atomic Code (FAC)로 계산된 W^{10+} - W^{48+}의 광자방출계수(PEC)와 open-ADAS 의 이온화 및 재결합 계수가 포함되었다. 또한 톰슨산란진단계로 측정된 전자 온도 및 밀도의 방사형 프로파일을 입력변수로 사용하여 CAES 의 시선을 따라 정규화된 자속좌표로 변환을 하였고 이를 바탕으로 텅스텐 주입 후 플라즈마가 정상상태와 코로나 평형 상태에 있다고 가정하여 텅스텐의 선방출광을 계산하였다. 첫번째 시도로, free parameter 인 확산(D)과 대류(V) 계수는 회전하는 플라즈마 안에서 질량이 큰 불순물의 밀도 비대칭성을 고려한 연구결과를 참고하였다[1]. 본 스펙트럼 모델링의 선적분된 방출광의 초기결과는 2016 년 KSTAR 캠페인의 측정 데이터와 비교하였을 때 W^{25+} -W^{30+}가 존재하는 4 - 6 nm 부근에서 유사한 스펙트럼 결과를 보였으며 더욱 자세한 계산 및 비교를 위해 여러 free parameter 를 바꾸어 가며 물리적인 해석을 진행할 예정이며 CAES 의 절대보정 및 KSTAR 의 이미징 볼로미터를 활용한 텅스텐 밀도 분포 분석 등이 진행될 예정이다.

참고:

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Nuclear fusion(C)/0113 P1-pl.012

크립톤 불순물 주입을 통한 KSTAR H-모드 플라즈마 ELM 억제 및 내부수송장벽 생성

홍주환 [1,2], 장주혁 [1,2], 송인우 [1,2], 선창래 [3], 전태민 [1,2], 박재선 [1,2], 홍석호 [3], 최원호 [*1,2,4]

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Abstract :

플라즈마와 노벽간의 상호작용 등으로 핵융합 플라즈마 내에 필연적으로 존재하는 불순물 이온들은 플라즈마 노심에 축적되며 연료 이온을 희석시키고 방사광의 형태로 플라즈마 내부에 저장된 에너지를 지속적으로 감소시킨다. 반면 통제된 양의 불활성기체 불순물을 디버터 근처에 주입할 경우 플라즈마로부터 분출되는 고온의 열속으로부터 핵융합로의 내벽을 보호하는 역할을 하기도 한다. 즉 노벽과의 상호작용으로 발생한 탄소, 텅스텐과 같은 내벽재질 불순물뿐만 아니라, 본 연구에서 다루고자 하는 크립톤과 같은 불활성 기체 불순물의 수송 및 제어 연구 역시 핵융합 상용화를 위해서는 반드시 해결해야만 하는 중요 과제 중 하나이다. 이를 위해 본 연구센터에서는 디버터 가스 주입 시스템을 이용해 여러 조건의 크립톤 불순물 기체를 KSTAR H-mode 플라즈마에 주입하여 플라즈마에 미치는 영향을 살펴보는 실험을 수행하였다. 그 결과 5×10^{19} 개 이상의 크립톤 기체를 주입해 준 플라즈마의 경우 ELM 의 세기가 큰 폭으로 감소함을 D-alpha 방출광 분광계를 통하여 확인하였다. 이 뿐만 아니라 ELM 이 감소한 구간에서 계속 크립톤을 입사할 경우 ELM 이 완전히 사라지며 노심 부근(1.8 m $< R < 2.0$ m)의 이온온도와 전자온도가 급격히 증가하는 내부수송장벽(Internal transport barrier)가 생성됨을 확인하였으며, 이는 크립톤 기체를 입사하여 디버터 열속을 감속시키는 동시에 ITB 플라즈마를 형성하는 획기적인 결과이다.

Nuclear fusion(C)/0297 P1-pl.013

3 차원 자기장 섭동 인가시 KSTAR 불순물 방출광의 2 차원 단면 영상 재구성

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Abstract :

플라즈마 방출광의 파워분포는 핵융합 플라즈마의 파워 균형 및 불순물 수송을 이해하는데 필수적인 물리량으로, 안정적인 핵융합로 운영에 있어 매우 중요한 진단이다. 본 연구에서는 적외선 이미징 볼로미터 진단계를 활용하여 KSTAR 플라즈마에서 방출되는 플라즈마 방출광의 폴로이달 단면영상 재구성을 수행하였다. 플라즈마 방출광에 의해 가열된 백금 박막의 온도를 적외선 카메라로 측정하고, 박막 표면에서의 열확산방정식을 풀어 플라즈마 방출광 세기를 계산하였다. 측정된 방출광 세기는 진단계 시선을 따라 선적분된 값이므로, 폴로이달 단면영상을 얻기 위해 토모그래피 재구성을 수행하였다. 일반적인 D 자 모양의 플라즈마, 그리고 디버터 영역의 방출광 분포 등을 포함한 다양한 가상 팬텀 영상을 이용한 토모그래피 재구성 시험을 통해 코드의 유효성이 입증되었다. KSTAR 캠페인에서 3 차원 자기장 섭동이 인가되었을 때 불순물 수송실험을 수행하였으며, 이미징 볼로미터를 이용하여 플라즈마 전체 방출광 파워 변화와 불순물 방출광의 폴로이달 분포 변화를 관찰하였다. 해당 실험에서 3 차원 자기장 섭동이 인가된 이후 불순물 방출광이 대폭 감소하는 것을 확인하였으며, 자기장 구조 변화가 불순물 수송에 끼친 영향을 분석 중이다.

Plasma instruments, processing & applications(E)/0658 P1-pl.014

다채널 탐침장치를 이용한 KSTAR 플라즈마 변수 측정 및 ELM 특성

김관용 [1], 홍석호 [2], 박일서 [1], 홍영훈 [1], 손수현 [2], 이규동 [2], 남용운 [2], 정진욱[*1]

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Abstract :

토카막의 외곽 플라즈마 진단은 Far-SOL(Scrape Off Layer)영역의 물리적 현상과 플라즈마를 이해하는데 필수적이며 노심 플라즈마와 플라즈마 대향부품(Plamsa facing componets, PFCs)의 상호작용 해석에 매우 중요하다. 특히, 외곽 플라즈마(edge plasma)는 국제열핵실험원자로(ITER)에서도 중요한 이슈이다. 2016, 2017 년 KSTAR 캠페인에서 Far-SOL 영역 플라즈마의 이온 선속 및 전자온도를 부유고조화파 방법(Floating harmonics method, FHM)으로 진단하였다. 또한, ELM (Edge Localized Mode)이 있을 경우에도 플라즈마 거동을 다채널 탐침으로 측정하였다. 다채널 탐침장치는 16 개의 채널(4x4)로 구성되어 있다. ELM blob 이 다채널 탐침장치에 도달했을 때 전자온도는 평균 15.3 V, 이온 선속은 평균 5.3E+16 $cm^{-2}s^{-1}$ 수준이였으며, Inter-ELM 상태 일 때 전자온도는 평균 12.4 V, 이온 선속은 평균 3.7E+16 $cm^{-2}s^{-1}$ 으로 측정되었다. ELM suppression 실험에서는 전자온도가 평균 12.1 V, 이온 선속은 3.5E+16 $cm^{-2}s^{-1}$ 수준으로 측정되었다. 측정된 전자온도는 ECE 복사로 측정된 전자온도와 유사했고 이온 선속은 mm-Wave Interferometer 로 측정된 선밀도와 비슷한 경향성을 보였다. ELM blob 이 다채널 탐침장치에 도달했을 때, 전자 온도 및 이온 선속이 최대값으로 측정되었다. 또한, 측정된 값을 정규화하여 2 차원으로 분석한 결과 H-모드에서 ELM 이 위에서 아래로 이동하는 것을 관찰하였다. 분석 결과 ELM blob 의 이동 속도는 약 70m/s 이었다.

Nuclear fusion(C)/0162 P1-pl.015

Research on the behavior of neutral particles and electrons in X-point simulator system

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Abstract :

We have built a DC multi-dipole cylindrical chamber (2 m in length and 0.6 m in diameter) with an aim of studying behavior of neutral particles and electrons around magnetic X-point. The chamber is named MAXIMUS (MAgnetic X-point sIMUlator System). We plan to generate magnetic X-point via two axially flowing currents. MAXIMUS has numerous diagnostic ports where probes and optical diagnostic systems can be used for measurements. We emphasize on investigating the behavior of neutral particles as they act as plasma source and sink, affect L-H transition and structures of equilibrium profiles and control heat flux toward divertors in tokamaks. In this work, we present basic properties of plasmas in MAXIMUS.

Nuclear fusion(C)/0163 P1-pl.016

Training program for students in nuclear fusion

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Abstract :

핵융합연구개발사업 일환인 핵융합 전문 인력양성 프로그램은 2014 년부터 크게 두 가지 목적을 달성하기 위해 진행되었다. 1) 핵융합/플라즈마 관련 curriculum 이 없는 대학의 학생들에게 핵융합/플라즈마 교육 및 2) 핵융합 전공자들에게 단기연수를 지원하여 학생들이 졸업하였을 때 관련 분야 일자리를 찾을 수 있도록 돕기위함이다. 이를 목적으로 2 단계(2017 년 6 월 - 2019 년 5 월) 핵융합 전문 인력양성 프로그램에서는 핵융합/플라즈마 관련 온라인 강좌 제작, 단기연수 지원 및 핵융합 겨울학교를 실시한다

Nuclear fusion(C)/0869 P1-pl.017

Growth rate of electrostatic surface waves in a dusty plasma containing collision-dominated ion flow

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Abstract :

The effects of electron-ion collision and dust charge on the growing of the electrostatic surface wave propagating at the interface of semi-bounded dusty plasma whose constituents are electrons, negatively charged dust, and streaming ions are investigated. The surface wave can be unstable if the multiplication of wave number and ion flow velocity is greater than the total plasma frequency of electrons and dusts. The analytical expression of the growth rate is derived in terms of collision frequency, dust charge, and ion-to-electron density ratio. It is found that the growth rate is inversely proportional to the collision rate, but it is enhanced as the number of electrons residing on the dust grain surface is increased. In addition, the growth rate of surface wave is compared to that of the bulk wave and discussed.

The work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean Government (MISP) (NRF-2015M1A7A1A01002786).

Nuclear fusion(C)/0365 P1-pl.018

Measurement of Deuterium Retention in Tantalum

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Abstract :

Hydrogen-isotope retention and desorption behaviors in fusion materials are important issues. Tantalum, which is known to trap all implanted deuterium ions, can be used to calibrate the deuterium beam characteristics of an inductively coupled plasma (ICP) ion source. In this study, the deuterium retention behavior in tantalum was investigated by using a thermal desorption spectroscopy (TDS) clustered with an ICP ion source at Dankook University. The samples were irradiated with deuterium ions (1.5 keV and ～1×10^{21} D/m^2) at room temperature. TDS measurements were performed in-situ following deuterium irradiation ranging from room temperature to 1100 K at a linear heating rate of 0.5 K/s, and the amount of deuterium desorbed from the sample was obtained. Detailed results are presented.

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* "This work was supported by the National Research Foundation of Korea (Project No. 2015M1A7A1A01002234)."

Nuclear fusion(C)/0367 P1-pl.019

Study of Deuterium Permeation in Er2O3 Coating on SS316L

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Abstract :

Hydrogen-isotope permeation barrier is one of the important issues for tritium loss in nuclear fusion, which has been studied by many research groups. In this report, we fabricated erbium oxide thin films on SS316L substrates by using the metal-organic chemical vapor deposition technique for the future application of the hydrogen-isotope permeation barrier. The surface morphology of thin films were analyzed by field-emission scanning electron microscopy, with chemical composition by energy dispersive X-ray spectroscopy. Deuterium permeation experiments were performed by using a hydrogen-isotope permeation measurement system which has been custom-built at Dankook University. The quantitative experimental results of this work will be presented in detail.

Nuclear fusion(C)/0382 P1-pl.021

Irradiation effects in Ti-added Reduced Activation Ferritic-Martensitic Steels

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Abstract :

The Reduced Activation Ferritic / Martensitic (RAFM) steels are candidate materials for the blanket in a nuclear fusion reactor. The material will be exposed to harsh irradiation environment, hence, required to have irradiation resistance. In this study, we characterized and compared the irradiation hardening and swelling of Eurofer97 and (E97+Ti) steel. (E97+Ti) steel is a new RAFM steel developed at Korea Institute of Materials Science. The material includes titanium, which induces the formation of (Ti, W)C precipitates and refined $M_{23}C_6$ particles during tempering process. It is known that refined $M_{23}C_6$ particles contribute to increase fracture toughness by decreasing the initiation of crack, and MC-type carbides contribute to increase of the mechanical strength by blocking dislocation motion. Irradiation hardening and swelling are characterized by using ion irradiation and He irradiation, respectively.

Nuclear fusion(C)/0552 P1-pl.022

Identification of hierarchical mechanical properties of martensite in RAFM steel using CP-FEM

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Abstract :

RAFM (Reduced activation ferritic martensitic) steel is a potential blanket material for fusion reactor. The microstructure of RAFM is tempered martensite, which is transformed from prior austenite and has strong hierarchical structure consisting of packet, block, sub-block and lath. In this study, the mechanical properties of the lath (tempered) martensite are identified based on coupled experimental-numerical approach. For this purpose, the basic anisotropic elastic and plastic properties of laths, which are the fundamental unit of the RAFM, are identified using inverse crystal plasticity finite element simulation by comparing the stress-strain curve measured from micro-scale tensile tests. The simulation considers the orientation relationship between prior austenite and resultant lath, and the slip activities on in-habit plane and out of habit plan slips in the laths. Once the crystal plastic properties of the laths are identified, the scale of specimen for the simulation is extended using the micro-pillar test, which is validated by the experiment. As a future work, the approach will be applied to the prediction and optimization of the meso- and macro-scale mechanical properties of RAFM steel. 본 연구는 한국연구재단의 핵융합기초연구사업 (NRF-2016M1A7A1A01005904)의 지원을 받아 수행되었으며 이에 감사드립니다.

Nuclear fusion(C)/0323 P1-pl.023

내방사선 센서측정 칩 설계를 위한 회로 구조 및 방사선에 의한 성능 변화 분석

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Abstract :

핵융합 시스템의 정밀한 진단제어를 위해서는 핵융합로 안에서 온도, 압력, 전자기장 등의 센서 신호들을 측정하고 증폭하여 디지털 신호로 변환시키는 센서측정 칩이 필수적이다. 하지만 amplifier, filter, analog-to-digital converter 등의 민감한 아날로그 집적회로들로 구성된 센서측정 칩은 방사선 (중성자, 감마선 등)에 의한 누적방사선량 (TID) 및 단일이벤트효과 (SEE)에 쉽게 영향을 받으며, 이는 진단제어시스템의 정확도 및 신뢰도 저하, 그리고 핵심 전자부품 수명 감소의 직접적인 요인이 된다.

본 연구에서는 다양한 센서측정 회로 구조들 중에서 방사선 영향에 견고한 회로들을 분석하고, CAD 시뮬레이션을 통해 내방사선 센서측정 회로들을 설계하고 정확도, 전력소모, 입출력범위, 속도 등의 성능을 검증한다. 또한 방사선이 반도체 회로에 미치는 영향을 CAD 시뮬레이션에 반영하여 방사선 환경에서 센서측정 칩의 성능이 어떻게 저하되는지를 관측, 분석하며, 이를 토대로 내방사선 회로 설계 기법에 대해 고찰한다.

본 연구는 핵융합기초연구사업(과기정통부)의 지원을 받아 수행되고 있음.

2D material based junction transistor without gate insulator for radiation hardened electronics

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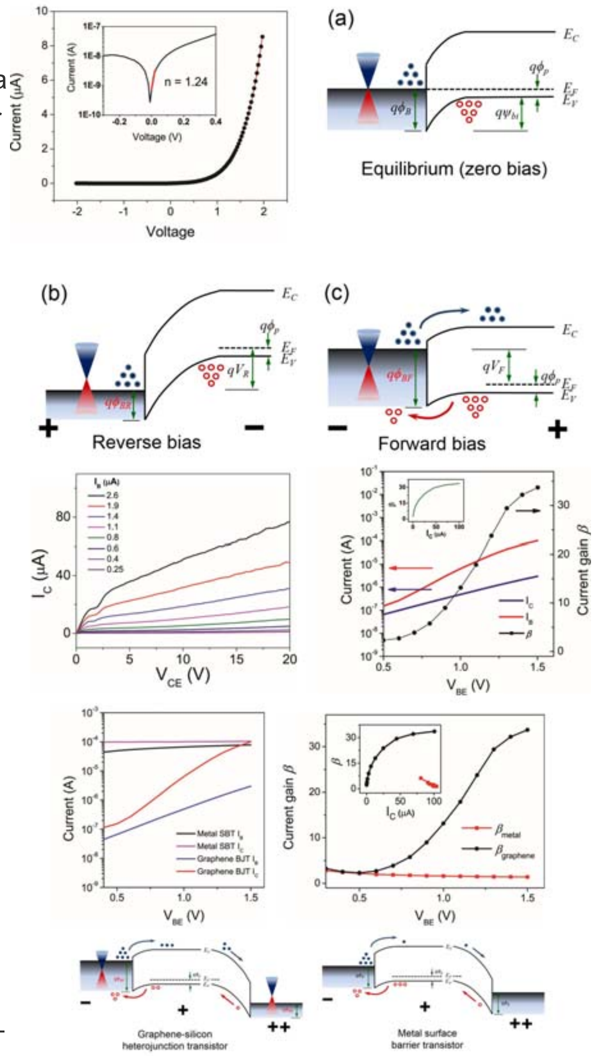
Abstract :



We have demonstrated a junction transistor based on a graphene-semiconductor heterojunction. The transistor fully utilizes the Fermi level tunability of graphene under bias to increase the minority-carrier injection efficiency of the base-emitter junction in the BJT. This transistor exploits a Schottky-like junction but has a significantly higher minority carrier injection efficiency that is analogous to a semiconductor p-n junction typically used in bipolar transistors. The transistor has an extremely thin profile, can be fabricated with a low temperature process (<110 ºC) that does not require a furnace. Importantly, the junction is formed without using any metal. This prevents potential issues that may stem from the irradiation of metal at the junction (e.g. metal ion migration, thermal instability, and low reverse bias tolerance). It is even possible to completely eliminate the use of metal at the contact by using a stacked graphene layer that is doped since the sheet resistance of monolayer graphene can be lowered by an order of magnitude with the aid of charge transfer doping. Graphene with strong carbon-carbon covalent bonding is known to be a robust material for radiation hardening. Moreover, since there is no dielectric layer in the active components of the transistor, it does not suffer from total ionizing dose effects attributed to hole accumulation at the dielectric–semiconductor interface. Due the lack of such effect, we expect robust device operation with minimal threshold voltage shift in the transistor. This work is supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. 2017M1A7A1A01016262). This research was supported by X-mind Corps program of National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Plannig (No. 2017H1D8A1031522).

Nuclear fusion(C)/0281 P1-pl.025

VNPFET 에서 Radiation 입사각도와 입사에너지 변화에 따른 SER 효과 분석

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Abstract :

본 논문에서는 3D TCAD(Technology Computer-aided Design) 시뮬레이션을 통해 VNPFET (Vertical Nano-Plate FET) 구조를 이용하여 Radiation 소스인 Alpha Particle 을 입사하였을 때 발생하는 SER(Soft Error Rate)효과에 대한 전기적 특성을 실험하였다. Radiation Effect 중 SER 이란 트랜지스터에 particle 이 입사해 들어오게 되면 전류가 변동되어 일시적인 트랜지스터 오류가 발생하는 현상을 말한다. 실험에는 5nm 의 채널 길이를 가지는 VNPFET 을 이용하였는데, GAA(Gate-all-around) 구조이면서 동시에 수직형태의 구조를 가지는 VNPFET 은 Nano-Wire FET 보다 폭이 넓기에 전자밀도와 Drain Current 가 높다는 장점을 가진다. Radiation 을 입사할 때의 소스는 Alpha particle 을 사용하였으며, 입사 각도를 25°, 50°, 75°로 설정하였고, 그에 따른 에너지 양을 1MeV, 5MeV, 10MeV 로 지정하고 400ps 에서 동일하게 입사할 때 VNPFET 에 발생하는 특성을 분석하였다. 에너지와 각도에 따른 시뮬레이션을 통해 50°로 Radiation 이 입사되었을 때 $I_{D,peak}$ 가 가장 크게 증가하고 입사 에너지가 커질수록 I_D 는 감소하는 것을 시뮬레이션을 통해 확인하였다.

Acknowledgement

이 연구는 핵융합기초연구사업(과기정통부)의 지원을 받아 수행하였음

Nuclear fusion(C)/0734 P1-pl.026

제일원리계산을 이용한 텅스텐 합금의 점결함 구조 분석

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Abstract :

핵융합로 내벽과 같이 고온의 환경에서 사용될 내열 소재로 텅스텐이 연구되어왔다. 하지만 활용 분야에 따라 내열 성능뿐 아니라 구조 소재로써의 성능 또한 중요하며, 특히 연성-취성 전이 온도와 같은 열기계적 성질이 관심을 모으고 있다. 텅스텐 순물질은 녹는점이 높아 내열 성능은 우수하지만, 열싸이클을 겪는 분위기에서는 연성-취성 전이 온도 등에서 단점이 나타났다. 또한 중성자 조사 분위기에서의 텅스텐 순물질은 점결함의 발생이 공공이나 전위 등의 생성으로 발전하는 것을 보여, 미세 조직상의 취약점을 보였다. 이를 보완하기 위해 여러 가지 텅스텐 합금에 대한 연구가 진행되고 있다.

본 발표에서는 제일원리 범밀도함수이론을 이용하여 텅스텐 합금 내에서의 점결함 구조를 살펴보고, 순물질에서의 점결함과 어떤 차이점이 있는 지 비교할 예정이다. 또한, 순물질과 합금의 점결함 구조가 중성자 조사 분위기에서 어떤 차이를 보일 수 있는 지도 살펴볼 예정이다.

이 논문은 2014 년도 정부(과기정통부)의 재원으로 한국연구재단의 지원을 받아 수행된 핵융합기초연구사업임(No. 2014M1A7A1A01030141)

Nuclear fusion(C)/0689 P1-pl.027

분자동역학을 이용한 벌크 텅스텐에서의 PKA 연속조사 시 온도 및 PKA 에너지의 변화에 따른 조사 손상 변화에 대한 연구

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Abstract :

이번 연구에서는 BCC 텅스텐에서 연속적인 PKA (primary knock-on atom) 조사에 의한 결함의 생성을 분자동역학 시뮬레이션을 통해 분석하였다. 온도 및 PKA 에너지의 영향을 분석하기 위해, 20, 30 keV 의 PKA 에너지 와 400, 1000 K 의 온도를 시뮬레이션 조건을 선정하였다. 시뮬레이션 조건과 무관하게 연속 조사에 의해 vacancy, interstitial defect cluster 가 생성되는 현상이 관찰되었다. 관찰된 defect cluster 들은 높은 에너지의 PKA 의 단일 조사 시뮬레이션에서 관찰되었던 defect cluster 와 일치하였으며, 이전의 낮은 에너지의 PKA 단일 조사 시뮬레이션에서는 관찰되지 않았다. PKA 에너지가 높을수록 모든 조사 횟수에서 더 많은 point defects 가 생성되었고, 이로 인해 vacancy 및 interstitial defect cluster 가 빨리 형성되었다. 시뮬레이션 온도의 변화를 주었을 때, 초기 2 번의 조사까지는 높은 온도에서 point defects 의 생성이 감소하는 경향이 관찰되었으나 그 후에는 온도의 영향이 미비해지는 경향이 관찰되었다.

Nuclear fusion(C)/0747 P1-pl.028

Sensitivity Analyses of Tungsten Plasma Facing Component for Typical Cooling Conditions

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Abstract :

Since components in fusion reactors exposed more severe operating conditions than those in fission reactors, researches on alternative materials have been performed continuously. Representatively, as plasma facing components(PFCs), tungsten has been widely used due its high melting temperature and resistance of plasma-material interaction. In the present study, two kinds of sensitivity analyses were performed according to typical cooling conditions of coolant. For this purpose, heat flux of the tungsten block constituting the PFC of divertor was set to 20 based on international thermonuclear experimental reactor(ITER) design document. Detailed heat transfer analyses were carried out by applying either three coolant wall temperatures or corresponding film coefficients. Also, the tungsten PFC was modeled by mono-block or multi-blocks. Finally, the comparative analysis results and key finding were discussed.

Nuclear fusion(C)/0475 P1-pl.029

Plasma density measurement with the time-domain-spectroscopy using laser-produced THz waves

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Abstract :

Electron density diagnostics is of importance as electron density is one of the key factors in plasma characterization. In this work, terahertz time-domain spectral measurement (THz-TDS) for plasma density is conducted. THz is generated via the two-color photoionization method using the Ti:sapphire femtosecond laser system with a pulse duration of 50 fs and an energy of 3 mJ/pulse. The results show that the Argon gas plasma was produced with a density of in the inductively-coupled plasma chamber, where the plasma is generated in a quartz tube with a dimeter of 2.5 cm and a length of 20 cm. This work suggests the feasibility of the THz-TDS as a promising diagnostic tool for plasma characterization.

[2] : Present address

Basic plasma phenomena(D)/0988 P1-pl.030

Temporal evolution of a laser-induced air-breakdown plasma by a Q-switched Nd:YAG laser

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Abstract :

Temporal evolution of an air-breakdown plasma, generated by an Nd:YAG Q-switched nanosecond laser pulse, was studied. The velocity of a shock wave spurted out from the plasma was determined as a function of time using the shadowgraphy technique. In addition to the shadowgraphy, the Nomarski interferometer method is also used for diagnostics of the laser-induced plasma. The electron density of the laser-induced plasma is extracted from the interference fringes by applying the Fast Fourier Transform (FFT) and Abel inversion. Furthermore, the plasma temperatures are obtained from the hydrodynamics and Saha equation methods, respectively, and they are compared.

Basic plasma phenomena(D)/0514 P1-pl.031

고밀도 플라즈마 포일과 전반사된 원편광 레이저의 불안정한 상호작용

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Abstract :

원편광 레이저는 플라즈마를 압축 및 가속시키는데 적합하다고 생각되어왔다. 기존의 이론은 플라즈마와 레이저의 효율적인 상호작용을 위해 $a_l \leq \zeta\ (= \pi n_e l_e / n_c \lambda)$를 요구했다. 그러나 1 차원 Particle-in-cell (PIC) 시뮬레이션에 따르면, 저 조건이 만족됨에도 불구하고 광압을 받는 플라즈마의 두께가 (압축되지 않고 오히려) 두꺼워질 수 있었다. 우리는 이 현상의 원인을 수식을 통해 분석하고, 개선된 조건 $a_l / \zeta \leq (1 + k^2 l_e^2/4)^{-1/2}$ 을 제시했다. 그리고 1 차원 PIC 을 통해 이 수식을 검증했다. 마지막으로, 원편광 레이저와 얇은 플라즈마가 안정적으로 상호작용하기 위해 요구되는 레이저 펄스의 초기 상태를 시뮬레이션 데이터를 통해 제시했다.

Plasma instruments, processing & applications(E)/0628 P1-pl.032

Diagnosis of Plasma Density by Faraday Rotation of Broadband Pulse.

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Abstract :

강한 외부 자기장이 존재하는 플라즈마에서 밀도 및 자기장을 진단하는 것은 토카막을 비롯한 플라즈마 실험환경에서 매우 중요한 역할을 담당한다. 밀도 및 자기장을 진단하는 방법에는 여러가지 방법이 있고 오랜기간 연구 되어 왔지만, 각각의 방법에 대한 제약으로 인해서 적용할 수 있는 범위가 한정적이며 , 특히 토카막 진단에 필요한 진동수(테라헤르츠파)에 해당하는 소스를 만드는 것은 힘든 상태이다. 이를 해결하기 위해서 Bruce I Cohen 이 repletometry 에 공간적으로 짧은 펄스(주파수 대역상으론 광대역)를 사용하여 많은 주파수 대역을 동시에 사용한 것 같은 효과를 냈던 것에 착안하여서 토카막 또는 외부자기장이 존재하는 플라즈마의 진단에 광대역 펄스를 사용하여 faraday rotation 을 통한 진단을 하였다. 광대역의 진동수로 인하여 faraday rotation 을 투과하는 성분만이 아니라 반사하는 성분도 이용이 가능하며, 이를 이용하여 밀도 및 자기장을 진단할수 있다.

Basic plasma phenomena(D)/0855 P1-pl.033

플라즈마를 이용한 테라헤르츠파 광원 3D 시뮬레이션

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Abstract :

테라헤르츠파 대역은 현재 전자기 스펙트럼에서 유일하게 아직 적절한 광원이 개발되지 못한 영역으로, 의료용 진단 및 영상 영역과 소자 및 군사 영역 등 뿐만 아니라 토카막 플라즈마 진단과 같은 다양한 응용 분야에서 큰 기대를 얻고 있다. 기존 광원의 문제의 해결책 중 하나로 플라즈마의 강점을 이용해 선택가능한 협대역의 진동수에서 공간적으로 coherent 한 고출력의 테라헤르츠파 광원을 시뮬레이션을 통해 보이려고 한다. 선행연구로 위 특성을 만족하는 광원을 2 차원 PIC 시뮬레이션을 통해 보였으며, 광원으로부터 방출되는 테라헤르츠파의 에너지와 특성 등이 의도대로 검출되는지 검증하기
위하여 기존의 결과를 바탕으로 3 차원 PIC 시뮬레이션을 수행하였다. 그 검증 과정 중 가장 기본적인 부분인 광원의 진동수 조절 가능성을 플라즈마 내부의 전자진동과 플라즈마 외부로 방출되는 테라헤르츠파의 진동수가 맞아떨어지는 것을 보였다.

Nuclear fusion(C)/0495 P1-pl.034

토카막 플라즈마 인터페로미트리 진단을 위한 레이저-플라즈마 기반 테라헤르츠파 광원

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Abstract :

토카막 플라즈마의 밀도와 자기장을 간섭계 (인터페로미트리) 및 패러데이 로테이션으로 진단하기 위해 테라헤르츠 대역의 강한 전자기파를 필요로 한다. KSTAR 플라즈마의 경우 1 ~ 5 THz 대역의 전자기파가, 향후 ITER 나 DEMO 의 경우 더 높은 진동수의 테라헤르츠파가 필요한데, 이러한 대역에서 높은 결맞음을 갖추면서 충분히 강한 테라헤르츠를 만들어내는 것은 매우 어려운 일이다. 두 개의 레이저를 스트립 플라즈마에 충돌시켜 플라즈마 다이폴을 생성시키고 이로부터 mJ 급, 5 ~ 20 THz 대역의 가변 진동수 테라헤르츠 파를 발생시킬 수 있는 새로운 방법을 소개한다.

이 연구는 '핵융합기초연구사업 (과기정통부)/공동 연구' 지원으로 수행되었다.

Nuclear fusion(C)/0626 P1-pl.035

Collective Thomson Scattering System combined with the MIR system in KSTAR

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Abstract :

A four-channel collective Thomson scattering (CTS) system being developed for electron-gyroscale turbulence study will provide simultaneous measurement of electron density fluctuations at four discrete poloidal wavenumbers up to 24 cm^{-1}. Due to upcoming new neutral beam injection (NBI) system, the microwave imaging reflectometer (MIR) [1, 2], which was developed for ion-gyroscale fluctuation measurement, has to be rearranged and the space has to be shared with the CTS system [3]. In order to effectively combine both the optical systems for the MIR and CTS system, a large aperture beam splitter will be employed for splitting the 300 GHz O-mode beam for the CTS system from the 78-96 GHz X-mode beam for the MIR system. Design characteristics of the optical systems and laboratory test result are presented in this paper. The modified MIR and new CTS system will be installed prior to the 2018 KSTAR campaign. This work is supported by the NRF of Korea under contract numbers, NRF-2015M1A7A02002627 and NRF-2014M1A7A1A03029865, and the Ministry of Science, ICT and Future Planning under the KSTAR project.

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Nuclear fusion(C)/0603 P1-pl.036

Fast ion driven drift wave instabilities in tokamak plasmas

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Abstract :

The RS(reversed shear) configuration plasma has been known as the good scenario for a steady-state tokamak reactor characterized by good confinement, high stability and a high fraction of self-sustaining bootstrap current[1-3]. There can be some instabilities in RS plasmas even though they show such a good performance. We are interested in the effect of fast ions(MeV energies) since many fast ions are generated by heating or fusion reaction in high-performance fusion devices. There can be fast ion driven instabilities. Most previous works focus on electromagnetic Alfvenic instabilities[4]. In this work, we look for possibilities of drift wave destabilized by fast ions in RS plasmas. We investigate the relevant physics which can cause any new instabilities in ITER or fusion reactor conditions.

This work was supported by National R&D Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning(No. NRF-2015M1A7A1A02002646)

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Resonant magnetic perturbation induced collisionless zonal flow decay in tokamak plasmas

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Abstract :

Non-axisymmetric resonant magnetic perturbation (RMP) is a useful tool to mitigate or suppress large edge localized modes (ELMs) in tokamak H-mode plasmas [1-3]. However, this results in an increase of the L-H transition power threshold [4-6]. Motivated by this experimental observation, we theoretically study the 3D magnetic field effect on zonal flows in tokamak plasmas using gyrokinetic equations, extending the previous works on axisymmetric tokamak [7,8] and LHD-like stellarator [9]. We show that tangential component of the 3D magnetic field (parallel to the original tokamak magnetic field) induces a slow secular radial drifts of toroidally trapped particles. Energy-dependence of these drifts causes a long term phase-mixing of zonal flows. Consequently, the zonal flows asymptote to the Rosenbluth-Hinton residual level in a short time scale, but further decay algebraically in time afterwards. This long term collisionless decay rate is comparable to the collisional decay rate for the present day tokamaks for $q_r\rho_i \lesssim 1$, but can be faster in the future machines with higher edge temperature. As zonal flows can play a key role triggering the L-H transition by regulating drift wave turbulence [10], our result indicates a lower zonal flow level and thus a higher L-H transition power threshold in the presence of stronger RMP field in tokamak plasmas.

This work was supported by National R&D Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science, ICT & Future Planning(No. NRF-2015M1A7A1A02002646).

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Basic plasma phenomena(D)/0069 P1-pl.038

헬륨 대기압 플라즈마의 물성 진단을 위한 충돌-방사 모델의 구성

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Abstract :

대기압에서 영역에서 발생되는 플라즈마 중, 대기압 플라즈마 제트는 대단히 좁은 영역에서 플라즈마가 발생되므로, 기존의 플라즈마 물성 진단방법으로 진단이 대단히 어렵다. 충돌-방사 모델은 플라즈마의 방출광을 이용하여 플라즈마 물성을 진단하는 방법이므로, 좁은 영역에서 발생되는 대기압 플라즈마 제트의 물성 진단이 가능하다. 본 연구에서는 헬륨 대기압 플라즈마의 물성 진단을 위하여 원자-전자 충돌 반응, 원자-원자 충돌반응 등 다양한 반응효과가 고려된 헬륨-충돌 방사 모델을 구성하였다. 헬륨 플라즈마의 전자온도와 전자밀도에 따른 헬륨 스펙트럼의 특성을 충돌-방사 모델을 이용하여 평가하였다.

Basic plasma phenomena(D)/0080 P1-pl.039

충돌-방사 모델의 광여기계수를 이용한 헬륨 플라즈마의 특성 연구

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Abstract :

충돌-방사 모델을 이용한 플라즈마 광진단은 플라즈마에 영향을 주지 않고 간단한 측정 장비로 플라즈마 물성을 진단할 수 있는 장점을 가지고 있다. 헬륨 플라즈마는 기저상태에서 n^1P 상태로의 유도 흡수가 대단히 커서, Ne <10^{11} cm^{-3} 헬륨 플라즈마에 대해서도 광포획효과가 중요한 역할을 한다. 본 연구에서는 광여기계수를 이용하여 광포획효과를 고려하였으며, 광여기계수가 고려된 충돌-방사 모델을 이용하여 저온 헬륨 플라즈마에 대해서, 플라즈마 동작 조건에 따른 플라즈마 내 입자의 공간분포 변화를 광여기계수를 이용하여 평가하였다.

본 연구는 핵융합기초연구사업(과기정통부)의 연구비 지원으로 수행되었음. (No. NRF-2017M1A7A1A02016145)

Nuclear fusion(C)/0107 P1-pl.040

Calculation of Stark broadening of Helium transition line in low temperature plasma.

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Abstract :

The spectral lineshape of plasma radiation is increased by a various interaction between radiation emitter and perturbation such as magnetic field, electric field, induced absorption of radiation, and so on. Especially, Stark broadening which is generated by ions and electrons in plasma is a function of electron density and temperature so that Stark broadening is a important plasma diagnostic tool in the field of the astroplasma and dense plasma, etc. In this research, we have calculated Stark broadening in low temperature helium plasma with the impact approximation of semi-classical perturbation method. We have discussed the validity of the impact approximation for the low temperature plasma.

Acknowledgement:

This research was supported by National R&D Program of “Basic nuclear fusion research” through the National Research Foundation of Korea(NRF) funded by the Ministry of Science and ICT (NRF-2017M1A7A1A02016145).

Nuclear fusion(C)/0108 P1-pl.041

헬륨 플라즈마내 플라즈마 방출광의 주파수 선폭 확대

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Abstract :

플라즈마 방출광은 플라즈마내 입자들 사이의 다양한 충돌에 의하여 플라즈마 방출광의 주파수 선폭이 증가하는 pressure broadening 현상이 발생한다. Pressure broadening 중 resonance broadening 과 van der Waals broadening 은 Stark broadening 과 함께, 플라즈마 방출광의 주파수가 증가하는 중요한 원인이다. 본 연구에서는 헬륨 저온 플라즈마에서 발생된 플라즈마 방출광의 resonance broadening 과 van der Waals broadening 을 계산하였으며, 각각의 주파수 선폭 확대를 natural broadening 과 Stark broadening 에 의한 주파수 선폭 확대와 비교 평가를 진행하였다.

본 연구는 핵융합기초연구사업(과기정통부)의 연구비 지원으로 수행되었음. (No. NRF-2017M1A7A1A02016145)

Nuclear fusion(C)/0803 P1-pl.043

국제 핵융합 재료조사시설(IFMIF)의 안정적 운전을 위한 고강도 빔 물리 연구

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Abstract :

중성자와 충돌 시 이를 일정기간 견뎌내는 저방사화 재료재에 대한 연구가 향후 핵융합 에너지의 경제성과 사회적 수용성을 좌우할 것으로 예상됨에 따라, 전세계 핵융합계에서는 핵융합부품-소재 물질 개발을 위한 고에너지 대용량 (14 MeV 의 중성자를 초당 10^{17} 개 이상 발생) 중성자원의 시급한 건설이 요청되고 있다. 이러한 중성자 조건으로 핵융합 재료조사 실험을 수행할 장치는 현재 존재하지 않으며, 유럽과 일본을 중심으로 한 국제공동 연구로 "국제 핵융합 재료조사시설 (International Fusion Material Irradiation Facility, IFMIF)" 프로젝트가 추진 중에 있다. IFMIF 가속기에서 발생되는 빔은 기존 가속기의 빔보다 훨씬 높은 빔 전류 및 빔 파워를 가지도록 설계되어 있어서, 공간 전하 효과가 클 것으로 예상되며 빔 halo 와 빔 손실, 빔 수송안정성에 대한 불확실성이 매우 높다. 이러한 우려를 불식시키기 위해 IFMIF 가속기에 대한 빔 halo 와 빔 손실, 빔 수송안정성 특성에 대한 연구의 필요성이 부각되고 있다. 빔 halo 와 빔 손실을 측정하기 위한 방법으로 이온화 챔버, 반도체모니터, Vibrating Wire Monitor(VWM), Halo Monitor Ring(HMR), PMT 에 기반한 측정방법, 그리고 CVD 다이아몬드 모니터가 고려되었다. IFMIF 의 진단 장비는 높은 민감도와 신뢰성, 4.5K 의 작동 여부, 방사선에 대한 저항성 등 여러 조건들을 충족시켜야 하며, 종합적 평가에 의해 현재 높은 강도와 방사선 저항성을 가진 다이아몬드 모니터가 우선적으로 고려 되고 있다. 이번 발표에서는 IFMIF 에 가장 적합한 CVD 다이아몬드 모니터의 구조 및 설계를 제안한다. 빔 수송안정성 및 특성 연구는 공간 전하 효과에 의한 영향을 시뮬레이션에 정확히 적용하기 위해 PIC 알고리즘을 이용하고 있다. 여러 PIC 코드들 중 TRACEWIN 과 WARP 를 사용하여 연구를 진행하였고, 이번 발표에서는 IFMIF 의 저에너지 빔 수송 구간 (LEBT) 에서 일어나는 Space-Charge Compensation 효과를 논의한다.

본 연구는 2017 년 핵융합기초연구사업(과기정통부) 지원을 받았습니다.

Nuclear fusion(C)/0520 P1-pl.044

Atomic data and CR modeling for transport and spectroscopic modeling of fusion plasma

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Abstract :

Electron-impact excitation for He I and dielectronic recombination rate coefficients and photon emissivity coefficients (PEC) for W ions have been calculated by using or modifying Flexible Atomic Code (FAC). These calculated data have been assessed by comparing other available theoretical and experimental data. Our calculated data have been used in transport/spectroscopy modeling for analyzing emission lines from KSTAR plasma. As well our calculated data have been provided in a self-developed and user-friend Web DB. Tungsten W44+-W46+ ions are abundant in 3-5 keV plasma temperature and have emission lines around 0.6 nm. W45+ and W46+ have emission lines around 6 nm and 12-13 nm as well as 0.6 nm. Accurate dielectronic recombination rate coefficients for W44-46+ were calculated by FAC. In addition PEC for Wq+ (q=5-48) emitting VUV of 14-22 nm were calculated efficiently by parallelizing FAC transition rate routine. Those PEC data was used in LOS integrated emissivity calculation with the impurity charge density distribution by SANCO transport modeling which results in better agreement than existing ADAS with the VUV spectra measured from W powder injection experiment in KSTAR.

Basic plasma phenomena(D)/1110 P1-pl.045

Correlation of effective polytropic index and anisotropic electron temperature in a magnetically expanding plasma

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Abstract :

Transition of thermodynamic behavior for the electrons in a divergent weakly magnetized plasma is explored in terms of anisotropic electron temperature. The typical effective polytropic index obtained in the frame of one-fluid, double-adiabatic magnetohydrodynamics is modified to account for the density drop and the field gradient, which are the natural features of magnetic nozzle. A parametric analysis for the paraxial-limited polytropic index is carried out on the energy anisotropy such as the different temperature and velocity in the parallel and perpendicular direction. It is assumed that the anisotropic temperature ratio has a different trend at the nozzle throat and far-field region due to the perpendicular heating of electron cyclotron resonance (ECR). The analytical result shows the existence of the high polytropic index over the value of 5/3 for ideal adiabatic gas expansion as well as the effective electron cooling down in the magnetically expanding collisionless plasma.

This research was supported by National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (Nos. 2014M1A7A1A02030165 and 2014M1A7A1A03045367).

Nuclear fusion(C)/1115 P1-pl.046

Proof of principle study on charge separation for direct energy conversion of charged particles in divertor region

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Abstract :

Our project investigates a possibility of the direct energy conversion of the kinetic energy carried by electrons and ions into the electric energy on the divertor region. In order to achieve the aim, the research has been carried out for the following two topics: charge separation method and divertor scenario. One is the manner to separate electrons and ions from magnetized plasma in curved magnetic field configuration with an ECR-driven divertor simulator, and the other is the scheme to apply the charge separation method for a small tokamak device with diverted plasma structure. It is found that the degree of charge separation is greatly affected by main parameters such as field curvature, electron temperature, plasma density, and drift velocity measured by the electrostatic probes. Those parameters lead to dimensionless variable as represented by non-adiabaticity parameter, which is a criterion that determine the separation of ions from the magnetic field. It is confirmed that the existence of the thermodynamic anisotropy and the transition of electrons via the polytropic index, and demonstrate that the phenomenon is related to the ion acceleration. In addition, a diverted plasma scenario has been developed in order to demonstrate the charge separation in Versatile Experiment Spherical Tokamak (VEST).

Nuclear fusion(C)/0389 P1-pl.047

Conceptual Design of Lower Hybrid Current Drive for KSTAR

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Abstract :

The mega-watt class Lower-hybrid Current Drive (LHCD) system for KSTAR consists of three subsystems; RF source, transmission-line, and launcher. It is to upgrade the current system of 5 GHz, 500 kW pulsed LHCD system in KSTAR to 2 MW CW operations. The present RF source of klystron (Toshiba TETD RD E3762) has been tested at 500 kW output for 1000 sec which is required for the ITER operations. We confirmed that all water temperatures in the cooling channels are saturated. We also investigated thermal distribution and stresses of the output windows as a critical component for CW operations. To maximize the power transmission from the klystron to the launcher in a low-loss transmission line, we designed a mode converter from the circular TE01 to rectangular TE10 modes. For the launcher design, the parallel refractive index of LH waves is determined through simulations on wave propagation and damping using ray tracing and Fokker-Planck codes. Then, we design the 5-GHz PAM launcher using HFSS and ALOHA codes. It is optimized for the proper RF radiation to minimize the RF reflection from the plasmas. And it is to facilitate the installation of the cooling facility for the CW operations. The conceptual design includes the high voltage power supply for MW operations.

Nuclear fusion(C)/0785 P1-pl.048

First-principles calculations on tritium solution and diffusion in Li_2TiO_3

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Abstract :

In order to establish a safe and sustainable tritium fuel cycle in fusion reactors, it is important to predict how the 14 MeV neutron irradiation and the lithium burnup change the performance and properties of tritium breeding materials during the reactor operation. However, the radiation damage processes and effects in tritium breeding materials are yet to be systematically understood. In fact, the radiation effects on breeder properties are not usually considered in the design of the fusion blanket, which may cause a problem in the long-term performance of the blanket.

In this year, we started a 3-year research project to construct theoretical models to predict changes of four important material properties (elastic constants, volume, thermal conductivity and tritium inventory) of Li_2TiO_3 (LT) during the operation of fusion reactors by means of multi-scale modeling techniques. Specifically, we aim to express the material properties as a function of radiation damages in the unit of dpa. In this presentation, after introducing the overall plan of this project, we will present preliminary results on the evaluation of tritium inventory in LT. At this stage, we do not consider the influence of radiation defects.

The tritium inventory and release in a He sweep gas, which may contain a small amount of D_2 for the release enhancement, is affected by (i) tritium generation rate, (ii) tritium/deuterium diffusion coefficients, (iii) tritium/deuterium desorption rates, and (iv) tritium/deuterium absorption rate. As the first step for modeling the tritium inventory and release in tritium breeders, we determine the solution energies and the activation energies for diffusion of tritium in LT by the quantum mechanical calculation using the VASP code in the present study. The calculation results show that tritium is solute in LT mainly with forming a hydroxyl by binding to a constituent O^{2-} ion. The stability of tritium is dependent on the angle of Ti-O-T, which would reflect the directional interaction of O2p orbital. The diffusion is basically composed of two types processes: a jump of tritium from one O^{2-} to another and a rotation of tritium around O^{2-} atom.

Nuclear fusion(C)/0790 P1-pl.049

Development of a simulator for release and retention behaviors of hydrogen isotopes in damaged tungsten materials

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Abstract :

The tritium retention in plasma facing components such as tungsten is considered as a key fusion engineering issue because the retention amount affects the feasibility and economy of tritium fuel cycle and restricts plasma operation scenarios to satisfy a radiation-safety regulation limit. In this decade, many researches were conducted to understand the behavior of tritium in tungsten under a radiation environment. For example, release behaviors of deuterium from tungsten specimens irradiated by neutrons or high-energy ions were studied by thermal desorption spectroscopy (TDS) in experiments. The interaction energies and mechanisms between hydrogen and lattice defects such as vacancies were investigated by first-principles calculations and molecular dynamics (MD) calculations in computational simulations.

In the present study, we developed a simulator to evaluate the release and retention behaviors of hydrogen isotopes in damaged tungsten. The simulator calculates variation in the concentration of hydrogen, hydrogen-defect complexes and defects in a tungsten material by solving rate equations numerically. The rate equations are built with kinetic models, which are based on the computational simulation results of hydrogen-defect interactions. In the current version, vacancies, vacancy clusters, grain boundaries and surfaces were taken into account as defects. The simulator is written by C/C++ and has a capability of openMP parallelization. Benchmark tests were performed in comparison with available TDS experiment data and deuterium depth profile data. The deuterium release patterns and the depth profiles were reasonably reproduced by the simulator in various damage conditions and heating conditions. Some subjects for further development and the future development plan will be discussed in the presentation.

This research has been supported by National Research Foundation (NRF) of Korea under Nuclear Fusion Basic Research program.

Nuclear fusion(C)/0053 P1-pl.050

Fabrication, Joining and Proton Irradiation of SiC_f/SiC for Fusion Reactor Applications

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Abstract :

SiC_f/SiC is the prime candidate for the structural components in fusion reactor owing to its excellent thermal properties and low induced radioactivity under irradiation. Being a covalent and brittle ceramic, the fabrication of damage-tolerant SiC-based composites has always been a major challenge. We report here the utility of electrophoretic deposition (EPD) to infiltrate SiC particulate matrix into Tyranno® SiC fabric and then subsequent hot-pressing of stacked fabrics at 1750°C and 20 MPa. Approaches such as ultrasonication-assisted EPD, stacking of SiC green tape, deposition of a weak pyrolytic carbon (PyC) coating on SiC fibers comprising Tyranno® SiC fabric, post-sintering thermal treatments were implemented to administer efficient matrix infiltration, high overall densities, and better toughness. For hollow tubular specimens, two types of preforms of filament wound and jelly-rolled with different woven structures were utilized.

Further to produce integrated SiC_f/SiC assemblies, simple geometries such as flats and tubes were butt-joined utilizing Ti-based MAX phase (Ti_3AlC_2) at 1750°C and 3.5 MPa for 1-2 h soaking time. Decomposition of Ti_3AlC_2 and diffusion of resulting phases into base materials yielded pore- and crack-free joints coupled with joining strengths close to 150 MPa. By inserting green tapes casted out of MAX phase, flats, tubes and bars specimens were joined to produce layered multichannel complex structures.

Irradiation-induced damage in proton-irradiated SiC_f/SiC up to a fluence level of 10^{18} p^+/m^2 (E > 14 MeV) were evaluated in terms of microstructural evaluation as well as variation in flexural strength. Crack formation, pore generation and surface amorphization with respect to SiC fiber and matrix in SiC_f/SiC sintered using Sc-nitrate and Al_2O_3-Y_2O_3 were compared. The matrix phase was comparatively more crack-resistant in the SiC_f/SiC with Sc-nitrate than that with Al_2O_3-Y_2O_3 although no significant changes in the flexural behavior before and after irradiation were observed.

Acknowledgments

This study was supported by the National R&D Program funded by the Ministry of Science, ICT & Future Planning (Grant no. 2014M1A7A1A02029408).

Nuclear fusion(C)/0221 P1-pl.051

Study on the burst mode laser by Q-switching for plasma diagnostics

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Abstract :

Diagnostics of pulsed plasma or rapidly changing plasma characteristics need a fast Thomson scattering system. The system is composed of a high frequency, high energy laser source and a fast spectrometer. Our final goal is to develop the burst mode laser and polychromator using VPHG, which will be combined to build the fast Thomson scattering diagnostic system. This system, which has the electron temperature detection range of 10 eV - 1 keV, will be used to study the plasma characteristics in VEST.

In this study, we fabricated the burst mode laser oscillator by Q-switching. Q-switching system is composed of 20 W Yb pulse laser, EO modulator equiped with BBO pockel cell.

As a results, we have achieved the burst mode operation at 1.6 kHz frequency and 0.1 mJ/pulse.

본 연구는 '고속톰슨산란에 의한 플라즈마 진단' 과제로 연구재단에서 핵융합기초연구사업(과기정통부)으로부터 지원받은 연구임.

Nuclear fusion(C)/0697 P1-pl.052

플라즈마 대면재용 텅스텐 합금 설계를 위한 고속대량스크리닝 실험

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Abstract :

핵융합로의 플라즈마 대면재로써 W 기반의 합금이 연구되고 있지만 제한적인 조성영역에 대한 연구만 이루어진 것이 한계이다. 본 연구에서는 넓은 범위의 조성을 갖는 W 기반 합금을 연구하기 위해 고속 대량 스크리닝 기법을 이용한다. 이 기법은 조합 합성법 (Combinatorial Synthesis)을 이용한 샘플 제작과 고속대량스크리닝 측정법으로 구성된다. 샘플 제작은 MEMS 공정과 Magnetron Sputtering 을 이용하여, 실리콘 웨이퍼 위에 수백개의 박막 샘플이 각기 다른 조성을 갖게 한다. 합성된 박막 시편들은 직접 제작한 로보틱 스테이지와 Membrane Deflection Method (MDE)를 접목해서 조성에 따른 기계적 물성을 측정할 수 있다. 이 방법은 기존의 단일 조성의 물성 평가보다 빠르게 광범위한 범위의 조성에 대한 기계적 물성을 테스트할 수 있을 것으로 예상된다. 이 기법을 조사 전 후의 샘플에 대해 수행하면, 이상적인 플라즈마 대면재용 재료를 획기적으로 빠르게 찾을 수 있을 것으로 기대된다.

"본 연구는 한국연구재단 핵융합기초연구사업의 지원으로 수행되었음 (과제번호 2017M1A7A1A01016221)."

Nuclear fusion(C)/0154 P1-pl.053

Fabrication and Testing of 3D Metal Printing Mockups for Plasma Facing Components of Nuclear Fusion Reactor

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Abstract :

The divertor should remove the extreme heat flux up to 10 MW/m^2 and the various type of divertor have been developed for enhancing the heat transfer such as hypervapotron, twisted tape insertion, etc. For the limitation of complexity to mechanical machining, three-dimensional (3D) metal printing technology by direct energy deposition is used to fabrication of multi-layer cooling devices for the development of fusion divertor research, and for the optimization of the thermo-hydraulic performance with water cooling in a Korean heat load test facility using an electron beam (KoHLT-EB). An optimized cooling structure was fabricated with Al-bronze commercial metal powder by using 3D printing. Preliminary thermal-hydraulic analysis was performed to confirm the effects of the inner cooling geometry with a conventional CFD code, ANSYS-CFX. 3D printed divertor mockup was designed and fabricated based on the optimization of the 3D cooling structure. KoHLT-EB was used to evaluate the enhancement of the cooling capacities. The present research results will contribute to the development of a Korean fusion reactor and DEMO program.
이 논문은 2017 년도 정부(과학기술정보통신부)의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구사업임 (핵융합기초연구사업, NRF-2015M1A7A1A01002474).
This research was supported by the National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT of the Republic of Korea (NRF-2015M1A7A1A01002474).

Elemental & group IV semiconductors(A)/0802 P1-se.001

Growth of GeS single crystal by gradient temperature method

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Abstract :

The orhohombic IV-VI monochalcogenides (SnSe, SnS, GeSe, GeS) have attracted considerable interest for the discovery of excellent thermoelectric performance. Some calculated publications also refer that Germanium sulfide (GeS) is very promising for thermoelectric applications as well as its excellent optical, photoelectrical and electric properties in two dimensional (2D-type. In this work, single crystal GeS was syntheized by gradient temperature mothod with the changing of concentration of precursor. Furthermore, GeS has been doped with some elements such as Ag, Sn, Se, Te and Bi. The structure and vibration properties of as-grown materiala were investigated by Raman spectra and X-ray diffraction (XRD). The surface morphology of GeS was also characterized using scan electron microscopy (SEM). We will discuss on the potential of these materials in electronic and optoelectronic devices.

III-V compound semiconductors(C)/1165 P1-se.002

Optical Properties of InAs/GaSb Multiple Quantum Wells by Photoreflectance Spectroscopy

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Abstract :

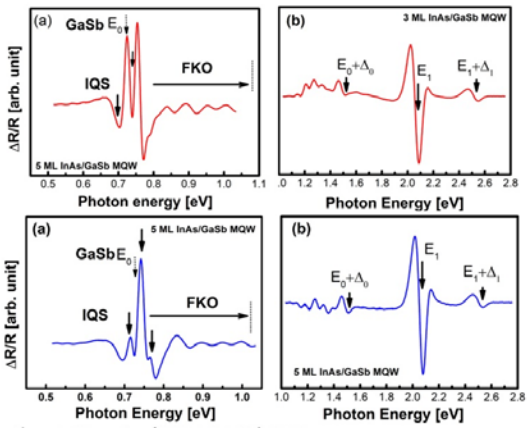

Figure 1. PR spectra of 3 ML InAs/ GaSb MQW
Figure 2. PR spectra of 5 ML InAs/ GaSb MQW

We have investigated optical transitions in the InAs/GaSb multiple quantum wells (MQWs) by photoreflectance (PR) spectroscopy with various temperatures and excitation intensities. PR measurements were performed using a 405 nm laser diode as an excitation source. The probe beam obtained from a tungsten-halogen lamp dispersed through a monochromator. The reflected beam was collected by using a Si (400 ~ 1100 nm : high energy region) and InGaAs (1200 ~2400 nm : low energy region) photodiodes.

