# AKC 2024

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**Beyond borders: Shaping the innovative Future Together**

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# Abstract Book

KSEACH
재중한인과학기술자협회

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## Contents

# Keynote

Keynote 1

## From Organoid Genetics to Mosaic Genetics

**Dr. Bon-Kyoung Koo**

Institute for Basic Science (IBS) Center for Genome Engineering, South Korea

One of the most remarkable strides in the field of stem cell research pertains to the discovery of the exceptional capacity for self-organization during the differentiation of stem cells in controlled laboratory environments. The utilization of organoids derived from human pluripotent stem cells (hiPSCs) or primary tissues holds tremendous promise in elucidating the intricate mechanisms underlying the development of the human nervous system, and its distinct characteristics, and comprehending the genesis, progression, and therapeutic strategies for nervous system disorders. These advancements have proven particularly invaluable in the field of neuroscience, where the limited accessibility to functional brain tissue necessitates the exploration, manipulation, and probing of human neurons and glial cells derived from individuals to unravel the intricate biology underpinning nervous system development and pathologies. Furthermore, we will present a range of instances that demonstrate the application of CRISPR technology and organoid models for neuroscience studies, containing concurrent knockout of paralogues, functional genetic screening, and precise gene correction, thereby highlighting the versatility and utility of these approaches.

Keynote 2

## The Cryogenic Phase Change Memory

**Prof. HongSik Jeong**

Graduate School of Semiconductor Materials and Devices Engineering, Department of Materials Science and Engineering, Ulsan National Institute of Science and Technology (UNIST), South Korea

Cryogenic electronic devices are in demand for quantum computing and spacecraft applications, leading to active research. Phase change memory (PCM) is a promising non-volatile memory with tunable conductivity for such storage systems. However, PCM has had a deficient understanding of switching mechanisms at extremely low temperatures for decades, which separates the device from such cryogenic storage technologies. A study on electro-thermal interactions under a wide range of temperatures should be conducted to assess the possibility of PCM compatibility with cryogenic device circuits. Here we examine the compatibility of prototypical chalcogenide Ge2Sb2Te5 for a cryogenic memory through its stable operations covering conventional performance metrics down to 4 K, controlling the direct contribution of ambient temperature to the carrier transport. In addition to the static performance of an increased $10^6$ on/off ratio thanks to the restraining of the thermally excited carrier for the off-state, instantaneous time-dependent analysis deconvolves the speed-power intricacy behind the diverse gap-states. The ambient temperature and the subthreshold slope as counterparts are the driving forces of threshold switching mechanisms that determine the carrier occupation of the gap states, suggesting the strategy for energy-efficient cryogenic devices based on the Ovonic threshold.

Keynote 3

## Asia-Pacific Infectious Disease Shield 2.0

**Prof. Choong-Min Ryu**

Korea Research Institute of Bioscience and Biotechnology (KRIBB), South Korea

GloPID-R brings together funders investing in research related to new or re-emerging infectious diseases around world. The aim is to increase preparedness and speed up the research response to outbreaks with pandemic potential. However, no regional hub was existed since Asia-Pacific regional hub launched by GloPID-R Korea at 2022. As a member of GloPID-R, GloPID-R Korea proposed “Asia-Pacific Regional Hub” in 2021. Korea Research Institute of Bioscience and Biotechnology (KRIBB) that serves as the headquarter of GloPID-R Asia-Pacific Regional Hub proposed and obtained a grant titled ‘Asia-Pacific Infectious Disease Shield (APIS)’ from the Ministry of Science and ICT of South Korea for developing and facilitating regional hub initiative. The APIS aims 1) to listen to real voices of LMICs in Asia-Pacific region, 2) to fill the gaps and Find priorities of infectious disease R & D and preparedness, and 3) to develop actionable and sustainable solutions for the next outbreak though Asia-Pacific network. In this presentation, we will provide our plan and preparation for APIS 2.0. Our vision is to establish the sustainable Asia-Pacific network of infectious disease preparedness for rapid and systematic response to combat infectious diseases in local site and whole continent level.

Keynote 4

## End-of-Life Electric Vehicle Battery Remanufacturing Enabled by Human-Robot Collaboration

**Prof. Weidong Li**

University of Shanghai for Science and Technology, China

Disassembly is a critical step in the remanufacturing of end-of-life products. It has traditionally been performed by either humans or robots. However, challenges such as high labor costs of humans and the limited ability of robots to perform intricate disassembly tasks have led to the increasing use of human–robot collaboration (HRC) for disassembly. In this keynote, some key enabling technologies of human–robot collaboration (HRC) for disassembly will be discussed. The application of HRC for disassembling end-of-life lithium-ion batteries will be briefly summarized.

Keynote 5

## Future of Aging

**Prof. Jihong Jeung**

Future Lab, Tsinghua University, China

The aging of the world's population presents a new challenge for humankind. When defining older individuals, we should consider not only their age but also their health and functional status. There is active research on human augmentation to improve sensory, cognitive, and motor abilities affected by aging and disabilities. This presentation aims to explore the effects of aging and discuss cases of augmentation related to aging.

## Tech 1-1. Innovation in Health and Disease A: Trends in Biology

**Chair: Prof. Hoseok Lee** (Kyung Hee University, South Korea)

Tech 1-1(1)

# Membrane Proteins Unveiled: 3D Structures Illuminating Cellular Mechanisms and Advancing Molecular Biology

**Dr. Ji-Hye Yun**

Institute for Basic Science (IBS) Center for Genome Engineering, South Korea

Membrane proteins stand as pivotal players in essential signaling pathways, mediating signal transduction both within and between cells, and orchestrating their physiological and pathological functions. Like conductors of an intricate biological orchestra, these proteins fine-tune the delicate symphony of life processes. Consequently, a comprehensive understanding of the structure, function, and mechanism of action of membrane proteins is the critical key to unraveling the mysteries of cellular signaling systems and advancing our knowledge and treatment of associated disorders.Recent revolutionary advances in scientific technology have been instrumental in unveiling the secrets of these complex molecules. Innovative methodologies such as lipidic cubic phase (LCP) crystallization and X-ray free-electron laser (XFEL) have emerged, opening new frontiers in membrane protein structure determination. Particularly noteworthy is the cryo-electron microscopy (cryo-EM) technique, which acts as a molecular-level camera, capturing membrane proteins in their native state. These cutting-edge technologies have contributed significantly to the high-resolution elucidation of membrane protein three-dimensional structures. This is akin to mapping the molecular world, enabling researchers to gain deeper insights into protein function and identify potential therapeutic targets. It's like piecing together an intricate puzzle, gradually completing the bigger picture of life sciences. The ongoing study of membrane protein structures holds immense promise for the future of medicine. It goes beyond satisfying scientific curiosity, laying the foundation for the development of innovative therapeutics. We stand on the threshold of an era of molecular-level precision medicine, and membrane protein research is poised to be the golden key that unlocks this new age. As we continue to decode the intricate language of membrane proteins, we edge closer to revolutionary breakthroughs in understanding cellular communication and disease mechanisms. This knowledge not only expands our comprehension of life at its most fundamental level but also paves the way for targeted therapies and personalized medicine approaches. Indeed, the study of membrane proteins is not just a scientific endeavor; it's a gateway to transforming human health and well-being in the 21st century and beyond.

Tech 1-1(2)

# Decoding early tumorigenesis: unveiling oncogenic drivers in the liver with mosaic mouse models

**Dr. Sujin Park**

Institute for Basic Science (IBS) Center for Genome Engineering, South Korea

The liver, as the primary and largest metabolic organ, significantly contributes to cancer-related mortality largely due to delayed diagnosis and poor prognosis. To improve the precision targeting of liver cancer and fatal liver diseases, we employed the Red2Onco to introduce well known oncogenes (KRAS and PI3K mutations) into the liver. This sophisticated approach in mouse genetic engineering enables the real-time monitoring of both oncogenic cells and neighboring wild-type (WT) cells from the initiation phase, thereby shedding light on the earliest mechanisms of tumorigenesis. Our finding revealed that PI3K mutant cells initiate accumulation of lipid droplets, subsequently followed by the surrounding WT cells over time, leading to hepatic steatosis. Notably, PI3K mutant cells did not exhibit nodular growth. Conversely, KRAS mutant cells showed clonal proliferation, finally resulting in the development of tumors in mice. Building upon these observations, we further characterized and delineated the distinct roles of these mutations in hepatocarcinogenesis, particularly in the context of a lipid-enriched liver microenvironment.

Moreover, we employed hepatic organoid models derived from R2KRAS and R2PI3K mouse lines to recapitulate the phenotypic and molecular signatures observed in vivo. In parallel, we investigated the upstream regulators of KRAS and PI3K signaling, namely receptor tyrosine kinases (RTKs), which are frequently overexpressed or mutated in hepatocellular carcinoma (HCC). By elucidating the interplay between lipid metabolism and oncogenic signaling pathways in liver cancer, our study provides novel insights into the molecular drivers of HCC and highlights potential avenues for targeted therapies, particularly in patients with concurrent fatty liver disease and oncogenic mutations or RTK activation.

