The Department of Physics at Ajou University

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DEPARTMENT OF PHYSICS, AJOU UNIVERSITY

Fig. 1: "Connecting Minds", the slogan of Ajou Vision 4.0.

AJOU UNIVERSITY

Ajou University, located in Suwon, about 30 km south of Seoul, was established in 1973 under the motto of "Asia's Best University for the 21st Century". Ajou has become a leading research university in South Korea, with more than 700 faculty members and 14,000 students (9700 undergraduate students, 3,700 graduate students, and 500 students in other courses). The main areas of strength in Ajou's academic and research programs are in the fields of natural science, engineering, information technology, bio technology, nano technology, medical science, business and international studies. There are collaborative partnerships with over 320 universities in 60 countries. Currently, approximately 750 international students are enrolled at the university.

Under the slogan "Change Society by Connecting Minds", Ajou Vision 4.0, a 10-year development plan, was announced in 2018. The vision presents five strategies: innovation in self-directed highly interactive education, creation of a high impact research hub, formation of an innovative ecosystem for industrial-academic cooperation, and realization of an open campus for creating shared values. The university strives to provide education focused on improving overall student competency, to conduct research utilizing institutional expertise, to preserve and create valuable resources that can be shared in society and to strengthen global competitiveness.

DEPARTMENT OF PHYSICS

The Department of Physics, launched in 1984, aims to develop fundamental capabilities for physicists through basic subjects and related experimental subjects, and to build up creative applications so that knowledge of physics can be applied to new fields, as required by industry or academia. Based on this perspective, the department offers BS, MS, PhD, and MS/PhD combined degrees in undergraduate and graduate program. Many undergraduate students are supported by scholarships through various funding programs. Graduate students are fully supported by Brain Korea 21 Plus (BK21+) and through teaching and research assistantships.

Fig. 2: Woncheon Hall and Energy Center in Ajou.

Faculty members in the department, consisting of 14 professors, actively carry out research and education specialized in optics and condensed matter physics. These two fields are most closely related to the display, semiconductor, and energy-related industries. Through the intensive courses of our major, the department trains and produce customized human resources into society. In addition, the faculty members in the department have the great fortune to be able to work together synergistically; consequently, as a research group, they are able maintain competitiveness in relation to the size of the department. The department also participates in large-scale projects such as BK21+; the "Human Resources Program in Energy Technology" of the Korea Institute of Energy Technology Evaluation and Planning; and the "Gyeoggi Regional Research Centers" of Gyeonggi Province. Most laboratories in the department are located in the Woncheon Hall and Energy Center at Ajou University.

RESEARCH AREAS

Optics Group

There are seven faculty members in the optics group. Their individual research interests are briefly described below.

In Sang Youl Kim and Sung Hyuck An's laboratory, they measure the polarizing conditions of light that change by reflecting or penetrating light to samples with thin film structures, using ellipsometry, and interpret the structure, properties, and heterogeneity of the specimens to improve understanding of those specimens. Because spectroscopic ellipsometry uses light of multiple wavelengths and therefore has very wide coverage, it can also deal with specimens of multi-layer thin film structures. In addition to the group's own research, the laboratory conducts studies of both the structure of various thin film materials and material analysis studies at the request of domestic and foreign laboratories and schools. Recently, it has been able to accurately measure ultrafine optical heterogeneity by producing, in cooperation with the company ElipsoTech, a transmissive polarometer,. and to present criteria for assessing the possible defects of optical films used in the LCD manufacturing process.

In the Kihong Kim's laboratory, the main research topic is how spatial and temporal non-uniformity of a medium affects the propagation characteristics of waves. The goal is to find a new wave phenomenon through theoretical studies of various situations. There is great interest in the Anderson localization phenomenon that occurs when spatial asymmetry is chaotic, and there is also much interest in the phenomenon where different kinds of waves are interconnected and converted due to non-uniformity. Surface wave phenomena and various nonlinear wave propagation phenomena are also the main subjects of the study. Applications include linear and nonlinear minerals and photons, electronic transport phenomena in Dirac materials, wave transformations and energy transformations in the earth and sun's atmosphere, and energy propagation in oceanic waves, such as tsunamis.

Dong-Il Yeom's research group develops advanced fiber laser systems and related nano-photonic devices based on low-dimensional materials, such as CNTs, graphene and other 2D materials. Their research includes the development of high-performance fiber lasers through the spatial and temporal mode control of lasers and the development of optoelectronic and nonlinear optic devices using low-dimensional materials. The group's work aims at providing applications for the military; for the laser industry, as directed; and for next-generation optical communications.