The PR was employed to investigate the inter-band transitions such band-to band (E_0), spin-orbit split off ($\Delta 0$), E_1 and $\Delta 1$ of GaSb [1] as well as their interface quantum states (IQS). PR spectra were measured at temperatures ranging from 10 to 300 K.

Figure 1 and 2 show the room temperature PR spectra for 3 ML InAs/GaSb MQW and 5 ML InAs/GaSb MQW, respectively. PR spectra of the InAs/GaSb MQWs showed the E_0 transitions, the Franz-Keldysh oscillation (FKO) and IQS. We confirmed the transition energies from 0.72 eV, 1.52 eV, 2.07 eV and 2.53 eV corresponding to the E_0, $E_0 + \Delta 0$, E_1 and $E_1 + \Delta 1$, respectively.[2] Comparison of room temperature PR spectra for 3 ML and 5 ML InAs QW, we observed sharp transition features due to the IQSs from the interface of InAs/GaSb.

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3 차원 LED 의 역방향 누설전류의 원인 및 그 해결 방안 분석

Analysis on anomalous reverse biased leakage current in 3-dimensional LEDs

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Abstract :

III-nitride 물질은 조성비에 따라 자외선부터 가시광까지 넓은 대역의 밴드갭 에너지를 보유하여 오늘날 발광 소자로 널리 활용되고 있다. 게다가 선택적 성장(selective area growth) 기법을 활용하여 3 차원 구조체를 형성할 경우, 결함 밀도 감소 및 다양한 반 및 무극성 면의 활용으로 높은 양자 효율을 기대할 수 있다 [1]. 최근에는 질화갈륨 기반 3 차원 구조체를 활용하여 형광체를 사용하지 않고도 백색광을 구현하는 연구가 진행되어 [2], 3 차원 LED 에 대한 연구 수요가 증가하고 있다. 하지만 3 차원 구조체는 2 차원 평면 구조와 비교하여 공정 조건이 최적화 되어있지 않아, 높은 양자효율에도 불구하고 낮은 최종 효율을 보인다. 효율을 감소시키는 원인으로는 3 차원 LED 에서의 비정상적인 역방향 누설 전류를 들 수 있다. 또한 구조체 단차에 의한 전극 끊김 현상 혹은 전류 밀집 현상 등이 광 출력을 낮추는 걸림돌로 존재한다. 본 연구에서는 3 차원 LED 의 높은 효율 및 광 출력을 위하여 역방향 누설전류의 원인과 그 해결방안을 모색하였다. 또한 3 차원 LED 공정 단계 별 구조 확인 작업을 통하여 성능 저하가 일어나는 단계를 찾고자 하였다.

3 차원 구조체를 성장하기 위하여 2 차원 GaN 박막에 절연체 마스크를 증착하고 포토리소그래피(photolithography) 방법을 이용하여 일부분을 표면에 드러내었다. 이후 금속유기 화학기상증착법(Metalorganic chemical vapor deposition, MOCVD)을 이용하여 GaN 3 차원 구조체를 성장하였다. 구조적 분석을 위하여 성장된 구조체의 주사전자현미경(scanning electron microscope, SEM) 이미지를 얻었고, 음극성발광(cathodoluminscence, CL) 신호를 측정하였다. 이후 전기적 특성 측정을 위하여 구조체 및 마스크 위 지점들 사이에서 전류-전압 특성을 확인하였다.

실험 결과 MOCVD 재성장 과정에서의 마스크의 절연 특성 저하를 확인하였다. 성장 시의 고온 및 수소와 암모니아가 혼합된 분위기는 절연 특성을 파괴하지 않은 반면, Ga 소스를 집어넣어 성장을 진행할 경우 큰 전류가 흐름을 확인하였다 [3]. 특히 비정상적인 누설 전류는 n 형 불순물원인 SiH_4 을 함께 주입하였을 때 크게 나타났다. Si 불순물이 누설 전류에 미치는 영향을 파악하기 위하여 XPS 분석을 통해 절연 마스크의 표면 상태를 확인하였다.

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III-V compound semiconductors(C)/1068 P1-se.004

Temperature dependent-photoreflectance of InSb/GaSb quantum dot

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Abstract :

We performed temperature dependent-photoreflectance (PR) of InSb/GaSb quantum dots (QDs) grown by droplet epitaxy. To investigate the effect of InSb QD on GaSb optical transitions, the InSb QD was embedded in GaSb matrix.

PR measurements were performed using a 405 nm laser diode as an excitation source. The probe beam obtained from a tungsten-halogen lamp dispersed through a monochromator. The reflected beam was detected by a Si (400 ~ 1100 nm) and InGaAs (1200 ~2400 nm) photodiodes. PR spectra were measured at temperatures ranging from 10 to 300 K.

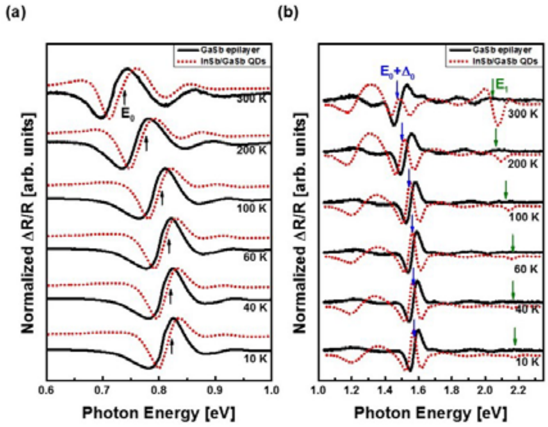

Figure 1. Temperature dependent-PR spectra for InSb/GaSb QD and GaSb epilayer as a reference.

Figure 1(a) shows PR spectra of the temperature-dependent GaSb band-to-band transition for InSb/GaSb QDs and GaSb epilayer. Dotted and solid lines represent the QD and the epilayer, respectively. In Fig. 1(b), the PR spectra show the transition between the conduction band and the spin-orbit split off band in the Γ valley ($E_0 + \Delta_0$), and the E_1 transition with various temperatures [1]. The GaSb E_0, $E_0 + \Delta_0$ and E_1 transition signal are blue-shifted as decreasing temperature due to the lattice shrinkage. In addition, the transition (X) around 1.25 eV was newly observed in InSb/GaSb QD. It will be discussed in the presentation.

III-V compound semiconductors(C)/1050 P1-se.005

Optical properties of InAs/GaAsSb submonolayer quantum dots by photoreflectance spectroscopy

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Abstract :

We performed photoreflectance spectroscopy (PR) to investigate the Sb-composition effect on the optical transitions for InAs/GaAsSb submonolayer quantum dot (SML-QD).PR measurements were performed by using a 637 nm laser diode as an excitation source. W-halogen white light was monochromized by monochromeater as a probe beam, and the reflected beam was detected by a Si photodiode. The SML-QDs were grown by a solid-source molecular beam epitaxy (MBE) system on a semi-insulating GaAs (001) substrate. Figure 1 shows the schematic layer structure of SML-QDs. The structure is consisted of a 400 nm undoped GaAs buffer layer, 40 stacks SML-QDs with InAs (0.5 ML)/GaAsSb (2.5 ML) and 20 nm cap layer. To form SML-QD, eight periods of InAs/GaAsSb/GaAs layers were embedded. [1] Figure 2 exhibits room temperature PR spectra of SML-QDs with various Sb compositions (%). When the Sb-composition is 0, the GaAs and InAs SML-QD transition are appeared at 1.42 eV and 1.33 eV, respectively. As increasing the Sb-composition from 0 to 19.4%, the SML-QD transition is shifted toward low energy due to the increment of Sb-composition while the GaAs band to band transition was maintained regardless of Sb-composition.

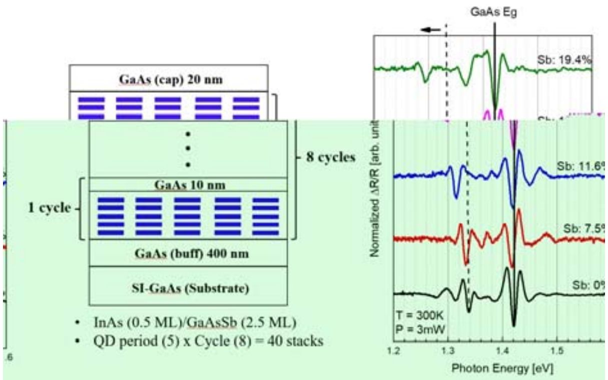

Fig. 1. Schematic layer structure of InAs/GaAsSb/GaAs SML-QD
Fig. 2. Room temperature PR spectra of SML-QDs with various Sb-compositions (%)

[1] S.H. Lee, J.S. Kim, S. Yoon, Y. Kim, S.J. Lee and C.B. Honsberg,Proceedings of the 45th International School and Conference on the Physics of Semiconductors “Jaszowiec”, Szczyrk, No. 5 (2016)

III-V compound semiconductors(C)/0933 P1-se.006

Boron nitride nanotube as an intermediate layer for high performance light-emitting diodes

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Abstract :

LED 소자는 고작 에너지의 20%만 빛으로 발산하고, 나머지 80%의 에너지는 열로 방출한다. 이렇게 발생한 열은 LED 소자의 신뢰성을 떨어뜨리고, LED 의 전기적, 광학적 특성에 악영향을 미친다. 최근에 최근 높은 열전도도, 화학적 내구도, 열적 내구도, 휨 특성의 장점을 가지는 graphene, hexagonal-boron nitride (h-BN), carbon nanotube 를 포함한 저차원의 나노물질을 사파이어 기판 위에 버퍼층으로서 사용하여 고품질의 GaN 박막을 성장하는 연구가 진행되었다. 하지만 h-BN 과 graphene 의 c 축방향으로의 dangling bonds 없기 때문에 낮은 표면 에너지에 의하여 GaN 박막의 직접적인 성장은 힘들다.

본 연구에서는 고효율, 고신뢰성을 갖는 LED 소자를 제작하기 위하여 우수한 열전도성을 가지는 boron nitride nanotubes (BNNTs) 를 사파이어 기판 위에 GaN 박막과의 중간층으로서 적용하였다. 그 결과, BNNTs 가 삽입된 LED 소자의 표면온도는 일반적인 LED 소자보다 평균 8℃ 도 낮았다. 이는 BNNTs 의 우수한 열전도성과 사파이어 기판에서 발생하는 결함들을 효과적으로 막았기 때문이다.

III-V compound semiconductors(C)/0882 P1-se.007

Influence of the surface morphology of the AlN buffer layer on the properties of GaN epilayer growth on Si(111) substrate.

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Abstract :

The influence of the surface morphology of the AlN buffer layer on the properties of GaN epilayer grown on Si(111) substrate has been systematically studied. The GaN epilayers were grown on Si(111) substrate using an only AlN buffer layer by metal organic chemical vapor deposition(MOCVD). Optimum V/III ratio and thickness could improve the AlN surface morphology and reduce the root mean square(RMS) roughness. Based on these results, the optimized AlN growth parameter was found to be essential to achieve an appropriate surface morphology for high crystal quality of GaN. A nearly crack-free 2.5 μm GaN epilayer was obtained with a 130 nm thick AlN buffer layer at a V/III ratio of 1860. The full-width at half maximum (FWHM) of (002) plane measured by x-ray diffraction was as low as 378 arcsec.

III-V compound semiconductors(C)/0250 P1-se.008

Facile growth of high-quality InSb thin films on GaAs (001) substrates by using $In_{1-x}Al_xSb$ continuously-graded buffer layer

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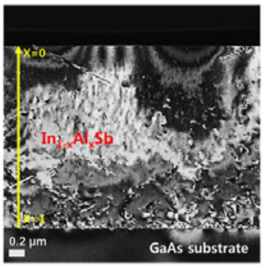
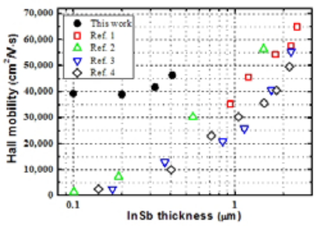
Abstract :





To grow high-quality InSb films on GaAs substrates, $In_{1-x}Al_xSb$ continuously-graded buffer (CGB) technique is used. Composition coefficient x of $In_{1-x}Al_xSb$ CGBs is determined from the flux of Al, controlled by its effusion cell temperature. Structural and electrical properties of $In_{1-x}Al_xSb$ CGB films are characterized by energy dispersive spectroscopy, strain mapping, transmission electron microscopy, and Hall measurements. The InSb thin films of 410 ~ 100 nm thickness, grown on $In_{1-x}Al_xSb$ CGB buffers/GaAs substrates by molecular beam epitaxy, exhibit electron mobilities of 46,300 ~ 39.290 $cm^2/V\cdot s$, higher than previously-reported ones for the same InSb thicknesses.

III-V compound semiconductors(C)/0065 P1-se.009

조성이 $Al_xGa_{1-x}N$ 화합물반도체 박막의 결정구조와 광학적 특성에 미치는 영향

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Abstract :

유기금속 화학증착법 (MOCVD)을 이용하여 사파이어(Al_2O_3) 기판(0001) 위에 GaN 박막을 먼저 성장한 다음 $Al_xGa_{1-x}N$ 박막을 성장하였고, 박막의 조성이 결정구조와 광학적특성에 미치는 영향을 연구하였다. 성장된 박막들은 결정구조를 알아보기 위하여 HRXRD 패턴을 이용하였고, 박막의 표면 상태를 알아보기 위하여 원자간력 현미경(atomic force microscope;AFM)을 이용하였다. 또한 박막의 화학성분과 결합상태를 알아보기 위하여 x 선 광전자분광분석기(x-ray photoelectron spectroscopy; XPS)를 이용하여 분석하였다. 박막의 광학적 특성을 알아보기 위하여 분광학적 타원 편광 분석법 (spectroscopic ellipsometry;SE)을 사용하여 실온에서 2.0 - 8.7 eV 사이 포톤에너지 범위에서 측정하였다. 측정된 데이터들은 유사유전함수 스펙트럼 $<\varepsilon(E)>=<\varepsilon 1(E)>+i<\varepsilon 2(E)>$에 나타난 $E0$, $E1$,그리고 $E2$ 와 같은 임계점 구조에 대하여 연구하였다. 타원 편광 분석법을 이용하여 획득된 데이터의 이계도함수를 이용하여 각각의 임계점 피크들을 구하였다. Al 의 성분이 증가함에 따라 피크는 고에너지쪽으로 이동하는 것을 볼 수 있었다.

II-VI compound semiconductors(B)/0622 P1-se.010

Sn 을 촉매로 성장된 Wurtzite CdTe 나노선

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Abstract :

금(gold) 나노입자는 기상-액상-고상 (vapor-liquid-solid) 기구에 의한 나노선 성장에서 널리 사용되는 촉매이다. 그러나 금은 나노선에 깊은 준위를 형성하므로 이를 대체할 새로운 촉매가 널리 탐색되고 있으며 하나의 가능성으로 저온의 융점을 가진 Sn 을 촉매로 사용하였다. FTO (Fluorine doped Tin Oxide) 기판을 이용해 물리기상전달법으로 전기로(furnace) 중심에 CdTe 분말을 두고, 저온부에 기판을 위치시켜 나노선을 제작하였다. X 선 회절(XRD), 전계방출주사전자현미경(FESEM), 투과전자현미경(TEM)을 이용하여 CdTe 나노선의 결정구조와 성장원리를 알아보고, micro-PL 장치를 이용해 CdTe 의 밴드갭을 분석한다. **This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2015R1D1A3A01015615).**

II-VI compound semiconductors(B)/0581 P1-se.011

Size-dependent photoluminescence and lifetime in CdSe nanocrystals

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Abstract :

Interest in colloidal semiconductor nanocrystals (NCs) has kept growing at an increasing pace, mostly driven by the exceptional optical properties these NC's possess. NCs whose excitons are confined in all three dimensions have the ability to tune the size for the wide area of applications. Among them, CdSe NCs can be used to synthesize the shape of nearly spherical morphology and emit visible light containing the three primary colors. For synthesizing high quality CdSe NCs need good precursors, solvents, ligands in a very broad size range. In this work, we synthesized monodisperse CdSe NCs which were synthesized by a hot-injection technique with different sizes. Absorption and photoluminescence measurements are performed to understand the optical properties of CdSe NCs with various size. Transmission electron microscopy are carried out to the size-dependent structural properties of CdSe NCs. Time-resolved photoluminescence were measured to examine the evolution of surface states for the CdSe NC's growth. Our results provide a thorough general framework to calculate and understand the optical properties of suspended NCs.

II-VI compound semiconductors(B)/0477 P1-se.012

micro-PL 을 이용한 Wurtzite ZnTe 나노선의 밴드갭 측정

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Abstract :

물리기상전달법으로 320˚C 의 저온에서 FTO(Fluorine-doped Tin Oxide) 유리 기판 위에 ZnTe 나노선을 성장하였다. FTO 의 주석(Sn)을 촉매로 하여 기상-액상-고상 (vapor-liquid-solid) 기구을 통한 ZnTe 나노선을 얻을 수 있었고, 그 결정 구조는 흔히 보고된 cubic zinc blende 가 아닌 hexagonal wurtzite 구조임을 확인하였다. 본 연구는 micro-PL 장치를 이용하여 상온에서 단일 나노선의 편광 의존 PL 및 파워 의존 PL 스펙트럼을 측정하였다. 이를 분석하여 그동안 알려지지 않았던 wurtzite ZnTe 의 기본 밴드갭 값을 측정할 수 있었다. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2015R1D1A3A01015615).

II-VI compound semiconductors(B)/0393 P1-se.013

Si 기판 위에 성장한 CdTe/ZnTe 양자점에서 CdTe 두께에 따른 특성 연구

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Abstract :

0 차원 구조를 가지는 화합물 반도체 양자점은 엑시톤의 방출 재결합(Radiatve recombination)을 바탕으로 레이저 (laser), 단일 광 자원(Single-photon sources), 양자 정보 처리 (Quantum information processors)와 같은 광전 소자로써 응용되어질 수 있어 주목되어지고 있다. 이와 같이 다양한 분야로써 양자점을 활용되어지기 위해서는 양자점의 크기, 분포, 모양과 같은 특성 조절과 광학적 특성에 대한 이해가 필요하다. II-VI 족 화합물 반도체 양자점 중에서도 CdTe 양자점은 높은 엑시톤 결합에너지와 녹색 스펙트럼 영역을 필요로 하는 광학적 장치들에 대한 응용 가능성을 높게 평가 받고 있다. 또한 Si 기판을 이용한 연구에서는 Si 이 가지는 고유 격자 상수로 인하여 박막 형성 시 발생하게 되는 격자 부정합 때문에 GaAs 기판 위 연구가 대부분 이며, 이에 따라 Si 위에 성장한 양자점의 연구가 부족한 상태이다. 하지만, Si 기판은 GaAs 기판에 비해 가격이 저렴하다는 장점을 가지며, 이로 인해서 대량 생산이 가능하다는 이점을 가지고 있다. 본 연구에서는 분자 선속 에피 성장법(Molecular Beam Epitaxy; MBE)과 원자 층 교대 성장법(Atomic Layer Epitaxy; ALE)을 이용하여 Si 기판 위에 성장한 CdTe/ZnTe 양자점에서 CdTe 두께에 따른 구조적, 광학적 특성을 연구하였다. AFM(Atomic Force Microscopy) 측정 결과 CdTe 두께가 증가할수록 양자점 크기의 증가와 동시에 밀도의 감소를 확인 할 수 있었다. 그리고 저온 광 루미네센스 측정(Photoluminescence; PL)을 측정 결과 CdTe 두께가 증가할수록 양자점의 피크 위치(Peak position)가 낮은 에너지로 이동함을 보였는데, 이는 CdTe 두께가 증가할수록 양자점의 크기가 커짐에 따라 가전자대와 전도대의 밴드갭(Band gap)이 감소하였기 때문이다. 또한 CdTe 두께가 증가할수록 양자점 피크의 반치폭(Full Width at Half Maximum; FWHM)이 증가함을 관찰 할 수 있는데, 이는 양자점 크기의 균일성 감소의 결과이다. 마지막으로 온도 의존 광 루미네센스 측정을 통해 CdTe 두께 변화에 따른 열적 활성화 에너지에 대해 연구하였다.

Nitrid & oxide semiconductors(D)/1070 P1-se.014

차세대 전력 반도체 소자용 후막 GaN 에피층 성장과 특성

유명선 [1], 진유신 [1], 김하림 [1], 임주현 [1], 박상훈 [1], 배숭근 [2], 전인준 [2], 전헌수 [2,3], 김경화 [2,3], 양민 [2], 이삼녕 [2], 안형수 [*2,3], 김석환 [4]

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Abstract :

고효율의 파워 반도체 소자의 수요가 증가됨에 따라 그동안 전자 소자의 핵심 소재로 사용되어 왔던 Si 과 함께 GaN, AlN 그리고 SiC 등과 같은 넓은 에너지 밴드갭 (WBG; wide band gap)을 가진 반도체 재료의 연구가 활발히 진행되고 있다. 이러한 WBG 반도체는 Si 에 비해 높은 스위칭 주파수 능력과 높은 항복전압을 가지며, 열전도율이 높아 초고전력의 전력 변환 장치의 핵심 재료로 응용이 가능할 것으로 기대된다. 화합물 반도체 에피층을 성장하는 기술로는 MOCVD, MBE, HVPE 등이 있으며, HVPE 방법은 금속 원료와 반응 가스를 이용한 방법으로써 낮은 공정 비용과, 높은 수율의 장점이 있으며, 단시간 내에 고품질의 후막 에피층을 성장시킬 수 있는 장점이 있다. 본 연구에서는 차세대 전력 반도체 소자용 후막 GaN 에피층을 소스영역이 RF 로 구성된 혼합소스 HVPE (mixed-source hydride vapor phase epitaxy) 방법에 의하여 성장하였다. 금속 Ga, HCl 가스, NH3 가스와 캐리어가스로 N2 가 사용되었다. 소스영역의 온도는 900 °C, 성장 영역의 온도는 1090 °C 에서 연속적으로 (0001) 사파이어 기판위에 성장되었고, GaN 에피층은 시간당 수십 ㎛의 성장률을 보였다. FE-SEM 측정과 EDS 측정 그리고 XRD 측정 결과로 부터 양질의 후막 결정성을 가짐을 확인 할 수 있었다. 이는 새롭게 고안된 HVPE 방법으로 양질의 차세대 전력 반도체 소자용 후막 GaN 성장이 가능하고, GaN 기판의 제작이 가능함을 알 수 있으며, 이 결과로부터 차세대 전력 반도체 소자의 응용이 기대된다.

Nitrid & oxide semiconductors(D)/1059 P1-se.015

고품질 후막 AlN 성장을 위한 HVPE AlN 에피층 성장

전인준 [1], 배숭근 [1], 전헌수 [1,2], 김경화 [1,2], 이재학 [1,3], 양민 [1], 이삼녕 [1], 안형수 [*1,2], 김석환 [4]

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Abstract :

AlN 는 자외선 영역의 광소자의 주재료로 사용되어 왔으나 높은 항복전압과 낮은 On-resistance 의 특성을 가짐으로써 최근에는 고전력의 파워 반도체 소자의 주 재료로 주목 받고 있다. 특히 AlN 는 GaN 와 SiC 처럼 Si 에 비해 높은 밴드갭을 가져 고주파수와 고전력 동작에 적합한 재료이기 때문에 Si 전자소자를 대체할 수 있고, 우수한 내구성과 열전도도를 가지고 있기 때문에 발열이 많은 고전력 파워 반도체에 적합한 물질이다. 그러나 AlN 을 성장할 때 생기는 사파이어 기판과의 격자 상수 차이와 열팽창계수의 차이로 인해 고품질의 AlN 에피층을 얻는 것이 어려우며, 결정 성장 후에 발생하는 관통 전위로 인해 누설 전류나 항복전압의 감소의 문제가 발생할 수 있어 이를 극복하기 위해 많은 연구가 요구된다. 본 연구에서는 혼합 소스 HVPE 방법을 이용하여 AlN 차세대 전력 반도체 소자의 기반으로 사용될 양질의 AlN 에피층을 사파이어 기판 위에 직접 성장하였다. 일반적으로 MOCVD 법으로 고품질 AlN nucleation layer 를 성장시키고 후막 AlN 을 성장시키는 것이 일반적이지만, HVPE 방법으로 직접 기판에 연속적으로 성장시킬 수 있다면 경쟁력 있는 방법이 될 것으로 기대된다. XRD 측정을 통하여 혼합 소스 HVPE 로 성장된 AlN 의 결정 구조상의 변화를 관찰하고, SEM 을 통해 성장된 에피층의 표면을 관찰하였다. 성장된 AlN 에피층은 강한 (0002) 면을 가진 회절 결과를 관찰할 수 있었고, rocking curve 결과를 통하여 소자의 제조나 AlN 기판을 성장시킬 수 있는 양질의 AlN 에피층이 성장되었음을 확인하고, 전력 반도체 소자를 위한 양질의 AlN 기판을 제조할 수 있음이 기대된다.

Nitrid & oxide semiconductors(D)/1053 P1-se.016

혼합소스 HVPE 방법으로 성장한 Mg-doped AlN 의 Mg 의존성

배숭근 [1], 전인준 [1], 전헌수 [1,2], 김경화 [1,2], 양민 [1], 이삼녕 [1], 안형수 [*1,2], 이재학 [1,3], 김석환 [4]

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Abstract :

전력 변환 장치의 에너지 손실을 최소화하기 위하여 넓은 에너지 밴드갭(WBG; wide band gap)을 가지는 반도체 재료인 SiC 나 GaN, AlN 등이 차세대 고전력 파워 반도체 소자의 주 재료로 연구되고 있다. SiC 는 자동차의 반도체 소자 재료로, GaN 는 고주파수의 IGBT 소자의 주 재료로 각광받고 있다. 한편 AlN 는 6.2 eV 의 넓은 밴드갭을 가지고 있어 자외선 광소자의 주 재료로 사용되어 왔으나, SiC 나 GaN 에 비해 높은 항복 전압과 낮은 On-resistance 를 가질 뿐 아니라 열전도율이 높아 초고전력의 전력 변환 장치의 핵심 재료가 될 것으로 기대되고 있다. 그러나 결정성장의 측면에서 고품질의 에피층을 성장시키기 힘들고, 소자로 응용되기 위해선 높은 전기전도성을 가지는 AlN 를 제조해야하는데, p, n 형 도핑의 어려움과 결정결함의 증가로 인하여 AlN 기반의 파워 반도체 소자 제조는 해결해야할 과제가 많다. 본 연구에서는 혼합소스 HVPE 방법을 이용하여 Mg 이 도핑된 AlN 에피층을 성장하고, 성장된 에피층의 특성의 Mg 의존성을 알아보았다. 하나의 소스 영역에 Al 과 Mg 을 혼합하여 성장 원료로 사용하였으며, 에피층의 표면 형상과 결정학적인 측면에서 도핑한 Mg 의 의존성을 분석하였다. EDS 와 XPS 측정을 통한 정성 분석에서 Mg 원소를 검출함으로, AlN 에 Mg 이 도핑 되어 있음을 확인하였다. 측정 결과를 바탕으로 성장된 에피층의 Mg 도핑 농도를 최적화 된다면 우수한 p 형 AlN 에피층을 성장하기 용이할 것으로 기대된다.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Nitrid & oxide semiconductors(D)/1022 P1-se.017

전자차단층에서 정공 트랩에 의한 AlGaN 계열 깊은 자외선 발광다이오드의 비정상적 광전류 역전

임승영 [1], 김태수 [1], 박용근 [1], 정건우 [1], 문영부 [2], 송정훈 [*1]

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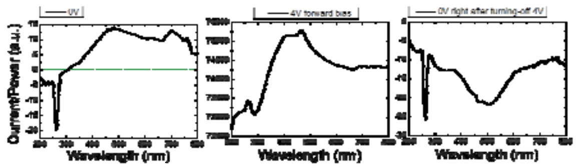
Abstract :



우리는 AlGaN 계열 깊은 자외선 발광다이오드에서 입사광 파장에 따른 광전류를 측정했고, 그 결과 가시광 영역의 흡수와 비정상적인 광전류의 역전 현상을 관측했으며, 이 현상과 활성층 주위 결함 형성의 관련성에 대해 조사하였다. 파장 의존성 광전류 측정에는 일반적인 265nm 깊은 자외선 발광다이오드가 사용되었으며, 폐회로 상태 0V 에서 측정했다. 그 결과 265nm 부근에서 흡수가 관측되었고, 300~800nm 에 넓은 범위에 걸쳐 추가적인 흡수가 관측되었다. 또한, 두 흡수에 의한 광전류의 방향은 서로 반대였다. 추가로 4V 의 순방향 전압을 걸어준 후 다시 0V 로 되돌려 측정한 결과, 서로 반대였던 광전류의 방향이 같아졌으며 원래 상태로 복구되는데 6 시간정도 소요됐다. 이러한 현상은 여태까지 어떤 발광다이오드에서도 관측되지 않았다. 이 현상들은 전자 차단층에서 일어나는 정공 포획에 의한 에너지 대역의 휨으로 일관되게 설명할 수 있으며, 이 해석을 확인하기 위해 온도에 따른 광전류 역전 현상의 변화도 측정했다. 온도가 증가함에 따라 광전류 역전이 복구되는 시간이 줄었고, 이는 포획에 의해 발생하는 효과에서 흔히 나타나는 현상이다.

Planar 구조의 Perovskite 태양전지 응용을 위한 진공증착된 NiOx p-type 산화물 반도체 박막 연구

정우일 [1], 오정석 [1], 차덕준 [1], 배수현 [2], 이상원 [2], 강윤묵 [3], 홍진표 [4], 양정엽 [*1]

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Abstract :

Planar 구조의 페로브스카이트 태양전지 응용을 위하여 hole 전도성 물질로 진공 증착된 NiOx 박막에 관하여 연구하였다. NiOx 박막은 고순도 Ni 금속 target 을 통하여 oxygen 과 Ar 가스를 이용하여 reactive sputtering 방법을 이용하여 증착 하였고, 후에 어떠한 열처리도 수행하지 않았다. NiOx 박막은 hole 을 효과적으로 전도시키고, electron 을 차단하는 역할을 수행한다. Sputtering 파워, O_2/Ar 가스 비, 작업 압력 따른 박막의 구조적, 광학적, 전기적 특성에 대하여 연구하였고, NiOx 박막을 가지는 Planar 구조의 페로브스카이트 태양전지의 광전효과에 관하여도 추가적으로 연구하였다. 그 결과 NiOx 박막은 sputtering 조건에 따라 (200) 또는 (111) 2 가지 결정 우선 방향을 가지고 증착되었고, 이에 따라 태양전지의 광전 효율 특성이 다른 것으로 관측되었다. 진공 증착된 NiOx 박막은 hole 전도 물질 및 electron 차단 물질로써 planar 구조의 페로브스카이트 태양전지에 좋은 후보가 될 수 있을 것으로 생각한다.

Nitrid & oxide semiconductors(D)/0700 P1-se.019

Effect of Oxide-Nitride-Oxide Thickness on Coupling Ratio and Back Tunneling in NAND Flash Memories

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Abstract :

Coupling ratio is one of important characteristics which determines flash memory's performance. Traditionally, to get larger coupling ratio in flash memory, oxide-nitride-oxide (ONO) structure was deposited between control gate (CG) and floating gate (FG) instead of single dielectric material. In this structure, silicon dioxide blocks electron back tunneling, while nitride makes capacitance large between two gate materials, so that floating gate voltage can be controlled easily by control gate bias. Therefore, the optimal thickness ratio between silicon dioxide and silicon nitride for ONO structure is very important issue. In addition, coupling ratio can be improved by selecting alternative high-k material, replacing silicon nitride. Thus, we modified ONO structure with various oxide-nitride thickness ratio and replaced nitride to high-k materials simultaneously to optimize ONO thickness ratio and material. Simulations were performed by ATLAS device simulator. Finally, we report these simulation results on the effect of oxide-nitride-oxide thickness on coupling ratio and back tunneling in NAND flash memories.

Nitrid & oxide semiconductors(D)/0660 P1-se.020

Contact Resistance of AlGaN/GaN Schottky Electrode

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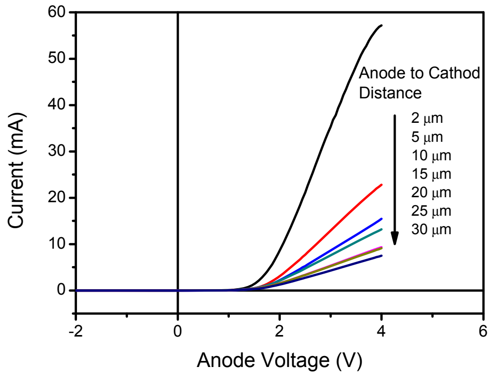
Abstract :
AlGaN/GaN 구조의 금속-반도체 쇼트키 접합에서 전류주입에 따른 Ni/Au 전극의 transfer length 를 계산하였다. 전류 주입효율이 좋을 경우 금속과 반도체 접합 전류는 transfer length 이내의 전극 가장자리에 집중되어 흐르며 AlGaN/GaN 위에 형성되는 저항성접촉의 경우 수 μm 이내의 transfer length 를 나타낸다. AlGaN/GaN 위에 형성되는 쇼트키 접합은 전류 주입 효율이 낮아 넓은 면적의 금속 접합이 필요하여 transfer length 를 고려할 필요가 없으나 전류주입 효율이 높은 경우 전류는 가장자리에 분포하여 이를 고려하여야 한다. 본 연구에서는 높은 전류 주입효율을 갖도록 AlGaN/GaN 위에 쇼트키 전극을 형성하고 선형적인 특성을 나타내는 2~4 V 의 전압에서 흐르는 전류를 고려하여 음극과 쇼트키 전극 사이의 거리에 따른 저항을 측정하여 쇼트키 접합의 저항과 transfer length 를 계산한 결과 쇼트키 전극의 transfer length 는 4.5 um 이었으며, 모니터 패턴을 이용하여 측정된 음극의 접촉 저항을 고려하면 쇼트키 전극은 1.8 Ω·mm 의 접촉저항을 나타냈다



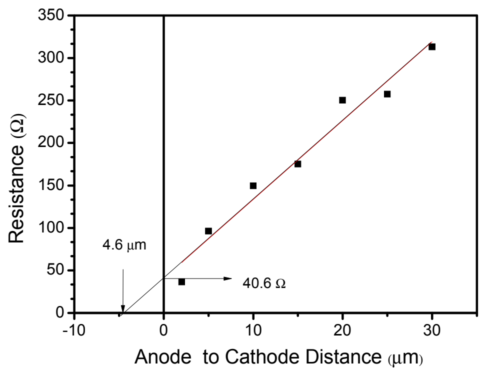


그림 1. AlGaN/GaN 위에 형성된 100 μm 폭의 Ni/Au 쇼트키 다이오드의 전류 전압 특성(좌)과 쇼트키 전극의 TLM 측정(우)

Nitrid & oxide semiconductors(D)/0492 P1-se.021

Cu 불순물이 도핑된 p 형 NiO 소재의 Cu 불순물 준위 분석

박성곤 [1], 방준호 [2], 이기문 [*1]

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Abstract :

기존의 a-Si 소재를 대체할 수 있는 소재로 투명 산화물 반도체 (TCO)가 주목받고 있으나 대부분의 산화물 반도체 소재가 ITO 와 같은 n 형 전도 물성을 갖는다는 한계가 있으며, 이는 p-n 접합 소자 등 다양한 산화물 기반 소자 개발의 걸림돌이 되고 있다. 이는 p 형 산화물의 valence band 가 산소 p 궤도 등 속박 특성이 강한 궤도로 이루어져 낮은 이동도를 보임과 동시에, n 형 소재에 비해 작은 band gap (~2 eV)을 갖는 근본적인 한계에서 기인하는 것으로 보고되고 있다. 본 연구에서는 Mott-Hubbard type 절연체 소재인 NiO 산화물에 Cu 도핑을 통하여 고투과도의 p 형 전도성 산화물 합성을 시도하였으며, 합성된 소재의 전기적/광학적 특성 분석을 통해 NiO 내의 Cu 불순물의 에너지 준위를 고찰하였다. NiO 산화물에 CuO 산화물 소재를 합성하여 $Ni_{1-x}Cu_xO$ ($0 \le x \le 0.3$) 소재를 합성하였으며, XRD 측정을 토대로 결정 구조를 분석하여 치환 도핑 여부를 확인하였다. Hall measurement 를 통해 합성한 bulk 소재의 온도에 따른 전기적 특성을 분석하였으며, 소재의 광학적 특성은 UV-vis 확산반사도 측정을 통하여 분석하였다. DFT calculation 을 통해 band gap 내의 Cu 불순물의 안정성과 에너지 준위를 고찰하였다.

Nitrid & oxide semiconductors(D)/0487 P1-se.022

V 불순물 치환을 통한 p 형 $NiWO_4$ 의 전도성 산화물의 합성 연구

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Abstract :

투명 산화물은 투명 디스플레이 및 태양 전지에서 투명 전극으로 많이 사용되고 있으나 주로 사용되는 ITO 를 포함해 n 형 위주의 연구가 대부분이며, 이는 다양한 산화물 기반 소자 개발에 한계 요인으로 지목되어오고 있다. 특히 현재까지 보고되어 오고 있는 p 형 산화물은 상대적으로 작은 band gap (~2eV)을 가지고 있으며, 또한 홀 도핑이 어렵기 때문에 고전도성 투명전극으로서의 연구가 부재한 실정이다. $NIWO_4$ 는 기존의 p 형 산화물 소재들에 비해 band gap (~2.97eV)이 큰 특징을 가지고 있다는 측면에서 불순물 치환을 통해 고투과도와 고전도도를 구현할 수 있는 p 형 소재로의 구현을 기대할 수 있다. 본 연구에서는 불순물 V 치환을 통한 p 형 $NiWO_4$ 산화물 소재의 전도도 향상 연구에 대해 보고한다. NiO 와 WO_3 및 V_2O_5 산화물 원재료 간의 고상합성(Solid-state reaction)을 통하여 W-site 에 V 이 성공적으로 치환된 $NiW_{1-x}V_xO_4$ 로 합성하였다. XRD 및 Hall Effect Measurement 를 통하여 결정구조와 전기적 특성을 분석하였고 이로 인한 홀 캐리어 전도도 향상을 관찰하였다. 또한 온도에 따른 전도도 변화 물성 측정을 통하여 V 불순물의 에너지 준위를 고찰하였다.

Nitrid & oxide semiconductors(D)/0414 P1-se.023

Effect of Al-dopants on the electrical and optical properties of ZnSnO-based thin-film-transistors

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Abstract :

Al-doped Zinc Tin Oxide (AZTO) thin films were fabricated by radio frequency (RF) co-sputtering deposition at room temperature on SiO_2/Si substrates. We used Al_2O_3 and Sn (10wt%, 30wt%)-doped ZnO targets. Al-doped ZTO TFTs were fabricated using bottom gate structure with conventional photolithography with negative-photoresist on SiO_2 (200nm)/ (heavily doped) p-type Si and Ag (Pt) electrodes were deposited. After fabrication, TFTs were annealed at 350 for 3 hours in air. To measure crystallinity and component of Al doped ZTO thin films, we used X-ray diffraction (XRD), field emission scanning electron microscope (FE-SEM) and X-ray photoelectron spectroscopy (XPS). Dielectric functions, Urbach energies, and optical gap energies of Al-doped ZTO thin films were measured using spectroscopic ellipsometry (SE). Possible defect peaks in the subgap region were investigated. We measured the threshold voltages (V_{th}), on-off ratios, field effect mobilities (μ_{FE}), and subthreshold swing (SS) of Al-doped ZTO TFTs from transfer characteristics of TFT. The Al-content dependence of the correlation of the electric and optical properties ZTO based TFT were investigated in detail.

Semiconductor devices(G)/1085 P1-se.024

극저온 칼로리미터를 이용한 미세 섬광 검출기에서 Luke-Neganov 포논 증폭기 최적 설계에 대한 연구

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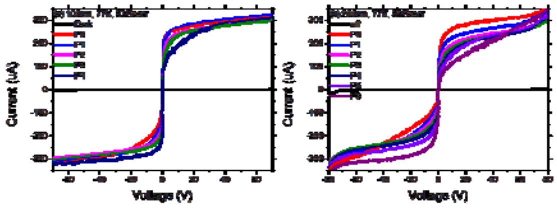
Abstract :



현재 사용되고 있는 극저온 반도체 섬광 검출기의 감도는 이론적으로 예측되고 있는 암흑물질의 검출과 중성미자가 없는 이중 베타 붕괴의 검출을 위해 충분하지 않다. 특히 낮은 에너지 영역에서 노이즈와 겹쳐서 측정이 되는 경우가 많아서 현재보다 더 높은 측정 감도를 갖는 섬광 검출기의 개발이 반드시 필요하다고 할 수 있다. 극저온 반도체 섬광 검출기의 감도를 높일 수 있는 방법이 1985 년 B. Neganov 와 1988 년 P.N. Luke 에 의해 제안 되었다 [1,2]. 기본적인 아이디어는 섬광을 검출하는 반도체 결정에 전기장을 인가해 섬광에 의해 생성된 전자 정공쌍을 표동(drift) 시킴으로써 옴열 (ohmic heat)을 발생시키고, 이를 통해 보다 높은 온도 변화를 이끌어 낼 수 있다는 방법이다. 즉 기존의 방법이 전자 정공쌍을 전도대와 가전자대에 생성시킨 후 에너지 완화 및 재결합 시 방출하는 포논만을 검출하는 방법이라면, Luke-Neganov 방법은 여기에 추가로 전기장을 인가시킴으로써, 전자와 정공을 표동시키고, 이 표동에 의한 추가적인 열의 발생을 야기시키는 방법이라고 할 수 있다. 이를 통해 10 배 이상의 감도를 갖고 문턱에너지를 획기적으로 낮출 수 있는 검출기의 개발이 가능하다고 알려져 있다[3]. Luke-Neganov 포논 증폭법은 원리적으로 일견 단순한 방법으로 보인다. 이는 반도체 광 검출기의 입장에서 본다면 대면적 photoconductive 검출기에 대응한다고 할 수 있고, 원리적으로 Si 반도체 결정에 전극을 달고 전압을 인가해 주면 된다고 할 수 있다.

본 연구에서는 Si 반도체를 이용한 미세 섬광 검출기를 제작하기 위해, Al 전극 설계에 따른 누설전류, band gap engineering 그리고 온도가 미치는 영향 등에 대해 연구하였다. 시료는 순수 Si 웨이퍼의 표면을 식각 후 SiO2 산화막을 형성하였고, 전극 하부에 식각과 p+ 도핑을 통하여 오믹 접합과 전극 사이의 표면상태에 의한 누설전류를 최소화를 유도하였다. 먼저 Al 전극의 디자인과 포화전류를 위한 전압과의 상관관계를 확인하기 위해, 전극 사이의 거리에 따른 암흑전류와 광흡수에 의한 전류 측정을 시도하였다. 암흑전류 측정에서는 전극사이의 거리가 멀어질수록 저항이 커짐으로 인해 누설전류가 감소함을 확인하였다. 광입사 위치에 따른 광흡수전류측정에서는, 그림 1 처럼, 전극사이의 거리가 100 μm 일 때는 시료의 모든 곳에서 40 V 이상의 전압이 걸리면 포화전류에 도달하였지만, 200 μm 일 때는 80 V 이상에서 도달함을 확인하였다. 이는 포화전류에 도달하는 전압이 광입사 위치에 따라 달라지고 전극사이의 거리가 멀어질수록 증가하는 것을 확인하였다. 검출기에 입사하는 모든 광을 흡수하기 위해서는 전극자체로서 빛을 가리게 되므로 전극사이의 거리가 멀수록 유리하다. 하지만 전극사이의 거리가 멀수록 포화전류에 도달하는 전압이 증가하게 되므로 특정 전압에서의 시료활용면적과 전력변환효율이 감소하고 누설전류에 의한 노이즈가 증가하는 단점이 생김을 확인하였다.

그림 1. 전극사이의 거리가 (a) 100 μm 와 (b) 200 μm 일 때의 레이저 입사 위치에 따른 광 흡수전류 측정.

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Semiconductor devices(G)/1000 P1-se.025

Electronic and optoelectronic performances from vertically stacked MoS_2/p^+-Si heterojunction diodes

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Abstract :

Atomically thin semiconducting n-type molybdenum disulfide (MoS_2) is one of the most studied 2D materials for device application using its electrical and optical properties. In this work, we fabricated a vertically stacked p^+-n heterojunction diode consisting of a heavily doped p^+-type Si substrate and n-type MoS_2 flakes by using a scotch tape-based mechanical exfoliation. Then the electronic and optoelectronic properties of MoS_2/p^+-Si heterojunction diodes were investigated systematically. We have performed the transient measurements under the illumination of 525-nm-wavelength LED source by square pulse with various light intensities, because the response time is important in optoelectronic device. In this measurement, it appeared that the photoresponsivity and specific detectivity of our devices are dependent both on the wavelengths and light intensities by using light emitting diode. And MoS_2/p^+-Si heterojunction diodes showed also the stability and reproducibility from periodically repeated on/off cycles. To measure the barrier height of silicon-MoS_2 interface and the electronic property of MoS_2/p^+-Si diode, I-V and C-V measurements were conducted by using a precision semiconductor parameter analyzer (Hewlett Packard, 4156A) and a capacitance-meter (Agilent, E4980A), respectively.

Semiconductor devices(G)/0816 P1-se.026

The influence of the mesoporous TiO_2 layer on the performance of perovskite solar cells

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Abstract :

Methyl ammonium lead iodide ($MAPbI_3$) perovskite solar cells (PSCs) with the use of a thin mesoporous TiO_2 layer have achieved over 20 % conversion efficiency. Although other PSCs structures have also been reported, until now only those containing mesoporous TiO_2 as scaffold have achieved such performance. In this experiment, we have investigated the role of mesoporous TiO_2 layer for PSCs, such as electrical, optical, and structural performances. The sample structure is FTO coated glass/compact TiO_2/with and without mesoporous TiO_2/$MAPbI_3$/spiro-OMeTAD/Au structure. The mesoporous TiO_2 layer was deposited on the compact TiO_2 by spin coating the TiO_2 solution containing TiO_2 paste (20 sized nm TiO_2 nanoparticles) and terpineol diluted in anhydrous ethanol solution at 2000 rpm for 20 sec, which was followed by drying at 125 °C for 1 minute. Structural measurements were performed by a scanning electron microscope and x-ray diffraction. Optical transmittance and bandgap of the mesoporous TiO_2 layers were measured by a UV-Vis spectroscopy. In addition, photovoltaic performances such as Jsc, Voc, FF, and efficiency were observed in order to analyze the effect of removed mesoporous TiO_2 on perovskite solar cells.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Semiconductor devices(G)/0792 P1-se.027

Enhancement of the Magnetic Properties of the Double MgO based p-MTJ at Annealing Temperature of 400℃ by inserting Ruthenium Diffusion Barrier

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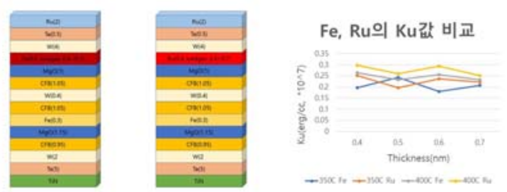
Abstract :



STT-MRAM 은 기존 DRAM 의 실리콘 기반의 c-MOSFET 공정기술이 사용가능하고, 비휘발성 특성을 가지고 있어 전력소비가 DRAM 의 1/5 수준 이하(~1 pJ/bit)이며, 또한 DRAM 과 같은 10 nsec 프로그램 속도를 가지고 있어 초고속, 초저전력 구현이 가능한 메모리 소자로 DRAM 을 대체할 수 있는 차세대 메모리로 각광을 받고 있다. STT-MRAM 에서의 핵심 구조인 CoFeB/MgO 기반의 Magnetic Tunneling Junction(MTJ)는 높은 Tunnel Magnetoresistance Ratio(TMR)과 Perpendicular Magnetic Anisotropy(PMA)의 특성이 있다. 그러나 400C 열처리를 하는 back-end of line(BEOL) 공정과정 중에 MTJ 의 자성특성이 열화되는 현상이 생긴다. 본 논문에서는 top electrode 물질의 interdiffusion 을 막아주고, magnetic layer 를 보호하는 역할을 하여 높은 PMA 성질을 갖게 해주는 CoFeB 층의 capping layer 에 대하여 더 적합한 구조를 제시한다. [substrate/Ta/W/CoFeB/MgO/Fe/CoFeB/W/CoFeB/MgO/capping layer]의 구조에서 capping layer 와 MgO 사이에 diffusion barrier 로 Fe 과 Ru 을 사용하여 어떤 물질이 PMA 유지와 interdiffusion 방지에 더 효과적으로 작용하는지와 각각 barrier 의 최적의 두께를 알아본다. Fe 를 diffusion barrier 로 사용한 이유는 기존 capping layer 구조 [W/Ta]보다 [Fe/W/Ta]가 더 높은 PMA 성질을 보였고, 대체 물질로 반응성이 적은 Ruthenium 을 사용하였다. 실험을 통하여 Transmission Electron Microscope(TEM)로 TMR 에 큰 영향을 주는 MgO 의 결정성을 확인하고, Secondary Ion Mass Spectroscopy(SIMS)로 열처리 온도에 따른 확산 정도를 알아보며 Vibration Sample Magnetometer(VSM)을 통한 PMA 자성 특성을 확인하고, 구해진 Ku 값을 통하여 thermal stability 를 구해본다. 350C 와 400C 열처리를 한 Fe 과 Ru diffusion barrier 의 두께에 따른 데이터를 근거로 기본 PMA 성질을 유지하면서 interdiffusion 을 막아주는 더 향상된 capping layer 구조를 제시하고 400C 의 열처리 과정에서 MTJ 의 손상여부를 확인한다.

**This work was supported by Basic Science Research program through the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No.2014R1A2A1A01006474) and Brain Korea 21 PLUS Program in 2014.

Semiconductor devices(G)/0714 P1-se.028

Electrical characterization of $CH_3NH_3PbBr_3$ Single Crystal

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Abstract :

Today, the power conversion efficiencies of organic-inorganic hybrid perovskites based solar cells exceeds 20% [1]. Furthermore, in the past few years, due to its remarkable optical and electrical properties, organic-inorganic hybrid perovskite has received great attention for its use in many other opto-electrical devices such as light-emitting diode (LED) [2], laser [3] and photodetector [4]. Most of these devices are based on perovskite thin films. Perovskite thin films, however, have higher trap density and grain boundaries that remain many questions in terms of their fundamental and intrinsic properties. On the other hands, unlike thin films, macroscopic single crystal can be an ideal platform for understanding these intrinsic properties. Recently, facile and rapid growth of organic-inorganic hybrid perovskite single crystals through inverse temperature crystallization(ITC) process has been reported [5-7].

In this work, we report the growth of $CH_3NH_3PbBr_3$ single crystals with its electrical characterization for better understanding their fundamental and intrinsic properties that is necessary for opto-electronic devices based on organic-inorganic perovskites. Thin and large single crystals were grown in few hours by ITC process and 100μm gap metal electrodes were directly evaporated on to the surface to characterize electrical properties of the crystals.

Semiconductor devices(G)/0649 P1-se.029

Two-terminal capacitor-less memory with vertical thyristor structure

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Abstract :

Dynamic random access memory (DRAM) with one transisttor and one capacitor (1T-1C) structure has been a mainstream with manufacturing the memory device. There are several advantages of 1T-1C DRAM including good integration and cheap cost. However, it faces a critical challenge with reducing the DRAM line width below 20nm because the difficulty of capacitor integration becomes hard as the line width decreases. The thyristor based capacitor-less 1T-DRAM has great memory chracterisitics such as high read current, non-destructive read conditon, and good memory margin. In this work, a capacitor-less two-terminal 1T-DRAM with vertical p-n-p-n structure has been studied. With the simulation for the proper thickness and doping concentration, the optimized p-n-p-n structure was made by a plasma enhanced CVD growth. To make the two terminal structure of thyristor memory, wet etching using KOH solution was performed using SiO_2 mask. The depth between the anode and cathode after etching process was acquired from the noncontact mode of atomic force microscopy (XE-100, Park systems) and SEM (nova nano SEM 450). Optical images were prepared to check the surface condition. We will discuss on structural and electrical properties of thyristor based memory device with different fabrication condition.

Semiconductor devices(G)/1140 P1-se.030

Observation of 2 dimensional semiconductors with nearfield scanning spectroscopy system

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Abstract :

Nearfield scanning optical microscopy(NSOM)는 근접장을 이용해 회절 한계 이상의 해상도로 광신호를 측정할 수 있게 해주는 시스템으로, 기존의 광학 현미경으로는 구분할 수 없었던 수십 나노 수준의 물질에 대한 광학적 정보를 받아볼 수 있게 해준다. 또한, 탐침을 수 나노까지 근접시켜 물질 표면의 Morphology 와 직접적으로 연관되는 광학적 신호 분포를 얻을 수 있다. [1] 이에 따라 발광 특성을 가진 다양한 고체 물질들의 국소지역에서 나타나는 현상들을 관찰하는 데 활발히 이용되고 있다. 특히 반도체의 경우 구성된 물질과 성장 환경에 따라 수십 나노 수준의 결점들이 형성되어 그 특성이 저하되거나 바뀌기 때문에, 이를 물리적으로 이해할 수 있도록 높은 해상도의 광신호 정보를 측정할 수 있는 장비로서 NSOM 이 활용되고 있다. [2]

한편, Transition metal dichalcogenide(TMD)로 알려진 물질은 수 원자 수준의 단일 층으로 분리해 냈을 때, Direct band gap 반도체가 되어 높은 광전기적 특성을 지니게 된다. [3] 그리고 그 성장 방법에 따라 표면의 퀄리티가 달라지는데, 이러한 변화는 물질의 광전기적 특성에도 영향을 미친다. 그러나, 이러한 구조는 보통 수십 나노 수준의 크기로 발현되어 기존의 광학 현미경을 이용한 광분석으로는 구분할 수 없는 수준으로 나타나며, 이러한 국소 지역에 생긴 변화로 인해 새로운 물리현상들이 나타나기도 한다. 따라서 수십 나노 수준의 물리적인 변화와 그로 인한 광학적 특성의 변화를 직접적으로 관찰하기 위해서는 이를 구분할 수 있는 해상도의 근접장 촬영 분광법이 필요하다.

본 연구에서는, 되먹임 회로를 이용하여 물체의 표면에서 근접장을 측정할 수있는 시스템을 직접 구축하고 두가지의 작동 모드(Illumination mode, Collection mode)로 동작하는 NSOM 시스템을 개발하였다. 그리고 2 차원 반도체 물질인 MoS_2 와 WS_2 물질을 각각의 모드에서 측정하여, 대면적으로 제작된 2 차원 반도체 물질들의 특성을 관찰하고 두 물질의 특성을 비교하였다.

[1] "Near-field optical scanning microscopy", U. Dürig, D. W. Pohl, and F. Rohner, Journal of Applied Physics 59, 10:3318 (1986)

[2] "Investigating carrier localization and transfer in InGaN/GaN quantum wells with V-pits using near-field scanning optical microscopy and correlation analysis", M. K. Kim, S. Choi, J. H. Lee, C. H. Park, T. H. Chung, J. H. Baek and Y. H. Cho*, Scientific Report 7, 42221 (2017)

[3] "Atomically Thin MoS_2: A New Direct-Gap Semiconductor", Kin Fai Mak, Changgu Lee, James Hone, Jie Shan, and Tony F. Heinz*, Phys. Rev. Lett. 105, 136805 (2010)

Biophysics(F)/0796 P1-st.001

GRIFFITH PHASES IN C.ELEGANS NEURAL NETWORK

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Abstract :

Critical points play an important role in understanding the behavior of many complex systems. In neuroscience, it is shown that only at criticality can brain structure support the recorded brain dynamics. A recent functional magnetic resonance imaging (fMRI) record shows that the brain tends to stay in a broad region near a critical point (Griffith phase) rather than staying at a unique critical point. Several new researches have found the existence of Griffith phases in some theoretical complex networks.

Based on the C.elegans neural network, we generalized into a modular scale free network with a power law directed network connecting the modules in the scale free network. We observed the Griffiths phases and some irregular points in the phase transition on the C.elegans neural network.

Biophysics(F)/0352 P1-st.002

Super-Helical filaments at surfaces: Kinetics and Elastic responses

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Abstract :

Biofilaments often behave in a way unexpected from the standard semi flexible polymer chain model (WLC) when squeezed to a surface, confined in microfluidic channels or clamped by their end. Among the proposed augmented filament models, beyond WLC, the super-helical filament model, where the filament forms a helix much wider than its diameter, provide a promising model. Besides a bending and twist modulus the model introduces two geometric parameters, the preferred curvature and preferred twist. We study this model by numerical Brownian dynamics, focusing on filaments confined to a surface by a strong potential. We analyze shapes and shape fluctuations under tension and hysteresis in extension and twist during a cycle of increasing/decreasing tension. Kinetic responses to tension and shape relaxation of the filament are also discussed.