Tech 1-1(3)

# Integrating Genetics and Bioinformatics to Enhance Biodiversity Research at the Center for Genome Engineering

**Dr. Heetak Lee**

Institute for Basic Science (IBS) Center for Genome Engineering, South Korea

The goal of biology is to understand the mechanisms of life. Traditionally, research has focused on a few model organisms using tools like whole organisms, cell lines, and organoids to study processes such as cell differentiation, gene expression, and enzymatic functions. However, these models represent only a small fraction of biological diversity. Many species exhibit unique traits, some conserved across lineages and others novel, making it essential to include a broader range of species in research for a comprehensive understanding of life's principles. This talk highlights biodiversity research at the Center for Genome Engineering (CGE) within the Institute for Basic Science (IBS), emphasizing the integration of non-traditional model organisms into biological studies to advance our knowledge of genetics, cell biology, and evolution. Firstly, we have developed the short conditional intron (SCON) cassette to create conditional transgenic animals. The SCON cassette, introduced between exons, significantly reduces target gene expression upon activation. We have explored its application in approximately 170 mammals and 80 fish species and provide a web service for this information. After initial use in mice, we propose extending its application to zebrafish and human iPSCs, demonstrating its versatility across species. Secondly, researching multiple species is challenging, particularly when breeding facilities are lacking. This issue is significant in studies of regeneration and aging, related to stem cells. Organoids offer a solution due to their ease of production and utility. At CGE, we have generated organoids from intestinal stem cells of around 20 species and conducted single-cell transcriptome analyses. We identified adult and revival stem cells in most species and revealed that functions and gene expressions in specific signaling pathways are conserved, though some genes showed species-specific differences. Finally, in collaboration with BGI Genomics and Chungnam National University, we are conducting a metagenomic analysis to identify novel Cas proteins. This project involves analyzing 270 terabases of data from deep-sea and ruminant bacteria, using a specialized pipeline for Cas protein identification. We are also collaborating with experts in structural biology and genome editing to evaluate the characteristics and functions of these new proteins.

Tech 1-1(4)

## Exploring liver disease research using mouse models

**Prof. Eun Jeong Kim**

Department of Biology, College of Natural Sciences,
Kyungpook National University, South Korea

Animal models play a vital role in enhancing our understanding of human disease processes, allowing researchers to pinpoint therapeutic targets and evaluate new medications. There is a diverse range of animal models for liver disease, each with differing levels of efficacy, which affects our understanding of the disease and the effective evaluation of therapeutic agents. Here, I present a detailed summary of the most commonly used experimental models of chronic liver disease, beginning with the early stages of fatty liver disease (both non-alcoholic and alcoholic) and progressing through steatohepatitis, advanced cirrhosis, and end-stage primary liver cancer.

Tech 1-1(5)

# Identifying mechanically triggered settling mechanism of the Pyropia yezoensis's carpospores

**Dr. Sinyang Kim**

Institute for Basic Science (IBS) Center for Genome Engineering, South Korea

Increased marine pollution and climate change have destroyed kelp forests, vital for marine juveniles and carbon sequestration. Many countries attempt artificial kelp forest restoration, but success is limited due to a lack of understanding of macroalgae germination and growth. This study aims to enhance restoration techniques by investigating molecular mechanisms of macroalgal spore settlement to enhance the settling and growth rate of the macroalgal spores. We focused on how spores settle and germinate, triggered by mechanical stimuli from substrates. We discovered that mechanotransduction is initiated through mechanosensing membrane calcium channels, increasing cytosolic calcium in response to substrate contact. This increase in calcium, along with reactive oxygen species (ROS), plays a role in settlement. Transcriptome analysis revealed high differential expression of fasciclin and extradiol reductase proteins, indicating their potential role in permanent settlement. Future experiments, including knockout assays, aim to confirm the roles of these candidate substances in spore settlement.

## Tech 1-2. Clean Energy A: Hydrogen & Carbon Neutrality

**Chair: Prof. Jung-Sik Kim** (Beihang University, China)

Tech 1-2(1)

# Metal-CO2 system

**Prof. GunTae Kim**

Shanghai Institute of Applied Physics, Chinese Academy of Science, China

tbd

Tech 1-2(2)

# Coupling analysis of SOEC and waste biomass resource utilization: A conceptual framework

**Prof. Han Ling**

Peking University, China

Hydrogen is a leading energy career which is regarded as “future fuel” for couple of decades under the carbon neutrality strategy. Furthermore, hydrogen can be considered multi-functional by being implemented into various applications. Also the manufacturing of green hydrogen is a complex process that is related to many industrial processes and resources such as the using of solar or wind power. The main drawbacks of SOEC that constrain further development is high specific cost and lower lifetime comparing with ALK and PEM. Considering the diversity and multi-scale of various supply chains from production to application of green hydrogen, multi-factor optimization may help to reduce its cost while enhancing the environmental and economic benefits. This study established a conceptual framework to analyze the coupling methods and benefit of green hydrogen and waste biomass energy utilization from the perspective of industrial ecosystem, then conducted a case study in Henan Province. Also the business model of green hydrogen industry such as vertical integration, technological innovation, and globalization is discussed.

Tech 1-2(3)

# Symmetrical solid oxide cells

**Prof. Bingbing Niu**

University of Science and Technology Liaoning, China

tbd

Tech 1-2(4)

# Rechargable battery technologies for boosting carbon neutrality

**Prof. Yao Liu**

University of Science and Technology Liaoning, China

tbd

Tech 1-2(5)

## H2 gas sensors: its scientific foundations, IP & commercialisation

**Prof. Jung-Sik Kim**

Beihang University, China

In high temperature SOFCs (Solid Oxide Fuel Cells), the performance of the cell can be altered by the variation in the temperature distribution throughout the cell/stack. Conventional thermocouples can provide limited information depending its location in the system. The investigation utilized own developed a multi-junction thermal array (MCTA) sensor to read out the true temperature of the SOFCs whilst working. In this work, the sensitivity of MCTA sensor is assessed. It is directly attached to the cathode surface of the anode-supported SOFC to monitor the temperature of the electrode during temperature ramping, OCV changes during anode reduction. MCTA sensor based readings reveals an area-selected reduction process as well as the effects of direct oxidation on cell's local temperature.

Beyond this point to exploit the sensor attached SOC, developed an electrochemical fuel cell based sensor for monitoring of gas contents such as hydrogen, in a hydrogen-natural (H2/NG) gas mixture to determine the calorific value of the H2/NG mixture. This device traces the hydrogen content within the (predominantly methane) stream, and provides an output current reading which correlates to the level of hydrogen in the stream. Present systems for inspecting gas composition to a necessary accuracy (eg. chromatography) are expensive due to their complexity and are not suitable for use in the field, which impedes their wider adoption. Kim and his group are looking to demonstrate an economical, robust and compact sensing platform which consists of H2 sensing and temperature sensing that can be deployed in point-of-use environments.

## Tech 1-3. Future Computing A: Quantum Information Technology

**Chair: Prof. Kihwan Kim** (Tsinghua University, China)

Tech 1-3(1)

# Quantum Information Research in KIST

**Dr. Yong-Su Kim**

KIST, South Korea

Quantum information science harnesses the fundamental principles of quantum mechanics to revolutionize computing, communication, and sensing. This paradigm shift promises unprecedented computational power, unbreakable encryption, and ultra-sensitive measurement capabilities, making it a frontier of scientific and technological advancement.

This presentation outlines KIST's (Korea Institute of Science and Technology) comprehensive approach to quantum technology research and development, aligning with Korea's vision to become a global leader in the quantum information field. KIST's strategy encompasses quantum core technology, quantum engineering, and quantum utility & services, focusing on three primary areas: quantum computing, quantum communications, and quantum sensing. Our core expertise lies in quantum optics and defects in solid systems, forming the foundation of our research efforts. The institute's cutting-edge research spans a wide range of quantum technologies, including room-temperature quantum computing systems, advanced quantum key distribution networks, and compact quantum sensing platforms. These developments are supported by state-of-the-art infrastructure and a collaborative ecosystem involving international partners and domestic industry.

As an "open research group," KIST is at the forefront of pushing the boundaries of quantum information science, contributing significantly to Korea's quantum information vision and the global quantum revolution. We are actively seeking and open to new collaborations with academic institutions, industry partners, and research organizations worldwide to further advance the field of quantum information and its practical applications.

Tech 1-3(2)

## Quantum engineering with atoms and light

**Prof. Gyu-Boong Jo**

HKUST, Hongkong

tbd

Tech 1-3(3)

# Room temperature single photon sources

**Dr. Sejeong Kim**

University of Melberen, Australia

tbd

Tech 1-3(4)

## Optical metasurfaces for quantum applications

**Prof. Dukyong Choi**

Australia National University, Australia

Optical metasurfaces, composed of two-dimensional (2D) or quasi-2D arrays of dielectric or metallic sub-wavelength-sized meta-atoms, provide a compact and innovative platform for controlling the polarization, phase, and amplitude of light. Over the past decade, they have been explored to design various functional optical devices, including metasurface lenses, holograms, and nonlinear sources. Owing to a significant potential for the miniaturization of bulky quantum optical elements, the metasurfaces research for quantum applications has been surged recently. This talk will briefly introduce the materials, fabrication, and applications of optical metasurfaces in quantum photonics, focusing on the generation, manipulation, and detection of quantum light. By developing on-chip quantum systems, meta-optics can advance various quantum technology applications.