Na Young Ha's research focuses on the implementation of new functionalities and efficiency enhancements in organic, inorganic, and hybrid photonic devices with nanostructured materials. Solution-processed organic, inorganic, and hybrid materials can be a low-cost alternative for conventional photonic devices with enhanced functionalities for conventional photonic devices because of easy fabrication, simple manufacturing steps, and the possibility of mass-production. We design, fabricate, and characterize organic and hybrid photonic devices such as lasers, photovoltaics, and light-emitting diodes with liquid crystals, organic/hybrid semiconductors, and carbon quantum dots.

Sunghwan Kim's research goal is to break down the boundaries between physics and biology. Nanoscale properties of biological materials have become more and more important to understand and control biological phenomena. We believe that our expertise, in studies regarding the interaction of quanta and biological materials in nanoscale, will provide useful and unprecedented ways to understand the nano-bio interface.

Jae-Ung Lee's research is focused on the synthesis and optical characterization of atomically thin two-dimensional materials. He has been working on the growth of wafer-scale two-dimensional transition metal dichalcogenides by using metal-organic chemical vapor depositions and the development of new optical characterization methods based on Raman spectroscopy. He is interested in building new structures based on two-dimensional materials and their emerging optical phenomena.

Condensed Matter Physics Group

Seven faculty members are involved in both experimental and theoretical studies covering most of the central topics of condensed matter physics.

In Youngtae Kim's laboratory, the characteristics of various dynamic systems using nonlinear dynamics and chaos theory are investigated through computer simulations and experiments. The lab is also carrying out a study on neuroscience that explores the function and operation of the brain, the greatest mystery of the 21st century. The main research topics are modeling and bifurcation analysis of nonlinear dynamics, measurement and analysis of dynamic characteristics of nonlinear electronic circuits and biometric systems, and signal analysis using nonlinear dynamics and chaos in the nonlinear kinetics. In neuroscience research, Yongtae Kim focuses on dynamic characteristics analysis of single neuron and neuron networks, and modeling and analyzing diseases (Parkinson's disease, epilepsy).

SoonIl Lee's laboratory specializes in fabricating thin films using low-dimensional materials such as carbon nanotubes, graphene, silver nanowires, and applying them in various fields, while analyzing the characteristics of the fabricated films. In particular, we combined them with opto-electronic devices such as solar cells and light emitting diodes so that we could research the field of flexible or semi-transparent opto-electronic devices. Moreover, we analyzed electrical and optical characteristics of the fabricated devices to improve their performance.

Ji-Yong Park's laboratory works on nanomaterials and nanodevices. Park's group is interested in understanding properties of nanomaterials and utilizing them for functional devices for electronics and optoelectronics applications. With nanoscale characterizations using scanning probe microscopy, Park's group tries to elucidate how the operation of nanodevices are correlated with the local electrical properties.

The Nanoelectronic Functional Materials Laboratory, led by Sang Woon Lee, aims to explore new materials using atomic layer deposition (ALD). Lee's group focuses on material properties of insulator/semiconductor/metal thin-films for electronic applications such as memories and logic transistors. In addition, Lee's research group is developing low dimensional materials, such as a two-dimensional electron gas in oxides heterojunction, for the applications in thin film transistors, memories, and sensors.

Jieun Lee's research focuses on the electronic and optical properties of two-dimensional materials, including gra-

phene, transition metal dichalcogenides and hexagonal boron nitride. Incorporating various optical spectroscopies, she explores emerging phenomena in these materials such as the spin/valley Hall effect, the Berry curvature effect and magnetoelectricity. She is also interested in quantum phenomena utilizing atomic defects in two-dimensional materials.

Hosung Seo's group (Computational Quantum Materials Lab.) uses theoretical and computational methods to understand and design quantum materials from first principles. The main focus of the research group is on solid-state materials platforms for quantum technologies such as quantum computation and quantum sensing. In particular, the group investigates the fundamental properties and applications of color-center-based quantum bits in solids such as diamond nitrogen-vacancy centers. The group plays an active role in understanding the decoherence dynamics of quantum spins in solids and is searching for new quantum bits in solid-state materials, in order to broaden the scope of materials platforms in solid-state quantum technology.

Acknowledgements: All of the faculty members in the department contributed to this article. Pictures were provided from communications team of the Office of External Affairs at Ajou University.

Na Young Ha is a professor and the head of the physics department at Ajou University. She received a PhD in physics from Ewha Womans University in 2005. She worked as a postdoctoral researcher in physics and astronomy at the University of Pennsylvania, USA and in organic and polymeric materials at Tokyo Institute of Technology, Japan. She joined the faculty of Ajou University in 2008. Her research field is photonic properties and applications of organic materials.