Complex systems(D)/1073 P1-st.003

Non-Enclaves Percolation on ER network and its critical behavior

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Abstract :

Phase transition of various percolation models and its critical behaviors are statistical physicists' long-time interest. In recent time, some models show discontinuous or hybrid transition which is inconsistent with classical percolation model. It means that those models belong to different universal class. Non-enclaves percolation (NEP) model [1], developed by M.Sheinman *et al.* for describing cytoskeletal system, is also one of the models showing discontinuous phase transition on 2-D lattice. In this work, we study NEP model on Erdös-Renyi network and its critical behavior. First, we solve this model theoretically by applying generating function method and calculate order parameter, susceptibility, and value of critical point. Its critical point is closer to zero than on ordinary random percolation (RP) model. Next we get results from Monte Carlo simulations and measure critical exponents to decide its universal class. We find these critical exponents are consistent with those of RP model, like our prior work on Bethe lattice. Both case can be regarded as infinite dimension lattice, so we can conclude that NEP model on infinite dimension lattice belongs to same universal class of RP model, unlike on 2-D lattice.

[1] Sheinman, M., et al. "Anomalous discontinuity at the percolation critical point of active gels." Physical review letters 114.9 (2015): 098104

Complex systems(D)/1069 P1-st.004

Mathematical description of link prediction methodology in terms of local similarity index

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Abstract :

Complex network analysis has become powerful tools for big data analysis. However, empirical datasets are usually incomplete, therefore some data are omitted in network. This missed links sometimes validity of the network analysis such as centrality or network parameters. We should check all of the unconnected link pairs to find missing link, but it takes much effort and costs because of sparsity of networks and large size. Link prediction provides more efficient way by making priority list for most probable missing connection. Similarity index is usually employed to make priority list. Understanding the behavior of similarity index is important to understand the characteristics of link prediction, but this topic has less attention. In this study, we investigate the mathematical description of link prediction process. By describing link prediction process, we will discuss about the characteristics of similarity index and dependency of link prediction performance.

Complex systems(D)/0954 P1-st.005

국내 대중가요 노랫말을 바탕으로 한 작사가 네트워크 분석

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Abstract :

음악을 구성하는 요소로는 음정, 박자, 그리고 가사가 있다. 최근 이런 각 요소에 대한 다양한 빅데이터 분석 연구들이 진행중이다 [1, 2, 3]. 본 연구에서는 음원 스트리밍 사이트인 멜론에 1945 년부터 현재까지 등록이 된 한국대중가요 데이터를 모아 분석하였다. 먼저 대중가요 노랫말에 대한 지프의 법칙(Zipf's law)과 힙의 법칙(Heap's law)을 확인하여 노랫말의 쓰임이 다른 문서와 크게 다르지 않음을 확인하였다. 노랫말 속 단어들의 등장 빈도를 이용하여 각 작사가 사이의 코사인 유사도를 계산하였다. 이로부터 사용된 노랫말 속 단어들을 바탕으로 작사가들 사이의 계층적 군집화(hierarchical clustering)를 할 수 있었다. 계층적 군집화를 통하여 각기 다른 장르별 군집이 있음이 확인되었다. 이러한 결과를 바탕으로 딥러닝 방법 중 하나인 합성곱 신경망(convolution neural network)을 이용하여 한국 대중가요의 장르 예측이 가능한가를 시험하였다.

[1] Doheum Park, Arram Bae, Maximilian Schich, Juyong Park, "Topology and evolution of the network of western classical music composers," EPJ Data Sci. 4 (1) 2 (2015).

[2] Jaehwan Lee, Hyewon Lim and Hyoung-Joo Kim, "Similarity Evaluation of Popular Music based on Emotion and Structure of Lyrics," KIISE Transactions on Computing Practices, Vol. 22, No. 10 (2016).

[3] Changjun Lee, Hanbyul Bang and Jee-Hyong Lee, "Music Recommendation System Using Text Analysis of Lyrics," 한국지능시스템학회 학술발표 논문집, Vol. 25, No. 2 (2015).

Complex systems(D)/0900 P1-st.006

What is going on in deep learning?

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Abstract :

Despite the widespread pratical success of deep learning, theoretical understanding of deep learning is very lack. Especially, deep neural networks (DNN) often have much more trainable model parameters than the number of training data. Nonetheless, DNN exhibit small generalization error. To understand why over-parameterized DNN find good generalize solution rather than just memorizing training data, I have done serveral experiments with DNN for the image classification task. In this experiment, I have measured changes of weight and activation in DNN over training time.

Complex systems(D)/0754 P1-st.008

Trade volume distributions in the country and product space of international trade

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Abstract :

Determining the best portfolio of both products and trade partners is important for the economic growth of each country, the underlying principles of which are little understood. Analyzing the international trade data in the period 1962-2000, we find that the distributions of trade volumes for a product category is different from country to country while the distribution of trade volumes for a partner country takes a universal form. Such difference is shown to be attributed to different scaling characteristics of the trade volumes with respect to the in-degrees of products and countries in the country-product network and the country-country network, respectively; The scaling exponent for the relation between trade volumes and country's indegree is universal while that between the trade volume and product's indegree is not. The identified scaling relations are father analyzed by investigating the relation between the architecture of the binary trade network and the weight distribution of the weighted trade network.

Complex systems(D)/0718 P1-st.009

Evolutionary prisoner's dilemma game on a cycle with long-range interactions

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Abstract :

We consider evolutionary game dynamics with long-range interactions on a cycle. Interactions between the members are mimicked by a simplified prisoner's dilemma game whose payoffs are given by the cost and benefit of the donation. In our model, both game interaction and competition strengths decay algebraically with the distance between two players but with different exponents, alpha for the game interactions and beta for the competition. For infinite beta, where competition occurs between the nearest neighbors only, we find that the evolutionary game dynamics reduces to that of short range interactions with alpha dependent effective numbers of the nearest neighbors. We also investigate the condition for the evolution of cooperation for finite beta numerically and present the threshold values of cost to benefit ratio for different sets of alpha and beta values.

Complex systems(D)/0627 P1-st.010

Multidimensional characteristic of heterogeneous networks and its effect on dynamic fluctuations

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Abstract :

We have previously shown that the dimensionality and heterogeneity of a network determine the scaling behavior of the dynamic fluctuations on it [1]; strongly heterogeneous networks having high spectral dimensions may display diverging fluctuations if their degree exponents are sufficiently small. Yet the dimensionality of many complex networks is not so simple, as their connectivity patterns appear different depending on scale. Here we investigate the spectral density function of model networks and show its crossover behavior from a fast to a slow algebraic growth in sparse heterogeneous networks. Two spectral dimensions are derived, the larger of which characterizes the neighborhood of hub nodes and the smaller is related to the long-range connections of hubs. Knowing those multiple dimensions is essential for understanding the dynamic fluctuations in heterogeneous networks, which is found to display diverging fluctuations if one of those spectral dimensions is sufficiently low. Such multidimensional characteristics of real-world networks are discussed.

[1] H.-H. Yoo and D.-S. Lee, Phys. Rev. E 93, 032319 (2016)

Complex systems(D)/0208 P1-st.011

Structural Lethality of Metabolic Reactions across Species

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Abstract :

In living organisms, the metaholic reactions with the cells which generate necessary products from their substrates are essential in order to sustain their lives. The reactions are indirectly connected with each other through sharing the same products or the same substrates, so if one reaction malfucntions, the failure may spread into a part of or the whole of the system. In this work, we try to estimate how lethal a reaction is via network structure only across species. We compute the size of the cascading failures after the operation of one reaction ceases as an indicataor of the reaction's lethality. Analyzing the metabolic data of 5470 bacteria, we explore what factor correlates with the lethality.

Complex systems(D)/0144 P1-st.012

구성 정보 분석에서 나타나는 풍경 이미지에서의 황금비율

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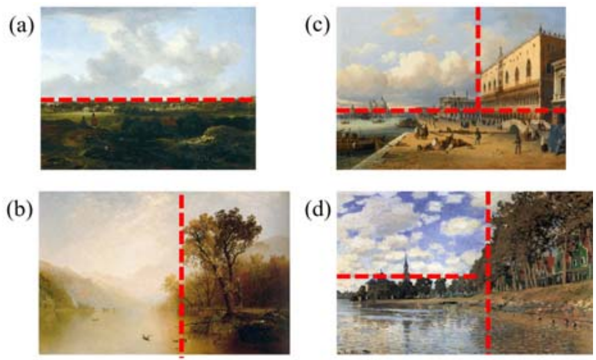
Abstract :



최근 연구에서 전체 이미지를 점차 균일한 색상의 영역으로 분할해 나감에 따라서 구성 복잡도를 구할 수 있음이 밝혀졌다. 특정 블록에 대한 공간 분할은 수평선 혹은 수직선에 의한 이중 분할로 진행되며, 분할 위치는 분할에 의한 색상 정보가 최대가 되는 지점이 된다. 따라서 공간 분할 방향과 위치에 대한 정보는 색상의 공간 구성 특성을 파악하는 데 활용할 수 있다. 본 연구에서는 서양 미술사조별 풍경화에 대하여 첫 번째와 두 번째 공간 분할이 일어나는 위치를 분석했다. 그 결과에 따르면 시대별로 선호하는 비율이 변하며, 특정 시대에서 황금비율(0.6±0.05)을 선호했다.

다음은 그림에 대한 설명이다.

(a), (b) 1 차 분할에서 황금비율이 생기는 예 (c), (d) 1 차부터 2 차 분할까지 황금비율이 생기는 예

Granular systems & soft matters(E)/0924 P1-st.013

막걷기 모형의 생성함수를 통한 게임 시스템에서의 강화에 대한 통계적 분석

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Abstract :

막걷기 모형은 확률적 시스템을 분석하기 위한 도구로써 사용되어왔다. 본 연구에서는 막걷기 모형을 이용하여, MMORPG 에서의 강화로 대표되는 게임 시스템 내부의 강화 시스템에 대해 분석할 것이다. 강화 시스템에서 강화 시도된 것은 사라지거나, 혹은 한 단계 더 강화된다. 이러한 특성을 각 격자마다 확률이 다른, 불균질한 막걷기 확률을 가진 모형을 통해 분석할 것이다. 막걷기 모형은 간단하게 기술된다. m번째 격자에 있는 보행자는 p_m의 확률로 $m+1$번째 격자로 이동하며, $q_m(=1-p_m)$의 확률로 원점으로 돌아간다. 이는 m번 강화된 물건이 강화 시도 후 $m+1$번 강화되거나, 사라지는 - 또은 강화되지 않은 상태로 돌아가는 - 것을 기술한다. 이러한 막걷기 모형의 생성 함수를 통해, 강화에 대한 해석적인 결과를 도출할 것이다. 또한, Monte-Carlo 전산 시늉을 통해 이론적으로 얻은 결과를 재확인할 것이다.

Nonequilibrium systems(B)/1091 P1-st.014

Fundamental Diagram of TASEP with Local Defect and ZRP Hopping

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Abstract :

We study the fundamental diagram of a one-dimensional traffic flow, in terms of the modification of totally asymmetric simple exclusion process (TASEP) with a slow bond and inter-particle distance-dependent interactions, where the fundamental diagram is presented with the current and the bulk density of the system. In particular, we focus on the homogeneity of the density profile and the localization of the slow-bond (SB) effect as well as the condensation in zero-range process (ZRP). Based on the mean-field calculations of TASEP and ZRP for the fundamental diagram, we propose a phase digaram for the modified TASEP with SB with the SB strength and the ZRP hopping-rate control value. Finally, we numerically confirm the phase boundaries and discuss the possibility of the SB-free phase in the presence of particle-particle interactions.

Phase transition & critical phenomena(A)/1002 P1-st.015

Critical informative clustering in deep learning

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Abstract :

We study the sizes of clusters in deep belief networks(DBN) and see the emergence of power law distributions. In this study, we introduced the entropy of the frequencies as relevance. This entropy can be distinguished from the entropy of the distinguishable cluster, resolution. Given resolution, the power law cluster size distributions maximize relevance. A power law is a sign of criticality. Among the power laws, Zipf’s law can be thought as the critical point of phase transition between order and disorder, called the edge of chaos. Zipf's law has been known that the point of good information processing.Therefore, Zipf’s law clustering can help to construct the deep learning architectures according to the goals of the users. We believe that power law clustering of deep learning can lead to a better understanding of why it works better than any other methods.

Critical behaviors of the CI percolation on random networks

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Abstract :

Percolation on complex networks studies how the giant cluster of a network disappears under removing nodes or links. There are various strategies to select removing node, for instance random failure, high-degree attack, page-rank attack, k-core and CI (collective influence)-based attack etc.

Here, we study inter alia the so-called CI-based attack, or CI percolation, on random networks, which was introduced as a heuristic method for optimal percolation [Monore and Makse, Nature 524, 6568 (2015)]. The CI percolation is based on the value so-called 'CI', defined as CIi,l = (ki − 1) j∈∂Ball(i,l)(kj − 1), which incorporates both the degree of the node itself and its neighboring nodes at distance l.

In CI percolation, the node having the largest value CI is called 'top influencer' and gets eliminated successively. As a result the giant cluster collapses more quickly and suddenly, so that the percolation threshold becomes smaller than most of other previously-studied strategies.

We numerically investigate the critical behavior at the CI percolation transition. We estimate various critical exponents for l=1 and discuss the physical meaning of the obtained results.

Phase transition & critical phenomena(A)/0510 P1-st.017

Confined Polymers on a Square Lattice

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Abstract :

A confined polymer mimics properly the dynamic behavior of chromosome in a cellular nucleus between metaphase and interphase. Also, confined polymers on a lattice is related closely to Hamiltonian walks of graph theory and combinatorics. The genomic (or sequential) distance is usually defined as the seqential number difference between two non-bonded monomers on a linear polymer. The genomic distance is similar to the segment contour length of a Hamiltonian walk. We study a self-avoiding walk on a square lattice confined in various square sizes. We count the exact number for a sequential distance of geometrically nearest-neighboring two (non-bonded) monomers of a self-avoiding walk on a square lattice confined in various square sizes for the first time. The various properties of the exact number as a function of the sequential distance are discussed.

Phase transition & critical phenomena(A)/0345 P1-st.018

Improved Parallel Algorithm for Enumeration of Geometric Quantities of a Lattice Polymer

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Abstract :

We develop an efficient parallel algorithm by which the geometric quantities of an interacting self-avoding walk for a square-lattice polymer as well as the number of conformations for various geometric quantities can be exactly enumerated for each energy level. The key idea of our algorithm is based on that all conformations of a polymer chain can be made by extending those of a shorter polymer chain, called a starting conformation set. By using our efficient parallel algorithm, we exactly evaluate various geometric quantities, the radius of gyration, the end-to-end distance, and the monomer distance from an endpoint, of interacting self-avoiding walks on a square lattice up to thirty-nine steps. The exact number of conformations for three geometric quantities, the radius of gyration, the end-to-end distance, and the monomer distance from an endpoint, are obtained for the first time.

Nanomaterials and nanodevices(A)/0105 P2-ap.101

Anomalously polarized emission in low frequency resonance Raman spectra of monolayer WS_2

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Abstract :

Resonant Raman spectroscopy is used for investigating the interplay of the exciton band and phonons in 2-dimensional materials. When the excitation energy is matched with an exciton state, strong resonance effects are observed [1]. For example, several peaks are enhanced, or some new peaks appear at the resonance condition in few-layer WS_2. In the low-frequency region, a broad central peak is observed for excitation energies near the A and B excitons. In polarized Raman scattering with circularly polarized light, this central peak has the same circular polarization as the laser owing to the valley polarization of WS_2. On the other hand, we found that in linearly polarized Raman scattering, the central peak is stronger in cross polarization than in parallel polarization when the excitation energy is near the B exciton (~ 2.4 eV).

We carried out Resonance Raman measurements of monolayer WS_2 as a function of temperature from 80 K to 300 K using 2.41 eV and 2.33 eV lasers. Because the B exciton energy is increased as the temperature decreases, we can control the resonance condition. We found that both the parallel and cross polarized central peak is strongly enhanced near the B exciton resonance but the cross polarization is relatively stronger in that resonance condition.

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Nanomaterials and nanodevices(A)/0145 P2-ap.102

Polarization dependent Raman studies of $ReSe_2$

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Abstract :

We carried out Raman investigation of monolayer and few-layer $ReSe_2$. $ReSe_2$ has the 1T′ structure with in-plane anisotropy which gives polarization dependence of Raman intensity [1]. Furthermore, because $ReSe_2$ has only an inversion center, there is not a symmetry operation to rotate $ReSe_2$ about an in-plane axis [2]. We investigated polarization dependent Raman of monolayer $ReSe_2$ on a quartz substrate so that we could measure the up and down sides with the same sample. Compared to the polarization angle of maximum intensity for mode V(~162 cm^{-1}), the angle for mode IV(~126 cm^{-1}) was larger at one side while it was smaller at the other side. Also, we observed the polarization dependence for mode V of few-layer is different from that for monolayer.

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Nanomaterials and nanodevices(A)/0202 P2-ap.103

Raman study of interlayer interaction of 2H- and 3R-MoS_2

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Abstract :

We performed Raman measurements on few-layer MoS_2 with three different excitation energies (1.96, 2.41, 2.81 eV). We prepared 2H- and 3R-stacking type few-layer MoS_2 by mechanical exfoliation and identified the stacking order by the low-frequency Raman spectra (<100 cm^{-1}) [1]. We also observed Davydov splitting of the A_{1g} mode for the 1.96 eV excitation energy which is resonant with the A or B exciton states [2]. Since low-frequency Raman spectra and the Davydov splitting are the results of the interlayer interaction, we can estimate the force constants of 2H type MoS_2 with the linear chain model [3]. For the 3R stacking type, we analyzed the Davydov splitting and found that the peak ratio, and the peak position are different. We compared the force constant and found out that the interlayer interaction of 3R type is stronger than the 2H type by about 15%.

Nanomaterials and nanodevices(A)/0232 P2-ap.104

Control of copper nanowire network properties and application to transparent conducting layer in LED

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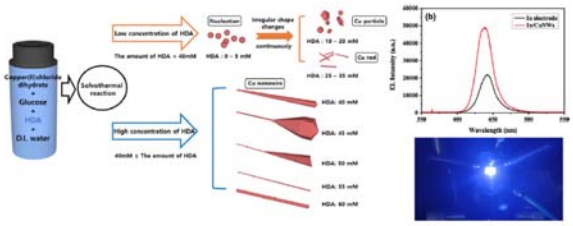
Abstract :



We report the control of structural, optical, and electrical properties of solution processed copper (Cu) nanowires (NWs) by varying the capping agent concentration and demonstrating the enhanced light extraction of GaN based light-emitting diodes (LEDs) using Cu NWs. Cu NWs were prepared by a simple solvothermal method, and the capping agent concentration effects on the growth of Cu NWs were systematically investigated. The different diameters of Cu NWs were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), UV–visible absorption, and conductivity measurements. All characterization results showed high aspect ratio nanowires with efficient transmittance and conductivity properties. When the synthesized Cu NWs were adopted as a transparent conducting layer, the electroluminescence intensity was improved by its spreading effects. This work will elucidate the influence of capping agents on the physical properties, optical properties, and electrical conductivity of Cu NWs for use as a transparent conductor in optoelectronic devices.

Nanomaterials and nanodevices(A)/0236 P2-ap.105

Thermoacoustic characteristics of MWCNT sheet Speaker

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Abstract :

The characteristics of the thermoacoustic speaker based on carbon nanotube sheet arranged in one direction have been investigated. Due to the excellent heat dissipation properties of carbon nanotubes, the carbon nanotube thermoacoustic loudspeaker showed high level and wide range sound pressure. The sound pressure and the heating level showed a linear relationship with the frequency and the magnitude of the applied voltage, and showed different characteristics depending on the length, width, and thickness of the carbon nanotube sheet. In this study, the sound pressure and heat characteristics according to AC, DC applied voltage, frequency and structural variables will be presented, and a mechanism of sound generation will be proposed.

Nanomaterials and nanodevices(A)/0240 P2-ap.106

Electrical properties of artificial skin based on CNT Sheet

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Abstract :

Transparent and flexible artificial skin based on CNT (carbon nanotube) sheet aligned in one direction has been investigated. In order to realize the touch function of artificial skin, a CNT sheet with excellent conductivity than ITO electrode is used as a transparent electrode, and a touch function is implemented using a mutual capacitance sensing method by arranging CNT sheets in the X and Y axes. This artificial skin showed a transmittance of 80% or more, and exhibited excellent touch sensing characteristics even when the radius of curvature was small. In this study, process for the artificial skin and sensing properties such as sensing margin, reaction time, and reproducibility according to the thickness and width of CNT sheet will be announced.

Improved On/Off ratio and stability of nonvolatile resistive memories based on P(VDF-TrFE)/ZnO nanocomposites

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Abstract :

Resistive random access memory (ReRAM) cells have grabbed much attention to realize nonvolatile memory devices owing to their advantages such as low-power consumption, high operation speed, high packing density, long retention time, and etc.[1,2] Among the basic parameters of ReRAMs, a high ON/OFF ratio is required to not only enable fast and stable detection of the state in the memory cell but also to simplify the circuitry to distinguish the storage information. However, currently, ReRAMs exhibit inferior device parameters such as low ON/OFF ratio and stability which limits its practical applications. In order to achieve enhanced resistance switching characteristics, recently, much attention has been focused on inorganic-organic based semiconductor-dielectric blends.[3–5] Among the various polymers, P(VDF-TrFE) possesses excellent stability, relatively high dielectric constant among the polymers. So, it has been extensively studied as a candidate for nonvolatile memory devices due to its excellent device air stability; however, P(VDF-TrFE) based devices have the disadvantage of being read-destructive.[6] In order to overcome the afore mentioned drawbacks, we have developed a new strategy through blending P(VDF-TrFE) with ZnO nanoparticles. Our P(VDF-TrFE)/ZnO nanocomposites based ReRAMs exhibit enhanced and stable resistive switching characteristics with an ON/OFF ratio as high as 7×10^6 and a retention time of 10^4 s.

The ReRAM cells were fabricated by mixing P(VDF-TrFE) with ZnO nanoparticles(NPs). The ZnO NPs were prepared from colloidal synthesis methods. Then, ZnO NPs were mixed with P(VDF-TrFE) with ratios of 15, 20, 25, or 30%, respectively. Then, the solution was deposited on n^{++}Si substrates by spin coating at 3500 rpm for 30 s, which was then followed by annealing at 140°C for 1 h.

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Nanomaterials and nanodevices(A)/0347 P2-ap.108

Gd 을 치환한 나노 페라이트의 가열시간에 따른 온열효과

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Abstract :

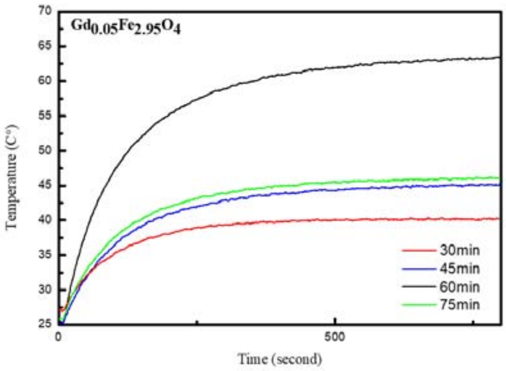

Fig1. Hyperthermia of ferrite

나노 페라이트 물질은 다양한 자성 특성으로 인해 바이오, 광학, 촉매와 같은 다양한 분야에서 응용되고 있다. 특히, 자기장내에서 나타나는 발열현상으로 인해 암세포를 사멸시키기 위한 바이오 분야의 연구가 활발히 진행되고 있다. 많은 연구팀에서 Fe3O4 의 자성특성의 활용범주를 넓히기 위하여 다양한 물질을 치환하는 연구를 진행 중이다. Gd 을 치환한 본 연구에서는 MRI 조영제로 사용되는 Gd 의 특성과 Fe3O4 의 자성특성을 융합하여 진단과 치료를 동시에 할 수 있도록 고온열분해법(HTTD)를 이용하여 Gd 페라이트를 제작하였고, 다양한 가열반응시간에 따른 온열효과에 대해 연구하였다. 본 연구에서는 자성특성이 높게 나타난 Gd0.05Fe2.95O4 나노 페라이트를 고온열분해법(HTTD)을 이용하여 합성하였다. 출발물질은 순도 99.9% Iron(III) actylacetonate, Gadolinium(II) acetylacetonate 와 용매인 Benzyl ether 를 사용하였으며, Oleic acid 와 Oleylamine 을 계면활성제로 첨가하였다. 각 물질을 조성에 맞추어 혼합한 후 200 ℃에서 30 분 유지 후 300 ℃에서 각각 30, 45, 60, 75 분을 가열한 후 7200 rpm 의 속도로 원심분리하여 하여 최종적인 나노 페라이트 물질을 제조하였다. 각 시료들은 XRD 를 통하여 결정학적 구조를 확인하였으며, Gd 페라이트를 Fullprof 프로그램을 이용하여 Rietveld 정련법으로 분석한 결과 큐빅 스피넬 구조를 가지는 단일상임을 확인하였으며, 공간그룹은 Fd-3m 으로 분석되었다. 각각 30, 45, 60 75 분간 가열한 시료의 격자상수는 반응시간이 증가할수록 8.363, 8.368, 8.370, 8.380 Å 으로 증가함을 보였다. VSM 장비를 이용하여 상온에서 1.5 T 까지의 자기이력곡선을 측정하였고 그 결과, 자기모멘트의 값이 변화함을 확인하였다. Mössbauer 측정결과 각 시료들의 6 라인의 흡수선 형태를 확인하였다. MagneTherm 장비를 이용한 발열특성 측정은 각각 40.24, 45.16, 63.33, 46.06 ℃ 로 60 분간 가열반응한 시료가 가장 높은 발열 특성이 나타남을 확인했다.

Nanomaterials and nanodevices(A)/0374 P2-ap.109

Study on non-uniform photoluminescence signal of monolayer WS_2

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Abstract :

We investigated the photoluminescence (PL) of monolayer tungsten disulfide (WS_2). Monolayer WS_2 samples were mechanically exfoliated on silicon substrates with a 285nm-thick SiO_2 layer. At room temperature, we used a 514.4-nm laser as the excitation source and observed a strong PL signal at ~2.0 eV. Whereas some of samples had a broad peak, others had a sharp peak at slightly higher energy. To understand the phenomenon, we performed PL imaging. We observed that the inner part of a sample showed a broad peak at 2.01 eV, whereas the edge part had a sharp peak at 2.04 eV. We measured PL spectra while changing the power of excitation for the inner part and the edge part. As the excitation power increased, the energy of the sharp peak did not change, whereas the energy of the broad peak redshifted. Also the intensity of the sharp peak increased and saturated, while the broad peak increased linearly. The higher energy peak is ascribed to the A exciton state and the broad peak at lower energy is due to trions.

Raman studies on polytypes of few-layer gallium selenide

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Abstract :

Gallium selenide (GaSe) is one of 2D transition metal monochalcogenides. Since GaSe has a high photoresponsivity and external quantum efficiency, it can be used in a photodevice such as a photodetector. [1] There are four different polytypes in bulk, designated as β-, ε-, γ- and δ-GaSe. Since different stacking orders result in different optical and electrical properties even for the same thickness, identifying stacking order is highly important. We performed polarized Raman spectroscopy of few-layer GaSe. We determined the thickness of GaSe by observing the positions of the A_{1g}^{1} and the shear mode. We found that there are different types of low-frequency shear modes even in the same-thickness flakes, which means that GaSe exists with different stacking order domains. On the other hand, the breathing modes which present interlayer vibration in the out-of-plane direction do not depend on the stacking order. In particular, we investigated trilayer GaSe and found four-types of low-frequency Raman spectra corresponding to different stacking orders. [2] The Raman measurements are compared with theoretical calculations and scanning transmission electron microscopy.

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Nanomaterials and nanodevices(A)/0494 P2-ap.111

산소 플라즈마 건식 식각을 이용한 선폭 감소 현상 연구

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Abstract :

반도체의 나노 단위 초고집적화 연구는 지난 수십 년간 진행되어 온 반도체 연구의 중요한 요소이다. 특히 실리콘 기반의 반도체를 대체할 것으로 기대되고 있는 그래핀을 10 nm 이하의 두께로 공정하면 스위칭 소자로 이용할 수 있다 [1]. 그래핀을 미세 패터닝 할 때 산소 플라즈마 식각을 이용할 수 있다 [2]. 이 연구에서는 그래핀의 미세 패턴 공정에서 선폭 감소에 대한 연구를 진행하였다.

E-beam lithography 를 이용하여 3 층 이하의 얇은 그래핀 위에 여러 개의 선폭을 가진 식각 마스크를 형성한 후 산소 플라즈마 식각을 하였고, 식각 전후로 주사전자현미경을 이용하여 결과를 확인하였다. 이 때 선폭에 관계없이 약 50 nm 정도 선폭이 감소하였다. 이를 개발할 경우 나노 단위의 미세 패턴 공정에서 광원이 가지는 한계 이하의 선폭 공정이 가능할 것으로 기대된다.

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Nanomaterials and nanodevices(A)/0508 P2-ap.112

Raman signatures of antiferromagnetic phase transitions in few-layer $NiPS_3$

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Abstract :

Transition metal phosphorus trisulfide (MPS_3) is one of the new class of layered materials, which can be exfoliated to atomically thin films. Some of the bulk MPS_3 ($FePS_3$, $MnPS_3$, and $NiPS_3$) have been known as magnetic materials with antiferromagnetic phase transitions. For few-layer MPS_3, as the dimension of these magnetic materials is changed from 3-dimension to 2-dimension, magnetic ordering can be affected. Below the Néel temperature, the Raman spectrum of bulk $NiPS_3$ showed two anomalous features: a broad peak, which is due to two-magnon scattering, and a Breit-Wigner-Fano (BWF) type signal [1]. Since these two features originate from the magnetic ordering of $NiPS_3$, the Néel temperature of $NiPS_3$ can be estimated by using these two features. We synthesized bulk $NiPS_3$ crystals by the vapour transport method and prepared atomically thin samples by mechanically exfoliating on SiO_2/Si substrates. By conducting temperature dependent Raman measurement, we found the signatures of antiferromagnetic phase transitions in few-layer $NiPS_3$. This study will pave the way to explore magnetism in 2D systems.

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E-beam lithography 와 O_2 플라즈마 식각 공정을 이용한 2 차원 물질 나노갭 형성

남궁선 [1], 정진호 [1], 임동석 [1], 김한울 [1], 김윤섭 [1], 이윤태 [1], 김길호 [*1]

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Abstract :

나노기술이 발전해가는 가운데 나노갭을 이용한 많은 응용연구들이 진행되고 있다. 반도체 물질에서의 나노갭은 단전자 트랜지스터, 화학센서, 바이오 센서 등 다양한 분야로 연구가 진행되고 있으며 이에 따라 더 정밀한 나노갭 형성에 대한 연구가 필요 시 되고 있다. 나노갭을 형성하기 위해서는 수 나노 수준의 정밀한 공정이 필요하며, 이를 위해 E-beam lithography 공정[1], 이온 빔[2], 전자 이동[3] 등 여러 가지 기술들이 이용되고 있다. 하지만 기존 연구실 단위에서 사용되는 포토리쏘 기술의 경우 마이크로 단위의 선폭에 그치고 있으며, E-beam lithography 의 경우에도 수십 나노 정도의 한계점이 존재하기에 더 정밀한 나노갭을 형성할 시에 한계가 발생하고 있다.

본 연구에서는 이를 극복하기 위해 포토리쏘 공정 개발에서 진행되었던 등방성 식각을 E-beam lithography 기술에 접목시키는 한편, 나노갭을 위한 패턴을 디자인하여 정밀한 나노갭을 형성하는 연구를 진행하였다. E-beam lithography 를 이용하여 PMMA 에 100 nm 대의 선폭을 진행한 후, 그래핀과 O_2 플라즈마의 화학적 반응성을 이용한 등방성 식각을 이용하여 좁은 48 nm 그래핀 나노갭 구조를 형성하였다. 등방성 식각을 활용 시 E-beam lithography 를 이용한 선폭의 한계를 극복하여 더 정밀한 나노갭 연구가 가능할 것으로 기대된다.

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Nanomaterials and nanodevices(A)/0596 P2-ap.114

Fabrication of ZnO-ZnS@polyaniline nanohybrid on FTO glass for enhanced Hydrogen generation

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Abstract :

Heterojunction structures are attracting lots of attention for enhancing the electron injection across the interface. ZnO-ZnS@polyaniline one-dimensional nanohybrid films are synthesized on conducting glass substrates in a controlled way, using a simple three-step electrochemical deposition, chemical sulfurization of ZnO nanowire array as reactive template and spin-coating technique. The Electrochemical measurements were performed using a 1 kW xenon lamp (Newport) with its infrared wavelengths filtered out by water, and wavelengths below 420 nm removed by an optical filter, enabling measurements under visible light. The light irradiance, measured by a thermopile detector, was 100 mW/cm2. A monochromator (74,000, Newport) was used to investigate the monochromatic responses (for IPCE, applied bias photon to current efficiency (ABPE), and band gap energy measurements) of samples. 1 The as-prepared ZnO-ZnS@polyaniline one-dimensional nanohybrids are found to exhibit significantly an enhancement in the incident photon-to-electron conversion efficiency as compared to ZnO nanowire arrays. The observed enhancement in photoelectrochemical activity is attributed to the photosensitization effect of visible light responsive PANI. The special electron structure in the heterojunction helped to reduce the energy barrier height at the interface and enhanced the separation of photo-generated carriers. Thus, the photoelectrochemical performance and the dispersing stability of the composite photocatalysts in water were highly improved. Hence, our proposed structure is a promising candidate as a photoanode for solar energy-to-hydrogen conversion devices. *Corresponding Author: (BeeLyong Yang), (Kumoh National Institute of Technology, Korea), (blyang@kumoh.ac.kr)

Band alignment offsets of PANI/ZnS/ZnO Heterojunctions

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Abstract :

Energy band alignments at heterointerfaces play a crucial role in defining the functionality of semiconductor devices, yet the search for material combinations with suitable band alignments remains a challenge for numerous applications. The energy band alignment at the heterointerface between ZnO, ZnS and PANI was studied using photoelectron spectroscopy. We investigated band offsets at PANI/ZnS and ZnS/ZnO interfaces in a typical PANI/ZnS/ZnO heterojunction PEC cell by combining x-ray photoelectron spectroscopy and optical absorption spectroscopy. X-ray photoelectron spectroscopy and optical absorption spectroscopy measurements indicate that the conduction-band offsets at both PANI/ZnS and ZnS/ZnO interfaces show type-II alignment with values of 0.54 eV and 0.41 eV, respectively. Our results suggest that, although type-II alignment for PANI/ZnS heterojunction can form less of a barrier to electron transport across the interfaces, the narrowing of the interface barrier increases recombination of carriers.

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Nanomaterials and nanodevices(A)/0602 P2-ap.116

Photo-electrochemical reduction of carbon dioxide to methanol using Ag-loaded NiO/$BaTiO_3$/FTO

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Abstract :

As a cathode material for fuel generation from CO2 reduction in a photoelectrochemical system, layered BaTiO3/NiO films were developed and their surfaces were decorated with transition metals (i.e. Ag, Au, Cd, Cu, Pb, and Sn). Deposition of the transition metals effectively enhanced CO2 conversion to fuel in terms of faradaic efficiency. In particular, Ag/NiO/BaTiO3 demonstrated outstanding performance among the transition metals: for methanol yield production with high faradaic efficiency at -0.16 V (vs. SHE), which was a higher potential than standard redox potentials of methanol formation from CO2. Moreover, electrochemical impedance spectroscopy (EIS) showed that the deposition of the transition metals onto BaTiO3/NiO electrode effectively generated photo-induced electron–hole pairs under visible light irradiation. The reported system consisting of Barium Titanate and over-layer Nickel oxide loaded Ag NPs exhibits remarkable stability with time.

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Nanomaterials and nanodevices(A)/0612 P2-ap.117

Optical property of Cu-ion-implanted perovskite zirconate nanostructures

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Abstract :

We investigated visible light emission by $AZrO_3$ (A=Ca, Sr, and Ba) nanocrystals (NCs) implanted with Cu ions using 325 nm photo-excitation. $AZrO_3$ NCs were synthesized using the combustion method. The synthesized NCs were annealed at various temperatures ranging from 600 °C to 1400 °C. Then, the Cu ion implantation was performed to the annealed samples with ion doses of 1×10^{14} to 1×10^{16} particles / cm^2. The XRD pattern of the sample confirmed that the Cu-ion implantation did not affect the structural property of the NCs. In the photoluminescence (PL) spectra, a sizable emission near 500 nm, caused by the Cu-ion implantation, was observed clearly, in addition to the emission near 400 nm due to structural defects of the host compound. As the Cu-ion dose and annealing temperature were increased, the emission near 500 nm became more powerful and the emission near 400 nm was gradually suppressed. The intensity and the spectral shape of the Cu-ion emission was found to depend on the A-site ions in close relation to the structural distortion. The absorption coefficient spectra exhibited that the band gap of the NC samples did not change wiht the Cu ion implantation. With the measured PL spectra, we calculated the CIE color coordinates, and found that the colors of emission was changed from violet to yellow.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Nanomaterials and nanodevices(A)/0619 P2-ap.118

Size Dependent Photothermal Explosive behavior of Au Nanoparticles driven by ns Laser Pulse

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Abstract :

Photothermal explosions of mono-disperse Au nanoparticles after illuminated by 6ns KTP Nd:YAG laser pulses were investigated. The solution containing mono-disperse AuNPs with size 40 nm and 100 nm were dropped on silicon nitride substrate and dried in the air. Then, they were irradiated by the laser pulses with energy 5~27.5 mJ and number of pulses 1~200. For 100 nm AuNPs, number percentage of exploded particles was increased in the pulse energy range between 5~20 mJ with mean slope 7.75. For 40 nm AuNPs, it was increased when the pulse energy was higher than 15 mJ with mean slope 2.10. The mean slope or exploded percentage increase ratio between 40 nm and 100 nm AuNPs was approximately 3.73 which fitted into Mie absorption ratio 3.60.

Nanomaterials and nanodevices(A)/0866 P2-ap.119

Growth Mechanism Observation of Organometallic Halide Perovskite Grain on Solvent Vapor Annealing

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Abstract :

The organometallic halide perovskite has attracted lots of attentions due to their outstanding progress in power conversion efficiency in photovoltaic devices. Recently, these interests and efforts have been extended to light emitting diodes(LEDs) in which the perovskite material is used as an emissive layer. The Bromine based perovskite ($MAPbBr_3$, MA=CH_3NH_3) exhibits suitable luminescent property with high quantum yield (QY), narrow full width half maximum (FWHM), resulting in proper visible LED applications. Since these properties are highly dependent on the perovskite film quality, controlling the morphology and the crystallinity of the perovskite film is of great importance for maximizing the device performance. For this reason, various techniques to control and optimize crystallinity and morphology of perovskite layer have been reported such as thermal precursor composition changing, thermal annealing and crystal pinning process.

Herein, we suggest a new morphology control method on the perovskite layer by using solvent vapor. The perovskite films fabricated by Vapor-Assisted Solution Process (VASP) were delicately controlled by using various solvent vapors. While the solvent vapor treatments, perovskite films were slightly dissolved and recrystallized. Finally, photoluminescence (PL) intensity of vapor treated films were significantly enhanced and the peak wavelength was blue shifted due to the formation of smaller grains.

Nanomaterials and nanodevices(A)/0956 P2-ap.120

Improved On/Off ratio and stability of nonvolatile resistive memories based on P(VDF-TrFE)/ZnO nanocomposites

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Abstract :

Resistive random access memory (ReRAM) can realize nonvolatile memory devices owing to their advantages such as low-power consumption, high operation speed, high packing density, long retention time, etc.[1,2] Among the essencial parameters of ReRAMs, a high ON/OFF ratio is critical since it can not only enable fast and stable detection of the state in the memory cell but also simplify the circuitry to distinguish the storage information. While taking advanges of inorganic-organic based semiconductor-dielectric blends,[3–5] P(VDF-TrFE) can provide including a relatively excellent stability, a relatively high dielectric constant among the polymers, and a large remanent polarization;however, P(VDF-TrFE) based devices have the disadvantage of being read-destructive.[6] Our P(VDF-TrFE)/ZnO nanocomposites based ReRAMs exhibit the enhanced and stable resistive switching characteristics with an ON/OFF ratio as high as 7×10^6 and a retention time up to 10^4 s.

The ReRAM cells were fabricated by mixing P(VDF-TrFE) with ZnO nanoparticles(NPs). The ZnO NPs were prepared from colloidal synthesis methods. Then, ZnO NPs were mixed with P(VDF-TrFE) with a ratio of 15, 20, 25, or 30%, respectively. Then, the solution was deposited on n^{++}Si substrates by spin coating at 3500 rpm for 30 s, which was then annealed at 140°C for 1 h. We measured electrical properties and memory operating mechanism of the film using Keithley 4200 and TEM respectively.

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Room-temperature detection of hydrogen peroxide vapor based on porphyrin nanofilm sensor

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Abstract :

The porphyrin nanofilm based hydrogen peroxide vapor sensors are demonstrated and utilized as sensor transducers for determination of hydrogen peroxide vapor at room temperature. The porphyrin solution, oxo-[5,10,15,20-tetra(4-pyridyl)porphyrinato]titanium(IV) (TiOTPyP) in chloroform, is simply spin-coated on a rigid and flexible substrates and then interdigitated Au electrode is sputtered on the porphyrin nanofilm to fabricate sensor transducer. The sensor shows a good response in a range from ca. 2 to 90 ppm, and can be utilized in highly sensitive, real-time hydrogen peroxide vapor sensors.

Nanomaterials and nanodevices(A)/0985 P2-ap.122

Fabrication of silicon nano-pillar structures by self-aligned Pt nano-droplet mask and dry etching.

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Abstract :

Silicon(Si) nano-pillar structures exhibit promising potential applications in many fields compared with the conventional counterpart. Therefore, development of a simple and cost-effective method for the fabrication of this kind of nano-structures is essential to enabling a wide range of advanced technologies in electronics and optics. In this work, a simple and fast method is presented and the fabrication process includes a rapid thermal annealing(RTA) and inductively coupled plasma-reactive ion etching(ICP-RIE). To fabricate the Si nano-pillar structure, thin platinum (Pt) layer was deposited onto an Si(111) substrate using ion-sputtering. Self-aligned (SA) Pt nano-droplets were formed by RTA process. The Si(111) substrate was etched with ICP-RIE using a self-aligned Pt nano-droplet mask. Effects of process parameters such as RTA temperature, ICP power and etching time on the properties of Si nano-pillar structure were investigated.

Nanomaterials and nanodevices(A)/1092 P2-ap.123

나노구조 산화막을 이용한 사고저항성 지르코늄 합금의 산화거동 및 물리적 특성 평가

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Abstract :

원자력 분야에서 널리 사용되어온 지르코늄 기반의 합금은 냉각재상실사고 발생시 고온 증기에 노출되어 산화되면서 막대한 양의 열과 수소를 방출하여 원전의 건전성에 심각한 위해를 준다. 우리는 내식성을 위해 Zr-Nb-Sn 합금의 표면에 고차원 및 육각형으로 인접한 나노 다공성 산화물 층을 제조하였다. 아노다이징을 통해 소량의 불소 및 탈 이온수를 함유 한 에틸렌 글리콜 전해질에 ~ 90 nm 의 평균 기공 직경을 갖는 나노 다공성 산화물 층이 형성되었다. 부식 연구는 열 중량 분석기 (TGA)를 사용하여 1000 ℃의 공기 중 및 증기 환경에서 수행되었습니다. TEM 및 SAED 패턴은 단결정과 유사한 대형 주상 산화물 입자의 형성을 확인합니다. 나노 기공 직경은 지르코늄 합금의 부식 거동에 중요한 영향을 미치지 않습니다. 또한 공기 중 및 증기 환경에서의 양극성 나노 다공성 구조의 산화 거동은 대기 중 N 의 존재로 인해 산화물 층에서 거의 균열이 형성되지 않는 것을 제외하고는 큰 차이가 없음을 발견했다. 또한 나노구조 산화막을 제조한 Zr-Nb-Sn 합금 튜브를 대상으로 인장 및 압축시험을 수행하였습니다. 이 연구에서 제안한 전략은 내식성을 위해 다른 금속, Mg, Fe, Ni, Co, Inconel, Hastealloy 등과 같은 합금에 유용 할 것으로 기대됩니다.

Nanomaterials and nanodevices(A)/1116 P2-ap.124

Surface Potential of Graphene depending on Substrates and Surface Treatments

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Abstract :

With the recent renewed renewable energy research to replace fossil fuels, triboelectric power generator has developed rapidly over the past few years. Triboelectric power generation was investigated utilizing a graphene for electrostatic induction and electrification. It is found that triboelectric power outputs were changed as engineering surface potential of graphene electrode. In this experiment, mechanical deformation was carried out using method customized pushing system to generate tribo-electricity between graphene electrode and PTFE polymeric surface. Surface potential was changed by two methods such as a doping and ion treatment for interfacing electrode for graphene. After surface treatment, we utilized scanning kelvin probe microscopy (SKPM) and non-contact atomic force microscopy (AFM) to observe surface potential and roughness, respectively. Such surface treatment changed the power of the triboelectric generators. This work opens up a new perspective on friction generators using graphene through treated metal electrode.

Nanomaterials and nanodevices(A)/1121 P2-ap.125

Proton Irradiation Damage Effects to the Zircaloy with nanostructured oxide layer

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Abstract :

In the nuclear reactor, zirconium alloys are selected as a material for nuclear fuel cladding because of its properties which are not only excellent in mechanical properties, but also have a small thermal neutron absorption cross section. There is a method of applying anodization technique to the surface of Zircaloy to increase the oxidation resistance in an accident environment. In this study, the Irradiation damage effect of the nanostructured oxide layer fabricated by the anodiation technique is confirmed by using the proton irradiation. On the oxide layer surface, a pillar capable of nano-compression test was prepared and the physical properties irradiated and unirradiated cases were compared.

Spin and magnetism(C)/0753 P2-ap.201

Thickness dependence physical properties of Fe3O4 films grown on SrTiO3 (110) and MgAl2O4 (110)/(001) substrates by PLD

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Abstract :

Magnetite (Fe_3O_4) thin films with varying thickness were deposited on $SrTiO_3$ (110) and $MgAl_2O_4$ (110)/(001) single crystal substrates by pulse laser deposition (PLD) technique in order to study the different physical properties. The surface of the Fe_3O_4 films on both substrates looks quite smooth for less thicker films and the roughness increases with increasing the thickness of films. The XRD data for the Fe_3O_4 films revealed (110)-oriented epitaxial growth on $SrTiO_3$ (110) substrate. All samples on both substrates exhibited uniaxial magnetic anisotropy within the film plane. The 17 nm sample on STO (110) exhibited an erected-square shape and the coercive field (HC) was ～1.5 KOe at room temperature. From TEM data it is seen that growth of Fe_3O_4 film on $SrTiO_3$ substrate is epitaxial, and the interface width thickness is less than 2 nm.

Spin and magnetism(C)/0992 P2-ap.202

$BaFe_2(PO_4)_2$ powders and thin films for Quantum Anomalous Hall effect

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Abstract :

Recently, some theoretical studies predicted that $BaFe_2(PO_4)_2$ and related materials can exhibit intriguing physical properties, e.g., two-dimensional Ising ferromagnetic behavior and quantum anomalous Hall effect.[1], [2] Here, we made $BaFe_2(PO_4)_2$ powders and thin films with different valence states of Fe ions. We analyzed the detailed structure of $BaFe_2(PO_4)_2$ powders and thin films by using x-ray diffraction and Rietveld refinement analysis. We also studied the valence state of Fe ions by using x-ray photoelectron spectroscopy. We will discuss the magnetic properties of $BaFe_2(PO_4)_2$ powders and thin films with different structures and chemical states.

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Spin and magnetism(C)/1103 P2-ap.203

Magnetoresistance Properties of Hybrid GMR-SV Films with Superconducting Nb, YBCO Buffer Layers

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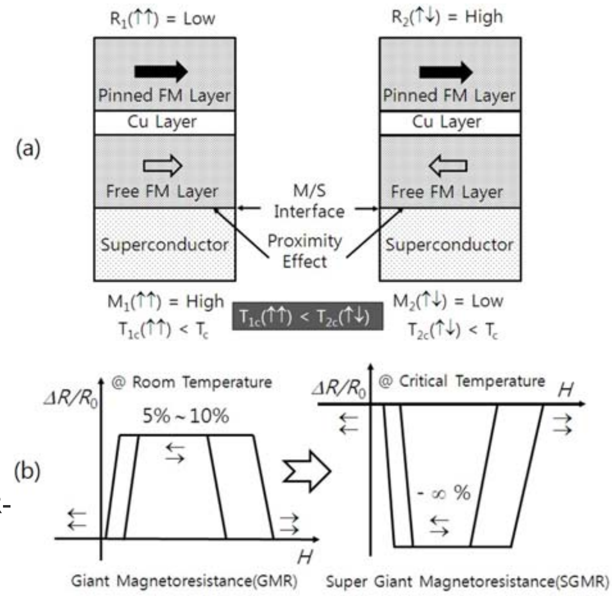
Abstract :



The enhanced magnetoresistance(MR) properties of Superconducting (Nb, YBCO) layers/NiFe(15nm)/CoFe(5nm)/Cu(2.5m)/CoFe(5nm)/NiFe(7nm)/IrMn(10nm)/Ta(5nm) multilayer structure were investigated. The value of MR(↑↑) is lower than MR(↑↓), and one of remanent magnetization M(↑↑) is larger than M(↑↓). The critical temperature(Tc1) for parallel state is lower than(Tc2) for antiparallel state. The Tc1 and Tc2 are lower than the original critical temperature(Tc) due to the remanent magnetization difference by the proximity effect at the interface of metal and superconductor, as shown in Fig.1(a). Hybrid type GMR-SV films with Nb, YBCO buffer layer will be occurred to the variation of critical temperature of superconductor due to the remanent magnetization difference by the proximity effect in the interface of metal and superconductor. The positive MR versus magnetic field curve of hybrid superconductor/GMR-SV films at room temperature is compared with the negative MR versus magnetic field curve of hybrid superconductor/GMR-SV films at the neighborhood of critical temperature. It suggests that the MR curve of hybrid superconductor/GMR-SV films will be measured at the neighborhood of critical temperature can be represented the SGMR(supergiantmagnetoresistance) ratio of -∞%, as shown in Fig. 1(b).

Spin and magnetism(C)/1127 P2-ap.204

The analysis of spin Hall assisted magnetization reversal based on Stoner Wohlfarth model

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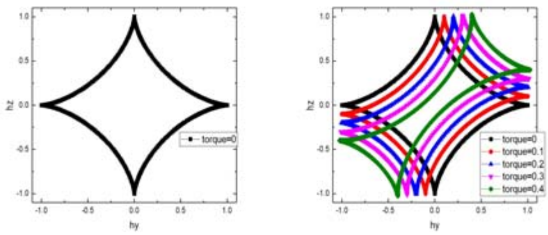
Abstract :



Spin Hall effect(SHE) is getting important, because magnetization reversal can be possible using SHE. So research is being carried in this field. [1, 2]

In our simulation, we suppose the magnetization of sample lying on yz plane and the sample has single domain.

We calculated 3 terms of torque. Anisotropy torque, torque caused by external magnetic field, and spin current torque.

After series of calculations, we made Stoner Wolfarth model when the spin torque existed.

Figure 1. the left figure is original Stoner Wolfarth model and the right is the modified Stoner Wolfrath model. It considered about spin torque effect at magnetization reversal.

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Spin and magnetism(C)/1128 P2-ap.205

Changed Characteristic of Perpendicular Magneto Anisotropy(PMA) in Ta/Pt(t)/CoFeB/MgO Structure

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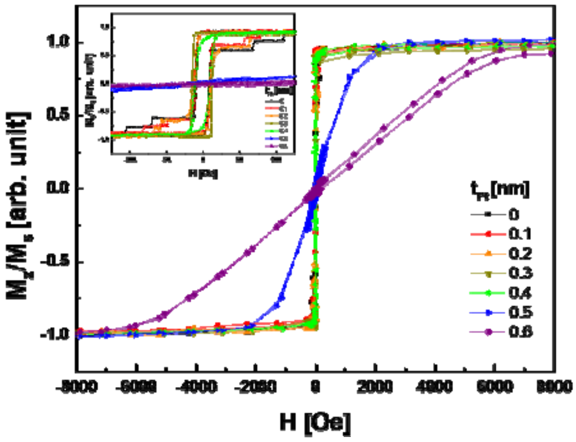
Abstract :



Introduction

Spin in a normal magnetic material polarized in plane direction of the sample due to shape anisotropy, however spin polarized in perpendicular direction is Perpendicular Magneto Anisotropy(PMA). CoFeB/MgO structure is typical structure in which the PMA characteristic appear, and is caused by orbital bonding of Co, Fe in CoFeB with Oxygen in MgO.[1,2,3] That structure commonly use Ta for buffer layer to defense an external factors come from the lower part. At this time, when oxygen located under the CoFeB layer, and increase the Fe-O-Ta bonding, the PMA property is deteriorated.[4] This study confirmed that inserted Pt layer between Ta and CoFeB can reduce the binding of Fe-O-Ta.

experiment

A sample structure is Ta(2nm)/Pt(x)/CoFeB(1.3nm)/MgO(3nm). The samples were deposited by DC magnetron sputtering in ultra-high vacuum chamber, annealed at 300℃ and then photolithographically processed. The magnetic properties were measured using anomalous Hall Effect.

Results and Discussions

[Figure 1]The PMA appears even when there is no Pt layer(Hk>0), but it can be seen that the M-H loop is improved as the Pt thickness is increased to 0.3 nm. Further, it is confirmed that the perpendicular magnetic anisotropy was gradually deteriorated at 0.4 nm or more. Based on the study, it is confirmed that the magnetic properties were influenced by the oxygen position in the sample, and it is confirmed that the coupling of Pt(t≥0.4nm)/CoFeB could reduce the PMA.

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Spin and magnetism(C)/1160 P2-ap.206

spin chemical potentials in a strong Rashba system up to room temperature

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Abstract :

전자가 가진 특성으로는 전하와 스핀이 있는데, 전하를 활용한 반도체 기술은 점점 한계에 다다르고 있다. 이로 인해 전자의 전하뿐만 아니라 스핀을 이용한 반도체 기술의 개발에 대한 연구가 꾸준히 보고되고 있다. 본 연구에서는 반도체 물질에 스핀전류를 발생시키고, 이 스핀전류의 화학포텐셜을 상온까지 측정하였다.

InAs 기반의 high electron mobility transistor(HEMT) 구조에서 채널 내에 흐르는 전자만이 느낄 수 있는 자기장, 즉 Rashba field 에 의해 채널에 스핀전류가 흐르도록 하였다. 채널 위에 증착된 강자성물질($Ni_{81}Fe_{19}$)의 자화방향에 따라 스핀전류의 up-스핀과 down-스핀의 화학포텐셜을 각각 측정하였다. 이와 같은 방법으로 상온에서 InAs 기반의 HEMT 구조에서 스핀전류가 흐르는지에 대한 여부와 스핀 화학포텐셜의 측정이 가능하다는 사실을 확인하였다.

Study on angular dependence of interfacial Dzyaloshinskii-Moriya interaction

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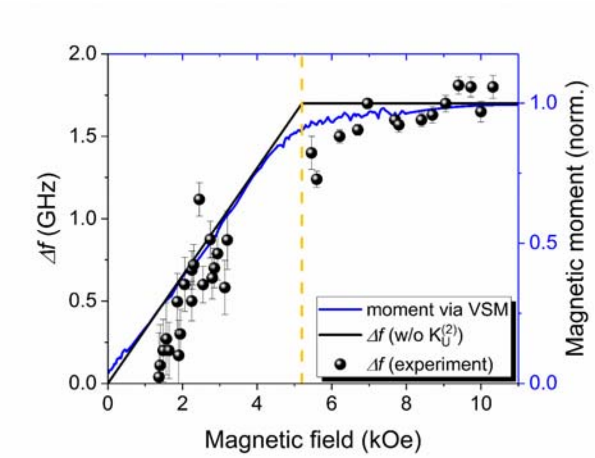
Abstract :



In ferromagnetic thin films, the broken inversion symmetry combined with large spin-orbit coupling at the interface between heavy metal and ferromagnet gives rise to the antisymmetric exchange interaction, namely the interfacial Dzyaloshinskii-Moriya (iDM) interaction [1, 2]. In the presence of iDM interaction, spin-wave amplitudes and frequencies become asymmetric with respect to spin-wave propagation direction [3]. In this work, we investigate angular dependence of iDM interaction using Brillouin Light Scattering (BLS) [4]. The perpendicularly magnetized sample of Si sub./Ta (0.75 nm)/Pt (3 nm)/Co (1 nm)/MgO (2 nm)/Ta (3 nm) annealed 30 min at 230°C is prepared using DC magnetron sputtering system. Figure 1 shows that relation between the iDM-induced frequency shift () and the in-plane magnetization moment controlled by an in-plane external magnetic field (H). *Δf* decreases with decreasing H as expected. However, a detailed comparison between *Δf* and the in-plane magnetic moment shows that they scale differently. This different scaling indicates that the iDM is not a scalar but a function of the polar angle of magnetization. This result is in consistent with a tight-binding model, which shows that *Δf* in case of m//z (z indicates the out-of-plane direction⊥H) is lower than that in case of m//x (x indicates the in-plane direction//H). The details will be further discussed.