Tech 1-3(5)

## Quantum optical approaches to quantum magnetism

**Prof. Myungjoong Hwang**

Duke-Kunshan University, China

tbd

Tech 1-3(6)

## Quantum Information Engine

**Prof. Kihwan Kim**

Tsinghua University, China

tbd

## Tech 2-1.

## - Sustainable Environment A: Agriculture and Environmental Health

## - Innovation in Health and Disease A: Trends in Biology II

**Chair: Prof. Jason Sewoong Lee** (The University of Queensland, Australia)

Tech 2-1(1)

## Development of sustainable and edible coating from fruit waste

**Prof. Michelle Ji Yeon Yoo**

Auckland University of Technology, New Zealand

A significant amount of peel waste is generated from fruit and vegetables, from household kitchens to food industry. They contain pectin, cellulose and bioactive compounds (eg. carotenoids and anthocyanins) which can be utilised to produce edible coating. Recent research has shown its use as a possible alternative to plastics to enhance sustainability in food packaging. In this study, edible coatings containing fruit peel-based pectin and cellulose nanocrystals were developed and characterised to establish their effectiveness as support matrices. Commonly consumed fruit such as orange, banana and kiwifruit were used in this study. Using hot acid extraction, pectin and cellulose were extracted. These were further purified and mixed with glycerol as a plasticiser. The coatings had relatively transparent colour resembling the fruit they originated from. Analysis by Fourier Transform Infrared Spectroscopy confirmed the presence of hydroxyl, carbonyl, alkyl groups, validating the successful extraction and integration of pectin and cellulose into the coating. Orange coating had the highest tensile strength (4.90± 0.10 N/mm²), whereas the highest stiffness (Young's modulus of 6.19± 0.00 MPa) was observed from banana coating. Analysis of water contact angle measurements exhibited enhanced hydrophobicity (51.83±0.29° to 55.34±0.57°), demonstrating their effective moisture barrier properties.

Antimicrobial activity from banana coating demonstrated enhanced antimicrobial activity against Salmonella enteritidis and Escherichia coli. The cellulose nanocrystals -pectin coatings provided excellent UV protection, especially at lower wavelengths (200–240 nm), when compared to aluminium foil. The results confirm the potential of using fruit peel-derived pectin and cellulose nanocrystals in developing sustainable, effective edible coatings. Edible coatings from fruit peels can be used to address environmental issues and have antioxidant and antimicrobial benefits arising from the naturally present bioactive compounds.

Tech 2-1(2)

# Analysis of metabolome from an environmental indicator species as an indicator to water quality disruption

**Prof. Tae-Yong Jeong**

Hankuk University of Foreign Studies, South Korea

Metabolomic dysregulation has been studied in aquatic organisms for better understanding and indicating aquatic toxicity and pollution. From my studies, mass-spectrometry based metabolomics has been applied to analyze the metabolome extracted from indicator species and the measurements help understanding deeper mechanistic insights and discover sensitive molecular indicators for the adverse effects of interest. This study reviews several case studies from my group measuring the metabolomic dysregulation by using liquid-chromatography mass-spectrometry in both targeted and non-targeted approaches. The cases studies are focusing on quicker and sensitive indicator development for aquatic toxicity prediction. Those are partly providing information related to mode-of-actions according to the annotation of dysregulated metabolites. Ambient variance was compared with sub-lethal exposures to pollutants. Additionally, predictability from acute to chronic exposures was tested based on metabolomic observations. Applications to emerging approaches will be also introduced, including the read-across between multiple pollutants and non-destructive pollution indication. Finally, it will be implicated that the results from the case studies have proven that metabolomic analysis tool has a potential for discovering early and informative indicator to aquatic toxicity; at the same time, there are many challenges to overcome, from limitations in model organism physiology, sample preparation, and instrumental analysis.

Tech 2-1(3)

# A gastrointestinal parasite infection model for chronic stress in livestock and its impact on meat quality

**Prof. Hannah Lee**

Lincoln University, New Zealand

Livestock stressors are known to have an impact on both animal welfare and meat quality. As a model of acute stress, we have previously demonstrated the impact of pre-slaughter simulated mustering on several important meat quality markers in lamb, including high pH [1, 2]. To examine a chronic stressor in livestock, we have adapted a model of a sub-clinical infection with gastrointestinal nematode(GIN) parasite infection in sheep. Six month old ram lambs were challenged with a mixed infection of Trichostrongylus colubriformis and Teladorsagia circumcincta (Treatment group, n=6), which are common gastrointestinal parasites frequently encountered in pasture, and compared with those without parasites (Control, n=6) (AEC2023-71). The goal is to understand how parasite infection can impact on inflammatory response as a proxy for animal welfare, along with determining if parasite infection has an impact on meat quality markers. We will also use an emerging metabolomics method, rapid evaporative ionisation mass spectrometry, to provide complementary analytical information on changes to organ and meat metabolite and lipid composition. This data will contribute towards defining and designing further investigations on chronic stressors in livestock. In future, characterised biomarkers of stressors could be used for enhancing animal welfare and confirm the relationship between minimising pre-slaughter stressors and improving the consistency of meat quality.

[1] Lee, Y.-Y. H., Ross, A.B., Jayawardena, R., Ham, E., Bentley, K.-A., Tsai, A., Taukiri, K., Maes, E., Clerens, S., Morton, J.D. (2022). The effect of farmyard stress on meat quality: a model enabling the search for predictive biomarkers of meat pH. In Proceedings 68th International Congress of Meat Science and Technology (pp. 200), 22-25 August 2022, Kobe, Japan.

[2] Ross, A.B., Lee, Y.-Y. H., Mou, D., Maes, E., Clerens, S., & Morton, J.D. (2022). Prediction of 24h pH and lamb meat quality parameters in different muscle fibre types using rapid evaporative ionisation mass spectrometry. In Proceedings 68th International Congress of Meat Science and Technology (pp. 257), 22-25 August 2022, Kobe, Japan.

Tech 2-1(4)

## Integrating epigenetic, metabolic and transcriptional changes associated with immunotherapy response

**Prof. Jason Lee**

The University of Queensland, Australia

The immune checkpoint blockade (ICB) therapy has achieved a remarkable clinical benefits in patients with different malignancies by boosting the power of host immunity in cancer cell elimination. However, they are effective only in distinct patient subsets or result in the emergence of drug resistance due to a special differentiation state known as T-cell exhaustion. Therefore, the molecular mechanisms of resistance to ICB therapy need to be further investigated to design the potential combination strategies of immunotherapy. Exhausted T-cells undergo metabolic insufficiency with altered signaling cascades, and epigenetic landscapes, which dampen effector immunity and cause poor responsiveness to ICB therapies. How epigenetic and metabolic changes affect T-cell exhaustion remains unclear. We have identified through the analysis of the TCGA dataset that more than half of melanomas (cutaneous, uveal and acral subtypes) overexpress several epigenetic modulators such as EHMT2, BRD2 and SIRT5. This overexpression leads to immunosuppression, and are novel targets that can be inhibited to improve outcomes for melanoma patients by boosting ICB response. We demonstrate that inhibition of EHMT2 leads to a significant cell death in melanoma cell lines (cutaneous, uveal and acral subtypes), but not in normal melanocyte in vitro. In vivo studies revealed that EHMT2 inhibition led to a dramatic reduction in tumor growth, while boosting the efficacy of the ICB therapy in an anti-PD1-refractory tumour model in vivo. We found a strong inverse correlation between the transcript level of epigenetic modifiers (EHMT2, BRD2 and SIRT5) and the T-cell gene signature, suggesting the potential of reinvigorating T-cells by inhibiting these epigenetic modulators. These data provide a compelling evidence that epigenetic modifiers act as barrier to immune cell function, and efficiently targeted to boost anti-tumour T-cell function in improving melanoma patient outcomes.

Tech 2-1(5)

# Development of an open-source and automated Nextflow pipeline for PhIPSeq analysis

**Dr. Preston Leung**

UNSW Sydney, Australia

Advances in sequencing technology such as Phage Immuno-Precipitate Sequencing (PhIPSeq) has provided the opportunity to investigate historical infections by identifying which viruses are recognised by the host immune response from a given library of viruses (termed the virome library). Several bioinformatics tools have been developed to support PhIPSeq and subsequent data analyses, e.g, Build Phage ImmunoPrecipitation Sequencing library (BIPS), Phippery and AntiViral Antibody Response Deconvolution Algorithm (AVARDA). However, these tools remain isolated from each other and integrating them to provide a streamlined and easy-to-understand output is non-trivial. Our project aims to build on VirScan, an approach that uses PhIPSeq to detect viruses and identify key species for downstream analyses (e.g. association testing for outcomes or identifying potential immunogenic peptides). Briefly, BIPS takes in a list of protein sequences and generates an oligonucleotide library for synthesis that is compatible with PhIPSeq. Phippery takes PhIPSeq output and calculates whether sequenced reads are significantly above background to be categorised as hits. Finally, AVARDA considers cross reactivity on sequence hits that potentially occurs between viruses with high genomic similarity. Using an exhaustive pairwise comparison approach, AVARDA calculates whether the combination of sequenced reads is sufficient to suggest infection by a specific species. Here, we adapt all three tools into WookFlow, a Nextflow pipeline with the goals to reduce the complexity of running software separately, optimise the runtime to increase the efficiency of PhIPSeq analyses and allow for expansion beyond viruses into the open-source pipeline.

## Tech 2-2. Future Computing B: AI applications

**Chair: Prof. Myunggeun Chun** (Chungbuk National University, South Korea)

Tech 2-2(1)

# Security requirement for AI based speaker recognition systems

**Prof. Myunggeun Chun**

Chungbuk National University, South Korea

This paper addresses speaker recognition systems and telebiometric authentication models using the technologies of AI based speaker recognition. Speaker recognition technologies has been considered for telebiometric authentication, which integrates speech over the telecommunications and biometric systems. Neural network-based speaker recognition refers to using neural network to create a mathematical representation of a speaker's unique vocal characteristics.

Here, the output of neural networks for a speaker becomes a unique vector which can be used for speaker verification or speaker identification. For this, the neural networks process raw audio signals or features extracted from these signals, such as Mel-frequency cepstral coefficients (MFCCs) or spectrograms. Convolutional neural network (CNN), which are used for audio represented in 2-dimensional forms like spectrograms, and recurrent neural networks (RNNs), which are effective at capturing temporal pattern in speech, have been adopted. The neural network is trained on a large database of speech samples from many speakers, learning to classify speakers or minimizing distances between embedding of same speaker. After training, the neural network produces predefined fixed size vectors that represent a speaker's unique vocal characteristics from a speech segment. on score of representing the matching between an enrolled speaker's GMM and the probe speaker's voice. In verification, the output vector of the trained neural network for a probe speaker's audio is compared to the registered vector for the claimed speaker using similarity metrics and to make a decision for authentication. This paper provides functional requirements for each subsystem comprising this AI based speaker recognition system. And several architectures for implementing telebiometric speaker authentication are described, including the case of integrating with voice assistant devices. This paper identifies threats and vulnerabilities at each step of the telebiometric speaker authentication system, including speech presentation, feature extraction, comparison, and decision-making. And it also provides countermeasures for the identified threats at each step of the telebiometric authentication.

Tech 2-2(2)

# The Rise of Edge Computing and IoT

**Dr. Young Choon Lee**

Macquarie University, Australia

Contemporary society heavily relies on ICT (information and communication technology) services, ranging from email and social networking to banking, manufacturing, safety, and security. The infrastructure for these services comprises three computing platforms across different network layers, cloud data centres, edge computing platforms and edge devices including Internet of Things (IoT). While edge computing addresses current data processing demands, this hierarchical model faces challenges with the explosive growth of real-time and location-aware data processing requirements. The disjointed use of these platforms overlooks the potential for collaborative use, especially considering increasingly capable edge devices as computing resources. Collaborative computing among these heterogeneous platforms is crucial to improve resource efficiency and enable emerging real-time applications like self-driving cars, drone surveillance, augmented reality (AR), and smart manufacturing. The potential impact of collaborative computing on resource efficiency is significant. With thousands of cloud data centres housing numerous servers and billions of edge devices generating zettabytes of data annually, even small improvements in resource utilisation can lead to substantial reductions in resource provisioning and e-waste, enhancing ICT sustainability. Additionally, reducing bandwidth consumption and latency in data transfer is crucial for sustainable real-time and location-aware data analytics. The main challenge in collaborative computing is overcoming the heterogeneity in capability, capacity, and connectivity among cloud data centres, edge computing platforms, and edge devices. This research aims to address these heterogeneity sources by transforming them into complementary characteristics. A concrete example of this approach is our recent work on distributed edge-based video analytics. This showcases how collaborative computing can leverage the strengths of each platform to create more efficient and effective solutions for data processing and analysis.

Tech 2-2(3)

# Optimized Machine Learning Model for Predicting Steel Corrosion in Reinforced Concrete by Electrical Resistivity Measurement Me

**Dr. Kevin Paolo Robles**

Dong-A University, South Korea

The objective of this research is to use Electrical Resistivity (ER), a non-destructive evaluation technique for concrete durability evaluation, together with different reinforced concrete parameters as determining variables in predicting steel mass loss (mL) of concrete specimens by employing multi-variate non-linear regression (MVR) analysis and machine learning algorithms such as Gaussian Process Regression (GPR), Support Vector Machine (SVM) and neural network. This study used 189 reinforced concrete cubes with different design strength (σ), rebar diameter (Φ) and clear cover (cc) exposed to different accelerated corrosion levels. Experimental data showed that the relationship between the ER and mass loss presented a decreasing trend and are affected the parameters mentioned. Through an MVR analysis, it can be concluded that the coefficient of determination (R2) increases if we supplement ER with Φ, cc, and σ as input variables. Moreover, incorporating concrete crack data resulted to higher coefficient of variations. In the comparison of different machine learning algorithms for the mL prediction, GPR has the highest R2 values for both cracked (0.93) and uncracked specimens (0.86). It can be concluded by the results of this study that electrical resistivity can be a powerful tool in estimating the steel mass loss in reinforced concrete specimens when supplemented by other concrete performance indicators.

## Tech 3-1. Innovation in Health and Disease B: Infectious Diseases

**Chair: Dr. Choong-Min Ryu** (Korea Research Institute of Bioscience and Biotechnology (KRIBB), South Korea)

Tech 3-1(1)

# Complementary Metal-oxide-semiconductor Photosensor-Integrated On-site Molecular Test for Foot-and-Mouth Disease Detection, Serotyping, and Foot-and-Mouth Disease-like Vesicular Diseases Differentiation

**Dr. Sang-Ho Cha**

FMD WOAH Reference Laboratory, Division of Foot-and-Mouth Disease Research,
Animal and Plant Quarantine Agency, South Korea

An on-site molecular test (OSmT) for Foot-and-Mouth Disease (FMD) was developed using a complementary metal-oxide-semiconductor (CMOS) photo sensor (CPS) with temperature control. CPS-OSmT was combined with direct real-time reverse transcription polymerase chain reaction (rRT-PCR), a highly portable device and a multi-well cartridge to produce a direct FMD CPS-OSmT for FMD virus (FMDV) pan-serotypic and serotype (O, A, Asia1) specific detection, and differentiation from FMD-like vesicular diseases. The multi-well cartridge had surface treatment technology for the proper distribution of sample/reagent mixtures for multiplex rRT-PCR. Direct rRT-PCR was developed for the amplification of viral genes from clinical samples (saliva, serum, and feces) without RNA extraction. Regarding specificity and limit of detection for 3D and VP1 detection of the three serotypes of FMDV in clinical samples, the direct FMD CPS-OSmT was comparable to laboratory-based rRT-PCR on benchtop thermocycler. In clinical trials, the diagnostic accuracy of the direct FMD CPS-OSmT was equivalent to or better than that of laboratory-based rRT-PCR using saliva for 10 days of FMDV infection in pigs. Moreover, the diagnostic sensitivity and specificity were both 100% for the diagnosis of clinical samples obtained from 2023 FMD outbreaks in the Republic of Korea. Furthermore, the system exhibited differential diagnosis of FMD-like diseases. Additionally, it transmitted diagnostic results to a cloud portal, enabling real-time remote monitoring and centralized management. Consequently, the FMD CPS-OSmT developed in this study can replace the current lab-based rRT-PCR for FMD diagnosis, to advance the current control of animal diseases with highly improved efficiency.

Tech 3-1(2)

# Application of newly developed peptide aptamers to rapid diagnostic system for infectious diseases

**Prof. Seonju Yeo**

Department of Tropical Medicine and Parasitology, Department of Biomedical Sciences, Medical Research Center, Institute of Endemic Diseases, College of Medicine, Seoul National University, South Korea

Outbreaks of infectious diseases are now being linked directly to global warming, with the risk spreading beyond tropical regions to temperate zones too.

As disease spreads more quickly between humans, rapid diagnostic technologies such as lateral flow assays and nucleic acid amplification become very important to prevent and control disease.

Therefore, the earliest detection methods are welcomed to give a warning before spreading disease at outbreak. However, due to limitation of development of monoclonal antibody generation, we have aimed the alternative antibody with peptide aptamers.

Peptide aptamers are small combinatorial proteins that are selected to bind to specific sites on their target molecules. Peptide aptamers consist of short, 5-20 amino acid residues long sequences, typically embedded as a loop within a stable protein scaffold.

During 7 years, we have discovered the parameters to design peptide aptamer based on protein-peptide interaction and determined the potential of peptide aptamers on rapid diagnostic system to replace antibody. These parameters to determine peptide aptamer were validated in many infectious diseases such as highly pathogenic avian influenza virus, zika virus, and malaria parasite.

We have successfully developed a peptide pair using simple epitope and paratope modification by prediction tools against the targets of pathogens and a novel peptide pair-based rapid fluorescent diagnostic platform could be performed in 20 min as POCT for detecting pathogens.

Tech 3-1(3)

# Localized Immunological Memory in Cynomolgus Macaques Following SARS-CoV-2 Infection

**Dr. Jung Joo Hong**

Korea Research Institute of Bioscience and Biotechnology, South Korea

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection induces localized immunological memory, notably within the lungs and lymph nodes of humans. Our study aims to assess if similar observations can be recapitulated in cynomolgus macaques, a model for SARS-CoV-2 infection, and determine whether this model can be used to further investigate the potential of localized immune memory in preventing re-infection. Samples from the upper respiratory tract, blood, spleens, lymph nodes, and lungs of healthy and SARS-CoV-2-infected macaques were analyzed using qPCR, TCID50, flow cytometry, intracellular cytokine staining, and enzyme-linked immunosorbent spot assay. Advanced techniques such as single-cell RNA-sequencing and spatial transcriptomics (ST) were utilized to explore lung-resident immunological memory. Following the resolution of SARS-CoV-2 infection, significant CD4+ and CD8+ T cell responses and germinal center activities were observed in lymphoid and lung tissues, with gene ontology analysis revealing an enhancement in immune and inflammatory response pathways. ST analysis highlighted distinct immune responses within lung structures, notably in inducible bronchus-associated lymphoid tissue and alveoli, emphasizing their crucial role in localized defense against SARS-CoV-2. Our findings confirm that, akin to humans, cynomolgus macaques develop localized immunological memory following SARS-CoV-2 infection, with marked immune activation in lung-specific regions essential for countering reinfection. These findings highlight the critical role of local immune memory in SARS-CoV-2 prophylaxis, providing valuable perspectives for the formulation of targeted immunological interventions and vaccine development.