(Fig. 1 Relation between *Δf* (black dot) and in-plane magnetic moment (blue solid line) with external in-plane magnetic field (H). The black solid line indicates the expectation value of *Δf* without $K_u^{(2)}$ term. The yellow dash line indicates the H_k field ~5.2kOe.)

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Devices and application(F)/0100 P2-ap.301

온도구배가 있는 열전물질의 전기저항의 새로운 측정방법

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Abstract :

오늘날 열전물질의 열전성능의 측정기술은 열전관련 산업의 발전에 발맞춰 그 정확도와 정밀도를 향상시켜야 할 필요가 있다. 열전물질의 특성 중 전기 전도도는 실험적인 방법으로 전기저항을 측정함으로써 평가할 수 있다. 그러나 열전물질은 재료내의 온도구배에 의한 열기전력이 매우 크게 발생하여 이로 인해 4 선 저항측정법 (4 wire method)과 같은 일반적인 측정법으로는 저항 측정값이 왜곡될 수 있다. 본 연구에서는 온도구배가 있는 열전물질의 저항을 측정하기 위한 새로운 방법에 대해서 기술하였다. 순간 부하전압 분석법(Instance Load-voltage Analysis, ILA)으로 명명한 이 방법은 온도구배에 의해 열전물질에 유도되는 열기전력과 회로구성에 의한 전압강하 그리고 회로에 흐르는 전류를 통해 열전물질의 저항을 산출한다. 측정시료는 온도에 따라 열기전력이 잘 정의된 E 형 써모커플로 제작하였다. 시료의 저온부를 20 °C 로 고정하고, 고온부는 30 °C 에서 90 °C 까지 온도구배 조건을 달리하면서 열기전력과 회로구성하면서 발생하는 전압강하와 전류를 측정하였다. 이때 측정된 열기전력과 IEC 60584 에서 제시하는 값과 비교하여 실험의 신뢰성을 확인하였다. 그리고 온도구배가 있는 시료의 온도를 특정하기 위해 열전달 모델로써 잘 알려진 잘 알려진 Fin 모델을 이용하였다. 측정결과로부터 ILA 법을 이용하여 온도에 따른 시료의 저항을 계산하였다. 계산된 저항값은 항온조건에서 4 선 저항측정법으로 측정한 기준저항과 비교하였다. 비교 결과, ILA 법으로 계산된 저항값은 기준저항과 ± 0.2% (0.0288Ω) 범위 내에서 잘 일치하였다.

Devices and application(F)/0156 P2-ap.302

High-performance microwave absorber, based on embedded resistors

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Abstract :

Manmade electromagnetic metamaterials (MMs), which consist of a periodic arrangement of meta-atoms, can include unnatural features by adjusting the electric permittivity and the magnetic permeability. By tailoring the arrangement of meta-atoms, the dielectric loss and the impedance matching can be optimized so that perfect absorption appears in a specific frequency range. Many researchers have contributed to MM absorbers (MMAs) that maintain the high-absorption performance in a wide frequency range, as well as a specific frequency range. In this work, we numerically and experimentally studied a wide-band MMA by broadening the bandwidth through embedding resistors to achieve low Q-factor and exploiting multiple resonances obtained by the rectangular patches of different sizes. We elucidate the absorption mechanism in terms of impedance matching with the free space and distribution of the surface currents at specific frequencies. The simulated absorption band over 97% turns out to be 0.99 – 3.0 GHz, and the corresponding experimental absorption in 0.95 – 3.15 GHz is also over 97%.
This work was supported by the Institute for Information & communication Technology Promotion (IITP) grant funded by the Korean government (MSIT) (2013-0-00375) and by the NRF funded by MSIT, Korea (No. 2017R1A2B4003916).

Devices and application(F)/0491 P2-ap.305

Al 도핑에 의한 $LiMn_2O_4$ 박막의 물리적 성질 및 이차전지 양극 특성 변화

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Abstract :

본 연구에서는 도핑된 리튬망간산화물 $LiAl_xMn_{2-x}O_4$ (x ≤ 0.3)를 sol-gel 방법을 이용하여 Pt 기판 위에 spin-coating 함으로써 박막 시료들을 제작하여 그 물리적 성질 관측 및 이차전지 양극의 전기화학적 특성과의 연관성에 대하여 조사하였다. 박막들에 대한 X-ray diffraction 측정 결과, 도핑된 시료들에서 이차상(secondary phase)은 관측되지 않았으며, $LiMn_2O_4$ 에서와 같은 cubic spinel 격자구조를 나타내며, 도핑량 증가에 따라 격자상수가 선형적으로 감소함을 보였다. X-ray photoelectron spectroscopy 측정 결과, Al^{3+}의 존재가 확인되었으며 팔면체 자리의 Mn^{3+}를 대체함이 관측되었다. 또한, 팔면체 자리의 Al^{3+} 이온은 전자 spin-orbit splitting 이 1.1 eV 로 결정되었다. $LiAl_xMn_{2-x}O_4$ 박막을 이용하여 비커형 반전지를 제작하고 그 전기화학적 특성들을 관측 및 분석하였다. 박막들에 대한 충전-방전 초기 cyclic voltammetry 측정 결과, 전지 충전-방전 과정에서 두 단계로 발생하는 Li^+ 이온 탈리 및 삽입 과정에서 피크 전압이 Al 성분비 증가에 따라 고전압쪽으로 이동함이 나타났으며, 이것은 Li^+ 이동에 더 큰 에너지가 소요됨을 나타낸다. 전류 0.1 mA/cm^2 을 충전-방전 하면서 진행된 cyclic performance 실험에서 Al 도핑량이 증가함에 따라 초기 방전 용량은 $LiMn_2O_4$ 에서보다 낮아졌다. 그러나 cycle 이 진행될수록 방전 용량이 역전됨이 나타났으며, 그 원인은 팔면체 자리의 Al-O bonding energy 가 Mn-O bonding energy 보다 크기 때문에 격자구조가 더 안정적으로 유지됨에 기인하는 것으로 해석된다.

Devices and application(F)/0499 P2-ap.306

O_2 플라즈마 처리를 한 MoS_2 전계효과 트랜지스터의 전기적 특성 변화

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Abstract :

2 차원 물질은 반도체 로직, RF 소자, 광학센서 등의 다양한 분야에서 새로운 반도체 물질로서 주목을 받고 있다. 이러한 점에서 이황화몰리브덴(MoS_2)과 같은 2 차원 물질에 대하여 반응성, 도핑, 표면결함 등에 대한 연구가 진행되었고 이러한 특성을 변화시킬 수 있는 방법들에 관한 연구가 이루어졌다. 이러한 특성을 변화시키는 하나의 방법이 플라즈마 처리를 하는 것이다. 플라즈마 처리는 2 차원 물질로 만들어진 소자의 물리적, 화학적, 전기적 그리고 광전기적인(optoelectrical) 특성을 조절하는 방법으로서 많은 연구가 진행되었다.

최근의 연구에서 O_2 플라즈마 처리를 하였을 때 광학적 특성 변화에 관한 연구되었었다. 하지만 전기적인 특성과 광전기적인 특성의 변화를 포괄적으로 연구된 적은 없다. 그래서 이번 연구에서는 MoS_2 전계효과 트랜지스터(Field effect transistor; FET)에 다양한 조건에서 O_2 플라즈마 처리를 하였을 때 전기적인 특성과 광전기적인 특성이 어떻게 변하는지를 관찰하였다. 먼저 50 kHz, 50 W 의 조건에서 플라즈마 시간에 따라서 소자의 특성이 어떻게 변하는 지를 관찰하였다. 그리고 50 kHz, 100 W 의 조건에서 플라즈마 시간에 따라서 소자의 특성이 어떻게 변하는 지를 관찰하였다. 그 결과 O_2 플라즈마 조건에 따라서 MoS_2 FET 의 이동도와 on/off 비율이 변화하는 것을 확인하였다.

Devices and application(F)/0558 P2-ap.307

Vriable Narrow Band Path Filters Depending on Temperature

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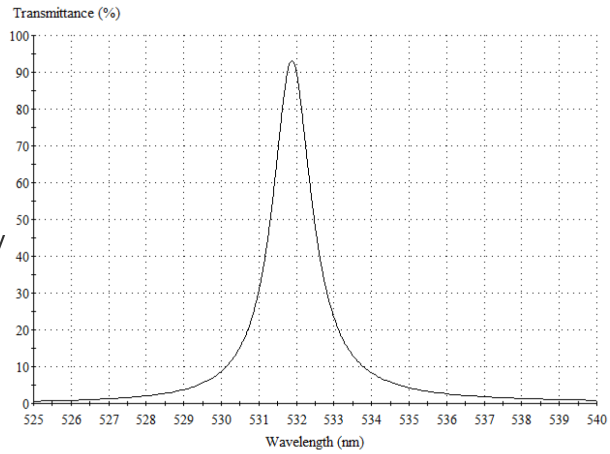
Abstract :



Variable narrow band path filters are key of optical components in variable-spectral detection applications and laser filters. Especially, linear variable band pass filters using band-shift filters are crucial optical elements in a number of different applications including astronomy and hyper-spectral imaging. But costs for fabricating those components are very expensive, thus we fabricated band-shift narrow band path filters only using SiO2, TiO2 and VO2 which generally used for thin film sources.

The vanadium dioxide thin films were prepared on BK7 glass substrates by RF sputtering with a vanadium dioxide disk target, and sputtering was performed at an RF power of 100 W for 1h at 400 °C. Thereafter, SiO2/TiO2 periodic multi layer deposited on the vanadium dioxide films, SiO2/TiO2 layers have been prepared by a reactive electron beam evaporation technique.

We designed and fabricated 532 nm, 633 nm, and 1064 nm narrow band pass filters, they have full width at half maximum 2 nm; very sharp shapes. Also it shows band shift near 10 nm according to the temperature variation.

Devices and application(F)/0577 P2-ap.308

Electrical Characteristics of AlGaN/GaN HEMTs Fabricated with MgF_2 Passivation

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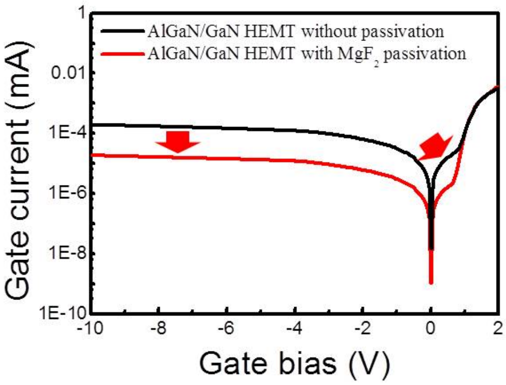
Abstract :



AlGaN/GaN 기반 high electron mobility transistors (HEMTs)는 높은 saturation velocity, 우수한 열적 안정성, 큰 밴드갭, 그리고 높은 two dimensional electron gas 밀도를 갖는 장점이 있다. 이러한 이유로 HEMTs 는 고출력, 고속, 고온도, 그리고 고주파수 특성을 위한 응용이 가능해 졌으며, 이에 대해 안정적인 구동을 위한 연구가 활발히 진행 중에 있다. 하지만, 마이크로웨이브 출력 파워를 제한시키는 current collapse 또한 매우 중요한 이슈로 다뤄지고 있으며, 이를 필수적으로 해결하기 위해 cap layer 를 통한 surface charge 조절 및 surface passivation 과 같은 방법이 고효율/고출력 특성의 HEMTs 제작을 위해 적용되고 있다. 이에 본 연구에서는 passivation 공정을 통한 게이트 누설 전류의 감소 및 이로 인한 드레인 전류 향상을 위한 시도를 하였다. 이를 위해 기존의 고온 열처리 공정으로 인한 소자 열화 현상을 초래하는 SiO_2 passivation layer 를 대체한 우수한 절연 특성의 MgF_2 를 적용함으로써 1-order 이상의 게이트 누설 전류를 줄일 수 있었으며, 드레인 전류의 증가를 확인할 수 있었다. 이러한 결과를 토대로 MgF_2 passivation layer 가 최종적으로 제작된 AlGaN/GaN HEMTs 의 surface charge trapping 을 효과적으로 감소시키는 것으로 보인다.

Devices and application(F)/0740 P2-ap.309

Fabrication of Cd-treated CIGS solar cell with Zn(O,S) buffer

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Abstract :

We applied Cd-reduced CdS(Cd-treatment)/Zn(O,S) buffer to CIGS solar cell, where CdS was made by dipping into CdS CBD solution for 2 min and Zn(O,S) was deposited by co-sputtering of ZnO and ZnS. The hybrid buffer provided improved short circuit current and open circuit voltage and resultantly high power conversion efficiency. The best CIGS solar cell with the hybrid buffer showed 12.69 % cell efficiency compared to the CdS-buffered standard cell with 13.06 %. The improved efficiency for Cd-treated solar cell was found to be consequence of enhanced response to blue wave length photon and surface passivation of absorber surface by the treatment.

Devices and application(F)/0755 P2-ap.310

기계 부품 내외부 표면 검사를 위한 비전 시스템 연구

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Abstract :

비파괴 검사는 기계 부품을 완제품에 도입하기 전 불량의 여부를 미리 판별하는데 유용하게 사용되고 있다. 그 중에서 이미지를 분석하고 판별하는 비전 검사는 사람의 눈을 대신하여 다양한 분야에 적용되고 있다. 본 연구는 자동차의 수많은 부품들 중에서 탑승자의 안전과 직결되는 브레이크 시스템을 구성하는 부품 중에서 제동력을 생성하는 브레이크 캘리퍼 내부 이물질 유무 검사 시스템과 연료의 연소 후 배기가스를 지정한 경로에 따라 배출하도록 하는 머플러 용접부의 정상 용접 검사 시스템을 연구하였다. 비전 검사는 외부 광원에 의한 노이즈를 최소화하기 위해 암실환경에서 고해상도 GigE 카메라를 이용하여 실험을 진행하였다. 360° 렌즈, LED 조명, 스텝모터를 적용하여 최소 0.2mm 의 이물질을 검출 할 수 있는 비전 시스템을 구현하였다. 배기가스 머플러에 대해서는 파이프 간의 용접 폭을 측정하여 머플러의 불량 여부를 분석하는 비전 시스템을 구현하였다. 본 연구를 통하여 개발된 비전 시스템은 실제 생산 라인에서 검수용으로 사용할 수 있도록 기능을 구현하였다. 제품 생산 공정에 본 연구를 통해 개발된 비전 시스템을 적용한다면 생산성 향상에 기여할 수 있을 것으로 기대된다.

Devices and application(F)/0767 P2-ap.311

Fabrication of Cu-poor based CIGSe Solar Cell by Using Non-Vacuum Spray Pyrolysis

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Abstract :

We fabricated Cu(In,Ga)Se_2(CIGSe) thin film solar cells by using non-vacuum ultrasonic spray pyrolysis and post-selenization process. We controlled amount of $CuCl_2$ in the chloride based precursor solution by 0.9, 0.8, 0.7 and 0.6 and deposited Cu(In,Ga)S_2(CIGS) thin film by spray pyrolysis. Subsequently, we performed post-selenization process for converting sprayed thin film into CIGSe thin film with improved crystallinity and substitution of S with Se. We characterized on post-selenized thin films by FESEM, Raman spectroscopy and XRD. To fabricate complete solar cells, we deposited In_2S_3 buffer layer by spray pyrolysis and continuously deposited i-ZnO and ITO window layers by sputtering process. We achieved conversion efficiency about ~9 % by using the precursor solution of Cu ratio 0.7. Further characterizations of c-f-T and J-V-T have been carried out to understand the factor of loss mechanism of the solar cells such as dominant recombination and defect energy levels and densities.

Devices and application(F)/0887 P2-ap.312

A Software Based Hysteresis Compensation using LabVIEW FPGA for Atomic Force Microscope Flexure Scanners

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Abstract :

Piezoelectric actuators are critical components in typical flexure scanners used in atomic force microscopy. However, nonlinear hysteresis is a major problem for piezo-actuated scanners. A number of practices have been used in the past to correct hysteresis. They often involve complex and costly hardware designs. Our present work is focused on a simple route of realizing the model-based Prandtl-Ishlinskii (PI) feedforward method used to compensate for hysteresis in atomic force microscope flexure scanners. The measured hysteresis ingrained in the piezoelectric scanner is used to obtain the inverse models whose output directly linearizes hysteresis. The model is implemented in LabVIEW FPGA (field programmable gate array). Contact mode imaging was performed to test the effectiveness of our model-based feedforward control approach. The intrinsic precision errors present in the open-loop control were reduced by more than 80%.

Devices and application(F)/1171 P2-ap.314

Analysis of RBC combined with MB by using a GMR-SV Device and multi turn μ-coil and PR μ-channel

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[1]Sangji University, Department of Oriental Biomedical Engineering, [2]Sookmyung Women's University, Department of Nanophysics

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Abstract :

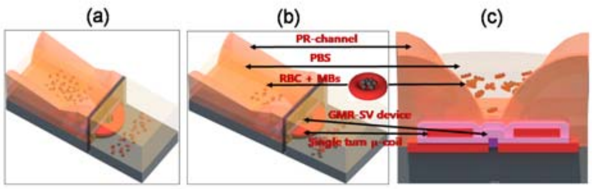

Fig. 3

The giant magnetoresistance(GMR)-spin valve(SV) device having a high linearity and a low hysteresis was developed as one biosensor to analyze the property of red blood cell(RBC). Three main magnetic properties of the dual-type GMR-SV film were a magnetoresistance ratio (MR) of 8.5%-10.0%, a magnetic sensitivity (MS) of 1.0%/Oe -1.5%/Oe, and a coercivity of 1.0 Oe - 1.5 Oe for the free NiFe layer. Those applied to the artificial isotropic property in-plane of the glass/Ta/NiFe/CoFe/Cu/CoFe/IrMn(or PtMn)/CoFe/Cu/CoFe/NiFe/Ta having a dual-type GMR-SV. The multuilayer structure with in-plane orthogonal easy axes controlled by the post annealing temperature of 105 ^{o}C was included of the free and the pinned ferromagnetic layers for applying biosensor. The RBC combined with the magnetic bead(MB)s can be captured on the 10 turn μ-coils, which maintain an enough magnitude of magnetic field for the detection of MBs attached to RBC. When RBCs combined with several MBs passed on the PR μ-channel with a diameter of a few μm, as shown in Fig. 3, the movement of those controlled by the electrical AC input signal applied to the 10 turn μ-coils. The RBCs captured above the GMR-SV device confirmed as the output signals for detection status. It implies that this device as biosensor can analyze the coupling force between hemoglobin and MBs for the deformed features of RBCs to pass the narrow capillary. Also, the dual-type GMR-SV device, multi turn μ-coil, and PR μ-channel can be applied to analyze a new property of the membrane's deformation of RBC coupled to MBs.

Nano and mesoscopic physics(E)/1147 P2-co.101

Direct transfer of optical orbital angular momentum to non-resonantly pumped exciton-polariton quantum fluid

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[1]Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea, Department of Physics and KI for the NanoCentury, [2]Korea Institute of Science and Technology (KIST), Seoul, Republic of Korea, Center for Opto-Electronic Convergence Systems

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Abstract :

† : First co-author , * : corresponding co-author, †, * : equal contribution

Exciton-polariton is bosonic quasi particle arising from strong coupling between cavity photon and quantum well exciton. This photon-dressed excitons (exciton-polariton) can form collective coherent state very close to Bose-Einstein Condensate. Harnessing quantized orbital angular momentum can lead to explore characteristics of basic topological object and quantum technology in various physical systems. In this study, we can transfer directly orbital angular momentum of off-resonant light to polariton condensate, generating quantized vortices in out-of-equilibrium. Direct transfer of orbital angular momentum from pump beam maintained robustly chirality and topological charge of vortices even in large energy relaxation. Our observation eliminate demands to control and fine-tune laser wavelength, size and shape of optical pump beam for creating quantized vortices. These results can suggest new stage towards versatile optical control of topological charge in diverse systems.

Nano and mesoscopic physics(E)/1058 P2-co.102

Top gated field effect transistor in $LaAlO_3/SrTiO_3$

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Abstract :

We make top-gated field effect transistor to control electric characteristics of two dimensional electron gas in $LaAlO_3/SrTiO_3$. The field effect transistor in $LaAlO_3/SrTiO_3$ has n-type behavior and depletion mode was observed at the gate voltage of -8 V. This field effect transistor also worked at low temperature (15 mK) while the two dimensional electron gas in $LaAlO_3/SrTiO_3$ hetero-interface was in superconducting region. The superconducting critical current was dependent on gate voltage. When the gate voltage is negative, the superconducting critical current tends to decrease as compared to when there is no gate voltage, and when the superconducting critical current is zero, it becomes quasi-particles tunneling.

Nano and mesoscopic physics(E)/1057 P2-co.103

Electrically-Controlled Carrier Guiding in Single-Channel Graphene Device

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[1]Ulsan National Institute of Science and Technology (UNIST), Department of Physics, [2]Ulsan National Institute of Science and Technology (UNIST), School of Electrical and Computer Engineering

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Abstract :

We propose a single-channel graphene device where charge carriers can be guided to a specific direction just by controlling the electrostatic environment in the channel. The almost perfect ballistic propagation of electrons and the angle-dependent electron transmission can be achieved in graphene with well-designed one-dimensional external periodic potentials. We have performed theoretical calculations on the time-evolving probability density of an electron wave packet in graphene superlattice structure, which is a Kronnig-Penny type of periodic potential generated with alternating n- and p-type doping regions in graphene. The alternating n- and p-type doping regions are formed by applying proper voltages on the comb-shape top gate and global bottom gate electrodes. Our calculations show that the propagation direction and spread of electron wave packet in graphene sensitively depend on the magnitude of superlattice potential. The ratio between the number of electrons flowing into the drain electrode and that of electrons flowing into the side drain is found to be modulated arbitrarily by tuning the biases applied to the top and bottom gate electrodes. Our work provides an efficient and scalable method to fabricate graphene field effect transistors with large on-off ratio while maintaining the high carrier mobility of graphene, associated with its zero band gap nature.

Nano and mesoscopic physics(E)/1029 P2-co.104

Ab initio study of 2D/3D heterostructures using MoS_2 and Si(100)

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Abstract :

With the discovery of graphene which is a representative and interesting two-dimensional (2D) material, various 2D materials including transition metal dichalcogenides (TMDs) have been actively explored due to their notable physical and chemical properties. Layered TMD materials consist of two transition metal atoms (M) and one chalcogen atom (X) with chemical formula of MX_2, and each layer is bound by van der Waals interaction. Unlike graphene with semi-metallic property, some TMD monolayers such as MoS_2 are suitable for application in field effect transistors (FETs) with their semiconducting characteristics.

For various applications of TMDs as electronic devices, we need to investigate diverse heterostructures using TMDs. In this study, density function theory (DFT) calculations have been performed to investigate the electronic characteristics of TMDs depending on the interaction between TMD and three-dimensional (3D) semiconductor. For the calculations, we select MoS_2 monolayer as 2D material and Si(100) as 3D material. Especially, we focus on the band alignment of MoS_2/Si(100) heterojunction. More details in electronic structure are analyzed by partial density of states (PDOS), work function, and charge density difference.

Nano and mesoscopic physics(E)/0997 P2-co.105

Investigation of the effect of external electric field on WS_2/Si heterostructures using first-principles calculations

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Abstract :

The van der Waals (vdW) heterostructures based on two-dimensional (2D) materials are in the limelight for wide applications in nano electronic devices. Among diverse 2D materials, transition metal dichalcogenides (TMDs) are one of key building blocks of vdW heterostructures with their attractive atomic and electronic characteristics. Diverse vdW heterostructures using TMDs such as MoS_2 and WS_2 have been attracting much interest: for example, TMD on conventional semiconductor such as Si have been actively investigated for optoelectronic applications. In this study, we investigate the atomic and electronic structures of WS_2/Si heterostructure using first-principles calculations. Especially, we report the effect of external electric field on the band alignment of WS_2/Si heterostructure depending on the number of WS_2 layers. Details in electronic structure are analyzed in terms of partial density of states (PDOS) and charge density difference.

Nano and mesoscopic physics(E)/0821 P2-co.106

Carbon coated Fe nano-powders using thermal DC plasma

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Abstract :

Carbon coated Fe nano-powder have been successfuly fabricated using thermal plasma, which is the well known physical method to produce the various kinds of nano-sized powders of metal, oxide, nitride, composite, etc. Nano-sized Fe have been recognized as a novel materials for the purification of environment, however, the protection of bare Fe nano-powder is highly needed as it is very sensitive and explosive when exposured to the humid atmosphere in a short time. It was found that carbon or few layers of graphite was covered on the outer surface of Fe nano-powder when the methane, CH_4 gas was used as a carbon source in thermal plasma.

In this work, the concentration of CH_4 was varid first from 1-4 kPa pressure with the balance of Nitrogen to observe the existence and thickness of grphite on Fe nano-powder. Then, the cathode of plasma was changed from the normal tungsten to the graphite rod. Effect of diameter of cathode was investigated on the size, morphology, passivation of Fe nano-powders and their production rate for the industrial usage. Also discussed are the stabiliy of thermal plasma from the material, diameter, tip shape of graphite cathode along with the anode crucible.

Nano and mesoscopic physics(E)/0342 P2-co.107

Stable hydrogen species induced by low-energy proton-beam irradiation in ZnO:Al

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Abstract :

The low-energy (200 keV) proton-beam was irradiated on Al-doped ZnO (ZnO:Al) with a high dose of ~10^{17} cm^{-2}. The penetration depth of protons into the sample was determined to be ~1.6 μm with the stopping power of 117.5 keV/μm by SRIM code. Electron spin resonance spectroscopy reveals that the implanted protons form a deeper energy level intensifying a peak at g=2.00, as well as a shallow energy level of g=1.96. The hydrogen species of the peak at g=1.96 exhibits delocalized electronic states, only shown after irradiation. Under high dose irradiation condition, implanted protons occupied two distinct lattice sites, enhancing thermal stability due to deeper energy level formation. This study may help in understanding the enhanced conductivity, originating from thermally stable hydrogen species by proton-beam irradiation.

Nano and mesoscopic physics(E)/0212 P2-co.108

Effects of bending in the Kane-Mele system of a nanoribbon geometry

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Abstract :

It is well known that spin orbit interactions cause a band gap in a honeycomb lattice, which is also characterized by the topological edge states in a nanoribbon geometry. In this work, we investigate the change in the edge states when the nanoribbon is bent. We consider two types of bending, width preserving bending and bond-length preserving bending. We obtain electronic band structure in the variation of bending parameters as well as spin orbit interaction strength. The bending of ribbons is found to give rise to the splitting of degenerated edge states. As the bending parameter is increased, the splitting becomes stronger with the topological nature maintained. We also discuss the change in the properties of the topological edge states by the detailed analysis of the wave functions.

Strongly correlated systems(B)/1161 P2-co.201

First-principles prediction of magnetic ground state of correlated oxides: the case for $LaMnO_3$

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Abstract :

$LaMnO_3$ is one of the prototypical materials in which charge, spin and orbital degree of freedom play together in producing complicated phase diagram. Despite of its long history, it is still challenging to correctly describe the magnetic ground state of $LaMnO_3$ from first-principles [1-3] due to many technical and fundamental issues among which most serious are the determination of interaction parameters and the intriguing dependence on the DFT and DFT+U functional formalisms [4]. In this study, we try a fully ab-initio prediction of bulk $LaMnO_3$. To estimate interaction parameters (Hubbard U and Hund J), we used constrained random phase approximation (cRPA) method. With these parameters and spin-unpolarized DFT+U with FLL (fully localized limit) double counting, we successfully obtained the A-type antiferromagnetic ground state with Mott-Hubbard gap (rather than the charge transfer type). On the contrary, the combination of different values of interaction parameters as well as the DFT+U formalisms can easily lead to the unphysical magnetic ground state solutions.

[1] H. Sawada and K. Terakura, Physical Review B 58, 6831 (1998)
[2] T. Hashimoto et al., Physical Review B 82, 045124 (2010)
[3] T. A. Mellan et al., Physical Review B 92, 085151 (2015)
[4] S. Ryee and M. J. Han (submitted)

Strongly correlated systems(B)/1141 P2-co.202

Pressure-dependent electronic structure and magnetic properties of $GaTa_4Se_8$: A first-principle study

Min Yong Jeong[1], Jae-Hoon Sim[1], Myung Joon Han[*1]

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Abstract :

The lacunar spinel compound, $GaTa_4Se_8$, exhibits fascinating material characteristics such as insulator-to-metal transition (IMT) and superconductivity under pressure. A recent first-principles study shows that the spin-orbit coupling (SOC) plays the key role in determining the electronic structure and magnetic properties [1]. In particular, $GaTa_4Se_8$ has been proven as the first and only established example of the $J_{eff} = 3/2$ ground state [2]. In order to understand the superconductivity and IMT for this new perspective, we performed the first-principles density functional theory calculations in consideration of SOC. Changes in electronic structure and magnetic properties of $GaTa_4Se_8$ are studied at various pressures.

[1] H.-S. Kim, J. Im, M. J. Han & H. Jin. *Nat. Commun.* **5**, 3988 (2014)

[2] M. Y. Jeong, M. J. Han *et al. Nat. Commun.* **(**in press), arxiv:1708.01416

Topological Hall Effect in Epitaxial Ultrathin SrRuO3 film

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[1]Institute for Basic Science, Center for Correlated Electron Systems (CCES), [2]Seoul National University, Department of Physics and Astronomy

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Abstract :

SrRuO3 is ferromagnetic material and it shows anomalous Hall effect (AHE) at low temperature. Although SrRuO3 has been studied in many decades, the accurate mechanism of unconventional Hall effect in SrRuO3 system is not yet established. We claim that we synthesized best quality SrRuO3 thin-film and we first discovered new topological Hall effect which is not derived from AHE in ultrathin SrRuO3 film. We expect that this discovery will help to reveal the unconventional Hall effect in SrRuO3 system.

Strongly correlated systems(B)/1017 P2-co.204

Renormalization of phonon frequency through Dzyaloshinskii-Moriya interaction in $Y_2Ir_2O_7$

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Abstract :

Conventionally, the exchange interaction is considered to analyze the phonon behavior as well as the Coulomb potential. However, Spin-orbit coupling make another spin Hamiltonian interaction terms that single-ion anisotropy (SIA) and Dzyaloshinskii-Moriya (DM) interaction, we should consider those interactions to understand unconventional phonon behavior in 5d oxide materials. The 2nd order derivative of spin-orbit coupling can affect the phonon frequency shift.

In our measurement, the seven IR-active phonon is revealed. Several phonon modes show the anomalous behavior in the resonance frequency shift near the T_N. Due to the is highly suppressed super-exchange (SE) interaction between magnetic Iridium spins, these anomalous behavior is considered to be originated from the spin-phonon coupling.

From the result of DFT calculation, the vector component of oxygen ion displacement is decomposed to identify the influence of the DM interaction. DM interaction parameter change is well matched with the renormalization of resonance frequency shift. Consequently, we conclude that strong spin phonon coupling is originated from the DM interaction.

Strongly correlated systems(B)/0999 P2-co.205

Lattice strain in the grain inside of (1-x)$BiFeO_3$-x$BaTiO_3$ bulk ceramic measured by X-ray microdiffraction

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Abstract :

(1-x)$BiFeO_3$-x$BaTiO_3$(BF-BT) solid solution ceramic has been studied as a cadidator for lead-free piezo-electric material. Previous reaserches showed that BF-BT cereamice revealed very good performance as a sensor or a acuator piezo-electrics material (d_{33}:~250 pC/N ,d_{33}*:~370 pm/V). The contents of $BaTiO_3$ and making recipie were critical in enhancing d_{33} value. Espcically, 33% $BaTiO_3$ concentration (x=0.33) specimen revealed the highest performance. The 33% $BaTiO_3$ concentration is near the Morphotropic Phase Boundary(MPB) region in phase trainsition from the rhombohdral structure to the cubic structure as $BiFeO_3$ to $BaTiO_3$. The mechanism of enhancing performance of electro-mechanical properties at the MPN region in many bulk-ceramics has not been clearly understand yet. The observation of crystal stucture changes in micron-scale would give insight in understanding this mechanism. By using X-ray microdiffraction(XMD), we observed crystal structure changes in micron-scale, which enabled resolving grains in bulk (1-x)BF-xBT solid-solution ceramics.(x=0.33 ~ x=0.50)

XMD set up at 4B beamline of Pohang Light Source (PLS) was used to investigate the local structural variations in the micron scale. X-ray white beam from the synchrotron radiation source was focused down to 1x1μm^2 by a pair of K-B mirrors, and scanned over the area of several tens of microns. BF-BT ceramic specimens had grains smaller than ~10 μm, so that Laue images had patterns from many grains. A special algorithm was developed to sort peaks from many grains to individual grains by monitoring spatial peak intensity

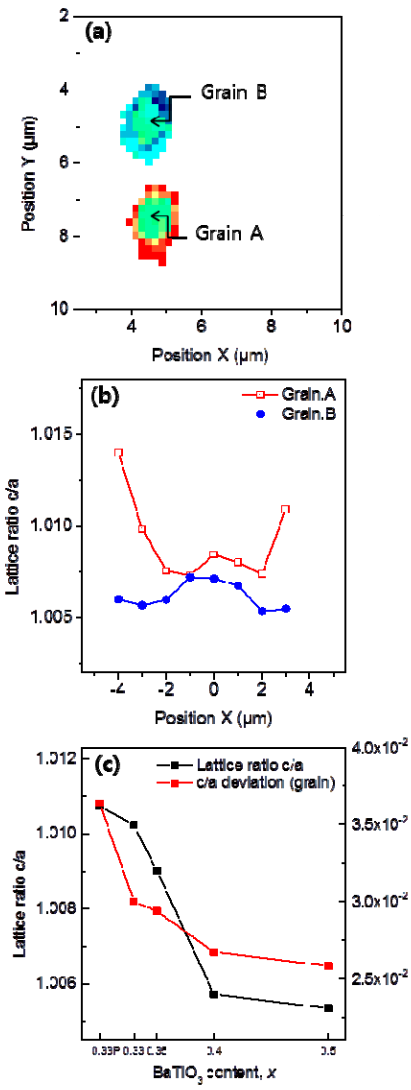

Figure 1 (a) lattice parameter ratio c/a map for two of grains in (1-x)BF-xBT(x=0.33). Grain A reveals higher c/a ratio at the gr ain boundary, and the grain B shows lower c/a ratio at the grain boundary. (b) c/a ratio line profile plot of the grains in Figure (a) (c) the average values of c/a and the deviations of c/a in a grai n for each BaTiO3 concentration.(average value)

distribution. From the Laue patterns of each grain, the 2D distributions of the c/a ratio and the lattice distortion angle were calculated and the correlations between crystal structure changes and electrical properties were investigated. Many grains showed higher or lower c/a values only near the grain boundaries and the variations were highest near the MPB(x=0.33).

Strongly correlated systems(B)/0950 P2-co.206

Unconventional charge dynamics of a semi-metallic layered iridate investigated by THz time-domain spectroscopy

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Abstract :

We investigated electrodynamics of Tb-doped Sr_2IrO_4 by using terahertz time-domain spectroscopy in a reflection geometry. At room temperature, the free carrier contribution of optical conductivity spectra is characterized by an extremely small scattering rate ~0.02 THz, and the bound charge excitation exhibits a linear frequency-dependent absorption edge. As temperature decreases, whereas the scattering rate remains almost the same, the spectral weight is reduced with an anomaly at about 180 K. We discuss these intriguing spectroscopic results in connection with a possible contribution of the Dirac-like band as well as the conventional band with a little dispersion both being located close to the Fermi energy.

Strongly correlated systems(B)/0919 P2-co.207

Electronic Structure Change of $NiS_{2-x}Se_x$ in the Metal-Insulator Transition Probed by X-ray Absorption Spectroscopy

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Abstract :

The electronic structure change of $NiS_{2-x}Se_x$ as a function of Se concentration x has been studied by Ni L-edge X-ray absorption spectroscopy (XAS). The XAS spectra show distinct features in Ni L3 edge, indicating whether the system is insulating or metallic. These features can be semiquantitatively explained within the framework of the congurational interaction cluster model (CICM). In the S-rich region, relatively large charge-transfer energy (△~5 eV) from ligand p to Ni 3d states and a little small p-d hybridization strength (Vpdσ ~1.1 eV) can reproduce the experimental spectra in the CICM calculation, and vice versa in the Se-rich region. Our analysis result is consistent with the Zaanen-Sawatzky-Allen scheme that the systems in S-rich side (x ≤ 0.5) are a charge transfer insulator. However, it also requires that the △ value must change abruptly in spite of the small change of x near x=0.5. As a possible microscopic origin, we propose a percolation scenario where a long range connection of $Ni[(S,Se)_2]_6$ octahedra with Se-Se dimers plays a key role to gap closure.

Strongly correlated systems(B)/0892 P2-co.208

Disproportionation of Ni charge valency on nickelate thin film surfaces

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Abstract :

Many researches have been fulfilled in epitaxial nickelates thin-film heterostructures, which exhibit a controlled metal-to-insulator phase transitions (MIT). Rare-earth nickelates have the generic formula RNiO$_3$, where the rare-earth element (R) is smaller than lanthanum, i.e. R = Pr, Nd, and so forth. In bulk rare-earth nickelates, it has been known that the MIT is closely related with the disproportionation of the Ni charge valence. Note that the associated physical properties are also sensitive to the cation and oxygen stoichiometry. Variations in the chemical composition critically affect the oxidation state of Ni atoms resulting in a difference in the MIT. It is likely worthwhile to examine how such charge disproportionation and MIT is dependent on the surface topography and the cation/oxygen content in rare-earth nickelate thin films.

In this work, we synthesized $NdNiO_3/LaNiO_3$ bilayer thin films having two surface types grown on (001) $SrTiO_3$ substrate and examined the temperature-dependent transport behaviors. It is shown that conductivity of nickelate bilayer thin film deposited by laser-ablated target surface is worse than that of nickelate bilayer thin film deposited by polished target surface at all temperature. And, an upturn behavior in the resistivity is observed at ~ 50.8 K. It is also found that the Ni^{2+}/Ni^{3+} ratio is higher in the bilayer thin film deposited by laser-ablated target surface compared to the bilayer thin film deposited by polished target surface. Microscopic studies of the chemical stoichiometry and crystal structure at the $NdNiO_3/LaNiO_3$ surface are highly desirable further for deeper understanding of the observed transport behaviors in our bilayer nickelate films. Our results can be utilized to optimize fabricating multilayer structure in high-quality complex oxide films using pulsed laser deposition.

Strongly correlated systems(B)/0805 P2-co.209

A global Influence of the local ferromagnetic impurities on electronic structure of the topological insulator $Cr_{0.08}(Bi_{0.1}Sb_{0.9})_{1.92}Te_3$

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Abstract :

The influence of the ferromagnetic dopants on topological insulators (TI's) is one of the most interesting subjects in the current condensed matter physics field. If the time reversal symmetry of TI's is broken, a gap is generated on the surface states, varying the properties of the undoped TI's fundamentally. We measured a local density of states (LDOS) of a Cr doped topological insulator $Cr_{0.08}(Bi_{0.1}Sb_{0.9})_{1.92}Te_3$ using the spectroscopic imaging scanning tunneling microscopy(SI-STM). Two kinds of impurities are found on the first quintuple layer - one set of impurities is placed on the top Bi-Sb layer, and the second set of impurities is found to be on the second Bi-Sb layer. By analyzing a correlation between the impurities and the gap magnitudes, we find that the impurities and the gap sizes are positively correlated. We will also present an anomalous feature of DOS's near the Fermi energy and its possible implications by analyzing the dI^2/d^2V mapping result.

Strongly correlated systems(B)/0787 P2-co.210

Polarized optical spectroscopy study on quasi one-dimensional spin ladder systems, $BaFe_2S_3$ and $BaFe_2Se_3$

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Abstract :

Since the discovery of pressure-induced superconductivity in $BaFe_2S_3$ (BFS) compound, intensive studies have been conducted on BFS and a similar compound $BaFe_2Se_3$ (BFSE). Both compounds have antiferromagnetic insulating ground states, however, when pressure is applied, they transit to metal and eventually show superconductivity. Moreover, they have one-dimensional spin ladder structure which will result in their anisotropic properties. Here, we present polarized optical spectroscopic results that can reveal the difference and similarity between two compounds and we also discuss how the spin ladder structure is related to the anisotropic optical properties.

Strongly correlated systems(B)/0775 P2-co.211

Reconstruction of the electronic structure in dimerized $IrTe_2$

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Abstract :

$IrTe_2$ exhibits a novel electronic transition where the valence transition, the charge ordering, and the J_{eff} = 1/2 dimerization of Ir^{4+} [1-4]. The system is crystallized to CdI_2-type (p3-m1) structure which is a layered dichalcogenide with van der Waals (vdW) bond gap. Te-Te ions facing on vdW bond gap form an anionic bond and result in three dimensional electronic structure [2]. Besides, Te-Te bonding acts as $(Te_2)^{3-}$ ion, then the valence of Ir above T_C ~ 280 K is 3+. Below T_C, two of five Ir ions change those valence to be Ir^{4+} and those ions develop the $q_{1/5}$ = (1/5 0 1/5) charge order and the J_{eff} =1/2 dimerization of Ir^{4+} ions [3,4]. All these transitions occurs coincidentally and the itinerant electronic structure is also influenced by the $q_{1/5}$ transition.

Although there have been huge amount of investigations are reported, a detailed study for the $q_{1/5}$ phase is barely reported [3,4]. Especially, its peculiar transition might affect the electronic structure including the Fermi surface (FS) and the nested band dispersion. Here, we performed angle resolved photoemission spectroscopy (ARPES), as well as ab-initio calculation in order to understand the electronic reconstruction in $q_{1/5}$ phase of $IrTe_2$. ARPES measurements reveals shadow bands which is attributed to the band-folding effect of $q_{1/5}$ CO unit cell. The following analysis using band unfolding analysis provide us more detail information about the dimerized Ir^{4+} orbital weight, as well as the nature of the novel electronic transition. These results provide a novel electronic paradigm of the spin–orbit driven charge-ordered states interacting with itinerant conduction electrons.

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Strongly correlated systems(B)/0748 P2-co.212

Magnetodielectric effect in $ErFeO_3$ single crystals

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Abstract :

We have investigated magnetodielectric effect relevant to the ordering of Er^{3+} moments in the single crystalline orthoferrite $ErFeO_3$. The sharp peak in temperature dependent magnetic susceptibility was observed along the *c* axis at T_{Er} = 4 K, indicating the order of Er^{3+} moments. The similar anomaly was also found in the dielectric constant at T_{Er}. Through the strongly correlated magnetic and dielectric states, isothermal magnetization and dielectric constant revealed the simultaneous non-linear variations below T_{Er}, which suggests the important role of magnetic rare earth ions in magnetoelectric characteristics of the orthoferrite compound.

Strongly correlated systems(B)/0708 P2-co.213

Magnetic proximity effect at the interfaces of $Nd_{1-x}Sr_xMnO_3$ multilayers

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Abstract :

Proximity effect is commonly found at interfaces in oxide heterostructures. Depending on the type of interfacing and the choice of materials, such effect is shown in many different forms: structural proximity effect, magnetic proximity effect, etc. In this presentation, we would like to address the magnetic proximity effect at interfaces of hole-doped manganite multilayers. We used pulsed laser deposition to alternatingly stack differently hole-doped $Nd_{1-x}Sr_xMnO_3$ (x ~ 0.5 and 0.3) sublayers, which have dissimilar magnetic Curie temperatures and saturation magnetic moments. X-ray reflectivity and x-ray diffraction studies confirmed the formation of high quality thin films with flat surface and well-defined interfaces. Magnetic characterization at 10 K shows increased magnetic moments as each layers became thinner. This result clearly indicates the ferromagnetic exchange interaction at the interface, leading to enhanced magnetization in the less-magnetic layers at the interfaces. This magnetic proximity effect is useful to design magnetic oxides with high magnetic moments. This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2015R1D1A1A02062175).

Strongly correlated systems(B)/0692 P2-co.214

Magnetic and dielectric properties in double perovskite Ho_2CrFeO_6

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Abstract :

We have investigated magnetic and dielectric properties in poly- and single-crystalline double perovskite Ho_2CrFeO_6. The temperature dependence of magnetic susceptibility undergoes successive magnetic transitions; the antiferromagnetic order at ~ 270 K, spin reorientation at ~ 170 K, and additional antiferromagnetic order associated with the arrangement of Ho^{3+} moments at ~ 10 K. From our examination of magnetic field dependence of dielectric properties at low temperature regime, we observe strong magnetodielectric effect which behaves similarly to the magnetic field derivative of isothermal magnetization, illuminating intriguing characteristics of the double perovskite.

Strongly correlated systems(B)/0688 P2-co.215

Magnetic and Dielectric properties of $Pb_3TeCo_3V_2O_{14}$

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Abstract :

We have synthesized polycrystalline $Pb_3TeCo_3V_2O_{14}$ which crystallizes in a trigonal structure with space group *P*321 and lattices constants, *a* = 8.559Å and *c* = 5.2167Å at room temperature. The temperature dependence of magnetic susceptibility reveals the two magnetic transitions at T_{N1}=8.6 K and T_{N2}=6.0 K, consistent with the previous results. From our investigation of isothermal magnetic and dielectric properties, we find the concurrent variation of both magnetization and dielectric constant by applying magnetic fields below T_{N1}, suggesting strongly-coupled magnetic and dielectric states with the non-centrosymmetric structure.

Strongly correlated systems(B)/0550 P2-co.216

Anisotropy in orbitally ordered Li_2RuO_3

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Abstract :

Li_2RuO_3 which is stacked up 2D honeycomb layer made with ruthenium has structural phase transition near 550 K which is related to the change of the space group from C2/m to $P2_1/m$[1]. By the transition, one third of inter Ru bonds are dimerized more than 15 % at room temperature. Moreover, these dimerized bonds form a herringbone pattern where the short bonds in the hexagon do not face each other[1]. The phase transition also increase resistivity and reduces magnetic susceptibility but there is no long range magnetic ordering[2] This pattern and high transition temperature cannot be found in related materials with other transition metal ion such as Li_2IrO_3. Those behaviors suggest that this phenomenon is related to the change of the orbitals[3]. Beside, because of high atomic number of ruthenium, electrons in Ru ion feel strong spin-orbit coupling about 0.15 eV. From these points, We can study how spin and orbital degree of freedom interplay in correlated system by studying this material. We measured anisotropy of the material by resistivity and magnetic susceptibility measurement. There is magnetic easy axis along b-axis, and smallest resistivity along a-axis.

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Strongly correlated systems(B)/0505 P2-co.217

Magnetodielectric properties of R_2CoMnO_6 (R=Ho, Y) Single crystals

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Abstract :

Lu_2CoMnO_6 is the double perovskite multiferroic that originates from cooperative displacements of oxygen ions via symmetric exchange striction. To examine the role of A-site magnetic ions on the magnetoelectric properties, we investigated magnetic field dependence of dielectric properties for Ho_2CoMnO_6 and Y_2CoMnO_6 which comprise magnetic and non-magnetic ions, respectively, with similar ionic sizes. While the dielectric anomaly emerges perpendicular to the *c* axis at the similar temperature, isothermal dielectric constant at low temperature appears to be fairly different, which presents the important aspect of double perovskite multiferroic with magnetic rare earth ions.

Superconductivity(C)/1157 P2-co.301

Annealing Condition Dependence of the Superconducting Property in the protect-annealed for electron-doped Cuprates

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Abstract :

It is important that not only finding proper crystal growth condition but also annealing the as-grown sample under low oxygen-partial-pressure to achieve superconductivity in electron-doped cuprates. It has been recently found that the so-called protect annealing results in much better superconducting property in terms of superconducting transition temperature and volume fraction. Firstly, we report protect annealing with proper condition in electron-doped cuprates, Pr0.9LaCe0.1CuO4 and dependence of superconducting property and pseudo-gap, which is measured by angle-resolved photoemission spectroscopy, in the protect-annealed electron-doped cuprates. Remarkably, we found that one showing better superconducting property possesses almost no pseudo-gap, while the other has strong pseudo-gap due to anti-ferromagnetic order.

Superconductivity(C)/1027 P2-co.303

Anisotropy of electron-phonon coupling in Rb-decorated graphene

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Abstract :

Two-dimensional van-der-Waals materials have been actively investigated owing to their remarkable electronic and optical properties with respect to three-dimensional counterparts. Graphene has been widely employed to study many interesting phenomena, such as half-integer quantum Hall effect and manybody interactions. Superconductivity is an enduring topic in the study of condensed matter physics, yet the superconductivity of graphene has remained poorly understood. There are intense efforts to realize superconductivity in graphene by doping an alkali metal on surface of graphene. Theoretical studies proposed that the critical temperature of superconductivity notably enhanced up to 8.1 K for the case of Li. However, a clear experimental evidence supporting theoretical proposal is still elusive.

In this study, we have successfully fabricated the ordered phases of Rb atoms on quasi-free standing graphene on hydrogen intercalated silicon carbide by means of angle-resolved photoemission spectroscopy (ARPES). We determine the anisotropy of the electron-phonon coupling constant from the variation of ARPES spectral widths with energy.

Superconductivity(C)/0940 P2-co.304

Model study of Josephson plasma soliton propagation

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Abstract :

Josephson plasma is a solitonic wave that propagates along the intrinsic Josephson Junctions stack, which was recently observed together with a phenomenological analysis of Sine-Gordon equation. In this study, we simulate the experiment starting from the model Hamiltonian including Andreev reflection and electron-hole interaction.

Superconductivity(C)/0828 P2-co.305

Optical properties of K-doped Ba-122 pnictides

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Abstract :

We measured $Ba_{1-x}K_xFe_2As_2$(K-doped Ba-122) single crystals at four different doping levels (2 underdoped, optimally doped, and overdoped) using an optical spectroscopy technique. We used a commercial Fourier Transform Infrared Spectroscopy (FTIR) type Bruker Vertex 80v spectrometer to obtain reflectance spectra of $Ba_{1-x}K_xFe_2As_2$ at various temperatures in a spectral range from Far-IR to Mid-IR. We applied a Kramers-Kronig analysis to get the optical constants including the optical conductivity. We estimated the superconducting gap from optical conductivity under the critical temperature. Also, we examined the doping and temperature dependent properties of the Fe-As stretching phonon.

Superconductivity(C)/0815 P2-co.306

Optical study of $Pr_{0.85}LaCe_{0.15}CuO_{4-n}$ by changing annealing condition

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Abstract :

It has been reported by many groups that the phase diagram shows distinct differences between electron and hole doped cuprates. However, a recent study shows that a specially prepared electron doped cuprates show a similar shape diagram to that of hole doped. Our single crystal samples were prepared by the flux method and the doping levels were controlled by the following annealing processes [1]. A series of $Pr_{0.85}LaCe_{0.15}CuO_{4-n}$ (PLCCO) samples with different electron doping levels (n = 0.11, 0.135 and 0.175) were prepared. We obtained reflectance spectra of the prepared electron doped cuprates using optical spectroscopy technique. Optical constants such as the optical conductivity were obtained by using Kramers-Kronig analysis from the measured reflectance. We compare the optical properties of our smples with those of the differently prepared electron-doped cuprates previously reported.

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Superconductivity(C)/0768 P2-co.307

Analysis of global and local hysteresis loops of GdBCO coated conductors with striations

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Abstract :

In applications of 2G high-temperature superconductor coated conductors, it is important to reduce the hysteresis loss. We used GdBCO coated conductors with striations which can be known to decrease the hysteresis loss. To analyze the hysteresis loss of striated GdBCO conductors, we measured not only global hysteresis loops but also local hysteresis. The global hysteresis loops were obtained with MPMS and the local hysteresis loops were obtained by using LTSHPM. Because of the demagnetizing effect in thin films, analysis of local hysteresis loops can be a useful approach to understanding of global hysteresis loops.

Superconductivity(C)/0360 P2-co.308

2G 고온초전도 선재와 금속 테이프 사이의 압력에 따른 접촉저항에 관한 연구

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Abstract :

2G 고온 초전도 선재는 지금까지 높은 자기장 하에서 단위 면적당 최대 전류를 흐르게 할 수 있는 도체입니다. 턴-턴 사이가 전기적으로 절연 된 코일에서는 퀀치가 발생하면 코일이 타버리게 된다. No-insulation (NI) 기술이 2G HTS 자석의 퀜치에 대한 안정성을 확보한다고 밝혀짐으로써 2G HTS 자석에 대한 연구가 매우 활발히 고자기장 분야에서 진행되고 있습니다. 자기보호(self-protection) 기능을 가지는 NI 코일에서 턴-턴 사이의 접촉 저항은 매우 낮으며 코일을 여자 시키는 데 오랜 시간이 걸립니다. NMR 및 연구용 고자기장 자석과 같은 DC 응용에서는 느린 충전 및 방전 속도는 문제가 되지 않지만 초전도 회전기의 회전자용 초전도 계자코일과 DC 인덕션 히터용 초전도 자석과 같은 대형 HTS 코일의 경우 NI 코일과 비교해서 상대적으로 빠른 충방전 속도와 기계적 강도가 필요합니다. 이 경우 금속 절연 (MI) 기술을 사용하여 스테인레스 강 (SS) 테이프와 같은 금속 테이프를 co-winding 하여 튼튼한 코일을 만듭니다. MI 및 NI 코일의 경우, 퀜치가 발생할 때 바이 패스 전류에 의해 생성되는 주울 열의 크기는 turn-to-turn 저항에 따라 달라집니다. 접촉 저항 (Rct)을 증가 시키면 충전 지연이 완화 될 수 있으며 높은 Rct 는 코일의 안정성을 낮추게 됩니다. 만약 2G 고온초전도 자석의 턴-턴 저항을 제어 할 수 있다면 2G 고온초전도 자석 설계에 매우 유용 할 것입니다.

따라서 본 연구에서는 인장기를 사용하여 수직압력에 대해 몇 가지 2G 고온초전도 선재와 금속 테이프들 사이의 접촉 저항을 측정하고 그 결과를 정리하여 보고 하고자 한다.

Superconductivity(C)/0285 P2-co.309

Angular dependence of the magnetization of GdBCO coated conductors

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Abstract :

In this study, we investigated angular dependence of the magnetization of GdBCO coated conductors in the applied magnetic field by using a horizontal sample rotator of MPMS. The experimental results can be analyzed by Bean's critical state model quantitatively. We assumed that the sample with rotation in the fixed magnetic field is equivalent to the sample in the changing magnetic field. To compare both cases, we measured the hysteresis curves of the sample in perpendicular applied magnetic field. In conclusion, we found that both experiments can be treated as equivalence from comparison of the hysteresis curves.

Surface/Interface/Nanomaterials(F)/1173 P2-co.401

Ultrafast terahertz study of topological insulator Bi_2Te_3 single crystal

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Abstract :

We observed femtosecond time-resolved response of the topological insulator (TI) Bi2Te3 by optical pump-probe (OPP) and optical pump-terahertz probe (OPTP) measurements. In OPP, we observed electronic responses superimposed by coherent phonon in the temperature and excitation power density (fluence) dependencies. We observed long-lived component (more than several picoseconds) in electronic responses that its behaviour is not explained by well-known origins such as phonon-phonon scattering. We suspect the long-lived component originates from the surface photovoltage, which is incurred by band-banding effect between distinct states of surface and bulk in TI. In OPTP measurement, we observed time-resolved reflectivity change in low energy region. Investigation of time-resolved low energy dynamics should provide us the behavior of photoexcited carriers, which is suspected to be Dirac fermions in surface state of TI.

Surface/Interface/Nanomaterials(F)/1159 P2-co.402

First-principles study for WS_2/BP stacked structures under applied electric fields

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Abstract :

Recently, two-dimensional (2D) materials have been actively studied in various fields. It is known that graphene, one of the 2D materials consisting of carbon atoms, has excellent electron mobility and permeability. Despite these excellent properties of graphene, one drawback in use of graphene in the electronic devices is that electron mobility of graphene is considerably reduced when the band gap is generated. To overcome such drawback, diverse 2D semiconducting materials have been investigated, including transition metal dichalcogenides (TMDs) and black phosphorus (BP). Layered structures such as TMDs and BP show the variations in electronic structure depending on the number of layers: As the number of layers increases, their band gaps are decreased. Here, we have studied atomic and electronic structures of heterostacks between WS_2, which is one of TMDs, and BP using density functional theory (DFT) calculations. Especially, we investigate the electronic structure of WS_2/BP stacked structures under applied electric fields.