Tech 3-1(4)

# The Unappreciated Role of Viral Internal Proteins in the Extracellular Compartment

**Prof. Doo Jin Kim**

Chungbuk National University College of Medicine, South Korea

Host immune responses, such as those initiated by pattern recognition receptor (PRR) activation, are important for viral clearance and pathogenesis. However, little is known about the interactions of viral proteins with surface PRRs or, more importantly, the association of innate immune activation with viral pathogenesis. In this study, we showed that internal influenza virus proteins were released from infected cells. Among these proteins, nucleoprotein (NP) played a critical role in viral pathogenesis by stimulating neighboring cells through toll-like receptor (TLR)2, TLR4, and the NLR family pyrin domain containing 3 (NLRP3) inflammasome. Through the activation of these PRRs, NP induced the production of interleukin (IL)-1β and IL-6, which subsequently led to the induction of trypsin. Trypsin induced by NP increased the infectivity of influenza virus, leading to increases in viral replication and pathology upon subsequent viral infection. These results reveal the role of released NP in influenza pathogenesis and highlight the importance of the interactions of internal viral proteins with PRRs in the extracellular compartment during viral pathogenesis.

## Tech 3-2. Sustainable Environment B: Urban Engineering

**Chair: Prof. Sunyoung Hlee** (Beijing Institute of Technology, China)

# AI-powered Smart Tourism 2.0

**Prof. Chulmo Koo**

Kyung Hee University, South Korea

Artificial Intelligence (AI) is revolutionizing the tourism industry, ushering in an era of "smart tourism" that promises to enhance traveler experiences, streamline operations, and drive sustainable growth. This paper explores the multifaceted applications of AI in tourism, including personalized recommendations, predictive analytics for demand forecasting, and intelligent chatbots for customer service. We examine how machine learning algorithms can analyze vast amounts of data to provide tailored itineraries, optimize pricing strategies, and improve resource allocation. The integration of AI with Internet of Things (IoT) devices is discussed, highlighting its potential to create seamless, interconnected tourist experiences. Additionally, we address the ethical considerations and challenges associated with AI implementation in tourism, such as data privacy and the need for human oversight. By leveraging AI technologies, the tourism sector can create more efficient, engaging, and sustainable travel experiences for the modern globetrotter.

Tech 3-2(2)

# What makes an AI-powered tourism recommendation helpfulness? - Spatio-temporal efficiency perspectives

**Dr. Ping Li**

Beijing Institute of Technology, China

tbd

# A Study on the Cultural Entrepreneur Model for regional revitalization in jeju Island, South Korea

**Hoyon Ryu**

Tsinghua university, China

In an era of local extinction, the revitalization of declining regions is a pressing issue. This study explores sustainable solutions for regional revitalization, focusing on the cultural potential of rural areas and the creative energy of newcomers. It examines local entrepreneurs who relocate to rural areas and revitalize these regions through entrepreneurial activities. By creatively using local resources, they produce cultural content and market products that reflect regional values. While supporting their livelihoods, they also act as cultural intermediaries, spreading regional culture. Their work transcends economic practices, serving not only to generate profit but also to connect local culture with a broader audience, contributing to community vitality. The study draws on Pierre Bourdieu's concept of cultural intermediation and China's "Rural Innovation Theory." A grounded theory approach was used to develop a model capturing how these entrepreneurs aid regional revitalization. Through qualitative interviews with 20 participants, 105 concepts were categorized into 13 major and 35 minor categories, forming a paradigm model. Six core categories describe the process of regional revitalization through cultural entrepreneurship: (1) starting a regional business, (2) motivation for rural life and lifestyle change, (3) rediscovering and using the region’s cultural and economic potential, (4) expanding business through local networks, (5) creating culture via trial and error, and (6) achieving harmony in living and working in the region. These categories show how local entrepreneurs blend economic practices with cultural production, fostering regional culture while promoting growth. Their activities highlight the interplay between cultural creation and entrepreneurship, blurring the lines between creation and consumption, and positioning them as agents of cultural and economic change. The study systematically develops models through grounded theory, including a paradigm model, stage analysis, typology analysis, and an integrated matrix model, to clarify regional revitalization through cultural entrepreneurship. These models are synthesized into a local entrepreneurship model, offering insights for entrepreneurs and policymakers. The Jeju case provides an example of how these strategies apply to revitalization efforts in Korea and other regions.

Tech 3-1(4)

# 서울 역사도심 도시 경관관리 정책 사례 연구

**Kyeongshin Kim**

Yeonsei University, South Korea

서울은 역사성, 상징성을 가진 대한민국의 수도이다. 서울의 역사도심에는 조선시대 경복궁이 자리잡고 있으며, 이는 중국 베이징의 자금성과 유사한 역사적 의미를 갖고 있다고 볼 수 있다.  이에, 경복궁 주변지역에 대한 엄격하고 체계적인 도시관리가 필요하였다. 서울시는 경복궁 주변지역에 대한 엄격한 높이 관리계획을 수립하고, 고밀고층 개발을 규제하여 왔다. 하지만, 재개발 등 고층고밀의 도시개발사업 규제로 경복궁 주변지역은 노후주택이 증가하고 도시미관 저해하는 등 주민 삶의 질이 저하되었으며, 개발억제에 대한 사유재산 침해의 문제가 지속적으로 제기되었다. 이를 위해 서울시는 경복궁 주변지역 경관관리 정책으로 건축물의 높이를 규제하면서도 도시가 활력을 되찾을 수 있도록, 공공한옥 매입 및 한옥수선비 등 보조금을 지원해주는 경복궁 주변지역 한옥보존정책을 수립하였다. 현재는 경복궁 주변 북촌 한옥마을, 서촌, 익선동 지역 등은 외국인 관광객의 핫플레이스로 선호되고 있으며, 저층의 한옥의 경관과 고층의 서울 도심이 어울어져 서울의 아름다운 경관을 보여주고 있다.

본 발표에서는 서울 역사도심 경복궁 주변지역의 경관관리를 위한 서울시의 정책 사례를 살펴보고자 한다. 서울시는 경복궁 주변의 도시 경관관리를 위해 한옥 등 건축자산 보전 활용을 위한 관리 및 지원을 시행하고 있으며, 미래 건축자산 조성을 통한 건축문화 진흥 및 경쟁력 강화를 목표로 한옥관리정책을 시행하고 있다. 한옥 등 건축자산을 위해 북촌, 서촌 도시재생활성화 사업을 추진하고 있으며 서울 우수한옥 인증 및 한옥 우수디자인 발굴 확대를 위한 정책을 위해 노력하고 있다. 또한 등록 한옥 및 우수건축자산 건축비용 지원을 위해 위원회를 운영하고 있다. 한옥 수리를 지원하기 위해 한옥지원센터를 운영하고, 한옥 등 건축자산 콘텐츠 조사 발굴 및 프로그램 개발 운영하고 있으며, 서울한옥포털 사이트를 통해 대시민 홍보를 하고 있다.  서울시 한옥은 도심에 대부분 밀집하고 있는데, 한옥 등록건수는 매년 증가하여 현재는 약 1200 건에 달한다. 이를 위해 서울시는 한옥 및 신축시 보조금을 지원해 주고 있는데, 24 년 현재까지 약 1,000 여건물 386 억 여원을 지원하였다. 한옥 보전을 위한 도시관리계획 현황으로는 북촌, 돈화문로, 인사동, 운현궁 주변, 조계사 주변, 경복궁 서측, 익선동 일대로 7 개 구역이 있다. 또한 서울시는 경복궁 주변 노후된 주택을 매입하여 33 개소에 대하여 공공한옥으로 건축하여 운영관리하고 있다. 공공한옥은 전통공예시설, 문화전시시설, 주거체험시설 등으로 직영 및 위탁운영되고 있다. 한옥이 증가하면서 외국인 관광객을 포함하여 북촌 방문객 수는 매년 증가하고 있다. 서울 경복궁과 북촌 한옥은 외국인이 꼭 방문해야하는 관광지가 되었다. 역사도심내 북촌 한옥밀집지역은 한옥이 잘 보존관리되어 관광객을 유치하였으나, 한옥보존관리를 위해 공공한옥 매입 및 보조금 지원 등 많은 사업예산이 소요되었고 개인에게 상당한 양의 보조금을 지원하는 것이 적절한 지에 대한 논의도 있었다. 실질적으로 한옥에 거주하고 있는 주민들 입장에서는 지나친 관광객 유입으로 오버투어리즘 문제로 주거환경이 저해되는 불편함을 호소하고 있기도 하다. 전반적으로는 경복궁 주변 도시경관 관리를 위해 한옥 보존정책을 수립하고 보조금 지원정책은 도시경관 보호와 지속가능한 도시발전을 통해 관광 활성화 등 도시 이미지 제고 및 도시경쟁력 강화에 효과적이라고 할 수 있을 것이다. 서울 역사도심 경관보호 정책은 한옥 보존 및 서울의 주거유형 다양화와 서울형 한옥단지 확대 발전 계획 수립으로 이어지고 있으며, 서울시 지속가능한 도시발전에 좋은 정책이라 할 수 있겠다.