Structural Degradation of $(C_6H_5(CH_2)_2NH_3)_2(Mn,Cu)Cl_4$ Thin Films in Ambient Environment

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Abstract :

Layered two-dimensional organic-inorganic perovskite thin films (A_2BX_4, A= a monovalent organic cation, B=a divalent metallic cation, X=a halide anion) have been proposed for a variety of industrial applications such as semiconducting channel in thin film transistors ($(C_6H_5C_2H_4NH_3)_2SnI_4$) [1] and multiferroics($(C_6H_5C_2H_4NH_3)_2CuCl_4$) [2] and optoelectronics devices($(C_4H_9NH_3)_2PbBr_4$) [3]. Particularly, $(C_6H_5(CH_2)_2NH_3)_2CuCl_4$ (shortly, Cu-PEA) and $(C_6H_5(CH_2)_2NH_3)_2MnCl_4$ (shortly, Mn-PEA) belong to a family of layered two-dimensional K_2NiF_4 perovskites where the inorganic part comprises a two dimensional network of corner-sharing BCl_6^{2-} octahedron. The interesting point is that they crystallize in the same space group (No. 61 P 2_1/b 2_1/c 2_1/a) at room temperature and show the almost same lattice parameters (a =7.187 Å, b= 7.344 Å, c=38.549 Å for Cu-PEA, a =7.207 Å, b =7.301 Å, c=39.413 Å for Mn-PEA), but different magnetic behaviors. Cu-PEA is a ferromagnet (T_C =9.5 ~13 K) [2], while Mn-PEA is a canted antiferromagnet (T_N = 44 K) [4]. It has been reported that organic-inorganic layered perovskite thin films can be readily prepared by a number of simple and versatile techniques such as sol-gel and spin-coating and Langmuir-Blodgett and evaporation. Even though the perovskite layers in all the previous cases were ultrathin (few to tens of nanometers), unencapsulated, and exposed to the air, structure stability of layered perovskite thin film against moisture has been rarely addressed so far. In this talk, the influence of organic solvents and relative humidity on structural and magnetic properties of unencapsulated Cu-PEA and Mn-PEA perovskite thin films synthesized by spin coating technique will be presented.

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Surface/Interface/Nanomaterials(F)/1052 P2-co.404

First-principles study of phenylthiol molecules on Ge(001) surface

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Abstract :

Organic functionalization of semiconductor surfaces has been a subject of intensive research owing to its potential applications. Various organic molecules were taken into consideration on the semiconductor surfaces to design tailored hybrids structures with desired electronic, chemical and electrical properties. Recently, various surface reactions at the molecular scale were observed using scanning tunneling microscopy (STM). In this regard, the adsorption of phenylthiol molecules on Ge(001)-c(4 x 2) surface has been studied using density functional theory calculations. Among various possible adsorption configurations considered, the most favorable configuration is found that the H-dissociated phenylthiol molecule is located at the inter-dimer site with the bonding between sulfur atom of H-dissociated phenylthiol molecule and down-Ge atom. The dissociated H atom is bonded to an adjacent up-Ge atom, passivating the dangling bond. Simulated STM image of this configuration explains well the adsorption features observed in the experiment. Details in electronic structure are analyzed in terms of partial density of states (PDOS), molecular orbitals and band structure.

Surface/Interface/Nanomaterials(F)/1041 P2-co.405

Electrical and thermal properties of metal-coated carbon fiber for lighter electrical metal wires

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Abstract :

In this study, we plated thin conducting Cu and Ni double layer in a thickness of 200–300 nm on the surface of carbon fiber that was supposed to replace the core of Cu wire for weight reduction. The metal-coated carbon fibers (MCF) exhibit comparable electrical properties to the bulk Cu including the electrical conductivity of $5.9*10^{-6}\Omega*cm$, temperature coefficient of resistance (TCR) of $1.14 *10^{-3}/K$. addition to electrical properties, the Joule heating of MCF revealed that the MCF terminated itself when the temperature of MCF significantly rose. This was due to the much lower burning temperature of carbon fiber, comparing to that of Cu, which can be beneficial in the prevention of a fire sparked by a hot metal wire. The temperature of suspended MCF is measured as a function of Ar pressure. The temperature of hot MCF changed by convectional heat loss at below 5 x 10-6 torr. It indicated that the MCF has huge potential for use as electro-thermal vacuum gauge in high vacuum range which has been unprecedented yet.

Surface/Interface/Nanomaterials(F)/1031 P2-co.406

Optically induced transient structural changes in GaAs and InAs

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Abstract :

We employ the time-resolved second harmonic generation (SHG) technique to investigate the non-thermal structural changes in semiconductors. After we illuminate GaAs and InAs crystals with femtosecond laser pulses of an 800 nm wavelength, we trace how the structural symmetry evolves as a function of time by monitoring the transient changes in SHG responses. For both GaAs and InAs, the SHG intensity exhibits an abrupt drop upon the photoexcitation, and recovers back within a few picoseconds. On the other hand, we observed distinct transient changes in the azimuth-dependent SHG signal; whereas a uniform four-fold reduction is observed for InAs, a selective two-fold reduction is detected for GaAs. We discuss these observations based on the electron-lattice thermalization and also the contribution of the surface band bending.

Surface/Interface/Nanomaterials(F)/1007 P2-co.407

패턴 된 유기박막을 활용한 그래핀의 직접 합성 및 물성 평가

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Abstract :

흑연, 탄소나노튜브, 다이아몬드 등과 같은 탄소 동소체인 그래핀은 벌집모양의 육각형 판상 격자구조를 가지는 2 차원 물질이다. 특유의 격자구조로 탄소원자 하나가 주변 탄소원자 3 개와 공유결합(sp2 결합)을 하고 있으며, 이로 인해 물리·화학적 안정성 및 역학적 유연성을 가지며, 200,000 $cm^2/V \cdot s$ 이상의 전하이동도, ~5000 W/m·K 열전도도, 가시광선 영역에서 ~99.7% 광-투과율을 가지고 있다.

이러한 우수한 고유 물성들 때문에 그래핀을 얻기 위한 다양한 방법들이 연구 개발되어 왔다. 특히, 화학기상증착법을 사용하여 대면적의 그래핀 합성법이 가능해지고 난 이후, 그래핀의 기초물성 연구는 물론 응용 관련 연구가 더욱 활발해 졌다.[1] 한편, 기존의 화학기상증착법은 촉매금속 위에서 그래핀 대면적으로 합성되다 보니, 전자소자 또는 응용 분야에 적용하기 위해서는 그래핀을 전사 및 리소그래피, 식각 공정이 수반되어야 한다. 이러한 공정과정 중에서 발생하는 잔류물(촉매 금속 또는 폴리머)들로 인하여 표면이 오염되거나 손상이 되어 기대한 만큼 고유의 우수한 물성을 발현하지 못할 수 있다.[2,3]

본 연구에서는 공정의 단순화 및 오염 이슈를 최소화하기 위해 전사공정이 필요 없는 패턴 된 유기박막으로부터 그래핀의 직접합성 및 물성 평가를 수행하였다. 감광-폴리머와 포토 및 레이저 리소그래피 공정을 활용하여 기판 위에 패턴을 형성시켰다. 그래핀 합성을 위해서는 탄소원과 탄소의 재결정화를 위한 충분한 에너지가 요구된다. 탄소원으로써 감광-폴리머(탄소를 포함하는 유기분자) 박막 패턴을 사용하였고, 준비된 기판을 진공 퍼니스 안에서 다양한 열처리 조건 하에서 그래핀을 합성해보았다. 열처리에 조건에 따른 그래핀의 품질 변화를 라만 스펙트럼으로 관측하고, UV-Vis-NIR 분광계를 이용하여 투과도 측정을 수행하였다. 또한 패턴 합성된 그래핀을 기반으로 간단한 소자를 제작하여 기초 전기물성을 평가하였다.

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Surface/Interface/Nanomaterials(F)/0897 P2-co.408

Dry transfer technique for $TMPX_3$ based-heterostructure and its application

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Abstract :

van der Waals (vdW) materials have attracted significant attention over the past decades because of their interesting low dimensional physical properties. Among the various vdW materials we are very interested in the recent entry of new magnetic vdW materials: Transition metal phosphorus tri-chalcogenide ($TMPX_3$). And their successful exfoliation and characterization have been performed down to monolayer of these materials.[1-4] vdW heterostructures, devices made by stacking different 2D crystals on top of each other, have recently emerged by various transferring and stacking technique.[5-7] However, so far, there has been no report and trial of heterostructures with few-layer $TMPX_3$ which is an essential step for promising future study on magnetic vdW heterostructure. Here, we report the first fabrication of vdW heterostructure with few-layers of $NiPS_3$ by using dry transfer technique in detail. We performed vertical transport measurements in this system and successfully observed semiconducting/insulating behaviors with the key features of Schottky junction. We expect that these results would be helpful for many futher research on magnetism and spintronics in vdW systems.

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Surface/Interface/Nanomaterials(F)/0839 P2-co.409

Charge transfer effect on blue luminescence at the interface of functionalized silicon nanocrystals

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Abstract :

Silicon nanocrystals (Si-NCs) have been much attention because of the potential applications such as optoelectronic devices, bioimaging and photovoltaics. At the beginning of the researches about the Si-NCs, the luminescence phenomena induced by quantum confinement effects (QCE) have mainly been investigated. However, it wouldn’t be enough to realize the visible spectrum from red to blue due to the limitation of size control of nanocrystals.

To realize the entire visible spectrum from the Si-NCs, there have been much studies about surface-functionalization of Si-NCs with various materials. Unlike luminescence originated from QCE, surface-functionalized Si-NCs have showed entire visible emission by changing surface chemistry. As a result, Si-NCs could become a potential candidate for optoelectronic applications.

In this work, we fabricated surface functionalized Si-NCs with various materials such as allyamine, dodecylamine and diphenylamine. For those samples, we observed blue luminescence ranging from 400~500nm by photoluminescence spectroscopy. To investigate the origin of this luminescence larger than the band gap of hydrogen passivated Si-NC, we performed subsequently the transmission microscopy, the time resolved photoluminescence, Raman spectroscopy and Fourier transform infrared spectroscopy. By analyzing these results, we conclude that the blue emission should be originated from charge transfer occurring between silicon and surface materials.

[Acknowledgements : NRF-2016M2B2A4912288, NRF-2015R1D1A1A01060381]

Surface/Interface/Nanomaterials(F)/0788 P2-co.410

Control of Cu-phthalocyanine molecular orientation on MgO(001) for Spintronic Performance in hybrid Magnetic Tunnel Junctions

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Abstract :

For the development of organic spintronics, the control and identification of crystal formation in organic thin films are crucial since the molecular orientation and order are known to have a significant effect on performance of organic electronic devices.[1] It is generally known that the choice of substrate, substrate temperature, and film thickness are the primary factors influencing organic crystal structure and orientation.

In this work, the influence of cool-down temperature on the molecular orientation and the surface morphology of the Cu-phthalocyanine (CuPc) films grown on MgO(001) has been studied using the surface sensitive techniques of metastable de-excitation spectroscopy (MDS), Raman spectroscopy and atomic force microscopy. In conjunction with density functional theory (DFT) calculation, the MDS results indicate that the enhanced CuPc molecular ordering with the b-axis of beta-type CuPc parallel to the MgO(001) surface can be achieved by cooling process below 200 K, whereas in the case of the CuPc molecules grown on metal surface (Fe) the CuPc film was more disordered and consisted of the crystallites of a rough shape. The beta-CuPc phase has been observed for the films grown on substrates above ~ 200 °C or post-annealed above 300 °C in the literature. To the best of our knowledge, the cooling-assisted approach for enhancing phase transition in CuPc films has not been reported before. In Si(001) 5 nm MgO(001) 15 nm Fe(001) 1.6 nm MgO(001) t nm CuPc (t = 1.2~ 5.0) 25 nm Co magnetic tunnel junctions (MTJs), we found that the CuPc molecular orientation can affect the magnetoresistive response of the MTJs.

By further investigation of the cooling temperature dependence of morphology and ordering of β-CuPc film, it may be possible to achieve thin CuPc films of uniformly oriented crystallites in combination with the molecular-substrate interaction strength. A highly ordered CuPc structure with the same in-plane orientation forms on MgO(001) surface due to the relatively weak interfacial interactions.

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Surface/Interface/Nanomaterials(F)/0707 P2-co.411

X-ray Absorption Spectroscopy Study of Zinc Titanates Obtained by Annealing the ZnS/TiN and ZnO/TiN Thin Films.

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Abstract :

We investigated the local electronic structures of oxidation-controlled TiN thin films using X-ray absorption spectroscopy. To obtain photocatalytic titanium oxide, we annealed the ZnS/TiN and ZnO/TiN films at 700 °C for 1 min in various oxygen ambience. The oxidation activity at the interface between the bottom material and TiN was controlled by adjusting the oxygen pressure supplied during post-deposition annealing (PDA). After the PDA, the TiN layers were sufficiently oxidized. The phase of titanium oxides evolved depending on the bottom materials and the PDA conditions. At a low $P(O_2)$, either an anatase or a rutile local structure was dominant. On the other hand at a high $P(O_2)$ such as $P(O_2)$=2Torr or $P(O_2)$=5Torr, $ZnTiO_3$ emerged. The local structures of the titanates was examined by XANES and EXAFS analysis. This phase appeared to be a mixture of perovskite $ZnTiO_3$, ilmenite $ZnTiO_3$ and ZnO. The emergence of titanate and the evolution of the local structures of titanium oxides with increase of P(O2) appeared faster for ZnO/TiN. The oxygen migration from ZnO might have facilitated the catalytic reaction of the oxidized TiN. We can control the phase of oxide formed on the interface of layered film by adjusting the PDA condition or selecting the bottom material. It implies that we can engineer the electronic properties of the interfaces between oxide (or sulfide) and the oxidized TiN by tailoring the catalytic activities of titania.

Surface/Interface/Nanomaterials(F)/0671 P2-co.412

Modifications of magnetic and thermal properties in polycrystalline oxide thin filmsModifications of magnetic and thermal properties in polycrystalline oxide thin films

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Abstract :

Polycrystalline transition metal oxide thin films compose various potentials for modifying its physical properties. Unlike single-crystalline thin films, translational symmetry breaking, defect concentration and reduction of strain at grain boundaries can be effective to electrical, magnetic, and thermal properties. In this study, we enhanced magnetic and thermal properties compared to single-crystalline thin films grown by pulsed laser epitaxy. In particular, the reduction in compressive strain due to coalescence at the grain boundaries is evidenced by structural analyzation such as x-ray diffraction pattern and topographic images of atomic force microscopy of the polycrystalline thin films. The structural variations associated with the grain boundaries further enhance ferromagnetic transition temperature among all the other oriented single-crystalline thin films. Likewise, reduction of thermal conductivity without deteriorating electronic transport appears, and lead to enhanced thermoelectric efficiency in the epitaxial polycrystalline thin films, compared with their single-crystalline counterpart.

Surface/Interface/Nanomaterials(F)/0635 P2-co.413

Characterization of Piezoelectric Enhancement in 1-Dimensional Monoclinic $KNbO_3$ by Piezoresponce Force Microscopy

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Abstract :

We present piezoresponse force microscopy (PFM) measurement on hydrothermally grown potassium niobate ($KNbO_3$, KNO) nanorods. Single phase KNO NRs with different crystal structure, monoclinic and orthorhombic, were individually dispersed on Pt substrate for PFM measurement. The effective value of piezoelectric constant, d_{eff}, is 83.5(1) pm/V for monoclinic KNO NRs, which is 1.6 times larger than that of the orthorhombic KNO NRs (54.2(1) pm/V). The effective piezoelectric constant could be derived by Landau-Ginzburg-Devonshire thermodynamic theory. The piezoelectric enhancement of monoclinic KNO is related to the unconstrained rotational polarizations, which is similar behavior in $Pb(Zr,Ti)O_3$ or $BiFeO_3$ with monoclinic phases of morphotropic phase boundary. In addition to, approximately 6% piezoelectric enhancement compared to as-grown KNO NRs was observed as a result of the alignment of the polarization of KNO NRs by applying bias on monoclinic and orthorhombic KNO NRs. Therefore, the piezoelectric properties of the monoclinic KNO are remarkable for application in energy harvesting devices.

Surface/Interface/Nanomaterials(F)/0599 P2-co.414

Electrical-transport properties of $SrTiO_3/LaAlO_3/SrTiO_3/CaTiO_3/SrTiO_3$ perovskite heterostructure

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Abstract :

A two-dimensional electron gas is formed between the band insulators $LaAlO_3$ and $SrTiO_3$ and has various characteristics such as superconductivity and ferromagnetism. However, device applications have been hampered by its limited low mobility. In this study, we fabricate a heterostructure which a $CaTiO_3$ is inserted as a buffer layer to improve the low mobility.$SrTiO_3/LaAlO_3/SrTiO_3/CaTiO_3$ heterostructure thin films were grown on $SrTiO_3$ substrates by Pulsed Laser Deposition to investigate the effects of $CaTiO_3$ buffer layer. The quality of the films and epitaxial relation to the $SrTiO_3$ substrates were investigated by High Resolution X-Ray Diffraction. Electrical properties were measured using the Physical Property Measurement System. As a result, it is expected that the mobility of the system will be improved depending on the thickness of the $CaTiO_3$ buffer layer.

Surface/Interface/Nanomaterials(F)/0459 P2-co.415

The role of oxides of Pt-groups in CO oxidation reaction

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Abstract :

By utilizing Ambient-Pressure X-ray Photoelectron Spectroscopy (AP-XPS) and residual gas analyzer (RGA), the surface chemical states on Pd(100) are investigated as CO oxidation reaction occurs. At the onset of CO oxidation, the surface temperature increases sharply due to exothermic nature of the reaction and (sqrt(*5) × sqrt(5)*)R27 PdO surface oxide forms. The observed PdO remains stable as CO/O_2 varies. During the CO oxidation reaction, the change of surface work function occurs due to the formation of surface oxide. Interestingly, the work function of Pd oxide is differnt from that of a-phase of PtO_2, implying the reactivity of PdO is different from that of a-phase of PtO_2 under reaction conditions.

Surface/Interface/Nanomaterials(F)/0134 P2-co.416

Photoactivity enhancement by the natural convection control in hydrothermal synthesis of iron oxide nanorods.

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Abstract :

In this study, akaganeite (β-FeOOH) nanorods (NR) array was synthesized on a fluorine tin oxide (FTO) glass substrate with two ways; with/without natural convection control in hydrothermal synthesis. After thermal annealing process, phase transformed hematite (α-Fe_2O_3) NR array was examined by SEM, XRD, and UV-VIS spectroscopy measurements. The phase transformed hematite NR were further applied to the fabrication of photo-electrochemical cell (PEC) cell. In SEM analysis, it could be verified that the way of natural convection control induces the additional secondary NR growth in unwanted areas. Although it is difficult to find meaningful differences between two ways through the various characterizations except SEM, there was obvious enhancement of photoactivity in the way of natural convection control. These results imply the way of natural convection control in hydrothermal synthesis is more effective method to fabricate PEC cell using hematite NR, and the detailed analyses are discussed in the conference.

Bio/Soft-condensed/Organic materials(D)/0155 P2-co.417

UV-Vis absorption of Galvinoxyl-doped P3HT films

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Abstract :

The effect of annealing of the galvinoxyl-doped solid P3HT film is shown on the UV–Vis absorption spectrum. The spectrum consists of an intense band in the range between ~350 and 650 nm and other three weak bands at around 690, 770 and 880 nm. The decays of the three weak bands at around 690, 770 (left arrow) and 880 nm (right arrow) show distinctive differences between the R.T. sample and the annealed samples up to 150 ^{o}C. The peaks decreased distinctively even after 50 ^{o}C and then even the peak position shifted to longer wavelength for the 100-150 ^{o}C annealing.

The center-peak around ~550 nm is ascribed to the absorption caused by P3HT. For the isolated Gx radicals in the P3HT solid films, the energy transition in the absorption spectrum located at ~860 nm and 770 nm was assigned to D_0 --> D_3 and D_0 --> D_4 transition, respectively**,** where D_0 is the ground state, and the D_n is the nth excited state.

In our UV-Vis spectrum, the peak position even shifted to longer wavelength at 100-150 ^{o}C annealing; the shifts of the absorption peak may imply that the chemical environment has been modified, as was in the ESR result where the g-value at 100-150 ^{o}C changed, reflecting any structural change at high temperatures. Consequently, our UV-Vis absorption data is not inconsistent with our ESR data reflecting the scavenging of Gx radicals after being annealed.

Optical information(E)/1010 P2-op.001

Characterization of multi-cycle laser pulses in the time-domain using tunneling ionization

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Abstract :

The characterization of the ultrashort laser pulse is an essential task for the studies of light-matter interactions. Time-domain Observation of Electric field (TIPTOE) is a new pulse characterization technique which can measure the temporal profile of the laser pulse without complicated vacuum equipment. In this study, we show that TIPTOE method can be applied in a multi-cycle regime. We characterize the temporal profile of the multi-cycle laser pulses under different dispersion conditions. The experimental results are compared with the measurements obtained by the frequency resolved optical gating method.

Optical science(A)/1166 P2-op.003

Measurement of refractive index of gold nanoparticles by spectral-phase change analysis of ultrafast pulses

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Abstract :

We have investigated the refractive index of gold nano-particle and nano-rods, where the core of a particle structure in 120 nm diameter is coated with a shell thickness 20 nm, and the length and the diameter of nano-rods are 53 nm and 13 nm, by using ultrafast spectral-phase analysis. Spectral interference between a sample-transmitted pulse and a reference pulse was measured as a function of delayed time. Given the amplitude and phase of a reference obtained by FROG (frequency-resolved optical gating) technique, the spectral interference was analyzed as a function of delay time. As an alternative technique to measure refractive index spectrum, the spectral-phase analysis allows to analyze the modulation of a transmitted pulse

Optical science(A)/1097 P2-op.004

Control of optical-field-induced charge separation by band engineering

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Abstract :

We demonstrate that a charge separation at a rate of light frequency (PHz, 1015 Hz) driven by a sub-cycles optical wave-form with incorporation of an injection field can be precisely controlled by band engineering of a wide-gap piezo material. We find that the dynamics of the charges follows a change of effective mass in a specific direction, which is managed by the band engineering effect. This demonstration may provide the development of a highly delicate control of optical-field-induced processing for PHz devices.

Optical technology(B)/1014 P2-op.006

Super-continuum generation by induced phase modulation with two laser pulses in a gas-filled hollow-core fiber

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Abstract :

Strong field processes such as above threshold ionization, high harmonic generation, and attosecond pulse generation can be controlled by few cycle or single cycle laser pulses. Such a short laser pulse can be obtained through the spectral broadening of the pulse. When two laser pulses co-propagate in a nonlinear medium, the amount of the phase modulation is determined by the coherent superposition of the two laser pulses. Since the phase modulation can be induced by each other, the process is called the induced phase modulation. Here, we demonstrate that the super-continuum generation can be enhanced through the induced phase modulation using two color laser pulses. We numerically solve the propagation equation using 800 nm and 400 nm pulses. The temporal and spectral properties of the laser pulses after passing through the fiber are discussed.

Optical technology(B)/0715 P2-op.007

빔 균질기의 간섭 효과과 레이저 빔 이미지에 주는 영향 분석

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Abstract :

빔을 중첩시켜 균질 효과를 얻는 빔 균질기는 간섭 효과에 의한 영향을 받는다. 간섭 효과는 광선 추적을 통해 계산한 빔에서는 관측할 수 없는 미세한 불균일 패턴을 만들어낸다. 본 연구에서는 빔 균질기에 의해 나타나는 간섭 패턴을 분석하여 간섭 효과가 레이저 빔 이미지에 주는 영향을 분석하고 실험 결과와 비교하였다.

Optical technology(B)/0498 P2-op.008

레이저 충격 피닝을 위한 사각 빔 균질기의 작업거리 특성 실험

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Abstract :

레이저 충격 피닝은 고출력 레이저 펄스를 통해 금속 타겟의 표면특성을 강화하는 기술이다. 레이저 충격 피닝에 사각 빔 균질기를 적용하면 효과적인 표면 커버링 및 균일한 피닝 효과를 기대할 수 있다. 레이저 충격 피닝을 위한 사각 빔 균질기는 금속 타겟의 다양한 형상과 질감을 고려해 긴 작업거리를 가지도록 설계해야한다. 이를 위한 사전 연구로서, 금속 타겟의 플라즈마 한계치 이상에서의 사각 빔 에너지 효율 범위 및 균일도 범위로 레이저 충격 피닝을 위한 사각 빔 균질기의 작업거리를 정의한 바 있다. 본 연구에서는 사각 빔 균질기를 구성하고 이전에 정의된 작업거리를 적용하여 실험적으로 작업거리 특성을 연구하였다.

Optical technology(B)/0213 P2-op.009

특수광섬유를 적용한 반사형 디지털 홀로그래피 구현

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Abstract :

첨단부품소재의 마이크로 및 나노급의 결함 및 형상을 측정하기 위하여 간섭계를 이용한 광영상 장치 연구는 활발하게 진행되어 왔다. 그 중에서도 디지털 홀로그래피(Digital Holographic)는 간섭계를 이용한 대표적인 광영상 시스템으로 광간섭 효과를 이용하여 표면 형상이나 단차 등의 정보를 획득하는데 활용하였다. 기존의 디지털 홀로그래피는 벌크 광학계 기반의 시스템으로 위상변화를 유도하기 위해서 기계적 방법이 사용되어 왔다. 특히 제어가 쉬운 PZT(piezoelectric transducer)를 많이 사용되어 왔는데, PZT 를 이용한 기계적 방법은 안정성과 반복성에 있어서 단점을 가지고 있다. 본 논문에서는 특수광섬유를 이용하여 기계적인 움직임이 없이도 위상 변화가 가능한 반사형으로 측정이 가능한 디지털 홀로그래피 시스템을 제안하고자 한다. 간섭계의 기준단에 연결된 특수광섬유에 펌핑광을 입사시켜 원하는 위상 변화를 유도하도록 하였다. 2π 의 위상이 변하는 동안 8 장의 이미지를 획득하고 이를 이용하여 표면 형상을 복원하고자 하였다. 이러한 기법은 펌프광의 광세기를 전기적으로 제어함으로써 위상 제어에서의 자유도 부여가 가능하며, 미세 위상 특성 제어가 안정적으로 가능한 장점을 가질 수 있다. 또한 광섬유 기반의 간섭계를 구성하여 기존의 벌크 기반 시스템보다 간결하게 시스템을 구성이 가능하다. 이러한 기법을 이용하여 반사형 디지털 홀로그래피 구현하고 이를 통한 실험 결과를 제시하고자 한다.

This work was supported by the Ministry of Trade, Industry & Energy (MOTIE, Korea) under Industrial Technology Innovation Program (No. 10063530) and also supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government (MSIP) (No. 2017R1A2B2009732).

Optical technology(B)/0146 P2-op.010

Sub-nanoliter volume measurement using Digital Holographic Microscope

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Abstract :

Sub-nanoliter volume measurement with fast non-contact is desirable for fabrication process. We have set-up digital holographic microscope (DHM), which includes rotating ground glass (RGG), for measuring sub-nanometer sub-nanoliter liquid volume. The DHM is based on interferometric principle, which allows non-contact monitoring. We have measured dye liquid volume in the range sub picoliters using DHM. The DHM method prevents contamination and loss of media. Therefore, the proposed method is well suited for high precision and fast non-contact online monitoring of dye liquid volume in micro dispensing process for various applications. We have applied this method to measure the droplet volume of OLED dispensing and laser induced forward transfer.

Other optics(G)/0904 P2-op.011

Iridiscence of elytra of jewel beetles *Chrysochroa fulminans*

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Abstract :

The elytra of the jewel beetles *Chrysochroa fulminans* show metallic green with purple stripes. It is well known that the iridiscence observed in some beetles is produced by multilayer thin-film interference. We investigated the structural colors and optical properties of jewel beetles, *Chrysochroa fulminans fulminans*. The angle-dependent color change of elytra was examined. Theta-2theta scan method was used to characterize the angle dependent reflections of the elytra. Also interference fringes from the jewel beetle's surface of elytra by using the diode laser (532 nm) were observed and analyzed. SEM images of jewel beetle's elytra were examined.

Other optics(G)/0885 P2-op.012

고체상반응법을 이용한 $Gd_2ZnTiO_6:Eu^{3+}$ 적색 형광체 제작 및 특성 분석

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Abstract :

최근 white light-emitting diodes (WLEDs)가 일반 조명에서 주로 활용되면서 효율을 증가시키는 연구에 대한 관심이 증가하고 있다. 일반적으로 WLED 는 황색 형광체(YAG)를 청색 LED 에 도포하여 제작하지만 적색 발광 요소가 부족하기 때문에 색연지수가 낮고 색온도를 조절하기 어렵다는 문제가 있다. 이를 극복하기 위하여 자외선 LED 와 적, 녹, 청색 형광체를 조합하는 연구가 진행되고 있으며, 이렇게 제작된 WLED 는 청색 LED 기반의 WLED 보다 향상된 성능을 나타낸다. 따라서, 백색을 구현하기 위해서 효율이 높은 적색 형광체에 대한 개발이 요구되고 있다. 이러한 적색 형광체는 졸-겔법, 수열합성법, 침전법, 고체상반응법 등 다양한 방법을 이용하여 제작할 수 있다. 이 중 고체상반응법은 간단한 공정과정을 통하여 재료의 낭비를 줄이면서 대량으로 형광체를 제작할 수 있다는 장점이 있다. 따라서, 본 연구에서는 고체상반응법을 이용하여 Eu^{3+} 이온이 도핑 된 Gd_2ZnTiO_6 적색 형광체를 제작하였고, 이에 대한 구조적, 광학적 특성을 분석하였다. 제작된 구조는 전계방출형주사전자현미경(field emission scanning electron microscopy)를 이용하여 관찰하였고, 형광 특성(photoluminescence excitation and emission)을 분석하여 최적화 된 Eu^{3+} 이온 농도를 도출하였다.

Other optics(G)/0726 P2-op.013

희토류가 도핑된 borate 유리 세라믹 내부에 은나노입자와 산화물결정 형성에 따른 형광분석

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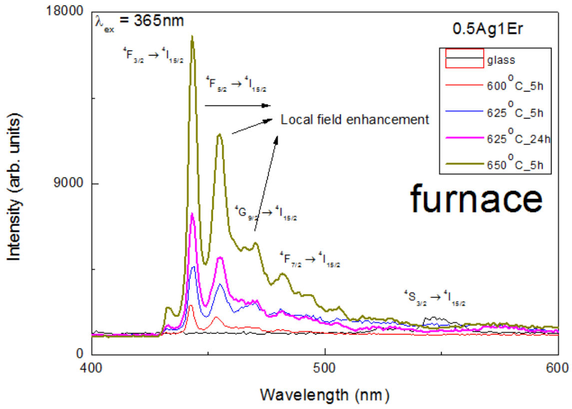
Abstract :



유리 내부에 은나노결정을 형성해 표면 플라즈몬 공명(surface plasmon resonance, SPR)을 발생시켜 ‘빛 가둠(Trapping)' 효과를 유도하면 흡수율을 높일 수 있다. 본 연구는 금속나노입자의 광학적 특성과 희토류이온이 도핑된 유리 내부에 나노결정체를 형성하여 down-up conversion 효율이 향상되는 이 두 가지 장점 모두 활용해 형광효율을 극대화 시키려는 시도이다. 열처리 전 팸토초 레이저를 조사하여 Ag-O 결합본드를 분리시킨 후 CO2 레이저와 전기로 열처리를 통해 Ag^+ 이온들의 환원을 유도하여 나노입자를 형성하였다. 열처리 후 파랑색 영역의 형광이 강하게 나타났고 이에 대한 메터니즘을 설명하였다.

Other optics(G)/0500 P2-op.014

Theoretical study of an optomechanical resonator in the reversed dissipation regime for ultralow temperature measurement

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Abstract :

Cavity optomechanics is an important platform for which the interaction between light and the motional degrees of freedom of a mechanical oscillator can be engineered for specific objectives such as cooling the mechanical state or amplifying the electromagnetic field. Here we theoretically examine an optomechanical resonator coupled to both mechanical and optical energy reservoirs in the reversed dissipation regime. We show that in the case of quadratic coupling between the electromagnetic field and mechanical oscillator, the linewidth of the noise spectra of the cavity field is dependent on the mean phonon number of the mechanical oscillator. Using advanced fabrication methods for nanophotonic devices, we propose to develop reservoir engineered optomechanical devices for temperature measurement in the quantum regime.

Other optics(G)/0465 P2-op.015

단일 LED 칩 이용한 해상용 LED 등명기의 광학 설계

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Abstract :

초기의 LED(light emitting diode)는 광 출력이 낮아 각종 기계장치의 표시용 소자로 많이 사용되었으나, LED 기술의 발달로 고출력 고휘도로 색 표현이 가능하게 되었다. 따라서 교통 신호등, 대형 전광판, 자동차표시과 같은 디스플레이로 사용하고 있으며, 높은 광량을 요구하는 백열등, 형광등과 같은 실내외 조명에서도 LED 가 사용되고 있다. 이러한 LED 의 발달로 초기의 LED 등명기는 다수의 LED 를 사용하여 제작되었다. 하지만 광학 설계만 새롭게 한다면 한 개의 LED 만을 사용하더라도 LED 등명기에서 요구하는 광도를 만족시킬 수 있다.

8 NM 급의 항로표지용 등명기 광학 설계를 하기 위하여 국내 소형급 LED 등명기 제품의 광도 및 소비전력등을 분석하고 국내 해상용 등명기 표준규격서를 참고하여 부동광도 및 발산 각을 설정하였다. LED 칩은 CREE 사의 XHP 35 HI 의 Ray 데이터를 사용하여 광학 설계 프로그램인 Lighttools 를 이용하여 시뮬레이션 하였다. LED 광을 수평으로 발산하게 하기 위하여 렌즈 대신 포물선 반사판과 원뿔 반사판을 이용하였고 광효율을 올리기 위해 반사판의 초점거리를 달리하여 광학 설계를 하였다

Other optics(G)/0272 P2-op.016

해상용 LED 등명기의 광학 설계 및 시뮬레이션

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Abstract :

선박의 안전한 운항을 위하여 각종 항로표지가 사용되고 있으며, 특히 우리나라는 작은 섬들과 해안선이 복잡하여 항로 표지는 매우 중요한 실정이다. LED 해상용 등명기는 2003 년 최초 개발되어 현재까지도 많은 연구 및 개발이 되어왔지만 대부분이 현재까지도 수평 배광을 만들기 위해 Fresnel lenses 의 사용을 하고 있다. 하지만 Fresnel lenses 는 까다로운 제작방법과 많은 비용을 필요로 한다.

이러한 문제를 해결하기 위해 Fresnel lenses 를 사용하지 않는 새로운 형태의 이중 반사 해상용 LED 등명기를 개발 중이다. 현재 개발중인 이중 반사 해상용 LED 등명기는 LED chip 이 수직되게 반사체에 빛을 발산하고 있어 이중 반사를 하는 과정에서 빠져나가지 못하는 빛이 발생하였다. 이 빛을 최대한 빠져나갈 수 있도록 다른 구조물을 이용하여 수직되게 발산하는 LED chip 을 기울여 발산하게 하여 광도 및 소비전력 등을 개선 하였다.

이중 반사 해상용 LED 등명기의 광도 및 소비전력을 개선하기 위해 비교대상으로 기존의 이중 반사 해상용 LED 등명기를 참조 하여 광도 및 소비전력 등을 분석하였고 국내 해상용 등명기 표준규격서를 참조하여 부동광도 및 발산각을 설정하였다. LED chip 은 CREE 사의 MLBAWT-W51 의 데이터를 사용하여 광학 설계 프로그램인 Lighttools 를 이용하여 시뮬레이션 하였다.

Photon technology(C)/1108 P2-op.017

Optimization of dose distribution of the CNT-based miniature X-ray tube for interstitial brachytherapy

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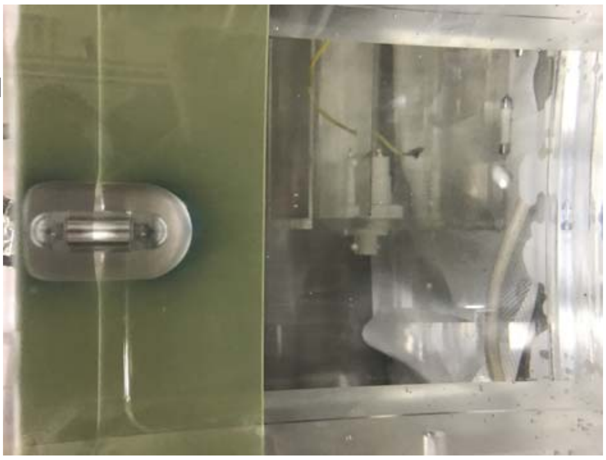
Abstract :



Postoperative intravaginal brachytherapy for endometrial cancer is usually performed with radioisotpe such as Ir-192 high-dose rate afterloading. The carbon nanotube based X-ray tube can be applied to treat endmetrial cancer, the advantage being its low energy and relatively steep dose gradient. To create and evaluate homogeneous cylindrical dose distribution around cylindrical applicator, dwell weightened factor were obtained. The point assumed X-ray source was moved in steps of 12 mm top of the applicator. The irradiation time was determined by Monte Carlo calculation, and the predetermined time was performed at each position. The dose distribution was measured using Gafchromic EBT film in water chamber and PMMA slabs. The results were compared with the Monte Carlo calculation. The irradiation time based on the delivery of 5 Gy to a 5 mm depth was 30 min. The differences between measurement and calculation were within 7%. It is possible to create a homogeneous cylindrical dose distribution of the CNT-based miniature X-ray tube through the superimposition of multiple dose distribution of point source.

Photon technology(C)/0696 P2-op.018

Fabrication and Evaluation of Surface Applicator of Electronic brachytherapy device based on Carbon Nanotubes to Treat Skin Diseases

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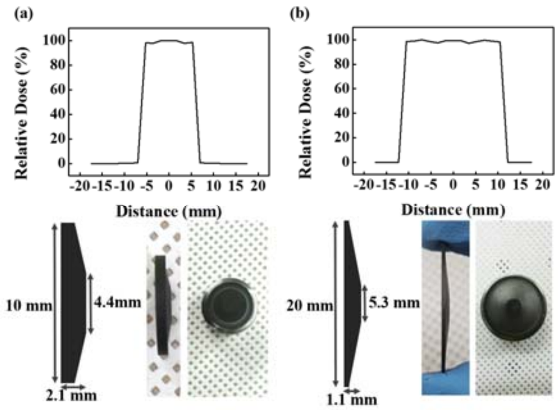
Abstract :



X-ray tubes provide an alternative to radioisotopes in brachytherapy for treating skin diseases. However, when only X-ray tubes are used for treatment, problems, such as inhomogeneity caused by the proximity of the source to the treatment area and the destruction of normal cells by radiation reaching outside the skin lesion area, arise. Therefore, an applicator has been designed and manufactured to solve these problems. The applicator is comprised of a shielding component and a flattening filter, which the latter is able to be freely removed from and reattached onto the former. The shielding component is designed so that it wraps around the miniature x-ray tube with a thickness of 3 mm and is composed of stainless steel. The fabricated shielding component shields the area outside of the skin lesion region from the X-rays generated. The flattening filter is designed to improve the uniformity of the dose distribution at the irradiated area. The designs of the flattening filter were made after considering the radiation attenuation factor, and they were optimized based on the flatness of the dose distribution. The materials that were considered to be used for the fabrication of the filter were aluminum and graphite. However, the optimal thickness of the flattening filter, if built with aluminum, was 20 ㎛, making an aluminum filter too difficult to actually manufacture. Therefore, the flattening filter was fabricated with graphite with a thickness 1.1mm, the calculated optimal thickness value. A miniature X-ray tube with a carbon-nanotube electron emitter was employed as the X-ray source. The dose distribution obtained by using the X-ray tube with applicator has good flatness, symmetry and penumbra.

Photon technology(C)/0102 P2-op.019

Enhanced Absorption in a Photonic Crystal Resonator Coupled with a Microfiber

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Abstract :

우리는 photonic crystal 을 이용한 간섭계(Photonic Crystal Resonator, 이하 PCR)에서 Coherent Perfect Absorption(CPA) 현상을 이용한 흡수 증가를 연구하였다. numerical simulation 상에서, PCR 에서의 CPA 가 780 nm 의 파장을 가진 coherent light 를 기준으로 실현 가능함이 입증되었다. 실험적으로 측정하기 위하여, PCR 은 silicon on insulator(SOI)에 제작되었다. PCR 에 coherent light 를 입사하기 위하여, microfiber 와 PCR 사이의 coupling 을 이용하였다. Microfiber 에서 PCR 로 입사되는 양쪽 빛 사이의 상대적인 위상을 변화시켜 CPA 에 기반을 둔 흡수의 증가를 실험하였다. 우리는 최적화된 PCR 에서 상대적인 위상에 따라 최대 80%까지 증가된 광학적 흡수를 확인하였다.

Quantum electronics(D)/0898 P2-op.020

원통형 레이저매질의 열렌즈 정밀 측정 및 비점수차 보상

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Abstract :

높은 평균출력을 가지는 레이저 증폭기의 설계를 위하여, 원통형 레이저 매질의 열렌즈를 정밀하게 측정하고, 불균일한 펌핑에 의해 발생할 수 있는 비점수차를 분석하고 보상할 수 있는 방법에 대해 논의하였다. Shack-Hartmann 센서를 이용해 펌핑 동작 전후의 레이저 매질을 통과한 측정빔의 파면을 얻었고, 매질을 GRIN 렌즈로 취급하는 광선추적 방법을 통해 매질에 축적된 열량을 역으로 구하였다. 상기 방법은 매질에 입사되는 측정빔을 별도 측정할 필요가 없고, 열렌즈의 주평면을 고려하지 않아도 되므로 실험이 용이하다. 또한, 측정빔의 편광 조건에 따라, 열응력에 의한 성분을 구분하여 측정하는 것이 가능하여 열효과의 정밀한 분석에 활용될 수 있을 것으로 기대된다. 이와같은 정밀한 측정을 통해, 레이저 매질의 펌핑이 불균일하여 생기는 수차 또한 분석할 수 있는데, 그 예시와 함께 보상을 위한 기법을 제시하였다.

Quantum electronics(D)/0808 P2-op.021

Fabrication and Characterization on the Surface Ligand Controlled Organometallic Halide Perovskite Quantum Dots and its Application for Light Emitting Diodes

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Abstract :

Organometallic halide perovskite have triggered global attention due to their outstanding and optimistic energy conversion efficiency in photovoltaic field. The interesting photovoltaic properties of these materials make them as promising candidates for light emitting diodes(LEDs). However, LED performance based on the perovskite emissive layer still remain in suffer due to the high exciton dissociation efficiency of perovskite film which reduce radiative recombination of exciton. Therefore, to increase radiative recombination efficiency, various methods have been proposed (i.e., crystal pinning, quasi- 2D film, quantum dots(QDs)). Among these methods, perovskite QD is promising method due to their high photoluminescence quantum efficiency and reproducibility. However, perovskite QD LEDs still need more development to exploiting its potential for commercial application.

Herein, the colloidal perovskite QDs were synthesized at various solvent to control its photoluminescence quantum yields (PLQYs) by changing QD core crystallinity. It is found that increase on the solvent electric field capability index leads to the presence of lead vacancy in the core crystal structure which decreases PLQY of synthesized QDs. PLQYs of synthesized perovskite QDs were further improved through surface ligand engineering process. Initial oleic ligands were successfully exchanged to the shorter ligands with various alkyl chain lengths. PLQYs of perovskite QDs were significantly enhanced due to reduced non-radiative exciton recombination which originated from surface dangling trap level. Finally, perovskite QD LEDs treated by ligand exchanged process exhibits 2.5 times higher current efficiency compared to pristine perovskite QD LEDs.

Quantum electronics(D)/0633 P2-op.022

Two-Photon CNOT Gate in Circuit QED System with Triple-Leg Stripline Resonator

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Abstract :

We theoretically propose a two-photon gate operation in circuit QED system, where a qubit is coupled to microwave photon modes of triple-leg stripline resonator. Unlikely from linear stripline resonator, triple-leg stripline resonator can support two-fold degenerate photon modes among others. By coupling them to a single qubit, we have shown that one photon mode is directly coupled to a qubit, while the other is intact and only acts as a spectator photon. Our system closely resembles a special cavity QED system, where an atom in a cavity is exclusively coupled to the left or right polarized photon mode alone. Two photon states with distinct polarities can be selectively manipulated by using a single qubit control and time evolution of the system. We have demonstrated that two photon controlled-not(CNOT) gate can be realized by applying a specific sequence of operations.

*This work is supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (NRF-2016R1D1A1B01013756).

Quantum electronics(D)/0308 P2-op.023

Quantum dot transport in a few layers of ReS_2

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Abstract :

Transition metal dichalcogenides (TMDCs) have been extensively explored due to their energy band gaps. Among them, rhenium disulfide (ReS_2) has anisotropic carrier transport and photonic response that vary with the axial direction, ReS_2 offers interesting opportunities for applications in various electronic and optoelectronic devices. Here we demonstrate quantum dot transport in two-terminal devices on a few layers of ReS_2 at low temperatures. ReS_2 flakes are exfoliated on a highly doped p^{++} silicon substrate covered by a 300 nm thermally grown SiO_2. The p^{++}-Si is used as a global backgate. Ti/Au (10/100nm) contacts separated by ~300 nm are defined by electron beam lithography. At room temperature, the field-effect mobilities are extracted to be 20-40 $cm^2\ V^{-1}s^{-1}$, which is comparable to the mobilities reported in previous work. Then, the devices are measured at the temperature of 4.2 K. We observe Coulomb diamonds at low source-drain bias and high gate voltages, indicating that quantum dots are formed between two electrodes.

Quantum electronics(D)/0076 P2-op.024

LED 여기 Nd:KGW 레이저 설계

정치현 [1], 이범준 [2], 이상후 [2], 임정섭 [2], 정우열 [2], 김국현 [2], 이종훈 [*1]

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Abstract :

레이저 다이오드(LD)여기 고체레이저는 고효율 특성으로 기존의 고체레이저 시장을 장악하였지만 펄스레이저는 QCW 가 고가이어서 보급이 느려지고 있다. LED 는 저가이고 선폭이 넓지만 펄스 여기가 가능하다. Nd:KGW 결정은 흡수 선폭이 매우 넓어서 LED 여기에 적합하지만 발진 특성은 Nd:YAG 에 비하여 떨어진다. 본 연구에서는 Nd:KGW 를 LED 로 4 면에서 여기하는 레이저 장치를 설계하고, 여기흡수 분포를 ZEMAX 로 시뮬레이션 하였다. LED 는 직접 결정에 전달하거나 빔 전달 광학계를 통하여 결정에 보낸다. 흡수분포를 계산한 결과는 LASCAD 로 보내서 레이저 발진 특성을 조사하였다.

Accelerator-based particle physics experiments (C)/0167 P2-pa.101

1.7 MV 탄뎀 가속기 빔라인의 외기 PIXE 용 외기빔창

하준목*1, 이승호 1, 김계령 1, 석재권 1, 김민영 1, 조용섭 1

1 한국원자력연구원, 양성자가속기연구센터

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Abstract :

한국원자력연구원 양성자가속기연구센터의 1.7 MV 탄뎀 가속기는 이온 주입, RBS/ERD 측정, 표준 중성자 생성, PIXE 분석을 위한 4 개의 빔라인으로 구성된다. PIXE (Particle/Proton Induced X-ray Emission) 분석 기술은 수 MeV 정도의 에너지로 가속된 입자빔을 시료에 조사 시 시료로부터 나오는 특성 X-선을 분석하여 시료를 정성, 정량 분석할 수 있는 방법으로, ppm 이하의 극미량 원소까지 정밀 분석할 수 있다. 파리 루브르 박물관에서는 1989 년도부터 탄뎀 가속기를 자체 보유하여 문화재 복원 및 보존처리를 위해 외기 PIXE 분석기법을 활용해오고 있으며, 양성자가속기연구센터에서는 차후 문화재 복원 및 보존처리 활용 목적으로 기존 PIXE 빔라인을 외기 PIXE 빔라인으로 업그레이드 할 예정이다. 진공챔버 내에서 시료를 측정 및 분석하는 기존 PIXE 는 시료의 교체 시간이 길고, 액체, 분말, 문화재와 같은 대형 시료는 측정이 어렵다는 단점을 가진다. 반면 입자빔만을 가속기에서 빔창 (Beam Window)을 통해 대기중으로 인출하여 시료를 진공 밖에서 조사/분석하는 외기 PIXE 분석기술은 기술의 특성상 기존 PIXE 의 문제점 극복 및 문화재, 미세먼지와 같은 대형, 분말 시료 분석이 용이하다. 외기빔창은 외기 PIXE 빔라인 구축의 핵심 부품으로 외기빔 인출 및 진공 유지를 위해 사용된다. 양성자가속기연구센터 내 외기 PIXE 빔라인 구축을 위해 외기빔창 개발이 이루어졌다. 이번 학회에서 이 외기빔창 개발에 대해 발표하고자 한다.

Acknowledgement: This work has been supported through KOMAC (Korea Multi-purpose Accelerator Complex) operation fund of KAERI by MSIT (Ministry of Science and ICT)

Accelerator-based particle physics experiments (C)/0243 P2-pa.102

RIVET for vector boson transverse momentum spectra measurement at CMS experiment

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Abstract :

The Rivet toolkit (Robust Independent Validation of Experiment and Theory) is a system for validation of Monte Carlo event generators. It provides a large (and ever growing) set of experimental analyses useful for MC generator development, validation, and tuning, as well as a convenient infrastructure for adding your own analyses. Rivet is the most widespread way by which analysis code from the LHC and other high-energy collider experiments is preserved for comparison to and development of future theory models. It is used by phenomenologists, MC generator developers, and experimentalists on the LHC and other facilities.

The production cross sections of the weak vector bosons, W and Z, as a function of transverse momentum, are measured by the CMS experiment and compared with RIVET.

Accelerator-based particle physics experiments (C)/0259 P2-pa.103

Tracking algorithm for muon-beam tests of RPCs at GIF++/CERN

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Abstract :

We have tested thin-gap RPCs developed at KODEL, candidated for future RPC triggers at RE3/1 and RE4/1 regions of CMS, using intensive gamma background provided by the Gamma Irradiation Facility (GIF++) and 100-GeV H4 muon beams at CERN. In the future Phase-2 LHC runs, the maximum particle rate is expected in the maximum eta region of 2.4 is 600 Hz cm^{-2} when the LHC luminocity reaches a maximum value of 7×10^34 cm^{-2} s^{-1} in the Phase-2 LHC runs. In the present R&D using the GIF++ and the H4 muon beams, we developed a dedicated algorithm that exclusively reconstructs the muon tracks presenting with the intensive gamma signals in the RPC detectors. The current tracking algorithm was applied to thin double-gap and dual-bi gap RPCs tested at GIF++ in 2016 and 2017 and enables us to prove the detector performance required for the future Phase-2 LHC runs.

Accelerator-based particle physics experiments (C)/0275 P2-pa.104

Computational-Science-based Research on Dark Matter

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Abstract :

The standard model has been established after the Higgs boson had been discovered. However, there is nothing known about dark matter, which occupies approximately five times of standard model particles in space besides the fact that they have mass. The cross-section of dark matter is much smaller than that of the existing standard model. The range of predicted mass is wide ranging from a few eV to PeV. Therefore, massive data on astronomy, accelerator and simulation is required for this study and the efficient processing of them is also required. Experiment–theory–simulation converged computational science is required in the research of dark matter. For the coverage of data, computational science and deep learning, dark matter research platform is suggested. It will enables us to prove the mystery of dark matter more efficiently.

Accelerator-based particle physics experiments (C)/0277 P2-pa.105

Feasibility study on B meson decays to 6 leptons

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Abstract :

Feasibility study on B meson decays to 6 leptons

Accelerator-based particle physics experiments (C)/0304 P2-pa.106

Study of Charge Flip for Same-Sign Dilepton Channel Heavy Majorana Neutrino Analysis using the CMS detector at 13 TeV

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Abstract :

The same-sign dilepton channel is one of the significant features in heavy Majorana neutrino analyses due to its rare signature in the SM. One of the major background for this channel is the contribution from the charge mis-measurement in the more abundant opposite-sign dielectron events. By the hard emission of photon, the charge of an electron is likely to be mis-measured, which is referred to as an electron charge flip. From this poster, we show the detailed studies of electron charge flip rate using Z to dielectron events taken from the CMS detector in 2016.

Accelerator-based particle physics experiments (C)/0400 P2-pa.107

Study of the Calorimeter Trigger Simulation at the Belle II Experiment

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Abstract :

The Belle II experiment at KEK in Japan is under final stage of construction to probe New Physics beyond the Standard Model by measuring CP violation and rare decays of beauty, charm quark and tau lepton. The experiment is being performed at the SuperKEKB e^+ e^- collider with 80×10^34 cm^(-2) s^(-1) as an ultimate instantaneous luminosity. As a severe beam background environment is highly anticipated in e^+ e^- collision, a simulation study of the Belle II calorimeter trigger system is very crucial to develop and test appropriate trigger algorithm. We report preliminary results on various trigger logic and efficiencies of physics events upon beam background using the Belle II Geant4-based analysis framework called Basf2.

Accelerator-based particle physics experiments (C)/0404 P2-pa.108

Firmware Study of the Electromagnetic Calorimeter Trigger Boards at the Belle II Experiment

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Abstract :

The Belle II at the SuperKEKB collider in Japan has been constructed toward a physics run in early of 2018 with an ultimate target of 40 times higher instantaneous luminosity than the KEKB collider. The main physics motivation is to search for the New Physics from heavy quark/lepton flavor decays. In order to select an event of interest efficiently under much higher luminosity and beam background environment than the KEKB, we have upgraded the Electromagnetic Calorimeter(ECL) hardware trigger system. It would be realized by the improvement of ECL trigger logic based on two main triggers, the total energy and the number of clusters, with an FPGA-based flexible architecture and a high speed serial link for the data transfer. In this report we present the current status of firmware development using FPGA chips in ECL trigger boards,

Accelerator-based particle physics experiments (C)/0424 P2-pa.109

Slow Control System for the Electromagnetic Calorimeter Trigger System at the Belle II Experiment

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Abstract :

The Belle II experiment which has been being ready at SuperKEKB factory at KEK in Japan is a particle physics experiment, the purpose of which is to study the New Physics effect using properties of heavy quark and lepton weak decays. During trigger and DAQ operation upon beam collision, it is important that status and real-time results of the detector have to be monitored all the time for handling unexpected situation. Slow control system, built with Control System Studio(CSS) which is a GUI window design tool based on Eclipse, is one of monitoring program controlling non-time-critical hardware.

In this study, we report the status on slow control system for the trigger of Electromagnetic Calorimeter(ECL) detector.

Accelerator-based particle physics experiments (C)/0479 P2-pa.110

Jet discrimination with machine learning

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Abstract :

An efficient quark/gluon jet discrimination method would be of enormous importance to the field of particle physics. This study compares different machine learning tools to find the best quark/gluon jet discrimination method. We compare deep learning-based jet image discriminators to those traditionally used for quark/gluon classification, such as boosted decision trees trained on jet shape variables.

Accelerator-based particle physics experiments (C)/0511 P2-pa.111

Simulation of Dual-Readout Calorimeter for Circular Electron Positron Collider Experiment

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Abstract :

Full calorimeter geometry for circular-electron-positron collider experiment has been constructed in GEANT4 simulation. Each tower consists of Dual-Readout Module. Each tower was calibrated with 20 GeV electron. Energy resolution and response of electron and pion of which energy range is between 10 GeV and 100 GeV was investigated at eta 0.01111 and 1.006195. For pion, energy resolution and response was derived with and without dual-reaout method.

Accelerator-based particle physics experiments (C)/0640 P2-pa.112

Data Quality Monitoring Study of Calorimeter Trigger System at the Belle II Experiment

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Abstract :

The Belle II experiment will start physics runs in early 2018 at the SuperKEKB factory. The Data Quality Monitor (DQM) is one of the critical subsystems in the Belle II data acquisition (DAQ) system. The DQM online system will keep monitoring a proper Trigger and DAQ operation by analyzing online triggered event samples quickly and by visualizing trigger related histograms via a live browser GUI called the control system studio (CSS). We will report the current status of the DQM for the Electromagnetic Calorimeter(ECL) trigger system.

Accelerator-based particle physics experiments (C)/0709 P2-pa.113

Study for calorimeter detector design for Circular Electron Positron Collider using GEANT4

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Abstract :

Study for calorimeter detector design with wing shape geometry for CEPC experiment is presented. The structure of barrel and endcap of the wing shape geometry with projective and dual-readout concept using GEANT4 is discussed. Validation for PMT calibration is performed with electron beam with energy range from 10 GeV to 100 GeV. The performance of this detector design is compared to another calorimeter design (wedge shape geometry) for CEPC.

Accelerator-based particle physics experiments (C)/0773 P2-pa.114

Study of Electroweak Production of Zγ+2jets in the Standard Model

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Abstract :

We present a study of electroweak(EWK) production of Zγ+2jets in the Standard Model (SM) using detector simulation in pp collisions at the LHC.

This EWK process helps us to understand more about the SM in novel phase spaces, previously unobserved processes and can also serve as portals to probe new physics effects such as Anomalous Trilinear or Quartic Gauge Boson Coupling(ATGC or AQGC).

The analysis is performed by using Feynman Rules/MadGraph5 aMC@LO framework. We generate events on Signal and each backgrounds. In the Vector Boson Fusion(VBF) process, we use a photon, leptonically decaying Z boson(Z-> l l , l=e, μ), and two VBF-like jets well separated in rapidity and with large invariant mass. Then we select two electrons, one photon and two jets. Finally we calculate significance using number of events.

Accelerator-based particle physics experiments (C)/0782 P2-pa.115

Search for B^0 decays to dark-photon pair at Belle

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Abstract :

We present a status report of a search for the rare B decays to a pair of dark photons using full Y(4S) data sample of 772M BB pairs collected with the Belle detector at the KEKB asymmetric-energy e+e− collider. We reconstruct a dark photon using its decays to e+e-, mu+mu-, and pi+pi- final states. In this poster, signal extraction procedure and the calculation of expected branching fraction of the decay are presented.