Tech 3-2(5)

# Generative-based community sustainable tourism development

**Prof. Myungja Kim**

Kyung Hee University, South Korea

tbd

## Tech 3-3. Future Computing A: Quantum Information Technology II

**Chair: Prof. Samyoung Cho** (Chongqing University, China)

Tech 3-3(1)

## Software Development for a Full-stack Quantum Computer by KISTI

**Dr. Junghee Ryu**

KISTI, South Korea

The global race in quantum computing (QC) development has gained significant momentum, with major players like IBM in the US and the European Quantum Initiative program at the forefront of innovation. Notably, IBM's fully programmable circuit-based quantum computers are already available via cloud-based services, marking a significant milestone in the field. Recognizing QC's transformative potential for high-performance computing, South Korea has embarked on a national project to develop a full-stack, gate-based quantum computer. This talk provides an overview of this flagship QC initiative in the Republic of Korea, with particular emphasis on the software infrastructure being developed by the Korea Institute of Science and Technology Information (KISTI).

Launched in June 2022, this initiative aims to create a 50-qubit quantum computer using electron charges in Josephson junction arrays. The project unites four key institutions: Korea Research Institute of Standards and Science (KRISS), Sungkyunkwan University (SKKU), Ulsan National Institute of Science & Technology (UNIST), and Korea Institute of Science and Technology Information (KISTI). KISTI's role focuses on software development and theoretical research with classical simulations of quantum circuits. Their framework includes a web-based programming interface (Q-Circuit Studio), various backend resources, and essential services for authentication, data management, and resource allocation. The Q-Emulator, built on the PENNYLANE SDK, is being optimized for large-scale circuit simulations using MPI processes. As part of the application research, the team is exploring the viability of variational quantum algorithms for tight-binding simulations of semiconductor structures, demonstrating the project's commitment to both fundamental and applied quantum computing research.

Tech 3-3(2)

## Developing TCAD for integrated quantum photonic circuits

**Prof. Youngik Sohn**

KAIST, South Korea

Integrated photonic circuits are an invaluable platform that underpins a wide range of quantum technology applications, including photonic quantum computing, all-optical quantum repeaters for quantum internet, distributed quantum sensing, and the miniaturization of laser systems for trapped ions and neutral atoms, among others. Consequently, developing a reliable tool that can accurately predict the behavior of quantum photonic circuits in various configurations is of paramount importance.

While such predictive tools are commercially available and maturing in the realm of classical integrated photonics, driven by the high demands from industry, the development of precise design tools for quantum photonic integrated circuits is still in its nascent stages and remains under rigorous scientific scrutiny.

In this talk, I will discuss the efforts underway in my research group to advance this field, focusing on the development of Technology Computer-Aided Design (TCAD) for quantum integrated photonic circuits.

Tech 3-3(3)

# Exploring Magnetic Proximity Interactions in van der Waals Heterostructures for Quantum Information Technologies

**Prof. Junho Choi**

Kyunghee University, South Korea

Van der Waals (vdW) heterostructures integrated with ferromagnetic and non-magnetic semiconductors represent a unique platform for exploring magnetic exchange interactions and introducing magnetism into non-magnetic semiconducting layers. Implementing magnetic proximity interactions (MPIs) in existing quantum information platforms promises a new direction toward hybrid systems that combine conventional quantum technologies with vdW heterostructures to enhance functionality. For example, highly sensitive quantum magnetic sensors, secure quantum communication channels via spin-polarized states, and robust qubit systems utilizing spin-orbit coupling and topological states can be developed based on the MPIs in vdW heterostructures. In this context, interfacial properties such as electronic wavefunction overlap, spin-dependent charge transfer, and band hybridization are critical to control and optimize the MPIs in these materials. Importantly, MPIs have been demonstrated as critical tools for manipulating the quantum properties of vdW heterostructures. Here, I will discuss how MPIs can manipulate the spin and valley degrees of freedom in $MoSe_2/CrBr_3$ heterostructures. Additionally, I will introduce the creation of free-space chiral quantum light emitters via the nanoindentation of $WSe_2/NiPS_3$ heterostructures at zero external magnetic field.

Tech 3-3(4)

## Quantum acoustics: single electron-deterministic single photon conversion

**Prof. Seok-Kyun SON**

Kyunghee University, South Korea

A surface acoustic wave (SAW) is a combination of strain and electrostatic potential waves that propagate at the sound velocity along a piezoelectric crystal's surface. This potential wave can collect electrons from a two-dimensional electron gas (2DEG) and transport them through a depleted channel. The SAW minima form a continuous series of dynamic quantum dots, each transporting a controllable number of electrons along the channel. A single-photon source driven by a surface acoustic wave (SAW) is developed and characterized as shown in figure 1. This single-photon source is based on a SAW-driven lateral n-i-p junction in a GaAs quantum-well structure. On this device, the lateral n-i-p junction is formed by gate-induced electrons and holes in two adjacent regions. The SAW potential minima creates dynamic quantum dots in a 1D channel between these two regions and can transport single electrons to the region of holes along the channel. Single-photon emission can therefore be generated as these electrons consecutively recombine with holes which can potentially be instrumental in implementing scalable quantum processors and quantum repeaters, by facilitating interaction between distant qubits.

Tech 3-3(5)

## Qubits, New Experimental Tools for Science: Challenges and Opportunities

**Prof. Donghun Lee**

Korea University, South Korea

tbd

Tech 3-3(6)

## Information about quantum phases and phase transitions of matter

**Prof. Samyoung Cho**

Chongqing University, China

Over the past few decades, rapid progress has been made in understanding the foundations of quantum physics through an in-depth understanding of quantum coherence and quantum correlations, which has led to remarkable developments in discovering and understanding novel quantum phases of matter, and in developing quantum information that can be applied to storing, transporting, manipulating, and protecting quantum states. In particular, quantum coherence and quantum correlations enable not only to characterize the exotic quantum phase of matter lacking characterization in terms of conventional order parameters, but also to explore another aspect of the nature of quantum phases of matter and quantum phase transitions in condensed matter physics.

In this talk, quantum coherence and quantum correlations in many-body systems are discussed by using their information theoretical measures such as the relative entropy of coherence, the l1 norm quantum coherence, the Jensen-Shannon divergence, quantum entanglement entropy, and quantum mutual information. Especially, spin nematic phases without magnetic long-range order are introduced in one-dimensional spin lattice systems and various quantum phase transitions between uniaxial or biaxial spin nematic phases are discussed in association with distinct behaviors of quantum coherence and quantum correlations.

## Tech 4-1. Innovation in Health and Disease C: NanoBio Engineering

**Chair: Prof. Oh Soek Kwon** (Sungkyunkwan University, South Korea)

Tech 4-1(1)

# Development of a platform for in vitro diagnostic devices for hazardous substances

**Dr. Pan Kee Bae**

HGUARD Inc., South Korea

tbd

Tech 4-1(2)

# Structure-Guided Engineering of Thermodynamically Enhanced Cas9 for Efficient Gene Suppression

**Prof. Yongho Kim**

Sungkyunkwan University, South Korea

Proteins with multiple domains are essential for complex biological functions, especially in genome editing, where precise domain interactions and a comprehensive structural understanding are critical for optimizing protein performance. In this study, we present a structure-guided protein engineering approach utilizing cryo-electron microscopy (Cryo-EM) to develop a thermodynamically enhanced SaCas9 for CRISPR interference (CRISPRi) applications. Through thermodynamic analysis and molecular dynamics simulations, we identified dispensable domains that could be removed to improve protein stability without compromising the DNA recognition function of Cas9. Cryo-EM analysis of the engineered Cas9, termed of sdCas9, revealed preserved structural integrity with reduced atomic density in the deleted regions, confirming that the thermodynamically enhanced sdCas9 maintained its functional DNA-binding precision. To apply sdCas9 in CRISPRi systems, we fused it with the Krüppel associated box (KRAB) domain, a nuclear localization sequence (NLS), and a poly-arginine tag (7Arg), collectively referred to as sdCas9-KRAB-R. This fusion demonstrated effective nuclear localization and resulted in potent gene suppression across multiple cell types. Furthermore, direct delivery into the mouse brain exhibited enhanced knockdown efficiency, highlighting the potential of structure-guided engineering in developing tailored CRISPR systems for specific applications. This study underscores the potential of integrating structural analysis with computational and experimental approaches for protein engineering, improving the design of precise CRISPR systems for therapeutic and research applications.

Tech 4-1(3)

# Development of human-like artificial sense

**Dr. Hyunseok Song**

KIST, South Korea

tbd

Tech 4-1(4)

# Clinical metagenomics for improved surveillance and diagnosis of infections in New South Wales, Australia

**Prof. Ki Wook Kim**

School of Biotechnology & Biomolecular Sciences, Faculty of Science, University of New South Wales, Sydney, Australia

Despite major advances in metagenomic sequencing and its obvious benefits over conventional methods, targeted nucleic acid tests and serological assays remain the gold-standard for diagnosing infections in Australia, as with other countries. However, there is a continuous increase demand by clinicians and surveillance efforts to assay for not routinely screened targets using agnostic tests, especially post-pandemic. Post-pandemic (SARS-CoV-2), major statewide and nationwide investments have boosted high-throughput sequencing capacity at major testing hospitals/centers, further improving access and feasibility. Many of the approaches and the bottlenecks to translation of clinical metagenomics in diagnostic practice are broadly applicable and consistent across all major testing centers in Australia. In New South Wales, two main approaches continue to be utilised for pathogen genomics: 1) hybridisation capture (pan-viral), 2) meta-transcriptomics (pan-microbial). However, the specific workflows for clinial metagenomics differ between testing sites in both the wet-lab and bioinformatics workflows, without a standardised approach, which is a key barrier to implementation of clinical metagenomics for effective surveillance and diagnoses of emerging infections. In our experience of applying clinical metagenomics on clinical specimens (both children and adults) collected between 2021-2022, agnostic metagenomic sequencing on leftover specimens after testing negative for infections on routine diagnostic screening, detected unexpected viruses at high-levels (full/near-full length genomes recovered) for multiple cases, which would otherwise be undetected. This included an atypical fatal childhood case of encephalitis caused by Newcastle Disease Virus, a pigeon variant of Avian Paramyxovirus type 1 (Emerging Infectious Diseases, 2023). Therefore, there are undeniable benefits (e.g. total cost and time savings, increased sensitivity, complete genome sequence characterisation, agnostic, etc.) and strong rationale for application of clinical metagenomics to improve pathogen detection and diagnosis of infectious diseases in public health. However, the available modern metagenomic tools/approaches still remain predominantly in the research domain due to several key barriers to implementation.