Accelerator-based particle physics experiments (C)/0783 P2-pa.116

Slow Control Monitoring Framework for the Belle II Data Acquisition System

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Abstract :

For the Belle II experiment, Slow Control Monitoring Framework is needed for each subdetector. Before starting the data acquisition (DAQ) for Phase 2 operation of Belle II, the framework should be developed for managing and representing the DAQ information for each subdetector. In this poster, the current status and the goal of the framework are presented.

Accelerator-based particle physics experiments (C)/0798 P2-pa.117

Higgs to di-muon search

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Abstract :

The dimuon decay mode of the Higgs boson has a small branching ratio which makes it a difficult process to witness. Nevertheless, verification of the Higgs interactions are required so that we may obtain a deeper understanding of the Standard Model. The search for the Higgs to dimuon decay mode is conducted using advanced multivariate techniques utilizing data obtained by the CMS detector from $\sqrt{s}$= 13 TeV proton proton collisions at the Large Hadron Collider.

Top quark mass measurement using J/psi meson

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Abstract :

The measurement of the top quark mass by using charmed mesons within b-quark jet is known as an alternative solution. This method can reduce the jet energy uncertainties, because it does not use a jet when extracting the top quark mass. In this presentation, we will focus on the J/psi which is decayed to dilepton such as m+m-. Through the CMS detector, we can get a clear invariant mass shape of the J/psi, and minimize noise effects from backgrounds and pileup energy. Lastly, we will end up measuring the top quark mass by using J/psi.

Accelerator-based particle physics experiments (C)/0814 P2-pa.119

Measurement of top quark mass using D meson in b-jet

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Abstract :

The measurement of the top quark mass is a very important topic at LHC because top quark mass is one of fundamental parameters to research “Standard Model”. Top quark has a strong effect on the mass of higgs boson because it is the heaviest quark. So, if we can measure the top quark mass more precisely, it is possible to measure the higgs boson mass more accurately.

We can measure top quark mass by reconstructing D^0 and D^*. We used an isolated lepton from W boson and 2(3) tracks from D^0(D^*) in b-jet. The invariant mass of the lepton and D meson will be used to extract the top mass. Thus, in this presentation, we researched ttbar events including D-in-jet. These events were extracted from 13 TeV LHC data in 2016.

Accelerator-based particle physics experiments (C)/0830 P2-pa.120

JetMET trigger validation and DQM in CMS

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Abstract :

As one of the mandates of the STEAM group, they are tasked with monitoring the performance of individual triggers. Towards this end, they coordinate the validation and prompt monitoring of triggers with the various POGs and PAGs that are responsible for those triggers. We are involved in the validation task about JetMET trigger and development of prompt monitoring code about dijet for JEC. In this poster, those will be introduced.

Accelerator-based particle physics experiments (C)/0853 P2-pa.121

GEM Detector response simulation with Geant4

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Abstract :

Triple Gas Electron Multiplier (GEM) detectors are being developed for the upcoming muon system upgrade of CMS experiment at LHC, CERN. The triple GEM detectors will work in heavy radiation environments that consist of photons, neutrons, electrons and protons. We need to know how these backgrounds affect to the detector and sensitivities of the detector to these kind of particles. The sensitivities of the Triple GEM to the various sources are calculated as function of the energy of the incident particle with using Geant4, a general particle simulator.

Accelerator-based particle physics experiments (C)/0854 P2-pa.122

KNO Candidate Sites and Geological Survey Results

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Abstract :

KNO(Korean Neutrino Observatory)는 CP 대칭성 깨짐과 중성미자 질량 순서를 결정하고, 양성자 붕괴를 탐색하며, 세계 최대의 지하 중성미자 망원경으로서 초신성 폭발과 태양의 핵융합반응에서 나오는 중성미자를 관측 할 수 있다.
KNO 검출기가 설치될 지하시설의 후보지로 대구의 비슬산, 영천의 보현산이 유력하다. 최근 이 후보지들에 지반 탐사를 수행하여 암반강도의 프로파일들을 얻었으며, 스트레스 분석을 통해 터널과 검출기가 위치할 지하공간(cavern)의 개념적 설계를 바탕으로 KNO 건설에 필요한 비용과 공사기간 등을 산정하였다.
이 발표에서는 후보지의 선정 배경과 KNO 검출시설 구축의 용이성, 지반탐사 결과에 대해 보고하고자 한다.

Accelerator-based particle physics experiments (C)/0858 P2-pa.123

GEM Detector Performance Test

송동현 [1], 박인규[*1], 이상훈 [1], 정영군 [1], 장세덕 [1]

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Abstract :

GEM detector operates at a low voltage compared to other detectors and has short dead time of ~20ns. The CMS detector has to cope with a huge amount of incident particles, especially in the forward region and detectors with a short dead time is advantageous. The GEM detector has strong durability and is ideal for this forward region. The small (10cm x 10cm) GEM detector's performance is tested.

Accelerator-based particle physics experiments (C)/0886 P2-pa.124

Study of PMT configuration in the JSNS2 experiment.

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Abstract :

The JSNS^2 experiment aims to search for the existence of sterile neutrino at J-PARC. A 1 MW beam of 3 GeV protons incident on a spallation neutron target produces an intense neutrino beam from muon decay at rest. Neutrinos come predominantly from muon plus decay. The experiment will search for muon anti-neutrino to electron anti-neutrino bar oscillations which are detected by the inverse beta decay interaction, followed by gammas from neutron capture on Gd. The JSNS^2 experiment will use PMT's to detect this signal. Optimization of the PMT configuration is essential to optimize the sensitivity of the experiment. This poster shows energy resolution according to different PMT configurations, such as different positions, total number of PMT's and PMT size.

Property Changes to Polymers after Electron Irradiation

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Abstract :

Polymers are widely used in the company for their variety in application. They are available in articles ranging from household appliances to industrial scales. Recently, the polymer market has grown significantly in the automotive industry. Headlights and large parts of the interior frame of cars now consist of polymers. However, even with their excellent properties, polymers are not yet able to replace glass as main windscreen material. This is due to the thermal and mechanical properties of polymers. If these problems can be solved by a polymer enhancement process, further polymerization of cars is possible.

This research is concerned with a novel way of preparing cured, ultraviolet absorbing polymer for practical application. Polymers are currently being coated and removed by winding chemical, thermal and mechanical processes to meet industry requirements. These conventional methods are very sensitive to small state changes, can cause environmental damage, are expensive, and represent design constraints. Thus, a simple one-step process is extremely lucrative in the development of polymer-based polymer-based materials.

Research has shown that polymethylmethacrylate (PMMA) could be mechanically enhanced by the electron beam irradiation process. When the electron fluence was less than 1×10^{15} electrons/cm^2, PMMA showed severe signs of deterioration due to irradiation degradation as expected. However, at a fluence of more than 1×10^{17} electrons/cm^2, PMMA samples were mechanically mechanically improved. The surface hardness of the PMMA samples increased from a value of 0.26 to 2.8 GPa after electron irradiation [1].

A further study showed that the light absorbing property of polymers could be altered by the electron beam irradiation process. Irradiation of polystyrene (PS) with electrons caused a shift in the band gap, whereby the polymer absorbs photons of different wavelengths depending on the electron fluence [2]. This is most likely due to the production of polycyclic aromatic hydrocarbons (PAH) after electron irradiation. According to "Spectral Atlas Polycyclic Aromatic Compounds", the presence of specific PAHs causes a specific photon absorption peak to occur [3].

Ultimately, this research focuses on the development of a simple method for the production of cured, UV-absorbing plastics. With the development of such a process lucrative opportunities can be gained by the broad use of polymers.

Calibration Study of the Calorimeter Trigger System at the Belle II Experiment

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Abstract :

We have been developing the trigger system using the Electromagnetic Calorimeter(ECL) which is one of sub-detectors in Belle-II experiment at KEK in Japan. To make a decision of physics events in online trigger level, we should identify the energy deposit in the crystal and the event timing. So we have performed the energy calibration by estimating FADC value to energy deposit conversion factor, and the calibration which is to measure time offset constants upon hardware conditions.

We introduce the ECL trigger system in brief and report the ECL trigger calibration method.

Accelerator-based particle physics experiments (C)/1109 P2-pa.127

Two dimensional dose distribution analysis of electron beam irradiated uPVC film

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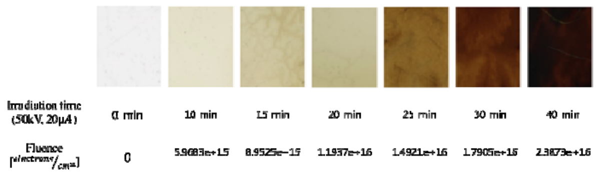
Abstract :



This paper suggests that using uPVC film is a lot more useful when analyzing spatial resolution or iso-dose curves of energetic electron beam than using other dosimeters such as ionization chambers, semiconductors, and radiographic films. These difficulties have resulted in a research for a radiation dosimeter with high spatial resolution which does not require a special developmental procedure and gives accurate values of absorbed dose. Image formation occurs as a dye-forming, in which energy is transferred from an energetic photon or particle to the receptive part of the leuko-dye or colorless molecule through chemical structure changes.

When a film is irradiated with an electron beam, a color change is visibly observed and can be digitized with scanner. Particularly the dose and digitized red values are linearly matched well so unknown dose irradiated on the film is predictable. However, the main advantage of using a film is that it can analyze spatial distribution rather than dose measurement.

The PVC's radiation interaction gives rise to macro-radicals deriving from C–Cl or C–H bond scission reactions. During this interaction, the following reactions can take place. As a result of Raman analysis, post-irradiation PVC shows carbon's G-peak which means pristine PVC becomes more carbonaceous as electron beam is irradiated. This induces the transmission rate of light to be low and relationship between the amount of fluence and light transmittance can be analyzed.

uPVC film serves several important functions in electron gun calibration as a radiation detector and an archival medium. Film provides excellent 2D spatial distribution of radiation in the area of interest. It is essential to consider the error of the fitting function as it should be minimized to better optimize the veracity of the film analysis. Furthermore, rather than considering a pure uPVC film, a heterogeneous polymer mix primarily composed of uPVC can be used in the future to potentially enhance the performance in terms of reliability and accuracy.

Accelerator-based particle physics experiments (C)/0531 P2-pa.128

Study of Effect of PMT Tilt on Charge Collection in the JSNS2 Detector

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Abstract :

JSNS2 is an experiment proposed to search for the existence of sterile neutrino with $\Delta m^2 \sim 1eV^2$ using intense anti-muon neutrino beam from the J-PARC Material and Life Science Experimental Facility(MLF) at Japan. The detector with a fiducial volume of 17 tons is to be located 24 meters from the mercury target where anti-muon neutrinos are produced. The JSNS2 detector must be moved outside of the MLF during the maintenance period of the mercury target for three months each year in order to avoid interference between the maintenance work and JSNS2 experiment. PMTs installed inside the detector would be moved or tilted while the detector is on moving, which would affect the charge of the signal collected by PMTs. This presentation shows the preliminary result on this effect for various tilted angles using a detector simulation.

Particle physics theory(A)/0765 P2-pa.129

GEM in muon reconstruction

윤예빈 [1], 박인규[*1], LEE Jason[1], 강예찬 [1], 고병학 [1], 송동현 [1], 전다정 [1]

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Abstract :

The goal of the muon system upgrade of the CMS detector at the LHC Phase II upgrade is to increase performance of muon reconstruction. The coverage of the muon endcap will be extended to cover the highest η range, 2.0 < |η| < 2.8.

The new GEM detectors have been included in the standard muon reconstruction algorithms and the performance of muon reconstruction is shown.

Field and string theory(B)/0254 P2-pa.201

New Dirac theory described by FW spin operator and its nonrelativistic approximated Hamiltonian

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Abstract :

New Dirac theory is constructed by using FW spin operator and its nonrelativistic approximated Hamiltonian is derived. We discuss the implication of new nonrelativistic Hamiltonian and its feasibility of experiment.

Field and string theory(B)/0442 P2-pa.202

Smarr relation for higher dimensional RN-Sch BH in quasilocal frame

KIM Nakwoo[1], LEE Yein[1], PARK Miok[*2], RICHARDS Matthew[3], STOTYN Sean[3]

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Abstract :

The Smarr relation is an algebraic relation between thermodynamic variables, which satisfy the first law of thermodynamics. By Brown-York, the first law of thermodynamics in a quasilocal frame is well constructed, where a pressure term additionally presents compared to an infinite observer. However, the Smarr relation is not studied yet. Here we found Smarr formula and examine it with the higher dimensional Reissner-Nordstrom Schwartzschild Black Hole in a quasilocal frame by Brown-York method with an action renormalized by Mann-Marolf counter term.

Non-accelerator-based particle physics experiments(D)/0112 P2-pa.301

Development of Genat4 profiling tool kit for low energy physics

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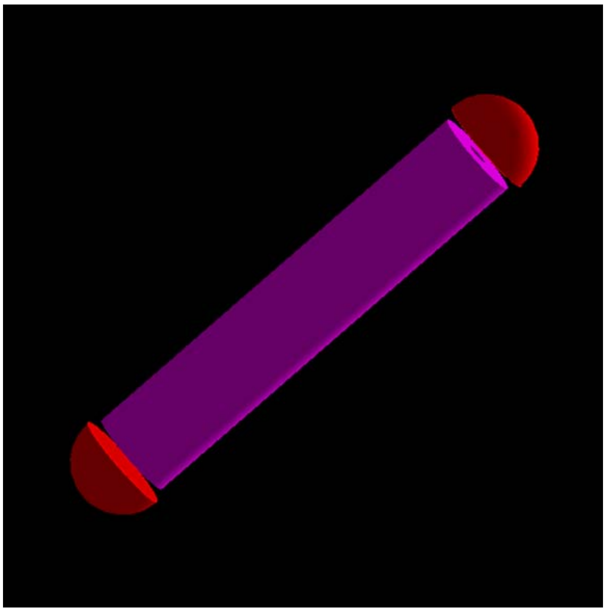
Abstract :



입자물리학 뿐만아니라 많은 물리 어플리케이션에서 다양한 소프트웨어가 컴퓨팅 아키텍처에서 개발되고 이론적 배경으로 많은 양의 시뮬레이션 데이터를 필요로 하고 있으므로 CPU 계산 속도나 머신의 메모리 문제가 발생하게 된다. 이를 위해 컴퓨팅 속도나 정밀함을 높일 수 있는 연구에 필요한 시뮬레이션 툴킷 개발이 필요하다. 현재 대표적인 시뮬레이션 툴킷은 정밀도가 높고 계산과학의 활발히 사용되는 Geant4 를 이용한 연구가 활발히 진행중이며 미국 페르미 연구소에서도 마찬가지로 Geant4 를 이용하여 high energy 프로파일링의 대한 연구가 이뤄지고 있다. 최근에 Geant4 시뮬레이션의 활용분야가 입자물리뿐만이 아니라 의학물리 분야의 방사선 소스를 이용한 치료와 양성자 가속기 치료 등 넓은 분야에서 활용되고 있다. 따라서 high energy 에 뿐만 아니라 low energy 분야인 의학물리 분야에서도 Geant4 를 이용한 시뮬레이션 툴킷 개발이 필요하다. 이를 위해 KISTI 의 Tachyon2 를 이용하여 프로파일링을 진행하였고 Geant4 의 Brachytherapy 응용프로그램과 방사선 소스 및 3 가지 physics lists 를 사용하여 프로파일링 도구의 성능을 확인하였다. 이 도구의 목적은 물리 목록 및 mesh 크기에 따라 low energy 어플리케이션에서 CPU 속도와 메모리 사용량을 확인할 수 있다. 이 어플리케이션을 분석한 결과 mesh 크기가 선형 의존성이 있음을 알 수 있다.

Non-accelerator-based particle physics experiments(D)/0280 P2-pa.302

Development of Measuring Devices for the Attenuation Length of LAB-based Liquid Scintillator

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Abstract :

원전중성미자는 원자로의 핵분열 과정에서 생성되어 검출기내의 양성자와 충돌하는 역베타붕괴(Inverse Beta Decay, , IBD) 반응을 일으킨다. 역베타붕괴에서 생성되는 양전자는 쌍소멸하며 빛을 내고 중성자는 주변의 원자핵에 포획되는 과정에서 빛을 내게 되는데 각각의 신호에 시간차이를 이용하여 구별한다. 이 때 생성된 빛은 광증폭관에 도달하는데, 사용된 액체섬광검출용액의 감쇠거리에 의존한다. 본 발표는 LAB 을 기초로 한 액체섬광검출용액의 감쇠거리를 측정하기 위한 측정 장비 개발 및 결과에 대해 기술하였다.

Non-accelerator-based particle physics experiments(D)/0398 P2-pa.303

Charge correction using neutron capture on hydrogen

신창동[*1], 김재률 [1], 문동호 [1], 박경환 [1], 박영서 [1], 임인택 [1], 주경광 [1], 김우영 [2], Serguey[2], 박명렬 [3], 최준호 [3], 장한일 [4], 권은향 [5], 김상용 [5], 김수봉 [5], 서선희 [5], 서현관 [5], 양정열 [5], 이동하 [5], 이용창 [5], 이현기 [5], 김종건 [6], 김종현 [6], 유인태 [6], 전상훈 [6], 정다은 [6], Carsten Root[6], 장지승 [7], 유종희 [8]

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Abstract :

The reactor neutrino candidate events with neutron captures on hydrogen are observed in the target and gamma catcher regions at RENO detector. The energy response differs in the two regions because the target region is filled with gadolinium loaded liquid scintillator. We have developed and applied a distinct energy conversion for each region according to the reconstructed vertex information. The decrease of observed charge and the degradation of vertext resolution took place in the target region as time goes by. We have developed a charge correction scheme to recover from the degradation. In this talk, we will describe the new charge correction using neutron captures on hydrogen to keep the charge stability.

Non-accelerator-based particle physics experiments(D)/0439 P2-pa.304

Developement of parallel ionization chamber

제갈진 [1], 김홍주[*1], 이혜영 [1], 이주영 [1]

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Abstract :

The ionization chamber is a radiation detector which collects ions and electrons generated by air ionization through application of electric field. These chambers need to be designed and manufactured for various applications. In this study, a small parallel plate ionization chamber of **5 × 5 × 5 cm3** was designed and made using aluminum, 1 mm thick copper plates for electrode and Teflon. The ionization chamber designed in this study refers to a commercial NACP ionization chamber. However, unlike the ionization chamber manufactured in the previous research, the flow of the electric field is stabilized by adding two copper guard rings beside the collector plate. The chamber was irradiated with the X-ray as a ionization source to confirm its sensitivity as a radiation detector.

Non-accelerator-based particle physics experiments(D)/0440 P2-pa.305

Delay energy and vertex correlation requirements for the neutron capture on hydrogen analysis at RENO

권은향[*4], 김우영 [1], Serguey[1], 박명렬 [2], 최준호 [2], 장한일 [3], 김상용 [4], 김수봉 [4], 서선희 [4], 서현관 [4], 양정렬 [4], 이동하 [4], 이용창 [4], 이현기 [4], 김종건 [5], 김종현 [5], 유인태 [5], 전상훈 [5], 정다은 [5], Carsten Rott[5], 김재률 [6], 문동호 [6], 박경환 [6], 박영서 [6], 신창동 [6], 임인택 [6], 주경광 [6], 장지승 [7], 유종희 [8]

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Abstract :

The RENO experiment has been taking the data since 2011. It is observed that some of selection criteria suffer from loss of detection efficiency because of decreased number of active PMTs and decreased attenuation length of liquid scintillator. Due to the detector degradation the reconstructed energy and vertex resolutions become worse and result in the decease of detection efficiencies with the delayed energy and vertex correlation criteria. We have developed modified criteria to recover those efficiencies. In this talk, we will present new methods to keep those detection efficiencies constant in time.

Non-accelerator-based particle physics experiments(D)/0536 P2-pa.306

Sensitivity calculation for radioactive background measurement of MoO3 powders with an array of HPGe detectors at Y2L

박수연 [1], 한인식 [*1], 김영덕 [2], 김고운 [1], 이무현 [2], 이은경 [2], 강운구 [2], Douglas Leonard [2]

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Abstract :

Since AMoRE-II requires extremely pure crystals with very low radioactive contamination under 2 microBq/kg for 228Th, the raw material (i.e, MoO3 powders) for the crystals needs to have a very low contamination less than 20 microBq/kg. A measurement of the powders In a single crystal HPGe detector (100% relative efficiency) at Yangyang underground laboratory (Y2L) gave a detection limit of about 1 mBq/kg. The detection limit is due to its background level. Recently, we have installed a new HPGe array of 14 detectors (70% relative efficiency each) with a lower background and a coincidence capability. We are going to present an expected detection limit (sensitivity) of the HPGe array for the MoO3 powers measurement using the background data and a simulation study.

Non-accelerator-based particle physics experiments(D)/0555 P2-pa.307

Charge correction for the IBD events and muons at RENO

김우영 [1], Serguey[1], 박명렬 [2], 최준호 [2], 장한일 [3], 권은향 [4], 김상용 [4], 김수봉[*4], 서선희 [4], 서현관 [4], 양정열 [4], 이동하 [4], 이용창 [4], 이현기 [4], 김종건 [5], 김종현 [5], 유인태 [5], 전상훈 [5], 정다은 [5], Carsten Rott[5], 김재률 [6], 문동호 [6], 박경환 [6], 박영서 [6], 신창동 [6], 임인택 [6], 주경광 [6], 장지승 [7], 유종희 [8]

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Abstract :

The RENO experiment has been taking data since Aug. 2011 and has seen decrease of observed charges by time. The reduced charges come from decreased attenuation length of gadolinium loaded liquid scintillator and decreased number of active photo-sensors. This resulted in a non-uniform charge response in the detector and worsened the energy resolution. We have developed a charge correction method using the peak energy of neutron captures on gadolinium. For muon events we have developed another charge correciton method using the observed spectra of visible energies. In this talk, we present the charge correction methods to make the observed charge response constant in time and uniform in the detector volume.

Non-accelerator-based particle physics experiments(D)/0637 P2-pa.308

Concept of multiple-cell cavity for axion dark matter search

JEONG Junu[1,2], YOUN Sungwoo[*2], AHN Saebyeok[1,2], KANG Chanshin[1,2], Yannis K. Semertzidis[1,2]

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Abstract :

In cavity-based dark matter axion search experiments, multiple-cavity design is commonly considered to increase both the search range of axion mass and the detection volume for a given magnet. We proposed a new idea, multiple-cell cavity, which provides a variety of benefits including larger volume of cavity, simpler design of the readout chain, and easier phase-matching mechanism compared to the conventional multiple-cavity design. We present the characteristics of the multiple-cell design and demonstrate the experimental feasibility using a double-cell cavity.

Non-accelerator-based particle physics experiments(D)/0657 P2-pa.309

Estimation of Cosmic Muon Flux at KNO Candidate Sites

김수봉[*4], 김재률[6], 임인택[7], 김우영[1], Carsten Rott[5], 주경광[6], 박명렬[2], 최준호[2], 장한일[3], 장지승[9], 신창동[6], 이동하[4], 서현관[4], 유인태[5], 양정열[4], Sergey Sergeyevich[1], 권은향[4], 이용창[4], 신창동[4], 문동호[6], 이현기[4], 서선희[4], 유종희[8], 전상훈[5], 김종현[5], 박경환[5], 김종건[5], 박영서[6], 정다은[5]

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Abstract :

Cosmic muons are one of the most major background sources for underground experiments. The muon fluxes at KNO candidate sites(Mt.bisul and Mt. Bohyun) are calculated using the MUSIC program. We will introduce modified Gaisser parameters and a simple Monte Carlo integration method. Calculated muon fluxes and spectra will be presented as a function of observed muon energy. The average energy and flux will be presented as a function of azimuthal angle. We will also present a survival probability of muons as a function of initial muon energy.

Non-accelerator-based particle physics experiments(D)/0661 P2-pa.310

Charge stability check using calibration sources at RENO

이용창 [4], 김우영 [1], Serguey[1], 박명렬 [2], 최준호 [2], 장한일 [3], 권은향 [4], 김상용 [4], 김수봉[*4], 서선희 [4], 서현관 [4], 양정열 [4], 이동하 [4], 이현기 [4], 김종건 [5], 김종현 [5], 유인태 [5], 전상훈 [5], 정다은 [5], Carsten Rott[5], 김재률 [6], 문동호 [6], 박경환 [6], 박영서 [6], 신창동 [6], 임인택 [6], 주경광 [6], 장지승 [7], 유종희 [8]

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Abstract :

We have been taking data with radioactive sources at various energies regularly, say, every month. The raw charges of the source data are corrected using the peak charge of neutron capture on gadolinium in the reactor neutrino candidate events. Based on the observed peak charges of the source data we have monitored the stability of charge response of the RENO detector. In this talk, I will present the monitoring results and any necessary correction

Non-accelerator-based particle physics experiments(D)/0674 P2-pa.311

RENO upgrade and its sensitivity study

김수봉[*4], 김재률[6], 임인택[7], 김우영[1], 주경광[6], 박명렬[2], 최준호[2], 장한일[3], 장지승[8], 신창동[6], 이동하[4], 서현관[4], 유인태[5], 양정열[4], Carsten Rott[5], 권은향[4], 이용창[4], 김상용[4], 문동호[6], 이현기[4], 서선희[4], 유종희[9], 전상훈[5], 김종현[5], 김종건[5], Sergey Sergeyevich[1], 박영서[6], 박경환[6], 정다은[5]

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Abstract :

After the current reactor neutrino experiments, there will be no experiment dedicated to the theta13 measurement for a while. The precision measurement of theta13 is valuable for determining the CP violating phase if combined with an accelerator neutrino beam experimental result. We plan to upgrade the RENO facility to make a precision measurement of theta13 and dm_ee^2 and to solve the problem with the 5 MeV excess in the measured reactor neutrino spectrum. We propose to add more identical detectors to the near and far detectors and to construct further far detectors located at 1.7 km away from the reactor array center. In this talk, we present the expected sensitivities with the upgraded RENO facility.

Non-accelerator-based particle physics experiments(D)/0705 P2-pa.312

An experiment for measuring intensity of high energy gammas from Tl-208 with ThO2 powders

LEE Eunkyung[1], KIM Yeongduk[*1,3], HAHN Kevin Insik[2], KANG Woongu[1], KIM Gowoon[4], LEE Moohyun[1], LEONARD Douglas S.[1], PARK Suyeon[4], JEON Eunju[1]

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Abstract :

In the nuclear data of Tl-208, decay intensities for gammas over 3 MeV have 100% uncertainties. Those gammas over 3 MeV from the 208Tl can affect the radioactive background in the AMoRE (Advanced Mo based Rare process Experiment). So an experiment using ThO2 powders with a high radioactivity is tested in a high purity germanium (HPGe) detector at the Y2L(YangYang underground Laboratory) to obtain more precise intensity values. In order to reduce a coincidence effect, 10cm thick Pb blocks were installed to cover the detector top assuming that 583 keV and 860 keV gammas would be removed. To estimate a probability to observe the high energy gammas, a total efficiency was calculated using attenuation length ratio combined with a Monte Carlo simulation study. A status of the experiment will be presented.

Non-accelerator-based particle physics experiments(D)/0731 P2-pa.313

Efforts on Purification of Liquid Scintillator

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Abstract :

We will present realistic and efficient purification methods of liquid scintillator(LS). The purification methods should be effective for a large amount of LS and in a reasonable duration. In order to reduce a purification period, a vacuum pump is used for the alumina-powder purification and micro-filtering methods. We have also made efforts to reduce the purification time for the water extraction method. In this presentation, We discuss performance and realistic applicability of those methods for purifying a large amount of LS.

Non-accelerator-based particle physics experiments(D)/0793 P2-pa.314

Supernova Relic Neutrino Sensitivity at KNO

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Abstract :

Neutrino has become a new window to our universe after the detection of neutrinos from sun and SN1987a. Hyper-Kamiokande (HK) is a next-generation water Cherenkov detector supposed to be built in Japan. It consists of two identical tanks (2 x 260 kton) with 40 % photo-coverage. With 20 times larger fiducial volume (2 x 187 kton) than current Super-kamiokande (SK), the sensitivity studies for Supernova Relic Neutrino (SRN) will be greatly improved by HK. Also for Korean Neutrino Observatory (KNO), an alternative plan of locating one of the two identical detectors to Korea, better SRN sensitivities are expected than HK in Japan because of the less muon flux and its spallation isotopes in a deeper (~ 1 km) Korean sites. In this talk, I will present sensitivity studies on SRN for various candidate locations of the two tanks.

Non-accelerator-based particle physics experiments(D)/0801 P2-pa.315

The high Q superconducting cavity for the Axion search

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Abstract :

We have been studying how to make the high Q superconducting cavity through magnetron sputtering method for the Axion search. In this work, we studied the radio-frequency (RF) surface resistance (R_s) of superconducting Niobium Titanium film on the inner surface of a hollow cylinder at low temperature (100mK - 10K) by measuring quality factor (Q) of it with the carefully designed caps and the 4.35 GHz RF electromagnetic wave. Two frustum caps are used to separate two degenerated modes (TM_{011}, TE_{111}), and the TE_{111} mode is used to measure the R_s of the Niobium Titanium film on the cylinder wall with a thickness of 1μm and an atomic ratio of 42:58. Through the four-probe DC resistance measurement using the Physical Property Measurement System (PPMS), it was found that the critical temperature of the film in the same condition was 7.9 K. The detail results will be presented in the poster session.

Non-accelerator-based particle physics experiments(D)/0811 P2-pa.316

RF chain analysis for axion search experiments using Simulink in Matlab

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Abstract :

To detect the notoriously weak axion signal, RF receiver chains require complicated circuits, consisting of multi-stage amplification and frequency conversion. Due to the complex design, evaluation of the properties of the entire system as well as individual RF components depends on actual measurements. RF blockset, which is a simulation tool of Simulink, an application in Matlab, provides an intuitive analysis method for simulating RF circuits. We demonstrate that this tool is very useful to evaluate the properties of RF systems and estimate important experimental quantities, such as signal-to-noise ratio and scan rate.

Non-accelerator-based particle physics experiments(D)/0819 P2-pa.317

Study of temperature dependence properties of NaI(Tl) crystal and PMT

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Abstract :

The COSINE-100 experiment searches for WIMP dark matter using an array of ultra low-background NaI(Tl) crystals. We have studied the internal background in more than ten prototype NaI(Tl) crystals and have developed methods to reduce background. Thermal noises are one of main source of Photo Multiplier Tube (PMT) noise. Such noise can be reduced in the low temperature environment. But scintillation properties of NaI(Tl) such as light yield will also change at low temperature. Therefore, we investigated the temperature dependence of scintillation properties of NaI(Tl) in the temperature range of -20°C to 30°C. The NaI(Tl) crystals were encapsulated in a copper case and quartz windows on opposite sides of crystal for optical coupling with PMT. The temperature dependence of NaI(Tl) scintillation light yield, decay time constant and PMT noise is analyzed and presented.

Non-accelerator-based particle physics experiments(D)/0901 P2-pa.319

AMoRE Muon Veto Counter and Event Selection

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Abstract :

The AMoRE (Advanced Mo-based Rare process Experiment) is an experiment searching for a neutrinoless double beta decay of Mo-100. A pilot experiment, AMoRE Pilot, has been running with a total of ~1.8 kg of six 40Mo100MoO4 (CMO) crystals in a cryostat at the Yangyang underground laboratory (Y2L, 600 m overburden from the surface). The AMoRE muon veto counter covers the AMoRE cryostat with 10 plastic scintillator counters (28 PMTs). We have developed several methods to select the muon events in the muon counter and checked the coincident background signals from the crystals. We will present on how to select a muons, the muon rate at the AMoRE experiment room, and the background level of the crystals by the muons.

Non-accelerator-based particle physics experiments(D)/0937 P2-pa.320

A measurement of 180mTa decay with a HPGe detectors Array

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Abstract :

A newly developed array of 14 ultra low background HPGe detectors (ARRAY) has been installed and is operating now in the Y2L underground laboratory. The main purpose of the ARRAY is to do rare decay searches by measuring gamma-rays from samples. Tantalum is one of the candidate samples since the 180mTa decay has never been observed to date. The background level study and Monte Carlo simulation with Geant4 toolkit have started for the Tantalum measurement. The Monte Carlo simulation study is to get the best detection efficiency among different sample configurations in the ARRAY. The background study is to see background reductions with a radon free system and with an additional sealing of N2 gas volume around the detectors. Status of the ARRAY, a simulation study of the 180mTa measurement and a background level investigation will be presented in this contribution.

Non-accelerator-based particle physics experiments(D)/0942 P2-pa.321

Discrimination of neutrino and antineutrino in the near detector of DUNE

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Abstract :

The Deep Underground Neutrino Experiment (DUNE), aiming at a precise measurement of CP violation phase and determination of the neutrino mass hierarchy, will use neutrinos and anti-neutrinos generated from the long baseline neutrino facility (LBNF) at Fermilab. The DUNE near detector (ND) will be installed in a pit with a distance few hundred meters to the proton target. ND has a goal to measure the unoscillated neutrino and antineutrino spectra, in order to perform accurate oscillation analyses. Therefore, ND will use magnetic field for its tracker region, which is behind liquid argon target in front, in order to distinguish particles' charge signs. This talk will explain the strategy of what described above, and compare the results with potential magnetized ND tracker options - High Pressure Gas Argon TPC and Straw Tube Tracker.

Non-accelerator-based particle physics experiments(D)/0980 P2-pa.322

Study of PMT saturation for JSNS2 experiment

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Abstract :

The JSNS2 experiment searches for sterile neutrinos with short baseline (~24m) using high intensity neutrinos produced at the mercury target of the MLF (Material and Life science experimental Facility) in J-PARC. JSNS2 will repeat the LSND experiment with a pulsed neutrino beam and a gadolinium loaded liquid scintillator detector. The 10 inch PMTs used in Double Chooz are considered to be reused if they are appropriate for detection of neutrinos at energies of a few MeV to ~300 MeV. We have tested the 10 inch PMTs for their linearity and any saturation at high gain. In this presentation, we report the PMT test results especially on the saturation of PMT signal.

Non-accelerator-based particle physics experiments(D)/0991 P2-pa.323

Detectors of Deep Underground Neutrino Experiment (DUNE)

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Abstract :

There are a number of technical options for neutrino detectors, though liquid Argon (LAr) time projection chamber (TPC) is the key concept to detect neutrinos by tracking particles. Two types of prototypes, single-phase and dual-phase TPC, will be ready for performance in 2018, which will be adopted as the technology for first two far-detector modules. Near detector is decided to be a different type with additional functions from far detector. There are several compelling candidate ideas for the near detector. Here we will review the designs of detectors and the requirements for physics goals of DUNE.

Non-accelerator-based particle physics experiments(D)/1056 P2-pa.324

Muon simulation with AMoRE–Pilot detector

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Abstract :

The AMoRE(Advanced Molybdenum based Rare process Experiment) is an experiment to search neutrino-less double beta decay of Mo-100. If it is found it means that the neutrinos are Majorana particles and we can measure their masses. The experiment is being carried out in the deep underground in order to observe the extremely rare events free from the backgrounds coming from the cosmic ray particles. However, even in the deep underground, there are still some cosmic ray particles that can affect the measurement and must be excluded as much as possible. A muon veto counter is a detector that can detect and veto cosmic muons coming to the inner volume of the detector where the main CaMoO4 (CMO) crystal detectors are located. We did a simulation to obtain distributions of energy deposits in the CMO detectors and in the veto counter by atmospheric muons and to estimate rates of the events. The event rate for the CMO crystals having energy deposits at a range of 2.8 MeV~ 4 MeV was 1.0123 events per day, and the rate at the ROI (3.024 MeV ~ 3.044 MeV) was 0.030675 events per day. Also, we investigated the time differences between muon veto counter hits and CMO crystal hits. Details of the simulation study will be presented.

3 MV 탄뎀 가속기 빔라인의 빔 광학 설계*

조용섭[*1], 하준목 [1], 석재권 [1], 김계령 [1]

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Abstract :

서울대학교 기초과학공동기기원에서 1998 년부터 주로 탄소 가속기 질량 분석을 위해 운영되고 있던 3 MV 탄뎀 가속기가 금년 하반기 한국원자력연구원 양성자가속기연구센터로 이전될 예정이다.
양성자가속기연구센터에서는 기존의 탄소 가속기 질량 분석 빔라인 더불어 이온 주입, 이온빔 분석, 재료 조사를 위한 3 개의 빔라인이 새로 설치될 예정이다. 새로운 빔라인을 위해 수소, 헬륨 등 기체 이온을 위한 duoplasmatron 형 이온원 및 실리콘, 구리, 철 등 금속 이온을 위한 sputter 형 이온원이 사용된다. 설치될 공간이 제한되어 3 MV 탄뎀 가속기에 의해 가속된 이온은 110 도 이극전자석에 의해 꺾인 이후 스위치 전자석를 통해 3 개의 빔라인으로 배분된다. 이 110 도 이극전자석 및 빔라인 부품 배치를 위해 이온원부터 표적까지의 빔광학 설계가 이루어졌다. 이번 학회에서 이 빔광학 설계에 대해 발표하고자 한다. *This work has been supported through KOMAC (Korea of Multi-purpose Accelerator Complex) operation fund of KAERI by MSIT (Ministry of Science and ICT).

Accelerator & beam physics(A)/0234 P2-pl.102

The evolution of the temporal pulse in a 3D time-dependent free-electron laser.

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Abstract :

We have analyzed the evolution of the temporal pulse in a 3-dimensional time-dependent free-electron laser (3D time-dependent FEL) oscillator. We have developed an extended 3D time-dependent FEL code to calculate the evolution of the temporal pulse in a free-electron laser oscillator. The effects of the evolution of the temporal pulse on the radiation wavelength with the range of 2.48 ~2.65 μm are investigated at wiggler length. The gain on various radiation pulse with the range of 0.1 to 1.2 cm are analyzed for the various time of 1.0ns to 0.2μs. The effects of the energy spread of electron beam with the range of 0.01 to 0.05% and the variations of the beam energy are investigated by the extended 3D time-dependent FEL code.

Accelerator & beam physics(A)/0239 P2-pl.103

홀 추력기 플라즈마 내 Xe^{+} 이온의 속도분포 진단을 위한 레이저유도형광 측정시스템 구축

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Abstract :

홀방식 플라즈마 추력기는 반경방향의 자기장과 축방향 전기장에 의해 방위각 방향으로 ExB 표류하는 전자에 의해 방전이 유지되고, 자화되지 않아 축방향으로 가속되어 분사되는 이온에 의해 추력을 발생시키는 이온원이다. 홀 추력기 플라즈마 및 분사되는 이온의 물리적 특성을 이해하고, 발생된 추력, 비추력 및 전력효율 등의 성능을 해석하기 위해서는 정확한 이온빔 진단이 필요하다.
레이저유도형광법(Laser Induced Fluorescence Diagnostics)은 가속 이온의 시공간 속도분포함수를 측정함으로써 플라즈마 포텐셜 구조를 재구성하고 플라즈마의 진동을 관찰할 수 있는 매우 유용한 진단법이다. 본 연구에서는 Xe^{+} 이온의 속도분포함수를 위치의 함수로 측정하기 위해 834.723 nm 를 Xe^{+} 이온의 여기파장으로 선정해 NIR tunable 레이저를 사용하여 LIF 시스템을 구축하였다. 채널 길이와 지름이 각각 25, 50 mm 인 원통형 홀 추력기에서 양극전압이 225 V 인 경우 21 km/s 까지 Xe^{+} 이온의 속도가 측정되는데[1], 이는 약 58 pm 의 도플러 편이에 해당하기 때문에 wavemeter 를 사용하여 빔의 제어 및 파장스캔을 수행하였다. 레이저빔은 지름 1.5 m, 길이 3 m 의 진공챔버 내로 입사되어 추력기 플라즈마를 지나도록 시준됐으며, 광전자증폭관과 Lock-in Amp 를 사용해 타겟 영역에서 발생한 LIF 시그널을 측정하도록 준비되었다.

[1] Y. Lim et al., Phys. Plasmas 21, 103502 (2014)

Accelerator & beam physics(A)/0300 P2-pl.104

초전도 Half-Wave Resonator 의 고주파 결합기 기초 설계

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Abstract :

양성자가속기연구센터에서는 2013 년부터 100 MeV 양성자가속기를 운영하고 있으며, 양성자가속기의 활용도를 높이기 위하여 양성자 빔을 표적으로 입사시킬 때 발생하는 2 차 입자에 대한 연구를 계획 중에 있다. 이를 위해 100 MeV 이후에 설치되어 빔에너지를 높일 수 있는 HWR 타입의 초전도 가속관 개발이 진행 중이다. 350 MHz 의 공진주파수를 가지는 HWR 에 사용될 고주파 결합기는 동축형으로 설계하였으며 최적 결합 조건에서 빔 가속에 필요한 고주파 전력은 약 60 kW 이다. HWR 의 공진주파수 디튜닝에 따른 첨두 고주파 전력을 분석하고 이때 필요한 고주파 결합기의 형상의 따른 결합 계수를 MicroWave Studio 전산 모사를 통해 도출하였다. 본 연구에서는 HWR 타입의 초전도 가속공동에 사용될 고주파 결합기에 대한 기초 설계에 대해서 논한다.

본 연구는 과학기술정보통신부의 연구비 지원을 받았음.

Accelerator & beam physics(A)/0461 P2-pl.105

Performance of the Pal-xfel high precision magnet power supplies

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Abstract :

In the PAL-XFEL, the total number of 632 of magnet power supply (MPS) have been operating since 2016. High current unipolar MPSs (>100A) were configured buck mode with single power stack or two. The corrector MPSs for low current were the H-bridge type for bipolar current driving. The nine different types of MPS were installed for beam dynamics in the PAL-XFEL machine. All MPSs had been tested and confirmed their performances before installation. We described here that the configuration and status of the MPS operation after installation on 2016.

Accelerator & beam physics(A)/0485 P2-pl.106

Preliminary Design of a superconducting electron beam ion source at KOMAC

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Abstract :

At Korea Multipurpose Accelerator Complex (KOMAC), we have been working on electron beam ion sources (EBIS) for multiply charged ion beams. An EBIS test bench with a commercially available EBIS has been constructed and characterized for multiply charged ions of Helium and Argon. We are also developing our own 7 Tesla superconducting EBIS (7T-EBIS) as an ion beam injector for a 200 MHz Radio-Frequency Quadrupole accelerator. Here, we present the progress on electron beam simulations of the 7T-EBIS design.

Acknowledgement

This work has been supported through KOMAC operation fund of Korea Atomic Energy Research Institute by Ministry of Science, ICT and Future Planning.

초전도 HWR 가속기 빔 정합 기초 연구

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Abstract :

양성자가속기연구센터에서는 운영중인 100 MeV 양성자가속기를 이용하여 펄스 중성자 발생 기초연구를 수행하고 있으며, 펄스 중성자 발생율을 높이기 위해 현재 건설되어 있는 가속기 터널 내부에 초전도 HWR (Half Wave Resonator)을 설치하여 양성자의 에너지를 160 MeV 까지 증가시키는 것을 계획하고 있다. HWR 은 구조 베타값이 0.58 이며 1 개의 저온용기 내에 4 개의 HWR 을 설치하는 구조이다. 빔 집속은 저온용기 외부에 설치된 Doublet 을 이용한다. 본 연구에서는 설계된 초전도 HWR 가속기와 기존 100 MeV 가속기와의 빔 정합에 대한 기초 연구 결과에 대해서 논한다.

본 연구는 과학기술정보통신부의 연구비 지원을 받았음.

Accelerator & beam physics(A)/0728 P2-pl.108

Commissioning Procedure of Linac and Undulators in PAL-XFEL*

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Abstract :

PAL-XFEL consists of the hard x-ray (HX) line with 4-10 GeV electron beam and the soft x-ray (SX) line with 3-3.5 GeV electron beam. The HX linac consists of four sections of S-band accelerating columns, three bunch compressors, an X-band linearizer, and a dog-leg line. HX and SX undulator lines have 20 and 7 undulators respectively. Also, phase shifters are installed between two undulators. We can control the gap of undulators and phase shifter and the vertical position of undulators. The HX line generates 0.1 nm FEL with 9.6-GeV and 140-pC electron beam. The electron bunch is compressed to 2.5 kA with 2 or 3 bunch compressors. We conduct commissioning the linac and undulators for PAL-XFEL. The Beam Based Alignment (BBA) of the linac is conducted by one-to-one to find the field center of quadrupole magnets. The quadrupole magent movers and Cavity Beam Position Monitor (CBPM) offsets in the undulator region are used for the BBA to align the trajectory of e-beam and FEL. The controlled parameters of undulators are optimized to maximizing FEL intensity. In this paper, we summary the commissioning procedure of linac and undulators and present the details.

Accelerator & beam physics(A)/0778 P2-pl.109

Numerical study on target/ion source for Li-8 beam at KOMAC

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Abstract :

It is conducted that a numerical study on a target/ion source (TIS) for Li-8 radioactive isotope beam (RIB) at Korea Multi-purpose Accelerator Complex (KOMAC). Li-8 is produced at a beryllium oxide (BeO) target by 100 MeV proton via $^{9}Be(p,2p)^{8}Li$ reaction. The produced Li-8 diffuses outside the BeO target and effuses to the ion source. The diffusion and the effusion processes are very important because they significantly contribute to determining an efficiency of the TIS. To enhance these processes, the target and a transfer line to the ion source in TIS are heated by the Joule heating. The present work calculates temperatures of the respective components of the TIS with various heating current. Also, the diffusion and effusion efficiency are estimated with the calculated temperature. Based on the results of the numerical study, detail design of TIS will be improved.

Accelerator & beam physics(A)/0849 P2-pl.111

Beam Position Monitor System for PAL-XFEL

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Abstract :

The X-ray Free Electron Laser of the Pohang Accelerator Laboratory (PAL-XFEL) produces 0.1 nm wavelength X-ray with a femtoseconds pulse width by using the self-amplification of spontaneous emission (SASE). For the successful commissioning and the stable operation of the PAL-XFEL, Beam Position Monitors (BPMs) are most the important instrument among the various kinds of electron diagnostic tools. In this work, the BPM system for the PAL-XFEL is introduced. From the pickup to the electronics, details of the BPMs are presented.

Accelerator & beam physics(A)/0899 P2-pl.113

DIAC 중이온 빔 조사 챔버 기초 실험
(Basic test of a heavy ion beam irradiation target chamber for the DIAC)

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Abstract :

2018 년 중이온 빔 인출을 목표로 하여 한국원자력연구원 핵융합기술개발부에서는 DIAC (Daejeon Ion Accelerator Complex) 중이온 빔 조사시설을 구축하고 있다.

DIAC 의 빔 조사 시설의 활용도 향상을 위해서는 다양한 시료를 취급할 수 있는 시료 홀더의 설계와 홀더를 제어할 수 있는 이송 시스템, 필요시 가열과 냉각을 할 수 있는 장치, 조사되는 빔의 특성을 확인하기 위한 진단장치 등 다양한 기구를 챔버에 설치하고 성능을 확인하는 작업이 필요하다.

본 연구에서는 빔 조사 챔버를 구성하는 시료홀더, 시료홀더 이송장치, 가열 및 냉각장치 등의 성능을 확인하기 위해 기초실험을 수행하였으며, 빔 조사 챔버의 진공 측정, 빔 조사 방향을 기준으로 시편 홀더의 상·하, 좌·우, 전·후 그리고 회전 등 이송시스템의 제어, 고온 시료 홀더의 히터 최대 가열온도, 냉각수 공급 및 순환 등 실험 결과에 대하여 발표 하고자 한다.

"이 연구는 2017 년도 정부(교육과학기술부)의 재원으로 한국연구재단의 지원을 받아 수행되었음"(No. 2015-M2B2A6031448)."

Accelerator & beam physics(A)/0907 P2-pl.114

RAON 가속기의 RF 시스템 개발 현황

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Abstract :

기초과학연구원 중이온가속기건설구축사업단에서는 IF, ISOL 등의 희귀동위원소 생성장치가 설치되는 가속기를 구축하기 위한 연구를 진행하고 있다. 이 가속기에는 RFQ 에서 나온 빔을 가속시키기 위하여 81.25MHz, 162.5MHz, 325MHz 의 주파수에서 운전되는 초전도 가속관을 사용하는 초전도 선형가속기가 설치될 예정이다. 이 초전도가속관에 공급되는 RF 시스템은 SSPA (Solid State Power Amp) 기반의 고출력 RF 전원장치와 이를 제어하기 위한 LLRF (Low Level Radio Frequency)으로 구성될 예정이다. 이 발표에서는 현재까지 진행된 라온 선형가속기의 RF 시스템 개발 현황과 구축 계획이 소개될 예정이다.

Accelerator & beam physics(A)/1035 P2-pl.115

Optimization of Electron Gun for C-band Klystron

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Abstract :

The efficiency and performance of klystrons are highly related to electron beam parameters which are typically determined from the electron gun structure. The key parameters of electron beams are laminarity, radius, perveance, and current profile at the beamwaist. In order to optimize these parameters, we adjusted the gun geometry using by the EGUN code and MATLAB code. For hot dimensions, we investigated thermal expansion effects at the operating temperature by the ANSYS code. It is compensated to the cold dimensions of the E-gun, cathode and anode structures.

*This work was supported by National R&D Programs (Grant numbers: 2014M1A7A1A02029891, 2016R1A6B2A01016828), through the National Research Foundation of Korea (NRF) and by the ITER technology R&D program funded by the Ministry of Science and ICT (MSIT), Korea.

Accelerator & beam physics(A)/1078 P2-pl.116

Nonlinear behavior in a free-electron laser oscillator based on a two frequency wiggler with higher transverse mode.

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Abstract :

To obtain the high gain and the high efficiency in free-electron laser oscillator, the two frequency wiggler was used. The nonlinear interaction between the electron and the radiation field with multi-transvers modes in a free-electron laser oscillator based on the two frequency wiggler has been studied. Those transverse modes of the emitted radiation are numerically studied using modified 1-dimensional free-electron laser model which is included two frequency wiggler effect, and the two frequency wiggler parameters were optimized.

Accelerator & beam physics(A)/1111 P2-pl.117

RF Cavity Design of Klystron Using 3D CST Program

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Abstract :

The klystron efficiency becomes an important issue for large-scale scientific facilities due to the high operating costs. In order to obtain higher efficiency, we investigate two klystron models: a base-line model and an alternative model. The base-line model is based on commercial units, while the alternative model is based on a multi-cell output cavity. We have determined design parameters of the output cavity, such as the number of cells, cell tuning frequencies and inter-cell couplings from beam-dynamics simulation using the EMSYS code. As the next step, the detailed RF design of the cavity has been conducted with beam-dynamics calculations using the CST Microwave Studio (MWS). Finally, the klystron design is confirmed by a start-to-end simulation from the electron gun to the collector using the CST Particle-in-cell (PIC) module.

*This work was supported by National R&D Programs (Grant numbers: 2014M1A7A1A02029891, 2016R1A6B2A01016828), by the BK21+ program through the National Research Foundation of Korea (NRF), and by the ITER technology R&D program funded by the Ministry of Science and ICT (MSIT), Korea.

RISP RFQ 초기 빔가속 시험

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Abstract :

기초과학연구원(IBS)의 중이온가속기건설구축사업단(RISP)에서는 four-vane 형태의 중이온용 RFQ 를 제작 및 설치하였다. RISP RFQ 의 운전 주파수는 81.25 MHz 이며 CW 운전을 할 수 있도록 설계되었는 데, 본 부지에서의 시험 및 운영에 앞서 시험시설을 구축하여 초기 빔가속 시험을 수행하였다. RF field tuning 과 conditioning 후 초기 빔 실험에서는 설계된 2 개의 RF coupler 중에 1 개만 설치하여 RF power 를 SSPA 로부터 공급받아 RFQ 에 인가하였다. RFQ 는 ECR 이온원에서 인출된 산소 빔을 이극 전자석, ESQ 및 copper 등을 포함한 LEBT 시스템을 통해 입력받아 10 keV/u 의 산소 +7 빔을 설계값인 507 keV/u 로 가속할 수 있다는 것을 인출된 빔 에너지 측정을 통해 확인하였다.

RISP 초전도가속관 QWR / HWR 시제품 수직 저온성능시험

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Abstract :

중이온가속기건설구축사업단에서는 초전도 가속관 81.25 MHz QWR (Quarter-wave resonator), 162.5 MHz HWR (Half-wave resonator), 325 MHz SSR (Single-spoke resonator)를 개발 및 시험하고 있다. 초전도 가속관 수직성능 실험을 위해 VCO-PLL 방식의 RF 시스템 및 데이터 획득 시스템을 구축하였으며, 현재 문지동 SRF Test Facility 에서 QWR 및 HWR 초전도 가속관의 시제품에 대해 수직 저온성능시험을 수행하고 있다. 액체 헬륨을 이용하여 QWR 가속관은 4.2K, HWR 가속관은 2.1K 로 냉각하여 각 가속관의 Q0 vs Eacc, 주파수 민감도 등을 포함하는 가속관 성능을 측정하는 실험이다. 본 발표에서는 초전도 가속관 성능실험을 위한 RF & DAQ 시스템 구축 및 현재 문지동 SRF Test Facility 에서는 수행하고 있는 QWR, HWR 시제품의 수직 저온성능실험에 대해 발표한다.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 – 2017.10.27, 경주 화백컨벤션센터

Accelerator & beam applications(B)/0066 P2-pl.201

거대 과학장치 PAL-XFEL 의 지반과 건물 바닥 변화를 실시간 측정하는 장치

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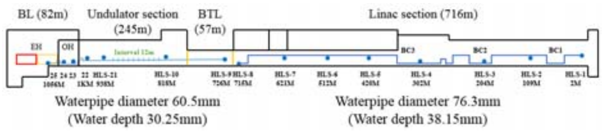
Abstract :



거대 과학장치를 구성하는 여러 가지 부품들은 측량(survey)과 정렬(alignment)을 통해서 정확한 3 차원 위치좌표(X, Y, Z)에 설치되고 운영되어야만 최적의 성능을 발휘할 수 있다. 그러나 지반은 시간이 지나면서 융기 또는 침강 현상이 발생되고, 이로 인해 건물 바닥의 변형이 발생한다. 지반과 건물의 변형으로 인해 설치된 부품들의 위치좌표가 변화하면, 구성품의 정렬 오차(ΔX, ΔY, ΔZ)가 발생한다. 이로 인해 시스템의 파라메터가 변화되고, 거대 과학장치의 성능이 저하된다. 건물 바닥의 변화를 실시간으로 측정하면, 건물 바닥의 높이 변화로 인해 발생하는 정열 오차를 예측할 수 있다. 건물 바닥의 높이 변화가 심한 지역을 선별하여 해당지역의 구성품을 신속히 재정렬 함으로서, 측량과 정렬 시간을 단축할 수 있는 이점이 있다. 이를 위해, PAL-XFEL 건물에는 HLS (hydrostatic levelling sensor)와 WPS (wire position sensor)를 설치하여 운영하고 있다.

Accelerator & beam applications(B)/0147 P2-pl.202

X-선 미세형광 실험에서 Al 차폐체에 의한 배경신호 제거

길계환[*1], 최효진 [1], 임재홍 [1], 박성호 [2], 송원용 [2]

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Abstract :

포항방사광가속기-II 의 4B 빔라인은 X-선 마이크로빔을 이용한 미세회절 실험과 미세형광 실험을 수행해오고 있다. 미세형광 실험에서는 집속된 X-선 마이크로빔에 대해서 시편을 2 차원적으로 이송시키며 형광검출기로부터 형광스펙트럼을 검출한다. 4B 빔라인의 형광스펙트럼에는 정체불명의 배경신호가 있어 미세형광실험의 해석에 작지 않은 어려움이 있어왔다.

우연한 기회에, 문제의 배경신호는 K-B(Kirkpatrick-Baez) 거울의 표면에 도금된 백금에 귀인하는 것으로 밝혀졌다. K-B 거울을 X-선 빔으로부터 이격시킴으로써 빔을 집속시키지 않은 상태에서는 형광스펙트럼에 문제의 배경신호가 전혀 나타나지 않는 것이 관찰되었다. 또한, K-B 거울 시스템 일부 외부 구간을 임시적인 금속 차폐체로 차단한 경우에도 배경신호의 의미있는 감소가 확인되었다.

본 연구에서는 새로이 알루미늄 판재로 차폐체를 설계하여 상기 배경신호를 완벽히 제거하고자 한다. 본 발표에서는 차폐체의 설계와 차폐체 설치 전후의 형광스펙트럼 변화를 상세히 기술한다.

Accelerator & beam applications(B)/0219 P2-pl.203

Progress of the RAON Fast Protection System Prototype

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Abstract :

In the RAON accelerator, the damage induced by an unexpected beam loss is one of the significant issues because the beam will reach up to 200 MeV/u energy and 400 kW power. Therefore, the fast protection system (FPS) is necessary to detect the beam loss and protect the accelerator equipment within a few tens of micro-second. To achieve this, the FPS prototype in the RAON accelerator has been developed and tested. The FPS prototype is based on the FPGA hardware platform design using ZC706 evaluation boards, and the EPICS IOC is also developed to monitor and control the system. To verify the performance of the prototype, the interlock test was also carried out by estimating the response time of the interlock signal to the mitigation output signal. Here we will present the progress of the FPS prototype and the future plan for the FPS in the RAON accelerator.