Tech 4-1(5)

## Integrated Nanogap Sensors for Biomolecular Quantitation

**Prof. Wan Soo Yun**

Sungkyunkwan University, South Korea

tbd

## Tech 4-2. Physical Science A: Innovation in High Energy Physics

**Chair: Prof. Sung-Soo Kim** (University of Electronic Science and Technology of China (UESTC), China)

Tech 4-2(1)

## Introduction to Symmetry Topological Field Theories

**Prof. Sungjay Lee**

KIAS, South Korea

tbd

Tech 4-2(2)

## Stability and topological nature of charged Gauss–Bonnet AdS black holes in five dimensions

**Prof. Imtak Jeon**

Huzhou University, China

We examine the thermodynamic characteristics and phase structures of a black hole within the framework of Einstein-Maxwell theory in five dimensions, incorporating a negative cosmological constant and a Gauss-Bonnet (GB) correction. For this, we follow the topological approach to black hole thermodynamics where the black holes are treated as topological defects in thermodynamic space. With this approach, the nature of black hole's local stability is studied by computing the winding numbers/topological charge around the zero points associated with the vector field constructed from the temperature of the extremal points and the generalized off-shell Gibbs free energy, respectively. Therefore, black holes are classified into different topological classes based on their topological number. In this study, we find that, in the grand canonical ensemble, the charged AdS black hole with the GB correction is in different topological class from the one without GB correction, but it belongs to the same classes as the one with and without GB correction of canonical ensemble. Our finding reveals that in the grand canonical ensemble, unlike the charged AdS black hole, the charged GB AdS black hole exhibits a liquid/gas-like first-order phase transition between small-large black hole phases due to the effect of GB correction.

Tech 4-2(3)

## Duality Reductionism

**Prof. Chiung Hwang**

USTC, China

While the perturbative description of quantum field theory (QFT) has been a highly successful framework for describing nature, many modern phenomena require going beyond it. In this talk, I will discuss the nonperturbative aspects of QFT from the perspective of duality.

Tech 4-2(4)

## Algebras and Geometries from 3d Supersymmetry

**Dr. Myungbo Shim**

Yau Mathematical Sciences Center (YMSC), Tsinghua University, China

We studied boundary vertex operator algebras (VOAs) from H-twisted 3d N=4 quiver gauge theories by means of [Costello-Gaiotto]. There are interesting observations including their relations with affine W-algebras and Higgs branch. Inspired by the relation between boundary quiver VOAs and affine W-algebras, we also propose the quiver reduction implementing a sequences the Miura maps providing free field realization. We will introduce basic ingredients of boundary VOAs from H-twisted quiver gauge theories, relation with the Higgs branch, and the quiver reduction procedure. This talk is based on 2312.13363 [hep-th].

## Tech 4-3. Future Computing B: Artificial Intelligence

**Chair: Prof. Feng Tian** (Duke Kunshan University, China)

Tech 4-3(1)

## Exploring Effective Representations Using Hyperbolic Neural Networks

**Prof. Dongmian Zou**

Duke Kunshan University, China

Hyperbolic Neural Networks (HNNs) have recently found successful in representing hierarchical and complex data. However, unlike other domains, the exploration of hyperbolic neural operations and the development of effective hyperbolic representations remains limited. We delve into developing HNN architectures and addressing the stability and robustness issues. In this talk, we discuss some of our recent findings in the following aspects: first, we investigate representation learning through hyperbolic convolutions with provable properties; second, we enhance representations with Gromov-Wasserstein regularization; third, we improve stability and robustness by designing hyperbolic operations and regularization techniques. Finally, we demonstrate the practical applications of these advancements in tasks such as few-shot image classification, graph classification, and anomaly detection.

Tech 4-3(2)

## Computational genomic approach to interpret non-coding disease risk variants

**Prof. Seong Kyu Han**

Inha University, China

Genetic factors that contribute to human diseases and traits extend beyond protein-coding variants, as numerous risk variants in non-coding regions have been identified by genome-wide association studies (GWASs). These variants, known as “regulatory variants,” alter the regulation of gene expression in the relevant tissue. However, identifying the specific cell type or tissue in which the regulatory variant exerts its function remains a significant challenge. In this study, we present statistical genetic- and machine-learning-based approaches to interpret regulatory variants in a cell-type-resolved manner. We established a resource of expression quantitative trait locus (eQTL) in kidney compartments with higher resolution and interpretability by incorporating single-nucleus open chromatin as a prior for Bayesian statistical fine-mapping. Our augmented eQTL does the following: (1) identifies causal regulatory variants among multiple indistinguishable SNPs that highly co-occur in a population, and (2) interprets the function of the regulatory variant by identifying the contributing cell types or cis-regulatory element, such as enhancers and promoters. Our eQTL map increased enrichment of partitioned heritability for kidney function traits and the number of variants colocalized with the GWAS loci. A subset of eQTL variants and genes were validated experimentally in vitro and using a Drosophila nephrocyte model.

Our eQTL resource can lead to better understanding of idiopathic and rare genetic disorders not explained by known protein-coding variants.

Tech 4-3(3)

# AI for 3D environment modeling, human computer interaction and decision making in the digital twin space

**Prof. Xie Ning**

University of Electronic Science and Technology of China, China

tbd

# Robustness of Deep Learning Models Against Distribution Shift

**Prof. Zhiqiang Gao**

Wenzhou-Kean University, China

Deep learning is a cornerstone in the realms of academia and industry, essential to the strides made in artificial intelligence. It is a key driver in the ongoing revolution of science, technology, and industrial evolution. However, despite its significant potential, deep learning also brings significant risks and challenges, especially regarding security and reliability, where current algorithms show their limitations. Deep learning models often exhibit a lack of robustness against distribution shifts, which can severely impact their performance. This is a critical issue for applications relying on deep learning, such as autonomous driving, medical diagnosis, and fraud detection. Distribution shifts can occur in several forms: domain shift due to varying image styles and capture conditions; common corruption from weather, blur, and natural noise; and adversarial attacks created with artificial noise. In this presentation, we will use computer vision examples to illustrate these distribution shifts and discuss the differences between them from both practical and theoretical perspectives. To enhance the robustness of deep learning models against such shifts, we propose three effective methods that have shown promising results on real-world datasets.

## Tech 5-1. Innovation in Health and Disease D: Breeding to Biotechnology in Rice

**Chair: Prof. Sun Tae Kim** (Pusan National University, South Korea)

Tech 5-1(1)

# Study of pollen germination and tube elongation process in rice for the new generation of hybrid rice production technology

**Prof. Ki-Hong Jung**

Kyung Hee University/National Research Foundation of Korea, South Korea

Fertilization in plants is essential for seed production, yet research on how sperm nuclei from mature pollen reach the ovule in monocots is quite limited. In monocots like rice, which have only one ovule per ovary, pollen with defects in pollen tube germination or elongation can't compete with wild-type pollen, making mutant production via traditional methods challenging. In contrast, dicots with multiple ovules per ovary allow defective pollen to still achieve fertilization, facilitating mutant research at the genetic and molecular levels. Recently, gene editing technology has advanced, allowing the production of homozygous mutants of target genes in rice. To identify key genes affecting pollen tube germination and elongation in rice, we performed large-scale transcriptome analysis to find genes highly expressed during these processes. We selected genes with abnormal segregation ratios in T-DNA insertion mutants and used gene editing technology to systematically verify their functions. As a result, we identified about 40 genes out of 627 candidates with abnormal segregation ratios. Detailed studies of these mutants have revealed the genetic and molecular characteristics of pollen tube germination and elongation in rice, an area previously unexplored. Altogether, I will comprehensively explain our laboratory's research achievements on pollen tube germination and elongation processes in rice

Tech 5-1(2)

# Advancing the development of more phosphorus-efficient rice

**Prof. Joong Hyoun Chin**

Sejong University, South Korea

Phosphorus (P) is essential for plant growth and crop yield, making its efficient use vital in agriculture, especially as phosphorus reserves diminish. This research aims to develop phosphorus-efficient rice varieties by integrating genetic, phenotypic, and breeding techniques to enhance phosphorus acquisition and crop performance. Many rice-growing regions face challenges with limited inorganic phosphate (Pi) availability due to soil fixation, while over-fertilization in others poses environmental risks. Understanding Pi transporters, internal Pi remobilization, and root adaptations in Pi-deficient conditions is crucial to identify rice varieties with improved phosphorus acquisition efficiency (PAE) and phosphorus use efficiency (PUE). Meta-QTL (MQTL) analysis further identified eight candidate genes linked to PUE through the synthesis of QTL data from 16 studies, leading to the mapping of 192 QTLs. These genes, such as OsARF8, OsSPX-MFS3, and OsWRKY64, were validated through transcriptome data and haplotype analysis, forming a foundation for breeding programs aimed at improving phosphorus efficiency. This initiative focuses on identifying key genes involved in phosphorus uptake and utilization. The OsPSTOL1 gene, found in the Pup1 QTL on chromosome 12, promotes root growth and enhances phosphorus acquisition in low-nutrient soils. Additionally, the OsPTF1 gene improves tolerance to Pi starvation. Combining these genes aims to create rice cultivars with superior phosphorus efficiency. Efforts to enhance phosphorus efficiency have included the development of NILs from rice varieties like IR64 (indica) and MS11 (japonica) through Marker-Assisted Backcrossing (MABC). In conclusion, this research integrates advanced genetic insights and breeding techniques to improve phosphorus efficiency. Through the identification of key genes like OsPSTOL1 and OsPTF1, combined with meta-QTL analysis and genome editing, this initiative seeks to create rice varieties optimized for phosphorus acquisition and better suited to changing environmental conditions. These efforts aim to ensure sustainable rice production and global food security.