Accelerator & beam applications(B)/0295 P2-pl.204

High Stabile Magnet Power Supply

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Abstract :

A high stable magnet power supply (MPS) was developed, which was a bipolar type with 200A of the output current at the 40V of output voltage. The MPS has been implemented by the digital signal processing technology using the DSP, FPGA, ADCs and so on. The output current stability of the MPS showed about 4 ppm peak-to-peak in a short term experiment at the 200A of its full output current. This paper shows the several design considerations being implemented to this high stable MPS. Some experimental data such as output stability, some waveforms and so on are given in this paper.

Accelerator & beam applications(B)/0704 P2-pl.205

D-D 핵융합 반응 중성자 발생장치용 200 kV 가속관 제작
(Fabrication of a acceleration tube for D-D neutron generators)

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Abstract :

D-D 핵융합반응을 이용한 중성자 발생장치는 이온원에서 만들어진 중수소 이온을 직류 고전압으로 인출하고 가속시켜서 구리위에 코팅된 티타늄 표적에 입사시킴으로써 중성자를 발생시키는 장치이다. 이 때 발생되는 중성자의 수율(yield)은 빔 전류와 가속 에너지에 비례하며 , 같은 전력이 표적에 입사되더라도 빔 전류를 증가시키는 것보다 빔 가속에너지를 높이는 것이 더 효과적이라고 알려져 있다.

본 발표에서는 200 kV 빔 가속을 목표로 제작된 세라믹-코바 (KOVAR) 4 단 가속관의 설계 제원과 절연 특성 및 중성자에 의한 코바의 방사화 특성 등을 보고하고자 한다. 또한 중수소 이온빔이 타겟에 입사될 때 발생되는 2 차 전자의 역류를 방지하기 위한 전극의 설치 및 2 차 전자 억제용 전위를 얻는 방안에 대해서, 기본 설계를 크게 변경하지 않는 범위에서 구현하는 방안을 보고하고자 한다.

Accelerator & beam applications(B)/1144 P2-pl.207

전자 사이클로트론 공명 위치 및 운전 변수 조절을 통한 이온빔 인출 최적화

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Abstract :

최근 집속 이온빔(Focused Ion Beam, FIB)은 고분해능 및 높은 수율을 요구하는 다양한 분야에서 사용되고 있으며, 극미세 구조 제작에 유리하여 기존 FIB 이온원으로 액체금속이온원을 주로 사용했다. 하지만 액체금속이온원은 한정적인 이온종만 활용할 수 있고 수명이 짧다는 단점이 있어서 액체금속이온원을 플라즈마 이온원으로 바꾸려는 연구가 활발히 진행되고 있다. 플라즈마 이온원의 인출 구에 고밀도의 양전극 국부 플라즈마를 생성하면 같은 플라즈마 밀도에서 더 높은 이온빔 전류를 얻을 수 있다. 양전극 국부 플라즈마를 형성하기 위해서는 충분한 밀도의 주변부 플라즈마가 필요하다. 본 연구에서는 주변부 플라즈마의 밀도를 효율적으로 증가시키기 위해 전자 사이클로트론 공명(Electron Cyclotron Resonance, ECR)을 활용한 소형 ECR 플라즈마 이온원을 개발하였다. 방전관 주변에 링 형태의 영구자석을 설치해 ECR 현상을 활용함으로써 낮은 파워에서 효율적으로 플라즈마를 방전하였다. 이온원 운전 변수를 조정하며 패러데이 컵을 이용해 빔 전류를 측정하고 빔 전류로부터 인출 구 부근 플라즈마 밀도를 예측하였다. 마이크로파 안테나 길이와 ECR 현상이 일어나는 위치 변화시키며 빔 전류를 측정하여 인출 구 부근 플라즈마 밀도를 최적화하였다. 본 연구를 통해 개발한 ECR 플라즈마 이온원은 차후 이온빔 광학계에 연결되어 FIB 장비로 활용될 예정이다.

Nuclear fusion(C)/0040 P2-pl.301

K-DEMO 핵융합실증로의 삼중수소 자급 타당성 조사를 위한 증식블랑켓 모듈 레이어 구조 최적화

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Abstract :

DEMO 운전이 시작될 2040 년경에 전세계적으로 공급가능한 삼중수소는 10 kg 안팎이므로, 2,200 MW 의 fusion power 를 가질 K-DEMO 핵융합실증로의 연간 삼중수소 사용량 89 kg (70% 가동율의 경우)을 공급하기 위해서는 삼중수소 자급 능력은 필수적인 요건이다. 이 연구에서는 K-DEMO 증식블랑켓의 레이어 구조를 최적화함으로써 삼중수소증식계수 최대화를 기하였다. 아울러, K-DEMO 1 차 냉각재로 우선 고려되고 있는 경수외에 경수에 비해 중성자 흡수/산란 단면적이 작아 증식 블랑켓의 보다 넓은 영역에서 삼중수소 증식이 가능한 중수를 사용한 경우의 삼중수소증식계수도 계산한다.

Nuclear fusion(C)/0082 P2-pl.302

레이저 산란을 이용한 오염 플라즈마 내부의 티끌입자 크기진단

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Abstract :

많은 플라즈마에서 티끌입자가 관측되며, 특히 토카막을 안정적으로 운전하고 핵융합 플라즈마를 제어하기 위해서 티끌입자에 대한 이해가 필수적이다. 본 연구에서는 펄스 레이저를 이용하여 티끌입자의 크기를 진단하였다. Dust dispenser 를 이용하여 플라즈마 챔버 내부에 250nm~3.5μm 크기의 silver dust 를 생성하였다. 생성된 티끌입자에 Nd:YAG pulse laser(wavelength : 532 nm, pulse width : ~4 ns, pulse energy : 250 mJ) 광을 입사시켜 산란되는 신호를 측정하였다. 측정된 산란신호의 세기는 Mie scattering 이론으로 분석, 티끌입자의 크기를 진단하였다.

Nuclear fusion(C)/0092 P2-pl.303

Bounce-averaged gyrokinetic simulation of trapped electron turbulence in elongated tokamak plasmas

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Abstract :

Plasma elongation effects on turbulence and zonal flow are explicitly investigated for the first time with global bounce-averaged gyrokinetic simulations for Collisionless Trapped Electron Mode (CTEM). Being the most efficient steady state turbulence simulation scheme for this problem, bounce-averaged gyrokinetic simulation provides deeper insights into nonlinear physics separated from linear effects in the investigation. Based on studies for limited range of parameters, our results show that shorter radial scale zonal flows which are prominent for CTEM are more enhanced with higher elongation leading to reduced transport. According to the single time radial correlation function, potential fluctuation exhibits two radial characteristic scales similar to previous gyrokinetic simulation and experimental measurements. A dual mode propagating in counter directions is observed with stronger sheared zonal flow for higher elongation.

Nuclear fusion(C)/0116 P2-pl.304

Thermo-Hydraulic Analysis of The KSTAR PF Cryogenic loop using SUPERMAGNET code

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Abstract :

KSTAR PF cryogenic circuit has been operated by the supercritical helium circulator in a forced flow and a unique feature of PF (poloidal field) is that the cryogenic inlets and outlets of PF1~4UL (upper and lower) coils has been installed at the inside of coil with large magnetic field variation zone. Hence the major heat load by AC loss is localized both at the inlets and outlets, so that a drastically reduced or even no temporal cryogen flow is frequently observed at the inlets of PF1~4UL coils. This kind of temporal blockage of cryogenic loop can seriously affect the thermos-hydraulic analysis of a superconducting magnet system and the dynamic behavior of the flow by AC loss is one of the key to secure for operational stability. Therefore, a full KSTAR PF cryogenic loop has been developed using the SUPERMAGNET code to investigate dynamic thermos-hydraulic behavior. The numerical simulation results were also compared to experimental data.

Nuclear fusion(C)/0129 P2-pl.305

Development of 6.75 nm extreme ultra-violet movie camera for studying tungsten impurity transport in KSTAR

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Abstract :

Quasi-continuum spectral lines around 3-7 nm which are generated by de-excitation processes of highly charged tungsten ions, i.e., $W^{20\text{-}46+}$ were measured using the KAIST CAES extreme ultra-violet (EUV) spectrometer when tungsten powders were injected into KSTAR plasmas during the 2016 KSTAR campaign. In order to study the tungsten impurity transport, an EUV movie camera sensitive to 6.65-6.85 nm photons has been developed. The camera consists of a LaN/B multilayer mirror, a fast decaying YAG:Ce scintillator coated with a 100 nm Zr thin film for blocking visible light photons, and an EM-CCD camera. The tungsten EUV camera typically captures EUV images at about 10 frames per second. The field of view of the camera covers 1x1 m^2 with 1 cm spatial resolution. The camera was installed at the KSTAR F-port and successfully captured some visible images with a visible band-pass filter in the 2017 KSTAR campaign for the performance test. The actual EUV imaging will be carried out in the 2018 KSTAR campaign.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Nuclear fusion(C)/0166 P2-pl.306

Full-orbit simulation of energetic particles in tokamaks

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Abstract :

Gyroradius of energetic particles (EPs) in the magnetic confinement fusion devices is substantially larger than that of thermal ions, which can be comparable to characteristic scale lengths of plasma profiles. Full orbit treatment of EPs is required to keep the large Larmor radius effects in the EP transport and associated MHD instabilities. We present full-orbit simulations of EPs in the tokamak configuration using POCA code. Full gyro-motions beyond guiding-center approximation are computed for the fast ions produced by neutral beam injection and the charged fusion-born products. Collisional effects of slowing down and pitch angle scattering in the EP transport are illustrated in the single particle motion. Coupling of full orbit following with MHD calculation will be discussed for simulating EP transport driven by non-axisymmetric magnetic fields and MHD instabilities such as Alfven eigenmodes.

Nuclear fusion(C)/0187 P2-pl.307

Phase-pattern formation in drift-wave turbulence

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Abstract :

Turbulent particle transport in fusion devices is an important issue.
In most cases, the transport is calculated using a quasilinear approximation,
the so-called 'i-delta' approach. This assumes that the transport cross-phase is given by linear theory.
However, there is experimental evidence that the cross-phase dynamics
is important during the L-H transition [1]. This is our motivation to study phase-pattern formation.
Starting from the simple representative Hasegawa-Wakatani drift-wave model, we derive a
renormalized Burgers-like equation for the cross-phase dynamics. In the linear limit, our model
recovers the phase equation of An et al. [2].

[1] T. Kobayashi et al., 'Turbulent particle flux suppression by radial electric field non-uniformity at edge transport barrier in JFT-2M tokamak', 7th APTWG, Nagoya, Japan (2017).
[2] C.Y. An et al., JKPS 69, 1290 (2016).

Nuclear fusion(C)/0228 P2-pl.308

Characteristics of internal transport barriers in KSTAR

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Abstract :

The resulting steep pressure of internal transport barrier (ITB) that creates a bootstrap current can provide the most favorable picture in the sense that obtaining high core energy confinement with large gradient in the plasma pressure is essential for the research of a magnetic confinement fusion. The ITB in the so-called “advanced tokamak scenarios” is also expected to be able to provide a possible route towards a steady-state high performance operation in a fully non-inductive current drive state. So the access of the ITB formation and its control is dealt with an important physics issue in the most of present and even future tokamaks.
The experiment of ITB formation in L-mode plasma with a marginal NBI majority heating successfully demonstrated that the ITB is an alternative candidate to achieve a high performance regime in KSTAR. Time trace parameters indicating the plasma performance such as temperatures, the stored energy and the β_N are comparable to the H-mode in the discharge. This is the first stationary ITB observed in a full superconducting tokamak, and is expected to be applied to the application of various steady-state high performance operation scenarios in the near future. In this work, we present characteristics of ITBs in KSTAR.

Nuclear fusion(C)/0284 P2-pl.309

한국형 핵융합 실증로에서 GATO 코드를 이용한 낮은 모드의 선형 자기유체역학적 플라즈마 안정성 분석 연구

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Abstract :

한국형 핵융합 실증로는 토카막 연소 플라즈마를 통해 전기 생산을 실증하는 것을 목표로 하고 있으며, 안정적인 정상 상태 (steady-state) 운전을 위해 핵융합 실증로 노심 플라즈마의 평형을 구성하고 기본적인 자기유체역학적 (Magnetohydrodynamics, MHD) 모드 안정성을 연구하는 것이 중요하다. 핵융합 플라즈마의 이상적인 선형 MHD 안정성 분석을 위해 GATO 코드를 사용하였다. GATO 코드는 입력된 플라즈마 평형을 구성 (mapping)할 때 물리적 변수들의 분포를 유지하여 자기 만족적으로 계산하고, 기본적으로 라그랑지안을 최소화하는 에너지 변분 원리를 사용하는데, 안정성을 판별하는 증가율을 구하기 위해 고유 값 문제를 푼다. 먼저 KSTAR 실험에서 얻은 평형 데이터를 사용해 GATO 코드를 실행하여 분석하였다. GATO 코드에 적용하기 위한 핵융합 실증로의 토카막 플라즈마 평형은 TES (Tokamak Equilibrium Solver) 코드를 통해 구하였다. 다양한 플라즈마 압력 및 안정도 (Safety factor, q) 분포를 가진 플라즈마 평형을 GATO 코드에 적용하여 낮은 모드의 선형 자기유체역학적 플라즈마 안정성을 분석하였다.

Nuclear fusion(C)/0298 P2-pl.310

Current Status of KSTAR Thomson Scattering Diagnostic System and System Upgrade Plan

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Abstract :

In KSTAR tokamak, Nd:YAG Thomson scattering(TS) diagnostic system is most important diagnostic system to measure an electron density and temperature profile. In 2017 KSTAR TS diagnostic system is measured 27 spatial points with 27 polychromators. Until last year, the signal-to-noise ratio was low and it was difficult to calculate the electron temperature and density. But this year, we were able to increase the signal-to-noise ratio by developing additional APD power supplies. This power supply haves 100 channels and trimmers for fine control of high voltage (H.V.) to APD (Avalanched Photo Diode). As a result, applied voltage to APD was nearly 325 V, this value is higher ~ 1.64 times than last KSTAR campaign. Additionally laser beam transmittance was increased 6 percent than last year. As a result, Signal-to-noise ratio is increased in TS profiles in 2017. In addition, a Fast digitizer was installed and tested to apply the Giga sampling digitizer in the following experiment. In this report, upgraded profiles measured by TS in KSTAR will be present. Also system upgrade plan will be discussed. System upgrade plan is focusing on the reducing collection optics vibration. For this we are designing a heavy and rigid tower that location is at the front of the TS collection optics port (N-port) in KSTAR. The collection lens is also re-designing to improve the MTF(modulation transfer function) and vignetting. In this report design of upgrading system will be discussed.

Nuclear fusion(C)/0312 P2-pl.311

Long pluse 중성입자빔의 Blip 신호를 이용한 Beam plasma 의 Slowing down time 평가와 비교

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Abstract :

토카막 플라즈마 내부에서 발생하는 중성자는 핵융합 플라즈마 분석에 있어서 필수적인 물리량이라고 할 수 있다. 특히 Kstar 와 같은 중형 핵융합로에서 측정되는 중성자는 플라즈마 내부 현상을 이해하는데 중요한 역할을 하는데, D-D 반응이 주를 이루는 Kstar 에선 중성자가 고속 입자들의 반응 정도를 말해주는 척도가 되기 때문이다. 이러한 중성자 분석의 일환 중 하나로 본 연구에서는 Long pluse 의 NBI 조사에서 진단의 목적으로 발생한 Blip 신호를 분석하여 NBI 의 Slowing-down time 을 분석하였다. Blip 의 간격은 대략 5~10ms 정도로 이 시간 동안 플라즈마의 prameter 는 거의 변화가 없다고 생각할 수 있다. 이 때 측정된 중성자를 이용하여 NBI 의 decay time 을 평가할 수 있으며 이를 이론값과 비교하여 NBI 가 플라즈마 내에서 어떤 거동을 보이는지 분석할 수 있다. 또한 이를 통해 NBI 에 의해 입사되는 고에너지 이온들이 플라즈마 내부에서 얼마나 잘 Confine 되는지 가늠해 볼 수 있을 것이다.

Nuclear fusion(C)/0332 P2-pl.312

Feasibility study of ECH system for advanced tokamak operation in KSTAR

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Abstract :

The main purpose of Korea Superconducting Tokamak Advanced Research (KSTAR) device is to explore the physics and technologies of high performance steady-state operation that are essential for ITER and future fusion reactor. To achieve this goal, a total of 28MW external heating power was planned and the main heating sources will be neutral beam (NB) and electron cyclotron wave (ECW). ECH/ECCD which has localized deposition profile and controllable antenna, plays a role in current profile, plasma rotation, and impurity control and NTM suppression. To achieve the operation of advanced tokamak, 6MW ECH/ECCD system will be installed until 2020 before the major upgrade of KSTAR. 4MW gyrotrons were decided in 105/140GHz, 300s, 1MW-class gyrotron made in GYCOM. KSTAR should be chose the frequency of two gyrotron. And a new antenna port which is the middle large O port was assigned for 6MW ECH/ECCD. This paper presents the overview of 6MW ECH system and the optimization study of heating and current drive about antenna position and EC frequency composition for advanced tokamak operation. And requirements of ECH system for advanced operation in KSTAR upgrade are discussed.

Nuclear fusion(C)/0344 P2-pl.313

Lower hybrid 주파수 영역의 고속파를 이용한 전류 구동용 안테나 연구

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Abstract :

정상 상태 운전을 위해 토카막 플라즈마의 중심부 또는 off-axis 에 효율적인 가열 및 전류 구동을 할 수 있는 보조 가열 장치에 대한 연구가 진행중이다. Lower hybrid 주파수 영역의 저속파를 이용하는 방법은 가장 효율적인 전류 구동 방법으로 알려져 있지만, 고온 및 고밀도 플라즈마에서 강력한 laudau damping 으로 인해 중심부까지 RF wave 가 도달하기 어렵다. Lower hybrid 주파수 영역의 고속파는 고온 및 고밀도에서 플라즈마 중심부까지 RF wave 가 전달되어 효율적인 가열 및 전류 구동이 가능하다. 본 논문에서는 Lower hybrid 주파수 영역의 고속파를 이용한 전류 구동용 안테나를 제안한다. 본 안테나는 Comb-line 구조의 진행파 안테나이며, 서울대학교의 VEST 장치의 자기장, 밀도 조건에서 고속파의 커플링 연구를 수행하였다.

이 논문은 2017 년도 미래창조과학부의 재원으로 한국연구재단의 지원을 받아 수행된 국책 연구 사업임 (NRF-2014M1A7A1A03045379)

Nuclear fusion(C)/0369 P2-pl.314

Preliminary design of fast-ion D-alpha (FIDA) diagnostics in KSTAR

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Abstract :

Confinement of supra-thermal particles is one of most important issues on the plasma performance and the safety in the fusion devices. In order to characterize the fast-ion confinement and transport in KSTAR high-performance discharges, preliminary design of fast-ion D-alpha (FIDA) diagnostic system has been performed recently. KSTAR FIDA spectrometer consists of the grism, two tele-lens sets, blocking strip and EMCCD. A narrow notch-filter strip was used for blocking the main D-alpha emission peak. The temporal, spectral and spatial resolution of the spectrometer are 10 msec, 0.018 nm and 3 cm respectively. There have been two active views which are red-shifted from the main D-alpha line (656.1 nm) in 2015 campaign and the blue-shifted in 2017 campaign. Fast-ion distribution functions for the several representative discharges and the weight functions of two KSTAR FIDA views have been calculated for evaluating the diagnostic coverage and sensitivity of the fast-ion phase-space. Background subtraction using beam-modulation and evaluation of bremsstrahlung intensity have to be considered because the expected FIDA intensity is much smaller than other emission components. Preliminary design in this presentation will be applied to the development of multi-view FIDA arrays in KSTAR.

Nuclear fusion(C)/0378 P2-pl.315

Effect of the pressure gradient in the connection region on the PBM staility

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Abstract :

The width of the plasma edge pedestal formed by the transport barrier and the pressure at the top of pedestal strongly affect the performance of fusion plasmas. To achieve the plasma of targeted performance in future devices such as ITER, optimization of edge pedestal is required. However, the improvement of the pedestal pressure and width still has many difficulties and understanding of its physics remains as a challenge. For this purpose, we have numerically investigate the dependence of pedestal properties such as the pedestal height and the pedestal width on the pressure gradient in the connection region, α_i . We use MISHKA [1], an ideal MHD stability code and EPED1 [2], a predictive model of the edge pedestal to analyse the edge stability and predict its structure. As a result, improvement of pedestal properties and stability can be achieved by reducing α_i , which is consistent with experimental findings [3, 4]. Also, the pedestal width and height increase with Shafranov shift (Δ_{sh}) [5, 6]. Especially, positive correlation between poloidal beta and pedestal height [7, 8] is found to be due to stabilization of PBM with Δ_{sh}. From this result, we suggest that it is possible to increase the pedestal height and width by increasing the core pressure and adjusting the peaking of the core pressure profile.

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Nuclear fusion(C)/0381 P2-pl.316

Effects of parallel flow fluctuation on zonal flow generation: A gyrokinetic simulation study

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Abstract :

When drift waves are coupled to ion acoustic waves in a three-dimensional system, it is expected that perpendicular zonal flow is driven by the compression of fluctuating parallel flow. In this work, we show that parallel flow fluctuation indeed contribute to ZF generation in ion temperature gradient turbulence. By using gyrokinetic simulations, we examine characteristics of the zonal flow generated by different levels of parallel flow fluctuations, which are obtained by varying the equilibrium parallel flow shear. Radial structures of zonal flow show clear differences in the cases with and without the equilibrium parallel flow shear. We perform an analysis of poloidal momentum transport in the framework of a kinetic version of the potential vorticity (PV) mixing theory. We estimate the total PV flux and a portion caused by the fluctuating parallel flow compression, which are found to be consistent with the zonal flow evolutions. The change of zonal flow radial structure in the presence of the equilibrium parallel flow shear is accounted for by the parallel flow compression contribution. This manifests the fluctuating parallel flow compression coupling drive of zonal flow.

Nuclear fusion(C)/0423 P2-pl.317

Spatial configuration of erosion and deposition of a-C:H thin films due to impinging deuterium and carbon ions in an ECR Chamber

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Abstract :

Magnetic fields in a vacuum chamber which contains plasma affect the motion of ions, resulting in a different deposition pattern from that without magnetic field. The effect of magnetic field has to be carefully investigated to understand the characteristics of redeposited layers in a fusion device under strong magnetic field. In order to clarify the deposition and erosion characteristics as well as the properties of deposited layers of plasma facing components, we have exposed a graphite target to deuterium ion beam produced in an electron cyclotron resonance (ECR) chamber to simulate the effect in a simple magnetic field configuration. We used a cavity structure with a standard a-C:H film on a Si substrate inside the coupon. Several coupons were installed vertically in the ECR chamber and the slit direction was parallel or perpendicular the B field. The optical constants were characterized by ellipsometric angles, Ψ and Δ, and chemical bonding structures were identified by Raman spectroscopy. Si substrates were positioned at the bottom and at the top of the coupons. According to ellipsometry, the standard a-C:H thin films at the bottom showed a significant erosion at the center due to the bombardment by deuterium ions. However, the standard a-C:H thin films at the top showed a deposition of new a-C:H films at the center. A very thin polymer-like carbon layer has been deposited on the top coupons. Raman analysis showed that the intensity ratio, i.e. I(D)/I(G), was enhanced at the center, indicating that sp^2 contents have been increased. For standard a-C:H films along the slits parallel to B field, erosion was the largest (-270 nm) at the middle position and deposition was the largest (175 nm) at the top position. However, along the slits perpendicular to B field, erosion was the largest (-115 nm) at the middle position and deposition was the largest (60 nm) at the top position. More enhanced erosion and deposition of a-C:H films along the slits parallel to B field are attributed due to the combined effect of ionized species of deuterium and C:H particles.

Nuclear fusion(C)/0529 P2-pl.318

Design features and commissioning of the pulse arc plasma source based on high power Marx generator for the VEST NBI system

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Abstract :

A high-power pulse arc ion source based on Marx generator has been developed at the Korea Atomic Energy Research Institute for the NBI system of the VEST which is a compact spherical tokamak at Seoul National University to study operating scenarios of the centrally heated reactor-relevant tokamak plasma. The NBI system was designed to heat the core plasma efficiently with incident ion beam energy of 20keV and total power of 0.6MW. However, the injection beam energy is required to be lower than 20keV under the initial target plasma parameters of VEST due to beam-plasma coupling efficiency. Consequently, the beam energy needs to be changeable for the pulse duration below 20ms. To satisfy this requirement, a pulse power system based on the two-stage Marx generator is designed by utilizing deep-cycle batteries and high-energy capacitors for generating high power pulse arc plasma, respectively. By using the power supply system, large area pulsed arc ion source is successfully commissioned, and characteristics of the filament heating and arc plasma discharge are analyzed under various operating conditions.

Acknowledgements

This work was supported by National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2014M1A7A1A03045372).

Nuclear fusion(C)/0583 P2-pl.319

Variations of divertor particle flux in the inter edge-localized mode crashes in KSTAR tokamak

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Abstract :

In the high confinement mode (H-mode) plasmas in fusion devices, the edge-localized mode (ELM) crashes expel significant fraction of particles and energy. Consequently, the particle flux to the fixed Langmuir probes on the divertor, radially outside the separatrix, increases up to an order of magnitude at the crash. In the KSTAR H-mode discharges, the particle flux to such Langmuir probes [1], in the inter ELM crash is also found to vary in significant magnitude, either rapidly or gradually. Although a change in the plasma shape and position is known to affect the particle flux, other possible factors are also explored in the present work. A rapid fall in the particle flux is typically accompanied by change in the phase of density fluctuations and/or the mode structure (frequency/amplitude), obtained using beam emission spectroscopy measurements in 2 dimensions (poloidal cross section). Further, the rapid fall in particle flux is accompanied by magnetic fluctuations in some cases, obtained through Mirnov coils, exhibiting clear peaks corresponding to the broadband turbulence. Hence the turbulent electromagnetic fluctuations in the edge or the scrape-off layer and the dynamics associated with mode structures [2], could be one possible factor. Often, the particle flux increases approximately in a linear fashion before the rapid fall. A comprehensive understanding is, therefore, necessary to elucidate the phenomena associated with the variations in the divertor particle flux.

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Feeble Zonal Flows (ZF) and Geodesic Acoustic Mode (GAM) near the Marginal Stability Boundary in Pedestal Plasma: a scenario for stationary I-mode

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Abstract :

The physics of high confinement discharges with edge transport barrier is a topic of great interest for fusion plasmas. A variety of regimes e.g. ELMy H-mode, I-mode and Quiescent H-mode etc. have been observed in most of the advanced tokamaks (e.g. ASDEX, D-IIID, KSTAR, JET, EAST etc.). I-mode is one of the attractive regimes characterized by high energy confinement closed to H-mode, but without impurity accumulation in core plasmas. It occurs when the direction of ion magnetic drift is away from X-point (unfavorable geometry) with heating power double than H-mode power threshold of favorable geometry [1-4]. I-mode evolves slowly over several confinement times until it hits to H-mode boundary. Therefore, preventing I-mode from entering into H-mode is an important topic. We here propose that I-mode arises in two-step process a) L-I transition phase – fast evolving phase, b) I- mode stationary phase – slowly evolving phase.

The present work reports the physics understanding of stationary I-mode staying just below the H-mode boundary. We first emphasize that the turbulence below the stable H-mode boundary plays a crucial role in stationary I-mode discharges. In the regime, it is identified that the electromagnetic dissipative electron mode turbulence develops and provides a free energy source for the nonlinear generation of GAM and ZF. With weak ZF, the turbulence may keep pedestal profile below the ballooning instability boundary - this may be viewed as a stationary I-mode. At the same time, the nonlinear advection of pressure fluctuations can generate GAM, a stationary feature of I-mode.

It is proposed that weak zonal flow is a key element for preventing the transition from I-mode to H-mode. The modulation instabilities of long-scale ZF and GAM in the electron turbulence are calculated. We present the parameter scaling of the stationary I-mode derived from the ZF stability threshold and compare it with the scaling reported for ASDEX and C-Mod [1-4].

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Nuclear fusion(C)/0648 P2-pl.321

KSTAR 에서 IR camera 를 이용한 실시간 외벽온도 감시시스템 개념설계

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Abstract :

KSTAR 에서 H-mode 플라즈마를 장시간 유지하는 것이 가능해짐에 따라서 플라즈마로부터 방출되는 열속에 의해서 내벽의 온도가 상당히 증가된다. 그렇게 증가되는 온도는 내벽에 손상을 주게 된다. 그중에 열속이나 가열장치의 입력파워가 한곳에 집중되어 국부적으로 온도가 상승하는 현상이 나타날 수 있는데 플라즈마를 안정적으로 유지하는 데 아주 위험한 요소로 작용된다. 따라서 국부적으로 온도가 상승하는 부분을 감시할 수 있는 시스템이 요구된다. 기존의 온도 감시장치는 대부분 열전대를 이용한 장치인데 이것은 반응 속도도 늦을 뿐만 아니라 국부적인 부분의 온도를 감시하는데는 부적합하다. 따라서 온도상승에 반응속도가 빠르고, 국부적인 온도를 측정할 수 있는 IR camera 를 이용한 온도감시 시스템이 필요하게 된다. 이번 논문에서는 기존의 핵융합장치들이 사용하는 시스템을 조사하여, KSTAR 장치에서 사용할 수 있는 적합한 감시시스템의 개념 설계를 제시하고자 한다.

Nuclear fusion(C)/0744 P2-pl.322

Synergy Effects of Top-launch ECCD and Midplane LHCD in KSTAR

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Abstract :

Recent ray tracing simulations show that the top launch of electron cyclotron current drive (ECCD) shows higher current drive efficiency compared with the outboard launch of ECCD [*Y.S. Bae et al., 22nd Topical Conference on Radiofrequency Power in Plasmas Centre de Congres, Aix en Provence, France 30 May - 2 June 2017*]. It is due to higher Doppler shift resulted from ray propagation nearly vertically parallel to the cold resonance layer. It could be expected that the high energy electrons resonating with EC wave launched from the top might fall into the resonance regions of the Lower-hybrid (LH) wave, hence that the current drive of LH wave is enhanced. To investigate the synergy effects between EC and LH waves, the CQL3D code [*Yu V. Petrov et al., Plasma Phys. Cont. Fusion **58**, 115001 (2016)*], which is solving the Fokker-Planck equation with the quasi-linear diffusions by the two waves, is used. It is found that there is strong synergy effects between the two waves in the current drive. The synergy effect depends on the launched parallel refractive index of LH wave and the EC-wave power.

Nuclear fusion(C)/0836 P2-pl.323

Plasma density profile measurements by using reflectometer during L-H transition

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Abstract :

The L-H transition threshold power is affected by many plasma parameters. The plasma density is one of such parameters. The threshold power is normally proportional to the density. However it is inversely proportional to the density at a low density region. This so called density rollover has been observed in many tokamaks. Therefore a scalar quantity such as line averaged density or center density is not a sufficient parameter that determines the threshold power. In this paper, the threshold power is investigated against the density profile shape, for example, the center density, the edge density, the density gradient, etc. It is essential to measure the density profile evolution with a fast time resolution during L-H transition. Microwave reflectometer is suitable for that purpose because it can measure the density profile in a time resolution of 25 ms [1]. The detailed time evolution of density profile structure during L-H transition is measured and the results will be presented.

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Nuclear fusion(C)/1061 P2-pl.324

Comparative analysis of electron temperature profiles measured by ECE and Thomson scattering diagnostics on KSTAR

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Abstract :

The electron cyclotron emission (ECE) diagnostics on KSTAR has been used to measure the electron temperature as well as its radial profile. The frequency range of the 76 Ch heterodyne radiometers covers from 78 to 162 GHz and it allows both low and high field side measurements. Comparably, the KSTAR Thomson scattering diagnostic system has been upgraded to perform simultaneous measurements of both electron temperature and density profiles. In this poster, the electron temperature measurements from both diagnostics during the 2017 KSTAR experimental campaign will be presented and results of the comparative analysis will be discussed. In particular, discrepancy of the instantaneous electron temperature measured by both diagnostics in some cases will be issued. Except such cases, the ECE and Thomson scattering measurements are in good agreement within experimental uncertainties.

Nuclear fusion(C)/1095 P2-pl.325

Effects of Resonant Magnetic Perturbation in Edge Pedestal Collapse

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Abstract :

Edge Localized Mode(ELM) crash is one of the major concerns in ITER plasmas. Large ELM crash induces significant heat load on the divertor plates, challenging the material limit. It is of a great interest to control ELM dynamics and reduce the heat flux on the plates. One of the promising control methods is applying magnetic perturbations(RMP), the feasibility of which has been extensively studied.

It has been suggested that in the pedestal collapse driven by ideal ballooning instability, the ballooning-parity fluctuations can nonlinearly produce tearing -parity fluctuations, rendering magnetic field-line stochastic.[1] This process is that the tearing fluctuations of high toroidal number $n>n_0$ driven by the linearly unstable ballooning fluctuations of low toroidal number n_0 couple nonlinearly to the tearing fluctuations of low n_0 and the associated large stochastic heat transport relaxes the pressure profile abruptly.

This work suggests that RMP can reduce the nonlinear excitation of tearing-parity fluctuations. This effects depend on the strength of ballooning instability and the amplitude of RMPs. The detailed analysis is presented with the implication for ELM collapse dynamics.

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Nuclear fusion(C)/1114 P2-pl.326

Experimental results of an neutral beam ion source for VEST tokamak plasma heating

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Abstract :

A neutral beam ion source for Versatile Experiment Spherical Tokamak (VEST)tokamak plasmaheating aimed to inject 0.5 MW Hydrogen beam has been developed. To prevent particle orbit loss and beam shine-through, beam energy is limited to less than ~ 20 keV. The high current ion beam extraction became important to the performance of the NB ion source and the ion source has been finished the primarily performance tests in the NB test stand at Korea Atomic Energy Research Institute. The performance of the ion source was measured. The results of experiments show that the ion source can extract sufficient ion beam power over than 0.75 MW (50 A / 15 keV) with 100 kW of arc power. The arc efficiency and beam perveance are estimated to be 0.5 A/kW and 20 ~ 25 up, respectively. From the experimental results at the NB test stand, design goal of delivering a 0.5 MW hydrogen beam into the VEST tokamak plasma will be achievable based on the optimum operating condition. This ion source has been installed in VEST NBI system at Seoul National University and commissioning is ongoing.

Acknowledgments

This work was supported by national R&D program through the National Research Foundation (NRF) of Korea funded by the Ministry of Science and ICT (NRF-2014M1A7A1A03045372).

Nuclear fusion(C)/1139 P2-pl.327

Preliminary study on the Alfvén eigenmode controls in KSTAR

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Abstract :

Supra-thermal (fast) ions existing in the fusion plasmas should be confined for long time (comparable to energy confinement time) to guarantee the enough amount of fusion reaction. However in fusion plasma experiments, fast-ions cause various kinds of magneto-hydrodynamic (MHD) instabilities which may enhance the fast-ion transport and reduce the fusion yield. Therefore the fast-ion-driven MHD modes have to be mitigated or suppressed, and several attempts to control the fast-ion MHD modes such as Alfven eigenmodes (AE) have been performed on KSTAR. Fast-ions generated by neutral-beam-injection (NBI) can drive the energetic particle modes including AEs due to enhanced fast-ion pressure or its gradient [1]. Since excitation condition of AEs is sensitive to fast-ion pressure and q-profile (location of rational magnetic surface), control actuators should be able to change those profiles. It has been studied intensively for the control of RSAE (reversed-shear Alfven eigenmode) in tokamaks [2,3] by means of changing ECH deposition locations. In KSTAR, similar experimental approach using the ECH has been applied to TAEs (toroidicity-induced Alfven eigenmodes) existing in the high poloidal beta discharges. It has been found recently that ECH has an important role in mitigation of TAEs for long duration and the AE-mitigated high-beta discharge could be achieved with the observations such as enhancement of stored energy and neutron emission intensity [4]. In addition, combination of the beam injection sources and energy seems to give the positive or negative effects to the AE mitigation [5], depending on the fast-ion pressure profiles. These experimental results imply that the localized ECH utilized with the fast-ion profile tailoring may enhance the performance of the discharge by improving the fast-ion confinement.

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Nuclear fusion(C)/1154 P2-pl.328

Progress on development of new antenna for KSTAR LHCD system

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Abstract :

New antenna for KSTAR LHCD system is under development in order to improve the power limit of initial LHCD antenna and with the goal of prototype development to be used in the 4 MW system for steady state operation after 2020. The prototype antenna is a passive active multijunction (PAM) type and designed for the injection of 500 kW RF power at 5 GHz with parallel refractive index of 2.0. In this paper, it will be presented the RF characteristic measurement and high power test result of the RF components for the power splitting of new antenna system such as toroidal splitters and poloidal splitters. The RF characteristics of the PAM such as a splitting ratio and phase relation and the problem we met during the construction of PAM will also be presented.

Nuclear fusion(C)/1175 P2-pl.329

KSTAR 환경에서의 파장에 따른 간섭계 성능 분석

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Abstract :

간섭계는 전자 밀도에 따라 플라즈마 내부를 통과하는 전자기파의 위상이 변화하는 현상을 이용하여 통과 경로상의 선적분 밀도를 측정하는 진단 장치이다. 간섭계는 빠른 속도로 전자 밀도의 평균적인 절대값을 측정할 수 있기 때문에 실시간 제어에 활용될 수 있으며, 다양한 위치에서 다채널로 측정한 결과를 분석하여 전자 밀도 프로파일을 재구성하거나 플라즈마의 삼차원적 거동에 대한 정보를 얻어내는 것도 가능하다. 이러한 간섭계 시스템의 설계에 있어, 플라즈마 내에서의 위상 변화량이 예상되는 선적분 밀도량과 사용하는 전자기파의 파장에 의해 결정되기 때문에 측정하는 환경과 목적에 따라 최적의 파원을 결정할 필요가 있다. 일반적인 핵융합 장치에서 사용되는 간섭계의 파장은 수 밀리미터에서 수백 나노미터에 걸쳐 있으며, 파원의 종류도 고체전자공학을 이용한 마이크로파 부품에서 적외선, 가시광 영역의 레이저까지 다양하므로 파원의 선택에 있어 실질적인 가용성 여부도 고려하여야 한다. 이와 같은 관점에서, KSTAR 에서의 플라즈마 물성 범위와 연구하고자 하는 목적을 고려하여 파장에 따른 간섭계의 성능을 분석하였다. 또한 이를 바탕으로 KSTAR 에 기설치되어 있는 다양한 간섭계 시스템의 성능 향상과 새로운 간섭계 시스템 개발에 대한 계획을 제안하였다.

Basic plasma phenomena(D)/0623 P2-pl.401

Characteriazation of Broadband Soft X-ray from Laser Plasma

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Abstract :

Broadband soft x-rays (200 ~ 1000 eV) can be generated by irradiating 150 TW(5.5 J, 30 fs) Ti:Sapphire laser pulse to the high-Z metals such as Tantalum(Ta) and Bismuth(Bi). The characteristics of broadband soft x-ray from the laser plasma source are studied using a flat-field spectrometer, which is constructed with a toroidal mirror and an aberration corrected concave grating (2400 grooves/mm). For example, photon flux, spectral intensities of x-ray with various laser-target conditions will be presented. In addition, the temporal profile of x-ray pulse is measured with an x-ray streak camera. Finally, possible application of this source to x-ray absorption spectroscopy for warm dense matter will be presented.

This work was supported by Institute of Basic Science (IBS-R012-D1) and National Research Foundation of Korea (NRF-2016R1A2B4009631) of Korea.

Basic plasma phenomena(D)/0629 P2-pl.402

AC conductivity measurement for warm dense aluminum using a chirped probe pulse

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Abstract :

We present an intense femtosecond pump – chirped pulse probe setup to study various properties of Warm Dense Matters (WDM) with high temperature (> 10,000 K) and solid density states. This method can avoid the effect from the laser fluctuation and timing jitter. The experimental setup was developed using the Ti;sapphire CPA laser (30 mJ, 35 fs) at GIST. The aluminum film (45 nm) deposited on a glass substrate (100 um) was pumped by a high fluence second-order harmonic pulse (400 nm, ~ 1 J/cm^2) to heat Al sample over 10,000 K isochorically. A chirped pulse (800 nm, < 10 ps) probe was produced using a glass-stretcher. Spectral reflectivity and transmissivity were measured and converted into temporal information. The dielectric functions are determined based on the Drude model, they are compared with the measurement.

This work was supported by National Research Foundation of Korea (NRF-2016R1A2B4009631, NRF-2015R1A5A1009962) of Korea.

Plasma instruments, processing & applications(E)/0333 P2-pl.501

EPICS based data acquisition and archive system for the KoHLT-EB

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Abstract :

Korea heat load test facility by using electron beam (KoHLT-EB) was constructed for the developments of plasma facing components (PFCs) to elucidate the ITER and DEMO technology. This electron beam facility with an 800 kW electron gun for a high heat flux with a maximum beam power of 300 kW is now in operation to conduct high heat flux tests for the plasma facing components. This facility is connected to the water cooling system for the test of high temperature targets. The temperature of this system is measured by calorimetry for the coolant temperature and heat flux, the thermocouples for the bulk temperature of the target and pyrometers for the mock-up surface temperature to the normal directions. The data acquisition system for temperature measurement for this facility is based on the National Instrument (NI) compact Reconfigurable Input Output (cRIO) and the Raspberry-pi that is an arm based single-board computer. The application has been developed by using the EPICS software framework and the irioCore software which is the virtual software layer for EPICS to communicate with FPGA resources embedded in the NI 9265 cRIO Chassis. Originated from ITER-CODAC, the irioCore is designed to handle general-purpose analog and digital inputs and outputs and has been modified for KoHLT-EB to support the NI-9214 cRIO module with 16 channel temperature input. In this paper the present status and future plan with the KoHLT-EB data acquisition and archive system will be presented.

Plasma instruments, processing & applications(E)/0446 P2-pl.502

An Integrated Model for Rectangular RF Driven Ion Sources

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Abstract :

KAERI is presently constructing a multi-purpose high-power large-area RF driven ion source. In order to estimate plasma parameters of the ion source and to design an impedance matching circuit, an integrated model for inductive discharges has been developed. The model contains a hydrogen plasma global model, a two-dimensional electromagnetic model, a calculation module for the relative plasma dielectric constant, and an impedance matching circuit module. This model enables one to calculate the plasma density, the electron temperature, the plasma load impedance, the antenna voltage and current, and the load and tuning capacitances in impedance matching circuit. In this study, taking into account the effects of a Faraday shield and isolation transformer, these parameters dependent on the RF input powers are investigated. In the presentation, the model results will be presented and discussed in more detail.

Plasma instruments, processing & applications(E)/0680 P2-pl.503

Preliminary study on plasma processing control based on plasma diagnostics

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Abstract :

As the minimum scale of the plasma processing pattern is less than 10 nanometers, processing yield is easily affected by small changes in the processing plasma characteristics. Because of this sensitive processing window, maintaining the plasma characteristics within the processing window attracts a lot of attention. In addition, maintaining the plasma characteristics between processing chambers also becomes important for obtaining the same processing yield.

Recently, various diagnostics methods are developed to monitor the plasma processing and to control chamber-to-chamber matching as well as yield of each chamber. Especially, optical emission spectroscopy (OES) is non-perturbing and readily available method to monitor. However, OES was been used without deeply considerations of its repeatability and reproducibility. These considerations are significant for OES to be a reliable reference method for monitoring and controlling the plasma processing.

This presentation shows the preliminary results of monitoring and controlling the plasma processing via OES. Firstly, we evaluate reliability of OES obtaining plasma characteristics. Through the evaluation, error elements effecting the reliability of OES were found. Various plasma processing of PECVD, PEALD, sputtering, and etching are planned to be investigated and controlled by the tested OES and diagnostics techniques such VI probe, microwave probe, and so on.

Plasma instruments, processing & applications(E)/0710 P2-pl.504

Density measurement of argon metastable atoms in a microwave plasma source based on the surface wave with a slit antenna

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Abstract :

A microwave plasma source based on the surface wave with a slit antenna was developed for the abatement of CF_4 from semiconductor manufacturing process. The plasma source was operated using a commercial magnetron with the average output power of 1 kW at an argon gas pressure of 0.1 ~ 0.3 Torr. In order to study the characteristics of this source, the space resolved density of argon Ar* ($^3P_2$) metastable atoms was measured using tunable diode laser absorption spectroscopy (TDLAS) for various discharge conditions [1]. For the measurement, lock-in technique was used due to the low absorption rate in the order of 10^{-3}, and the wavelength was chosen to be around 811.5 nm for the $1s_5 \rightarrow 2p_9$ transition. The pressure broaden absorption line profile was measured and analyzed to calculate the density. During the operation, argon metastable concentrations ranges from 10^{12} to 10^{13} cm^{-3}, and space resolved density profile is consistent with the plasma discharge shape. These results will be presented in this paper.

*This research was supported by the national R&D Program of ‘Plasma Advanced Technology for Agriculture and Food (Plasma Farming)’ through the National Fusion Research Institute of Korea (NFRI) funded by the government fund.

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Plasma instruments, processing & applications(E)/0902 P2-pl.505

Numerical Investigation on the Particle Behavior Injected into an RF Induction Plasma for the Spheroidization of Titanium Alloy Powder

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Abstract :

Titanium and its alloys are widely used in aerospace, medical devices, sports equipment and other industrial applications because of their unique characteristics, such as low density, high strength, excellent corrosion resistance, non-magnetic properties and biocompatibility [1]. However, their applications have been limited because they are hard to be machined and their machining costs are very high. Therefore, near-net shape technologies of titanium and its alloys such as powder injection molding, laser forming and warm flow compaction have been developed rapidly in recent years. In these processes, the size and morphology of power are very important factors. Fine powders are attractive because it is possible to prepare near net shape products with complicated shapes. Spherical powders also offer reduced internal powder friction and increased powder flowability during the processes.

An RF (radio frequency) induction plasma has been widely used to the preparation of nano-sized powder and the spheroidization of powder. Some researchers have reported that induction plasma can provide an attractive route to prepare spherical titanium and Ti-6Al-4V powders [1,2]. The flowability and packing density of the powders can be increased through a plasma treatment based spheroidization process. The purity of the powders can also be increased by vaporization of impurity elements during the plasma treatment. To understand and optimize this process, numerical studies are needed.

In the present work, the numerical simulations are conducted to study the particle behavior injected into an RF induction plasma for the spheroidization of titanium alloy powder. The effects of RF power input, the average diameter of powder and powder feeding rate on the plasma flow fields and the powder spheroidization are investigated to find the optimal process condition. From the numerical simulation results, it is expected that the spherical titanium alloy powder of 40 ~ 60 μm in diameter can be prepared by RF induction plasma thermal treatment at RF power input of 30 kW, argon plasma gas flow rate of 180 slpm, argon powder feeding gas flow rate of 4 slpm, powder feeding rate of ≤1.0 kg/hr.

Acknowledgement

The support by the Research Institute of Industrial Science & Technology is gratefully acknowledged.

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Plasma instruments, processing & applications(E)/0928 P2-pl.506

Experimental study on antibacterial efficacy with a dielectric barrier discharge air plasma at atmospheric pressure

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Abstract :

Recently, as the air pollution becomes serious due to the highly industrialization, various kinds of dust, exhaust fumes, bacteria and toxic gas are significantly increased. Hence, the harmful diseases are brought about to the human body. In particular, a Staphylococcus epidermidis (S. epidermidis) that caused the septicemia sepsis, urinary tract infection and infective endocarditis has to be sterilized in the air. Therefore, the application of the plasma at atmospheric pressure for air purification has been studied intensively [1]. In this study, an air atmospheric pressure plasma (APP) with a dielectric barrier discharge (DBD) device for sterilization of the S. epidermidis is described. The air APP with the DBD device is driven by a high AC voltage at 15 kHz. The reactive species such as O, OH and NO generated by the air APP are able to inhibit the growth of bacterial cells [2]. To verify the antibacterial efficacy, the air APP is analyzed with the OES measurement. Furthermore, the effects of sterilization are compared with those of the UV lamp.

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Plasma instruments, processing & applications(E)/0934 P2-pl.507

Study on Hydrophilic Effect on the PMSQ Surface using IndirectNonthermal Atmospheric

Argon Plasma operating with Microwave Power

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Abstract :

Polymethyl silsesquioxane(PMSQ)는 내마모성, 소수성 및 투명성을 가지며 필름 경도 및 열 안정성 등이 우수하지만, 재료 간의 접착력 면에서는 그렇지 않다. 접착력은 PMSQ 의 Hydrophilicity 과 관련이 있고 Hydrophilicity 은 플라즈마의 Surface Modification 특성을 이용하여 증가시킬 수 있다[1]. 본 연구에서는 10 W 미만의 대기압 Microwave 플라즈마[2]를 사용하여 PMSQ 표면에 Contact 하지 않고 처리하였다. 플라즈마 장치에 인가되는 주파수와 가스 유속은 일정하게 유지하였고, 시간과 거리에 따른 증류수의 Contact Angle 의 변화로 Hydrophilicity 의 증가를 확인하였고, Contact Angle 이 최대 80° 변화하였다. 10 W 미만의 대기압 Microwave 플라즈마를 Contact 하지 않아도 PMSQ 의 Si-CH3 결합의 제거 또는 구조를 변형시켜 PMSQ 표면의 Hydrophilicity 이 약 3 배 향상된 것을 확인하였다.

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Low dimensional nano-materials(F)/1105 P2-se.001

Ab initio study of bilayer heterostructures based on transition metal phosphorous trisulfide

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Abstract :

Recently, electronic and magnetic properties of two-dimensional monolayer transition metal phosphorous trichalcogenides (MPX_3, M=V, Cr, Mn, Fe, Co, Ni, Cu, Zn and X=S, Se, Te) have studied using the density functional theory (DFT) calculations [1]. In this study, we investigate diverse bilayer heterostructures based on transition metal phosphorous trisulfides (MPS_3, M = Mn, Co, Ni, Fe) to understand their electronic and magnetic properties. For the investigations, we have performed DFT calculations with the GGA+U method. Especially, we focus on the changes in electronic structure of MPS_3 heterostacks, compared to monolayer MPS_3 structures. Such stacking can cause different magnetic orderings depending on the different size of unit cells considered in the calculations.

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Low dimensional nano-materials(F)/0944 P2-se.002

Effect of stoichiometric ratios on thermal transport properties of $Cu_{2-x}Se$ system

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Abstract :

Thermoelectric conversion efficiency is determined by the figure of merit zT, defined as a function of Seebeck coefficient, electrical conductivity, thermal conductivity, and absolute temperature. Attaining high thermoelectric performance requires minimizing thermal conductivity while keeping high electric conductivity. This situation is achievable by enhancing phonon scattering through specific structural disorder (phonon glass) that also retains sufficient electron mobility (electron crystal). As a typical member of phonon glass electron crystal family, the copper-ion-liquid-like $Cu_{2-x}Se$ compounds show high thermoelectric performance due to high electrical conductivity and ultralow thermal conductivity. However, very small Seebeck coefficient is a deducted point in $Cu_{2-x}Se$ system. In this work, we synthesize $Cu_{2-x}Se$ system with different copper stoichiometric ratios, which are a series of compounds ranging from copper-rich Cu_2Se to copper deficient Cu_2Se to investigate the effect of stoichiometric ratios on thermal transport properties. Detail results will be discussed later.

Low dimensional nano-materials(F)/0683 P2-se.005

Liquid-exfoliated MoS_2 thin films and photovoltaic device application

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Abstract :

Recently, the two-dimensional (2D) materials such as transition-metal (TMDs) have received much attentions in the research fields from conventional silicon technology to transparent and flexible nanotechnology due to their outstanding mechanical characteristics. To prepare these materials, however, widely known methods like mechanical exfoliation and chemical vapor deposition (CVD) are not suitable for mass production because of limitation in large-area, random distribution of 2D flake and high temperature process. Unlike previous two methods, a liquid exfoliation method can be applied to obtain large-area manufacturing and allowing low temperature process. In this study, molybdenum disulfide (MoS_2) thin films were prepared by liquid exfoliation method and applied to fabricate photovoltaic device. MoS_2 nanosheets were formulated by ultra-sonication of MoS_2 powder for more than 12 hours in ethanol/deionized water solution with 1:1 vol.%. Two steps centrifuge (4500 rpm, 20 min) and (5500 rpm, 5 min) was employed for ideal size selection of MoS_2 nanosheets. The obtained MoS_2 nanosheets were deposited on n-type Si substrate by using oven evaporation technique. Finally, MoS_2 photovoltaic device with power conversion efficiency of 1.01 % was fabricated. In addition, for the application of transparent photovoltaic devices with liquid exfoliated MoS_2 nanosheets, the structure of Au/MoS_2/ITO/glass is tried in this research.

Low dimensional nano-materials(F)/0670 P2-se.006

Indium 불순물 치환 도핑에 따른 SnSe 층상구조 반도체의 전도 물성 및 열전 특성 변화

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Abstract :

Graphene 과 더불어 다양한 이차원 층상 구조 물질에 대한 연구가 보고되어 오고 있으며, 특히 MoS_2 등의 전이금속 기반의 이차원 transition metal dichalcogenide (TMD) 소재의 경우, 유한한 밴드갭 (> 1.0eV) 및 높은 전하 이동도 특성 (>500 cm^2/Vs)에 의해 차세대 반도체 소재로의 응용 가능성이 높을 것으로 기대되고 있다. 근래에 층상구조 SnSe 소재의 낮은 열전도 물성 및 그로 인한 고효율 열전 소재로의 응용 가능성이 보고 되고 있으나, 화학적인 불순물 도핑에 따른 전도 물성 및 열전 물성의 변화에 대한 연구는 아직 많이 부족한 상황이다. 본 연구에서는 SnSe 층상 구조의 이차원 소재의 In 불순물 치환형 도핑을 통한 전도 물성 및 열전 특성 제어 원리에 대하여 고찰해 보았다. X-ray diffraction (XRD)을 통하여 SnSe 반도체 소재의 Sn-site 에 In 불순물이 치환형으로 도핑이 됨을 확인 하였고, Hall 측정을 통하여 온도에 따른 전기적 특성 및 Seebeck 계수의 변화를 측정하였다.

Low dimensional nano-materials(F)/0630 P2-se.007

Exciton peak shift in the transition metal dichalcogenides $MoSe_2$ and WSe_2 with temperature and magnetic field

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Abstract :

We performed absorption spectroscopy on several monolayer compound films in the transition metal dichalcogenides (TMDC) family including $M\mathrm{Se}_2$ (M = Mo, W) grown on sapphire substrates. The absorption spectra were obtained from the transmission in the visible and near-infrared (NIR) regions (500 nm – 1000 nm) via CCD spectrometry. We observed that the A and B exciton peaks start to blueshift and narrow in both materials as the temperature decreases. Magnetic field dependence (up to 7 Tesla) will be presented as well.

Low dimensional nano-materials(F)/0482 P2-se.008

Indium 불순물 치환을 통한 n-type $SnSe_2$ 층상구조 반도체의 p-type 전이 현상

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Abstract :

높은 기계적 강도와 열전도도, 고전도성 등을 가지는 2 차원 소재 Graphene 의 발견으로 다양한 층상구조의 2 차원 소재에 대한 연구가 활발히 이뤄지고 있다. 근래에 유한한 Band gap 및 높은 전하 이동도 특성을 가지는 전이금속 기반의 2 차원 transition metal dichalcogenide (TMD) 물질을 통해 고이동도 반도체 소자로의 응용 가능성에 대한 연구가 보고되고 있으나, 화학적인 n 형, 혹은 p 형의 단일형 반도체로만 물성이 제한되어, 그 실질적인 응용에 한계가 있는 실정이다. 본 연구에서는 In 불순물 치환을 통한 n-type $SnSe_2$ 층상 구조 반도체의 p-type 전이 현상과 전자 물성 제어에 대해 보고한다. Sn 과 Se, In 원조성 간의 고상합성법을 통해 Se-site 에 In 불순물이 치환형으로 도핑된 소재의 합성을 시도하였으며, X-ray diffraction (XRD) 및 Hall measurement 을 통하여 결정 구조 및 전도 물성을 분석하였다. 또한 온도에 따른 전도도 및 홀전압의 측정을 통해 In 도핑에 따른 $SnSe_2$ 반도체 소재의 홀캐리어 농도가 1.5×10^{18} cm^{-3} 까지 성공적으로 증가됨을 확인하였으며, 이로 인한 홀 이동도 및 전도도의 변화를 고찰하였다.

Low dimensional nano-materials(F)/0469 P2-se.009

Control of growth parameters for high-quality MoS_2 and van der Waals heterostructures

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Abstract :

Two-dimensional (2D) materials and their van der Waals heterostructures have shown unprecedented physical properties due to the quantum confinement effect induced by their ultrathin structure. Therefore, it has been expected that 2D materials can be used as templates for next generation electronic devices. In order to investigate the intrinsic properties of 2D materials and demonstrate 2D-material-based devices, the mechanically exfoliated flakes have been used due to high quality of them, compared to the synthesized ones. However, this exfoliated method cannot be scaled. Chemical Vapor Deposition (CVD) technique has been considered as a promising method for production of large-scale 2D materials with a high purity and crystallinity. Nonetheless, CVD-grown 2D sheets show the deteriorate properties, differently from theoretical calculations. Low quality of the synthesized 2D sheets is attributed to the indispensable impurities and unavoidable defects, such as grain boundaries and vacancies, generated during synthesis process. Here we propose several parameters to control quality of 2D materials synthesized by CVD process. By controlling these growth parameters, such as temperature and gas flow rate, we can produce a high quality MoS_2 and van der Waals heterostructures of graphene/MoS_2 with a larger grain size and without grain boundaries. Our work provide new insights for how we can produce “great 2D sheets” with high quality, which can be expanded for practical applications.

Low dimensional nano-materials(F)/0467 P2-se.010

Growth of wafer-scale single crystal monolayer MoS_2

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Abstract :

In recent years, two-dimensional (2D) semiconducting transition metal dichalcogenides (TMDs) have attracted an extensive attention because of their unique structures and superior physical properties. Among of TMDs, molybdenum disulfide (MoS_2) with a band gap of 1.88 eV has been studied intensively because of high carrier mobility, strong exciton binding energy, and piezoelectricity, which are beneficial for next-generation transistors, photodetectors, and other applications. However, since conventional method to synthesize MoS_2 uses powders of MoO_3 and sulfur as sources, it is still difficult to synthesize high-quality MoS_2 on an amorphous SiO_2 substrate with uniform properties. Here we demonstrate a growth method for large-area single crystal monolayer MoS_2 on sapphire substrate. Molybdenum and sulfur are provided through evaporation of molybdenum film and H_2S gas, respectively. Due to epitaxial growth of MoS_2 on sapphire substrate, starting flakes are directionally aligned and finally become a single crystal without grain boundaries. The as-grown MoS_2 displayed an excellent uniformity and high crystallinity with strong photoluminescence intensity.

Low dimensional nano-materials(F)/0356 P2-se.011

Light-emitting tunneling diodes of CVD-grown MoS_2

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Abstract :

Since discovery of graphene, various methods have been proposed for production of two-dimensional (2D) materials. Mechanical exfoliation method is the most widely used one, which guarantee high quality of produced samples. Most of experimental studies have used a flake exfoliated from a bulk crystal. While this method is readily utilized for fundamental research and allows us for fabrication of a unit device, scalable application of two-dimensional materials has requested wafer-scale deposition of 2D materials with well-controlled properties. Chemical vapor deposition (CVD) is one of the most promising methods for production of large-scale 2D materials. However, the defects generated during growth are not avoidable, leading to alternation of the physical properties of 2D materials [1]. Among 2D semiconducting materials, MoS_2 is a direct band gap semiconductor, which can be used for optoelectronic applications. For example, fabrication of llight-emitting tunneling diodes was reported by stacking 2D materials of graphene, hexagonal boron nitride (hBN) and MoS_2 [2]. Here we demonstrate a tunneling device based on CVD-grown MoS_2, which has a potential as a light emitting diode. In our graphene/hBN/MoS_2/BN/graphene devices, electrons and holes were injected into monolayer MoS_2 from two graphene electrodes. Due to a long lifetime of the excitons in MoS_2 sandwiched by hBN, excitons emits a light through recombination of electrons and holes. Our device showed a tunneling I_{ds}-V_{ds} curve, which is a typical signature for Fowler-Nordheim (FN) tunneling. Electroluminescence(EL) and photoluminescence(PL) can be modulated by a gate bias (V_{gs}) due to tuneability of charge carriers. Our work shows a high potential of van der Waals tunneling device for light emitting applications.

[1] Plechinger, Gerd, et al. "A direct comparison of CVD-grown and exfoliated MoS2 using optical spectroscopy." Semiconductor Science and Technology 29.6 (2014): 064008.

[2] Withers, F., et al. "Light-emitting diodes by band-structure engineering in van der Waals heterostructures." Nature materials 14.3 (2015): 301-306.

Low dimensional nano-materials(F)/0330 P2-se.012

양극 산화 알루미늄으로 제작한 그래핀 나노 mesh 투명전극/Si 태양전지의 특성 연구

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Abstract :

그래핀은 우수한 물리적 및 화학적 특성들로 인해 전자소자뿐만 아니라 광 및 바이오 분야 등 다양한 분야에서의 활용 가능성이 기대되고 있다. 특히, 그래핀은 전자이동도와 투과도가 높기 때문에 투명전극으로서 많은 관심을 받고 있다. 본 연구에서는 그래핀의 우수한 광학적 및 전기적 특성을 바탕으로 그래핀 메시(mseh)를 제작하여 실리콘 기반 태양전지에 적용하였다. 그래핀 메시를 제작하기 위해 양극 산화 알루미늄 (Anodic Aluminum Oxide, AAO)을 이용하여 마스크를 제작하였다. 먼저 AAO 의 구멍 크기는 식각 공정의 시간을 조절하여 35 ~ 65 nm 까지 제작하였다. 이렇게 제작된 AAO 위에 Au 를 증착하고 AAO 만 제거함으로써 35 ~ 65 nm 의 크기를 갖는 Au 메시를 제작하였다. 제작된 Au 메시를 그래핀 위에 전사한 후 O_2 플라즈마 처리를 통해 Au 메시 구멍에 있는 그래핀을 제거한 다음 왕수로 Au 를 제거하여 다양한 크기의 그래핀 메시를 제작하였으며 라만 산란, 투과도, 주사 전자 현미경, 원자 현미경을 이용하여 광학적 및 구조적 특성을 분석하였다. 이렇게 특성 평가가 완료된 그래핀 메시를 투명전극으로 활용하여 실리콘 기반 태양전지를 제작하였으며 그 광전변환 특성을 평가하였다. 실험결과들을 바탕으로 다양한 구멍 크기의 그래핀 메시와 태양전지의 특성과의 연관성 및 메커니즘을 규명하였다.

Low dimensional nano-materials(F)/0261 P2-se.013

그래핀 양자점의 농도에 따른 그래핀 양자점/그래핀 전계효과 트랜지스터의 전기적, 광학적, 및 구조적 특성 연구

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Abstract :

최근 2 차원 물질들간의 이종접합을 통한 우수한 특성들을 바탕으로 제작한 광전자 소자들에 대한 연구보고가 많이 있어 왔는데, 특히 2 차원 물질들의 전기적 성질을 변화시켜 서로 다른 전기적 성질을 가진 물질 간의 동종접합을 형성하여 제작한 소자에 대한 연구결과가 많은 관심의 대상이 되었다. 본 연구에서는 그래핀과 그래핀 양자점의 동종접합을 통한 소자를 제작하고 그 특성을 평가하였다. 먼저, 화학 기상 증착법을 사용하여 Cu foil 위에 제작한 그래핀을 300 nm $SiO_2/n^{++}Si$ 박막 위에 전사하였다. 그리고 그래핀 전계효과 트랜지스터를 제작하기 위해 길이가 0.1 mm, 폭이 0.2 mm 로 패턴된 마스크를 이용하여 그래핀 위에 소스 및 드레인 전극으로 전자빔 증착법을 사용하여 5 nm Cr/30 nm Au 을 증착하였다. 마지막으로 그래핀 소자 위에 5 nm 크기의 그래핀 양자점을 다양한 농도로 스핀코팅하여 그래핀 양자점/그래핀 전계효과 트랜지스터를 제작하였으며 켈빈 프로브 힘 현미경, 라만 분광법, 광루미네센스, 및 전류-전압 측정을 통하여 전기적, 구조적, 및 광학적 특성을 분석하였다. 본 연구에서는 실험적인 결과들을 토대로 그래핀 양자점의 농도에 따른 그래핀 양자점/그래핀 전계효과 트랜지스터의 전기적, 광학적, 및 구조적 특성에 관한 메커니즘을 규명하고자 한다.

Low dimensional nano-materials(F)/0260 P2-se.014

다층 그래핀을 투명 전극으로 사용하여 제작한 유연한 페로브스카이트 태양전지의 그래핀 층수 의존성 연구

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Abstract :

최근, 페로브스카이트는 흡수계수와 유전상수가 크고, 전하확산거리가 길고, 엑시톤 결합에너지가 작아서 고효율 태양전지 물질로 각광 받고 있다. 지금까지 페로브스카이트 기반의 태양전지에는 인듐 주석 산화물(ITO) 또는 불소가 도핑된 산화 주석(FTO) 등 두 가지 투명전극이 주로 사용되어 왔으나 단단하고 부서지기 쉽기 때문에 유연한 소자에는 응용하기는 어렵다. 따라서 본 연구에서는 처음으로 여러 층의 그래핀을 투명 전극으로 사용하여 페로브스카이트 태양전지를 제작하였으며 층수에 따른 광전변환 특성을 연구하였다. 제작된 태양전지의 광전변환효율은 두 층의 그래핀을 사용했을 때 가장 높았으며 순방향/역방향에 따른 효율은 각각 13.07/13.37%로서 방향에 따른 히스테리시스 현상이 거의 없었다. 외부양자효율은 두 층 그래핀을 사용했을 때 약 80%의 값을 보였으며 약 100 시간 동안 단락전류(J_{sc}) 측정을 통하여 태양전지 특성이 거의 변하지 않는다는 것을 확인하였다. 유연한 소자에 응용하기 위해서 bending test 를 한 결과, 1000 번의 bending 이후에도 태양전지의 광전변환효율 값이 초기 값의 90 % 수준을 유지하는 것을 확인하였는데 이는 기존의 ITO 전극을 사용했을 때 보다 훨씬 좋은 결과이다.

Low dimensional nano-materials(F)/0258 P2-se.015

Ferromagnetic and ambipolar behaviors from MnO_2-doped MoS_2 flakes

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Abstract :

Two-dimensional (2D) materials have been widely studied due to their unique optical, mechanical, and electronic properties that make them possible in numerous potential applications. MoS_2 based devices such as field-effect transistors have been successfully demonstrated in 2-dimensional structure. In addition, MoS_2 materials have especially a spin-splitting property which is very suitable for spin-electronics applications. Atomically thin crystals, MoS_2 have been considered as a very interesting object due to its large direct band gap of 1.8 eV and high mobility, which promise potential applications in various opto-electronic devices, light-emitting devices, and solar cells. If localized unpaired spins can be aligned in single-layer MoS_2, a two-dimensional magnetic semiconductor will be realized. How to realize and manipulate ferromagnetic property in MoS_2 nanosheets then becomes a critical issue to be resolved. In this study, we report the ferromagnetic and ambipolar characteristics of MoS_2 field effect transistor. Room temperature ferromagnetism was demonstrated in MoS_2 flake doped by manganese dioxide through electrochemical method.

Low dimensional nano-materials(F)/0256 P2-se.016

금 나노입자 및 bis(trifluoromethanesulfonyl)-amide 로 이중 도핑된 그래핀 투명전극을 이용한 다공성 실리콘 태양전지

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Abstract :

실리콘 기반 태양전지의 효율을 높이기 위해 실리콘의 반사도를 낮추기 위한 방안으로 부피 대비 표면적의 비율이 높고, 반사도가 낮은 다공성 실리콘 (Porous Si, PSi)을 metal-assisted chemical etching 방법으로 제작하였다. 본 연구에서는 실리콘에 Au 나노입자를 1~7 초 동안 증착시간을 변화시켜 PSi 의 다공성도를 조절하였으며 실리콘의 식각 시간은 5 초로 고정하였다. 제작된 PSi 에 그래핀을 전사한 후 Au 나노 입자와 bis(trifluoromethanesulfonyl)-amide (TFSA)를 이중 도핑하여 그래핀/PSi Schottky 접합 태양전지를 제작하였다. 이중 도핑은 효과적으로 그래핀의 일함수 및 전기 전도도를 증가시킬 것으로 예상된다. 주사전자현미경을 이용하여 다공성 실리콘의 표면을 확인하였으며, Au 증착 시간이 증가함에 따라 다공성도가 증가함을 확인할 수 있었다. 또한 다공성도에 따른 반사도와 흡수도를 측정한 결과 실리콘의 비해 반사도는 낮아지고 흡수도는 증가하는 것을 확인하였다. Au 나노입자와 TFSA 의 유무를 확인하기 위해 XPS 를 측정한 결과 Au 와 TFSA 를 확인할 수 있었다. 태양전지의 효율을 측정한 결과, Au 의 증착시간이 5 초인 PSi 태양전지에서 10.69%의 최대 효율을 확인하였다. 실험결과를 바탕으로 다공성도에 따른 반사도 및 외부양자효율과 이중 도핑에 따른 태양전지 효율과의 연관성 및 관련 메커니즘을 규명하고자 한다.

Low dimensional nano-materials(F)/0252 P2-se.017

은나노선과 $AuCl_3$ 로 이중 도핑된 그래핀 투명전극을 이용한 Si 태양전지의 제작 및 특성 연구

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Abstract :

그래핀은 투명 전도성 전극으로서 매우 적합한 특성들을 지니고 있기 때문에 태양 전지에 응용하는 연구가 활발히 진행되고 있다. 그러나 화학기상증착법에 의해 제작한 그래핀은 면저항이 높아서 그래핀/Si 태양 전지의 광전변환 특성의 향상에 있어 제약이 따르게 된다. 본 연구에서는 은나노선(Ag nanowire, Ag NW)과 $AuCl_3$ 로 이중 도핑된 그래핀을 Si 태양전지에 적용하여 각 농도에 따른 구조적/광학적/전기적 특성이 태양전지의 광전변환 특성에 미치는 영향을 연구하였다. Ag NW 의 농도는 0.1 wt%로 고정하였으며, $AuCl_3$ 의 농도를 1 에서 10 mM 까지 변화시켜 소자를 제작하였다. 주사전자현미경에 의해 그래핀 위에 $AuCl_3$ 와 은나노선이 잘 흡착되어 있음을 확인하였으며 X 선 분광분석에 의해 Ag, Au, 및 Cl 원소가 존재함을 확인하였다. $AuCl_3$ 의 도핑농도가 증가함에 따라 면저항은 850 에서 29Ω/sq 로 감소하였으며 투과도는 최대 도핑농도인 10mM 에서 85%까지 감소하였다. 면저항 및 투과도 측정결과로부터 암전기전도도/광학전도도의 비율을 계산 한 결과, $AuCl_3$ 가 7.5 mM 도핑된 시료에서 최대 ~76 의 값을 보였으며, 이는 상업적으로 허용되는 최소수치(~35) 보다 높은 값이면 같은 농도에서 광전변환효율이 7.01 %로서 가장 높은 값을 보였다. 본 연구에서는 Ag NWs 와 $AuCl_3$ 의 이중 도핑에 따른 그래핀의 투과도, 면저항, 일함수, 및 반사도 분석결과를 바탕으로 태양전지 효율과의 연관성 및 관련 메커니즘을 규명하고자 한다.

Low dimensional nano-materials(F)/0151 P2-se.018

Observation, characterization, and modification of MoS_2 grain boundaries using atomic force microscopy

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Abstract :

Two-dimensional (2D) materials have been widely studied due to their unique electrical properties. Even though two-dimensional materials have great promises in future electronics, most of researches have been conducted with mechanically exfoliated flakes from a high-quality single crystal, which is not suitable for mass-production and large-scale electronic devices. On the other hand, chemically grown multi-grain films of 2D materials have degraded electrical properties due to various defects, such as vacancies and grain boundaries. Among them, one of main reasons for lower quality of the grown MoS_2 is the grain boundaries. The grain boundary leads to carrier scattering, resulting in reduction of carrier mobility, and acts as a starting point of long-term degradation. Therefore, understanding crystalline structure of grain boundary and its impact on electrical properties are critical for synthesis of high-quality large-area 2D materials. Nevertheless, there is no straightforward method to observe MoS_2 grain boundaries, without use of transmission electron microscopy and photoluminescence mapping. Here we introduce our recent results for observation, characterization, and modification of grain boundaries in chemical-vapor-deposited MoS_2 by using atomic force microscopy (AFM). Distinct crystalline structure of grain boundary and absorption of molecules at grain boundaries enable us to easily and clearly observe grain boundaries in a lateral force AFM image. Furthermore, we also find out that spontaneous degradation at grain boundaries occurs. Based on these results, we will suggest a possible mechanism for grain boundary etching phenomena.

Low dimensional nano-materials(F)/1055 P2-se.019

Silver Nanowire-Dispersed Graphene for Enhancing Gas Sensitivity

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Abstract :

Graphene has been widely used for gas sensor application because of its favorable properties such as a large surface area, room-temperature stability, high carrier mobility and low electrical noise. Unlike gas sensors using metal oxide semiconductors, which require high temperature (above 200^{o}C) to activate the gas adsorption, graphene has the ability to be operated at low or even room temperature. However, the gas sensitivity should be improved for practical applications. One of methods to enhance the gas sensing performance is to deorating graphene with nanostructure of noble metals, since it has good structure stability and creates the defects to weaken the strength of bonding between graphene and gas molecule. In this research, we investigate the performance of AgNWs-dispersed graphene (G/AgNWs) sensor under the illumination of UV light at room temperature. In order to fabricate sensor device, the integrated gold-electrode on Si/SiO_2 substrate was used. After graphene was transferred onto the electrode surface, AgNWs diluted in acetone was dispersed on graphene using spin coating method. The dispersion of AgNWs was controlled by the volume of AgNWs and the speed of spin process. The characterization of each synthesis materials and G/AgNWs was carried by AFM, SEM, XRD and Raman spectroscopy, which revealed the successful of fabrication. The sensor device was then tested with gases (NO_2, NH_3, H_2, VOCs) with and without UV light illuminance at room temperature. As the resulting, with NO_2, G/AgNWs sensor exhibited enhanced gas sensitivity and a shorter recovery time in comparison with graphene-based sensor under UV light. In detail, G/AgNWs reached 90% of equilibrium sensitivity (the state to define recovery time) in 4 mins after closing NO_2 flow (concentration of 5 ppm). This enhancement is discussed in terms of the variation in bonding strength of NO_2 adsorbed on graphene surface with the present of AgNWs, and the effect of the electron plasmon excitation phenomenon under UV light.

Low dimensional nano-materials(F)/0972 P2-se.020

Micro-Raman imaging of defects and strains in graphene

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Abstract :

일반적으로 그래핀의 도메인 크기가 커지면 커질수록 전기 수송 성능이 향상되는데 이는 도메인 경계에서의 운반자 산란이 줄어들기 때문인 것으로 알려져 왔다. 하지만 본 연구에서는 이와 반대되는 현상을 관측하였다. 즉, 도메인 크기의 증가에도 불구하고 오히려 전기 수송 특성의 저하 현상이 일어났다. 이에 대한 원인을 규명하기 위하여 그래핀의 넓은 영역에 걸쳐서 공간 분해 된 라만 산란 실험을 수행하였다. 그래핀에서의 D, G, 2D 포논 모드의 세기, 선폭, 에너지의 변화를 넓은 영역에 걸쳐서 영상화하고 이들 자료에 대한 통계 분석을 함으로써 도메인 형성 및 크기, 결함 분포, 변형 변화에 대한 공간 분해 된 정보를 취득하였다. 그 결과, 도메인 경계에서의 운반자 산란뿐만 아니라 개별 도메인 내부에서의 결함, 변형 및 변형 요동 등도 또한 전기 수송 특성에 큰 영향을 미친다는 것을 알 수 있었다. 이 논문은 정부(교육부)의 재원으로 한국연구재단의 기초연구사업(2016R1D1A1B03935270)과 나노원천기술개발사업(2016M3A7B4900135), 미래창조과학부의 재원으로 한국기초과학지원연구원(E37800), 산업통상자원부의 재원으로 그래핀소재부품사업(10044366)의 지원을 받아 수행되었음.

Organic semiconductors(E)/0779 P2-se.021

Performance and Stability Enhancement of Tin Halide Perovskite Solar Cells with Reducing Additives

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Abstract :

Tin-based halide perovskite materials have been successfully employed in lead-free perovskite solar cells, but the tendency of these materials to form leakage pathways from p-type defect states, mainly Sn^{4+} and Sn vacancies, causes poor device reproducibility and limits the overall power conversion efficiencies. Here, $SnCl_2$ which were added into the methylammonium tin iodide ($CH_3NH_3SnI_3$) perovskite solution is a reducing agent to prevent the oxidation of Sn^{2+} state to Sn^{4+} state. The performance of $CH_3NH_3SnI_3$ device doped $SnCl_2$ reach to 2.5% and improve their stability. The improved stability was rationalized based on the presence of $SnCl_2$, forming a layer on the surface of the perovskite. The layer is considered to cover the pinholes of the perovskite, which could operate as channels for water and oxygen ingress. This layer functions slowing down the oxidation of the underlying $CH_3NH_3SnI_3$ by water; $SnCl_2$ is known to form a stable hydrate or SnO_2 upon oxidation. These results mark an important step toward a deeper understanding of the intrinsic tin-based halide perovskite material.

Implications of ferroelectric polarization and hysteretic behaviors on hybrid perovskite absorber thin films

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Abstract :

Hybrid lead halide perovskite have risen to prominence with remarkable increase in efficiency based on their physical properties. One of the issues is controlling the hysteresis phenomenon. Origin of the hysteresis in current-voltage curves has been proposed for the difference in trapping efficiency, ion migration, imbalance between electron and hole fluxes into an electron transfer layer and a hole transfer layer, and ferroelectricity of the perovskites. We report our observations on the piezoelectric responses and ferroelectric property in the perovskite thin-films by using piezoelectric force microscopy which is one of atomic force microscopy techniques. We propose a device model to enhance the photo-conversion efficiency due to the contribution of ferroelectricity through examination for the nature of the hysteresis properties.

Organic semiconductors(E)/0338 P2-se.023

Optimization of Blue Sensitive Organic Materials for CMOS Image Sensor

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Abstract :

In general, the image quality of an image sensor is heavily influenced by the amount of light gathered at each pixel that makes up the sensor. In recent years, as the pixel size is smaller than 1 um for the high resolution CMOS image sensor, the portion of light receiving area is reduced. Then it is more difficult to absorb the light. To overcome this problem, existing backside illuminated (BSI) sensors have increased the light acceptance by moving the photodiode region to the top of the sensor. However, as the pixel size (<1.0 um) becoming smaller, it is also facing limitations. Therefore, it is necessary to develop an organic image sensor with higher resolution, absorption ratio and s/n ratio compared to silicon photodiode. The light absorbing ability of organic image sensor is higher than that of silicon, which is advantageous in that it can be deposited in the form of a thin film. If the thickness of the light receiving part is reduced, the angle of incidence through the lens can be relatively widened and the module can be downsized. In addition, since organic image sensors don't require color filters, existing problems of the image sensor such as crosstalk and noise due to the reduction of the pixel size can be reduced. In this research, blue sensitive organic materials are deposited on silicon to confirm the difference between dark and photo current. Also, we observe how the current tendency changes through the variation of organic material thickness.

Acknowledgments

This work was financially supported by the Brain Korea 21 PLUS Program in 2017.

Organic semiconductors(E)/0267 P2-se.024

Organic Material Based Green Sensitive CMOS Image Sensor

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Abstract :

Recently, CMOS Image Sensors (CIS) that using silicon photodiode are facing problems of efficiency of light acceptance due to pixel scaling down. At under 2.0 μm pixel size, technology was changed from Front-side Illumination (FSI) to Back-side Illumination (BSI). In addition, at under 1.0 μm pixel size, additional problems arise such as low light acceptance efficiency from long absorption depth of silicon material. Therefore, CIS need a development of new structure. Most of late structures have some techniques to improve efficiency of light acceptance like high aperture ratio in pixel structure or using top layer formed lens to collect incident light around pixel aperture. However, it can’t improve lowering of efficiency resulting from color filter. Using color filter, incident light intensity must decrease during passing through the filter layer. Therefore, the light acceptance efficiency issue still remains, so it need a new structure without color filter. Thus, using organic materials absorbing red, green, blue ranges of wavelength individually, there’s no decrease of light intensity in absorption layer and cross-talk issue of existing CIS structure will be solved. In small pixel device, efficiency of sensing characteristics improvement can be obtained coming from the structure without color filter layer and isolation between each pixel. In this work, using green sensitive organic layer, it is able to absorb specific wavelength without light intensity loss. Device characteristics were analyzed by measuring current between electrodes in dark and uniform intensity photo state. Furthermore, output voltage on floating diffusion area was measured in pulse operation of Si device.

*acknowledgement

This work was financially supported by the Brain Korea 21 PLUS Program in 2017.

Organic semiconductors(E)/0255 P2-se.025

Red Sensitive Organic-photoconductive Material Based CMOS Image Sensor

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Abstract :

CMOS image sensors (CIS) have been used in lots of industries such as surveillance, automobile, mobile phone. Conventional CIS is based on silicon photodiode. Because it is compatible with semiconductor fabrication process, it can be manufactured at low cost. As the demand for high pixel camera increases, the size of the photodiodes naturally become smaller. As the photodiode size getting smaller, crosstalk became inevitable phenomenon. When light goes through the color filter, small amount of light travel adjacent photodiode, which makes a false output signal. In this study, organic photoconductive materials are used to overcome this limit. Since organic materials have their own absorption wavelengths, CIS can be fabricated without the use of color filters. In addition, the thickness of the CIS device can be reduced. Crosstalk can be reduced compared to silicon photodiode which absorb almost all visible light. In this study, we focused on red-sensitive organic photodiode. Zinc phthalocyanine (ZnPc) and Titanyl phthalocyanine (TiOPc) are used for red sensitive organic materials. In this study, the thicknesses of organic materials are splitted in order to maximize difference between dark and photo current of organic photodiode. Pulse operation based on 4-Tr pixel structure is also studied to compare dark to photo voltage drop.

Acknowledgments

This work was financially supported by the Brain Korea 21 PLUS Program in 2017.

Semiconductor on soft substrates & other semicond.(H)/0593 P2-se.026

Highly efficient flexible Cu(In,Ga)Se_2 (CIGS) thin-film light absorber locally characterized by Kelvin probe force microscopy

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Abstract :

Cu(In,Ga)Se_2 (CIGS) solar cells reached to power conversion efficiencies (PCE) of 22.6% on rigid substrates, and 20.4% on flexible substrates each. One of the biggest challenge in fabrication of high-efficient CIGS thin films on flexible substrate is to find the optimized condition for incorporating Na ions. This is because Na affects the thin film properties. Therefore, we applied NaF layer and altered the annealing temperatures. Consequently, we could obtain CIGS thin films having four different PCE; 0, 6, 12, and 15%. Micro-Raman scattering spectra show their optical and crystalline properties, where CIGS absorber with 15% has uniform structure, and less amount of the secondary phase exist on the surface. For the electrical properties of CIGS thin-film surface, Kelvin probe force microscopy (KPFM) was used, measuring surface potential. Based on grain boundaries (GBs) models, 15%-efficiency sample has the highest energy barrier near the GBs, which is beneficial for carrier transportation. This can reduce the possibility of electron-hole pair recombination and improve open-circuit voltage (V_{OC}). We could also obtain surface work function distribution using KPFM (Φ_{CIGS} = ~4.7 eV). However, as copper selenide secondary phases were detected in the all samples, further research to get rid of undesirable phases is currently on the way.

Semiconductor on soft substrates & other semicond.(H)/0476 P2-se.027

Optical transitions of MAPbCl3-xBrx organic-inorganic perovskite crystals under high magnetic fields

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Abstract :

Despite the vast investigations of applications on solar cell devices, there are numerous unknown basic properties of methyl-ammonium (MA) lead halides perovskite materials. In this regard, we investigate optical transitions of such crystals in high magnetic fields to 19 T. We fabricate $MAPbCl_{3-x}Br_x$ (x=0, 0.5, 1 and 3) crystals by using conventional solution methods. For the photoluminescence measurements under magnetic fields, we use a 19 T cryocooled superconducting magnet and a 60 T pulsed magnet. Samples show strong temperature dependency while cooling from room temperature to the liquid helium temperature. We will discuss magnetic field dependency of the optical transitions including the reduced mass and exciton diamagnetic shifts.

산화 인듐 촉매를 이용한 절연 기판상의 대면적 그래핀 직접 합성

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Abstract :

현재 산업분야에서 그래핀을 합성하는 주요한 방법은 화학기상증착법(Chemical vapor deposition,CVD)으로 금속 기판위에 그래핀을 합성한 후, 화학물질을 이용하여 금속 기판에서 그래핀을 분리하는 방법이다. 그러나 금속 기판에서 그래핀을 분리하는 과정에서 그래핀에 결함이 생기거나, 그래핀으로부터 금속이 완전히 분리되지 않아 순도가 낮아지는 단점이 있다. 따라서 녹는점이 낮은 인듐 촉매를 이용하여 절연 기판 상에 그래핀을 직접 합성하려는 시도를 하였으나, 인듐의 응집현상으로 인해 균일한 대면적의 그래핀을 합성하지 못하였다. 따라서 인듐 촉매위에 녹는점이 높은 얇은 산화 인듐막을 합성한 후 이를 촉매로 하여 절연 기판상에 대면적의 그래핀을 직접 합성하는 연구를 진행하였다. 본 실험에는 양극산화를 통해 합성된 산화인듐과 공기중 가열을 통해 합성된 산화 인듐막을 이용하였다. 그 결과 결함이 있는 그래핀을 절연 기판상에 직접 합성할 수 있었으며 웨이퍼 스케일의 그래핀 필름을 관찰할 수 있었다. 그러나 산화 인듐막의 두께가 인듐의 두께보다 현저히 얇을 경우 합성 과정 중 인듐의 응집현상을 막지 못하여 대면적의 그래핀을 합성할 수 없었다. 따라서 산화 인듐막과 인듐 촉매간의 두께 조절을 통해 대면적의 균일한 그래핀을 절연기판상에 직접 합성할 수 있다. 본 연구를 통해 합성된 그래핀 필름은 반도체 분야 또는 플렉서블 디스플레이같은 첨단 분야에 사용될 수 있을 것으로 기대한다.

Low dimensional nano-materials(F)/0229 P2-se.029

Photo-responsive characteristics of MoS_2/ZnTMP hybrids and application to photo-transistors

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Abstract :

2 차원 무기반도체인 molybdenum disulfide (MoS_2)의 표면에 유기반도체 단분자 zinc 5,10,15,20-tetratrimethylphenyl porphyrin (ZnTMP)를 용액 분사 기법으로 코팅하여 무기/유기 하이브리드 전계효과 트랜지스터를 제작하였다. 제작한 트랜지스터 소자를 광학 현미경을 이용하여 관찰한 결과, 수 마이크로미터 (μm) 규모의 ZnTMP 가 MoS_2 의 표면 위에 쌓여있는 것으로 관찰되었다. UV/Vis 흡수 실험과 레이저 공초점 현미경[laser confocal microscope (LCM)] PL 실험을 통해 ZnTMP 의 광학적 특성을 조사, 분석하였다. ZnTMP 의 흡수 봉우리는 464 nm, 564 nm 부근에서 관찰되었고 주 PL 봉우리는 652 nm 부근에서 관찰되었다. 제작된 MoS_2 기반 전계효과 트랜지스터 소자의 전류 및 광전류를 ZnTMP 하이브리드 전과 후로 측정한 뒤 비교, 분석하였다. 그 결과, 하이브리드 후 모든 전압 구간에서 전류는 감소하였지만 광반응성(photo-responsivity)이 증가한 것을 확인하였다. 또한 암전류(dark current) 대비 광전류 비율(photo-to-dark-current ratio)이 같은 조건에서 최대 3 배 이상 증가한 것을 확인하였다. 입사광에 의해 ZnTMP 에서 방출된 광자에 의해 MoS_2 가 광여기되면서 전자가 발생하였고, 동시에 ZnTMP 가 광여기되면서 발생한 전자가 MoS_2 표면으로 이동하면서 광전류가 증가했기 때문으로 해석하였다.

Physics teaching(A)/0706 P2-te.003

Practical Instruction of [Electrical Workings] in Primary School Science

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Abstract :

The experimental device had been developed to measure the brightness and power of a bulb by connecting various bulbs and batteries. The device is composed of knife switches, bulbs, bulb sockets, large power resistances, terminals, batteries, and battery sockets. The bulbs or resistors are connected in parallel or in series by open and close of the knife switch and the currents and voltages flowing through the bulbs and resistors are measured by using an ammeter and a voltmeter. Since the light efficiency of the bulb increases as the power of the bulb increases, it is difficult to simply compare the brightness of the bulb according to the various connection method of bulbs and batteries. Therefore, the currents and voltages of bulb and resistance were measured by using an ammeter and a voltmeter, and the powers of bulb and resistance was measured and compared with calculation values. Since the resistance of large electric power is very small dependence on temperatures by electrical heating, the current and voltage of resistors composed of various circuits are more approximate to the theoretical calculation results than the case of light bulb.

Physics teaching(A)/0703 P2-te.004

Practical Instruction of [Mirror and Shadow] in Primary School Science

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Abstract :

The experimental device had been developed to measure shadow sizes of objects. The light source, object support and screen were placed on the track to move freely on the optical axis. A large power LED lamp was used to carry out the experiment even in the bright state, and it was installed in an opaque container to protect the eyes of the experimenter. Objects can be fixed on object supports of various shapes and sizes, and the screen is made of white acrylic plate. In the case of a very small spherical light source using this device, experiments on the size of shadows were performed and the theoretical formulas were derived from these results. The size and properties of the shadow depend on the various sizes of spherical light source and the planar light source. Because the experiment according to the movement of the light source in [The Change of Shadow Size] title depends on the distance between the light source and the object and the distance between the light source and the screen simultaneously, it is desirable to carry out this experiment on each variable.

Other physics teaching(E)/0233 P2-te.005

과학교육을 위한 눈의 동적 모형안에 대한 연구

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Abstract :

광학 관련 과학 개념들을 습득하기 위하여 눈의 역할에 대한 이해의 중요성이 강조되어 왔다(박현주, 1987; 오원근과 김재우, 2002; Goldberg 와 McDermott, 1987; Ronen, 1993). 눈은 하나의 광학계로서 외부의 물체로부터 방출된 빛이 눈의 여러 조직을 거치며 망막에 상이 맺히는 과정에 대한 이해는 눈의 조직들의 기능과 광학적인 상수들에 대한 다양한 정보들을 바탕으로 기하광학적인 방법으로 행해진다. 모형안이란 눈의 기하광학적인 모형으로서 눈의 조직들 사이에 존재하는 굴절면과 조직들의 광학적 특성을 나타내는 광학상수들을 근거로 눈의 기능을 설명할 수 있도록 설계한 도식적 모형이다.

과학교육에서도 눈의 구조와 기능에 대한 이해를 위하여 동적 모형안이 필요하다. 광학 관련 몇몇 교재들의 내용을 살펴보면(홍경희, 2011; Pedrotti 등, 2013; Hecht, 2013), 눈을 구성하는 조직과 조직의 생리광학적인 기능에 대한 서술이 정성적이고 개략적이어서 실질적으로 눈의 구조와 기능에 대한 이해하는 데 충분히 도움이 되지 못한다. 또한 교재에 따라 조직의 제원이 다르게 제시되고 있어 교육적인 면에서 조직의 대표적인 제원을 제시할 필요가 있다. 이 연구는 과학교육을 위한 모형안을 제시하는 것이다. 이 연구의 모형안은 근축광선을 바탕으로 각막과 수정체의 경계면을 구면으로 가정하였으며, 조직들의 재원은 대표적이라고 인정되는 것들을 사용하였으며, 수정체의 동적 모형은 고등학교 수준에서 이해할 수 있도록 구성한 것이 특징이라고 할 수 있다.

Physics teaching in secondary level(B)/0316 P2-te.006

Analogous Abduction in the Discovery of a Transistor and Application of modular project for the secondary students' Understanding of a Transistor effect.

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Abstract :

John Bardin, Walter Bratton and William Shockley of Bell Laboratory won the Nobel Prize for their transistor discovery and invention in 1956. The team analyzed the problems of mechanical switches, which were made of conventional vacuum tubes and relays based on a prior knowledges of solid physics. During two months, which was so called "magic month", from December 1947 to January 1948, they have succeeded in discovering the amplification effect using solid materials during setting various hypotheses and conducting experiments. The first stage is a 'point contact' transistor and the second stage is a 'field effect' transistor. Team members established a hypothesis for a new transistor model using a familiar vacuum-tube analogy. The discovery of transistors that enabled electrical switching at very high speed became a crucial trigger in the era of information age as they evolved into 'logic gates', 'IC chips' and 'microprocessors'.

We have developed four activity-centered Learning modules that allow secondary students to experience basic principles of Ohm's law, semiconductor devices, logic gates, and IC chips. In the process of learning this module, the students had difficulty implementing the switching effect of the transistor on the real circuit. However, by experiencing the scientific evolution from physical discovery to engineering, students were able to come up with an opportunity to understand scientists' creative thinking and the nature of science.

Other physics teaching(E)/0290 P2-te.007

과학교육에서의 인성교육에 대한 델파이 연구

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Abstract :

인성교육의 필요성이 강조됨에 따라 인성교육진흥법이 2015 년에 제정되었다. 인성교육진흥법은 바람직한 인성을 갖춘 시민을 양성하기 위해, 인성교육을 활성화하고, 체계적으로 지원하기 위해 제정되었다. 이에 따라 각 급 학교에서는 자체적인 인성교육 계획을 수립행해야 하며, 인성교육에 관한 일정 시간 이상의 교원 연수를 의무화 하고 있다. 이러한 인성교육의 중요성이 강조되는 법제적 환경 속에서, 실제로 과학교육 전문가들은 인성교육을 위한 인성 요소에 대해서 어떻게 생각하고 있는지 알아볼 필요가 있다. 본 연구에서는 과학교육에서 인성교육에 대한 인식을 알아보기 위해, 과학교육에서 박사학위를 수여받은 중등학교 교사, 대학교수 및 장학사를 전문가로 선정하였다. 총 40 명의 전문가들에게 델파이 설문지를 이메일로 보내었고, 그 중 20 명이 응답하였다. 2 회에 걸친 델파이 설문결과를 바탕으로 9 명의 전문가를 선정하여 포커스 인터뷰를 진행하였다. 전문가들은 타교과에 비해서 과학교육에서 인성교육의 가능성과 필요성을 제시하였다.

Physics teaching(A)/0841 P2-te.008

과학인성에 대한 과학교사의 인식 조사 도구 개발 및 적용

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Abstract :

본 연구의 목적은 과학 인성에 대한 과학교사들의 인식 조사 도구 개발과, 개발된 도구를 사용하여 과학 인성에 대한 과학교사들의 인식을 조사하는 것이다. 본 연구는 129 명의(초등 60, 중등 40, 고등 29) 과학교사들을 대상으로 수행되었다. 연구결과, 과학인성의 하위 8 개의 요인(문제해결능력, 자기관리능력, 자기성찰능력, 대화소통능력, 대인관계능력, 사회참여능력, 세계시민의식, 환경윤리의식)으로 구성된 총 40 개 문항의 '과학 인성에 대한 인식' 조사 도구를 개발하였다. 개발된 도구를 사용하여 과학인성의 하위 역량에 대한 인식과 과학 인성 지도의 구체적인 교수학습 상황에 대한 인식을 조사한 결과, 과학인성 교육의 필요성에 대한 높은 인식을 확인 할 수 있었다. 실제 과학인성을 교육하고 있는가에 대한 조사 결과 자기관리능력, 자기성찰능력, 사회참여능력, 세계시민의식에서 비교적 낮은 인식의 정도를 보여주었다. 성별에 따라 여교사가 과학인성에 대하여 유의미하게 더 높은 인식을 보여 주었고 연령, 경력에 따른 유의미한 차이는 확인되지 않았다. 학교 급 별로는 고등학교 과학교사가 사회참여, 대화소통, 대인관계, 사회참여, 환경윤리 영역에서 유의미하게 낮은 인식을 보여 주었다. 이러한 결과를 바탕으로 과학교육에서 인성교육의 방향에 대한 몇 가지 시사점에 대해 논의하였다.

Physics teaching(A)/0817 P2-te.009

교사를 위한 일반상대론 강의에서 일반공변성에 관한 논의의 특징

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Abstract :

일반공변성(general covariance)은 물리법칙이 모든 좌표계에서 동일한 형태로 쓰여야 한다는 요구 조건이며 이는 일반상대성이론에서 가장 핵심적인 개념이다. 그러나 일반상대론을 가르치고 있는 대학 및 고등학교 물리교육에서 일반공변성은 다루지 않거나 다루더라도 대부분 등가원리, 빛의 휘어짐 등 단편적인 개념과 현상 위주의 설명을 제시하는 수준에 그치고 있다. 본 연구는 현직/예비교사들을 대상으로 하는 사범대학 대학원의 일반상대론 수업에서 일반공변성 개념에 대한 확장된 논의를 통하여 학습해가는 과정을 분석하였다. 특히, 이번 발표에서는 열역학에서 나오는 이상기체 상태방정식의 공변성에 대한 토의 부분을 중점적으로 다룰 예정이다. 또한 일반공변성 개념을 학습하는데 도움을 줄 수 있는 방안(관련 예제 개발)을 제안할 것이다.

Other physics teaching(E)/0990 P2-te.010

양자역학의 개념적 구조: 양자얽힘과 C^2C2 의 논리-대수적 구조를 중심으로

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Abstract :

양자역학은 현대의 물리학에서 매우 중요한 부분을 차지한다. 하지만 그 성과에 비해, 왜 양자역학의 도구가 물리적 현상을 잘 설명할 수 있는지는 아직도 명확하게 밝혀지지 않았다. 이 질문에 답하고자 우리는 양자역학을 보다 쉽게 이해하기 위한 연구를 수행하였다. 먼저 양자역학이 왜 받아들이기 어려운지, 고전역학과 양자역학은 어떻게 다른지 슈테른-게를라흐 실험(Stern-Gerlach experiment)을 예로 들어 알아보았다. 또한 양자역학을 설명하는 몇가지 주요 해석들을 알아보았다.

양자역학을 기술하는 데에는 일반적으로 힐버트 공간이 사용된다. 하지만, 양자역학을 보다 쉽게 이해하기 위하여, 다루기 힘든 무한차원의 힐버트 공간 대신 우리는 두 복소수의 순서쌍으로 이루어지는 C^2 공간을 사용하여 접근하였다. 즉, 슈테른-게를라흐 실험에서 다루는 전자의 스핀과 같이, 물리량의 값이 2 가지뿐인 경우가 우리의 연구대상이다.,

편광 또한 C^2 를 사용해 기술할 수 있는 두-상태-계이다. 더 나아가 실험적으로 확인이 힘든 스핀에 비해 쉽게 확인할 수 있다는 장점을 갖고 있었기 때문에 우리는 편광을 이용해 양자지우개와 양자암호전송 등을 시뮬레이션하여 고전역학과 양자역학의 차이를 보다 직관적으로 이해할 수 있었다.

2017 년 가을 학술논문발표회 및 임시총회, 2017 KPS Fall Meeting
2017.10.25 - 2017.10.27, 경주 화백컨벤션센터

Other physics teaching(E)/0719 P2-te.011

Design and Simulation of Piezoelectric Energy Harvesting

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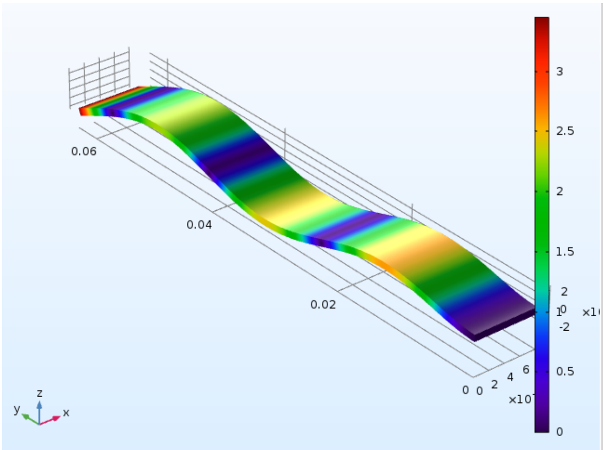
Abstract :



Energy harvesting has received many attentions in the past decades due to the increased of low and self-powered technologies, such as wireless sensor and portable electronic devices. This is because most of these technologies either are placed in remote places, such as bridges or civil structures, or use conventional batteries that should be constantly replaced, becoming a tedious or even an impossible task [1]. When these technologies are immersed in a vibration environment, piezoelectric energy harvester came up as a good alternative. One of the reasons is due to the improvement of the piezoelectric properties with the new materials, for instance the PMN-PT. Also, piezoelectric can efficiently work in a large mechanical vibration range compared to anothers vibration energy harvester (for example: electromagnetic transducer) [1]. In this work, we propose to investigate different kinds of energy harvesting, simulating one layer of PMN-PT piezoelectric material on different structures placed on a specific surface vibration. First we demonstrate the well-known cantilever structure using analytical distributed-parameter electromechanical model [2,3] and analyze the frequency response for power output. After, we will present the fixed-fixed beam configuration and the circular shape model frequency response analysis. At the end, we will summarize and compare the results.

[1] H. A. Sodano, D. J. Inman & G Park. Shock and Vibration Digest, 36(3), 197-205 /DOI: 10.1177/0583102404043275

[2] A. Erturk & D. J. Inman. J. Vib. Acoust 130(4), 041002 (Jun 11, 2008) /DOI:10.1115/1.2890402

[3] A. Erturk & D. J. Inman. Piezoelectric Energy Harvesting © 2011 John Wiley & Sons

Spin-orbit coupling in strongly correlated systems

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Abstract :

Strongly correlated systems, named due to the presence of strong electron-electron correlation, are the hosts of variety of interesting phenomena such as metal-insulator transition, magnetism including quantum spin liquid, spin-charge separation and unconventional superconductivity. This variety comes from the fact that all possible interactions played by all degree of freedoms (DOFs) in solid - lattice, charge, orbital and spin DOF are equally important in the fundamental level, enhanced by strong correlation.

Among many interactions in solids, spin-orbit coupling is highlighted recently due to its key role on the formation of topological state. When spin-orbit coupling is combined with correlation flavor, it can manifest many interesting results such as relativisitic Mott insulating phase driven by melting of orbital angular momentum quenching against the crystal field forced by spin-orbit coupling. In this tutorial, staring from basics of spin-orbit coupling and correlation effect in solid, recent examples from the presence of spin-orbit coupling and the correlation will be introduced.

Tutorial: Machine learning in search for new physics beyond the standard model/1008 T2.01

Machine Learning Algorithms for High Energy Physics

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Abstract :

심층신경망(deep neural networks)을 통한 학습기법의 비약적인 발전으로 인하여, 복잡한 데이터속에 담겨져있는 모델을 추출해내는 기계의 성능이 매우 빠른 속도로 향상되고 있으며, 이러한 기계학습알고리즘(machine learning algorithm)의 발전은 인간만이 할 수 있었던 작업들을 효율적으로 대체하는 수준을 넘어, 인간이 하지 못했던 모델링을 가능하게 한다. 고에너지의 진공으로부터, 최종 탐지기에 남겨지는 복잡한 전기신호까지, 광범위한 유효 시스템에서의 모델들과 데이터들의 거대 집합으로서의 고에너지 입자물리학은, 기계학습의 발전이 자연과학의 발전에 기여할 수 있는 매우 좋은 테스트베드가 되고 있으며, 이는 인공지능과 함께 할 과학의 미래를 예견해볼 수 있는 좋은 사례가 된다. 본 튜토리얼 세션에서는 기계학습을 통한 모델링의 의미와 여러가지 기계학습 알고리즘들을 예제와 더불어 상세히 설명하고, 고에너지 물리학에의 최신 응용 사례들을 소개하고자 한다.

Tutorial: Machine learning in search for new physics beyond the standard model/0617 T2.02

포스트 힉스 시대의 딥 러닝

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Abstract :

2012 년 힉스 입자가 발견되고 5 년이 지난 지금 힉스 입자의 질량을 자연스럽게 설명하거나 암흑물질의 후보가 되는 새로운 입자의 존재가 아직 확인되지 않고 있다. 그 동안 거대 양성자 충돌에서 충돌에너지는 높아지고 데이터의 양은 점점 쌓여 앞으로는 100 배가 넘는 데이터의 양이 더 쌓일 것으로 예상한다. 이런 포스트 힉스 시대에 딥 러닝의 필요성과 역할에 대해서 소개하고자 한다.

Tutorial: Super-resolution imaging/0420 T3.01

초고해상도 광학 이미징

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Abstract :

광학 이미징 기기의 해상도는 가시광선의 회절로 인하여 제한되기 때문에, 높은 개구수의 고분해능 광학 현미경도 약 250 nm 의 해상도를 가진다. 이러한 분해능의 한계 때문에 나노미터 규모에서 일어나는 생명현상의 생체 내 실시간 이미징이 불가능하였으나, 최근에 수십나노미터 분해능을 가진 광학 현미경이 개발되어 기존에 볼 수 없었던 나노미터 세계를 생체 내에서 직접 관찰할 수 있게 되었다. 본 튜토리얼에서는 해상도 한계를 극복하는 다양한 물리/화학적 원리를 소개한다. 그 중 STED(Stimulated Emission Depletion), SIM(Structured Illumination Microscopy)과 단분자 중심위치 측정을 이용하는 방식(PALM/STORM/GSDIM 등 여러 이름으로 통칭됨)의 세 가지 방식에 촛점을 맞추어, 이들의 작동원리, 장점, 단점 및 차이점을 논의한다. 또한, 각 방법을 어떠한 생명현상에 응용할 수 있는지 예제를 중심으로 소개하고자 한다. 덧붙여 최근 2-3 년 사이에 소개된 방법들 중, 샘플 자체의 부피를 팽창시키는 방법(expansion microscopy)과 기존의 초고해상도 광학이미징의 해상도를 뛰어넘는 방법(MINFLUX 등) 등의 이 분야의 최신동향을 살펴본다. 이를 통하여 분자 단위의 물리적 현상을 직접 세포 내에서 연구하는 생명물리연구의 방향을 제시하고자 한다.

Tutorial: Quantum entanglement and gravity/0047 T4.01

양자얽힘과 중력의 기초

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Abstract :

최근 양자정보, 특히 양자얽힘과 중력, 더 나아가 시공간의 기원의 연관성에 대한 관심이 높아지고 있다. 본 강의에선 비국소적 양자 상관관계의 하나인 양자얽힘의 정의, 물리적 의미, 기초적인 계산법을 살펴본다. 그리고 양자얽힘과 중력, 블랙홀, AdS/CFT, 그리고 양자장론의 관련성에 대한 그간의 연구결과와 양자중력 및 우주론등에서 앞으로의 활용에 대해 간략히 알아본다.

Tutorial: Quantum entanglement and gravity/0169 T4.02

홀로그래픽 양자얽힘 엔트로피와 중력

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Abstract :

최근 다양한 물리계의 양자적 성질들을 이해하기 위해 양자얽힘에 대한 많은 연구들이 수행되고 있다. 하지만 아쉽게도 강하게 상호작용하는 물리계의 경우, 양자얽힘을 계산하는 것은 매우 어려운 일이다. 이 튜터리얼 세션에서는 홀로그래피를 이용하여 한차원 높은 중력이론에서 강하게 상호작용하는 양자얽힘을 이해하는 새로운 방법론에 대해 논의한다.

Tutorial: Quantum entanglement and gravity/0314 T4.03

얽힘으로부터 시공간 이해하기

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Abstract :

홀로그래픽 얽힘 엔트로피의 연구 이후에 이를 이용하여 시공간을 이해하려는 시도가 많은 사람들의 관심을 끌게 되었다. 그래서 본 강의에서는 이러한 시도들을 나열하고 그것들이 왜 의미가 있는 지 살펴보겠다. 특히 블랙홀이나 다른 시공간이 형성되는데 어떻게 얽힘이 작용하는지 설명하고 시공간을 기술하는 아인슈타인의 장 방정식이 어떻게 얽힘 엔트로피가 만족하는 방정식으로부터 나오는지에 대해 알아볼 것이다. 또 중력의 안정성과 얽힘 엔트로피가 어떤 관계가 있는지 간단히 다룰 것이다. 이 외에도 여러 가지 관련된 최근의 해석과 결과들에 대해 소개할 것이다.

Tutorial: Introduction to Dirac and Weyl semimetals/0526 T5.01

Introduction to Dirac and Weyl semimetals

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Abstract :

Topological semimetals describe the state of matters in which the energy gap between the conduction and valence bands is closed at several points or along lines in the momentum space. Recently discovered Dirac and Weyl semimetals are such examples. Topological semimetals can be generated either via a band inversion or due to the symmetry protected band degeneracy at a high symmetry point in the Brillouin zone. In many cases, such a band contact point or line is protected by some topological invariants, which indicates the nontrivial topological properties of the relevant semimetal state. In this talk, I am going to give a pedagogical introduction to topological semimetals including Dirac and Weyl semimetals. I'll explain the general mechanism creating various topological semimetals and describe their topological properties. Also I'll discuss how to classify possible topological semimetals based on space group symmetry. Finally, I'll describe possible unconventional topological phase transitions mediated by semimetals carrying point or line nodes.

Special Sessions(A)/0776 W1.01

아인슈타인과 우주 - 100 년의 신화

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Abstract :

1917 년 아인슈타인은 자신이 완성한 새로운 중력인론인 일반상대성 이론을 우주에 적용하는 시도를 했다. 그는 우주원리를 도입하여 영원불변한 우주를 얻기 원했지만 그의 이론은 팽창하는 우주를 내놓았고, 허블에 의해 팽창의 증가거 발견됨으로써 현대 우주론이 시작되었다. 이 강연은 지난 100 년간 이루어진 우주에 대한 놀라운 발견들과 이것을 성취해낸 인류의 도전에 대한 이야기이다. 우주의 팽창, 우주마이크로파배경의 발견에서 암흑 물질과 암흑 에너지의 존재를 밝히기 까지의 과정과 시공간과 물질의 틀에서 어떻게 관측된 우주를 이해하고 있는가와 시공간과 물질의 궁극적 기원을 밝히려는 도전을 다룬다.

Special Sessions(A)/0632 W1.02

많음, 다름, 그리고 양자역학 (More, Different, and Quantum)

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Abstract :

"전체는 부분의 합보다 크다 (The whole is greater than the sum of its parts)"라는 유명한 명제는 노벨물리학상 수상자인 필립 W. 앤더슨(Philip W. Anderson)에 의해서 "많음은 다르다 (More is different)"라는 조금 더 시적인 명제로 압축되었다. 현대 응집물질 물리에서 가장 중요한 연구 분야 중의 하나인 다체 물리(Many-body physics)는 여기에 양자역학이 개입될 때 어떠한 일이 일어나는가에 대해서 관심을 갖는 분야이다. 본 강연에서 연사는 다체 물리에서 다루어지는 다양한 연구 주제들을 하나로 묶을 수 있는 개념인 "새로운 물질 상태의 창발(Emergence)"이라는 관점에서 다체 물리를 얘기하고자 한다.

Special Sessions(A)/1221 Y1.01

Quantum Black Holes and the Structure of Space and Time

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Abstract :

Theories of strings and D-branes can be used to describe objects that may be regarded as black holes or candidates thereof, but leave some properties of horizons and space-time structure underdeveloped. Yet one can also start off with black hole models using not much more than standard quantum field theory in combination with perturbative gravity. Then also, one can take gravitational back reaction into account, and find out where information is stored and how out-going particles are entangled. This yields a remarkably clear picture of the non-trivial space-time structure of black holes.

Special Sessions(A)/1222 Y2.01

The Quantum Properties of Magnetic Atoms on Surfaces

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Abstract :

The scanning tunneling microscope is an amazing tool because of its atomic-scale spatial resolution. This can be combined with the use of low temperatures, culminating in precise atom manipulation and spectroscopy with microvolt energy resolution. In this talk we will apply these techniques to the investigation of the quantum spin properties of magnetic atoms sitting on a thin film of magnesium oxide (MgO). In such a situation, the thin insulating film serves two important purposes: first, it provides a strong ligand field which is crucial to understanding the low-energy (magnetic) states of the metal atoms (adsorbate). Second, the insulating film electronically decouples the atom from the underlying conduction electrons, which in turn preserve the quantumness of the adsorbate.

In a first set of experiments, we will investigate the tunneling spectroscopy of 3d transition metal atoms at low temperature and in high magnetic fields. We find that the tunneling electrons can interact with the magnetic states of the adsorbate by exchanging energy and quanta of angular momentum. This leads to clear selection rules in this inelastic tunneling spectroscopy, which we coined ‘spin excitation spectroscopy’ (*Science* 2004). Due to the strong ligand field of the polar MgO surface, we find that adsorbates with spin larger than ½ show strong magnetic anisotropy, giving rise to non-trivial magnetic states (*Science* 2014, *PRL* 2015).

On our quest towards more quantumness we will then investigate the lifetimes of excited states. After a tunneling electron excites the adsorbate, it can be left behind in an excited state. Often this lifetime is far shorter than the time resolution of traditional STM, which is in the range of millisecond. We therefore developed an all-electrical pump and probe measurement technique that allows lifetime measurements down to nanoseconds (*Science* 2010). Surprisingly, we find lifetimes that vary from nanoseconds to hours, a truly amazing consequence of the quantum states of the different adsorbates.

Finally, we will explore the superposition of quantum states which is inherent to spin resonance techniques. We recently demonstrated the use of electron spin resonance on single Fe atoms on MgO (*Science* 2015). This technique combines the power of STM of atomic-scale spectroscopy with the unprecedented energy resolution of spin resonance techniques, which is about 10,000 times better than normal spectroscopy.