Tech 5-1(3)

## Sucrose promotes flowering by degrading the floral repressor Ghd7

**Prof. Lae-Hyeon Cho**

Pusan National University, South Korea

Sucrose plays a variety of roles in plants, acting as a signaling molecule and influencing various developmental processes. However, the precise molecular mechanisms through which sucrose regulates these functions are still not well understood. In this study, we show that sucrose promotes flowering in rice by modulating the stability of Ghd7, a key regulatory protein that typically acts to repress flowering. Exogenous sucrose application induced flowering by upregulating florigen gene expression, while reducing sucrose levels in the phloem—through genetic modification of a vacuolar invertase and a sucrose transporter—delayed flowering. Transcript analysis of floral regulatory genes indicated that sucrose specifically activated Ehd1, which functions upstream of florigen, without significantly influencing other upstream regulators. Protein stability assays following sucrose treatment showed targeted degradation of the major floral repressor Ghd7. We found that Ghd7 interacts with the E3 ligase IPI1, and sucrose treatment promoted K48-linked polyubiquitination of Ghd7 through IPI1, leading to its degradation. Mutants deficient in IPI1 exhibited delayed flowering, further supporting its critical role in regulating flowering-related proteins. Thus, we propose that sucrose induces flowering by triggering the degradation of Ghd7 via IPI1, acting as a key signaling molecule in this process.

Tech 5-1(4)

## Regulation of salt tolerance by phospholipase C-mediated signaling in rice

**Prof. Wenhua Zhang**

College of Life Science, Nanjing Agricultural University, China

The phosphatidylinositol-specific phospholipase Cs (PI-PLCs) play crucial roles in signaling transduction during plant development and stress response. In previous, our work showed that OsPLC1 is vital for salt tolerance in rice. In this study, we further investigated how OsPLC1 regulates salt stress response in rice. Disruption of OsPLC1 resulted in shorter roots, being more pronounced under salt stress. The expression of auxin reporter DR5:GUS and endogenous indole-3-acetic acid (IAA) levels were both elevated in osplc1 mutant roots under salt stress, indicating that OsPLC1 may influence auxin accumulation or transport. In suspension cells overexpressing OsPLC1, auxin efflux was reduced, while in osplc1 mutants, auxin efflux was enhanced, suggesting that OsPLC1 regulated auxin efflux. We also found that OsPLC1 interacts with auxin efflux carriers (OsPINs) to, particularly with OsPIN1a and OsPIN9. Additionally, OsPIN9 was shown to play a role in salt stress response, as disruption of OsPIN9 increased sensitivity to salt stress. Collectively, these findings suggest that OsPLC1 affects auxin transport in response to salt stress.

Tech 5-1(5)

# Biosynthesis of Sakuranetin regulated by OsMPK6-OsWRKY67-OsNOMT cascade confers *Ustilaginoidea virens* resistance in rice

**Prof. Yiming Wang**

Department of Plant Pathology, Key Laboratory of Integrated Management of Crop Diseases and Pests, Ministry of Education, Nanjing Agricultural University, China

Rice false smut disease, caused by the fungal pathogen Ustilaginoidea virens, significantly restricts both the production and quality of rice grains. However, the molecular mechanism underlying rice resistance against U. virens remain largely elusive. In this study, we conducted a transcriptome analysis of rice panicles upon U. virens infection, uncovering the critical roles of genes involved in sakuranetin biosynthesis in U. virens resistance. In vitro assays demonstrated that sakuranetin was most effective at inhibiting mycelial growth, spore germination, and host infection by U. virens. The expression of OsNOMT, the key enzyme in sakuranetin biosynthesis, is directly regulated by the transcription factor OsWRKY67. Furthermore, OsMPK6, a mitogen-activated protein kinase, interacts with and phosphorylates OsWRKY67, thereby modulating sakuranetin biosynthesis and resistance to U. virens. Moreover, the exogenous application of synthetic sakuranetin significantly reduces U. virens infection. In summary, our findings reveal that the OsMPK6-OsWRKY67-OsNOMT signaling cascade plays a pivotal role in rice resistance to U. virens by regulating sakuranetin biosynthesis.

## Tech 5-2. Physical Science B: Quantum Phenomena in Condensed Matter

**Chair: Dr. Duckyoung Kim** (Center for High Pressure Science and Technology Advanced Research (HPSTAR), China)

Tech 5-2(1)

## Hund's physics near the Mott transition in NiS2 under pressure

**Prof. Ji Hoon Shim**

Pohang University of Science and Technology (POSTECH), South Korea

Strong correlation effects caused by Hund's coupling have been actively studied during the past decade. Hund's metal, strongly correlated while far from the Mott insulating limit, was studied as a representative example. However, recently it was revealed that a typical Mott system also exhibits a sign of Hund physics by investigating the kink structure in the spectral function of NiS2−$x$Se$x$. Therefore, to understand the Hund physics in a half-filled multiorbital system near the metal-insulator transition, we studied pressure-induced metallic states of NiS2 by using density-functional theory plus dynamical mean-field theory. Hund physics, responsible for suppressing local spin fluctuation, gives low-energy effective correlations, separated from Mott physics, which suppress charge fluctuation at higher energy. This effect is prominent when Hund's coupling J becomes comparable to the quasiparticle kinetic energy, showing apparent scaling behavior of the kink position $E$k∼$J$$Z$, where Z is the quasiparticle residue $me/m$*. We suggest that the Hund effect can also be observed in the optical conductivity as a non-Drude-like tail with 1/$\omega$ frequency dependence and nonmonotonic temperature evolution of the integrated optical spectral weight at a fixed frequency. Our study demonstrates the important role of Hund's coupling for electronic correlations even in a half-filled system.

Tech 5-2(2)

## Superconductivity of metastable dihydride at ambient pressure

**Dr. Heejung Kim**

Seoul National University, South Korea

Hydrogen in metals is a significant research area with far-reaching implications, encompassing diverse fields such as hydrogen storage, metal-insulator transitions, and the recently emerging phenomenon of room-temperature superconductivity transition temperature (TC) superconductivity under high pressure. Hydrogen atoms pose challenges in experiments as they are nearly invisible, and they are considered within ideal crystalline structures in theoretical predictions, which hampers research on the formation of meta-stable hydrides. Here, we propose pressure-induced hydrogen migration from tetrahedral (T-) site to octahedral (O-) site, forming LaH_x^O H_(2-x)^T in cubic LaH2. Under decompression, it retains H_x^O occupancy, and is dynamically stable even at ambient pressure, enabling a synthesis route of metastable dihydrides via compression-decompression process. We predict that the electron phonon coupling strength of LaH_x^O H_(2-x)^T is enhanced with increasing x, and the associated TC reaches up to 10.8 K at ambient pressure. Furthermore, we calculated stoichiometric hydrogen migration threshold pressure (Pc) for various lanthanides dihydrides (RH2, where R=Y, Sc, Nd, and Lu), and found an inversely linear relation between Pc and ionic radii of R. We propose that the highest TC in the face-centered-cubic dihydride system can be realized by optimizing the O/T-site occupancies.

Tech 5-2(3)

## Nonlocal Coulomb interactions in perovskite transition metal oxide

**Prof. Bongjae Kim**

Kyoungpook National University, South Korea

Employing the density functional theory incorporating on-site and inter-site Coulomb interactions (DFT+U+V), we have investigated the role of the nonlocal interactions on the electronic structures of the transition metal oxide perovskites. We highlight the significant role and nonlocality of intersite Coulomb interactions, V, comparable in magnitude to the local interaction, U. Our DFT+U+V results exemplarily show the representative band renormalization, and deviations from ideal extended Hubbard models due to increased hybridization between transition metal d and oxygen p orbitals as occupation increases. We further demonstrate that the inclusion of the inter-site V is essential for accurately reproducing the experimental magnetic order in transition metal oxides.

Tech 5-2(4)

# Machine Learning Prediction Models for Solid Electrolytes Based on Lattice Dynamics Properties

**Prof. Sooran Kim**

Kyoungpook National University, South Korea

Recently, machine-learning approaches have accelerated computational materials design and the search for advanced solid electrolytes. However, the predictors are currently limited to static structural parameters, which may not fully account for the dynamic nature of ionic transport. In this study, we meticulously curated features considering dynamic properties and developed machine-learning models to predict the ionic conductivity, σ, of solid electrolytes. We compiled 14 phonon-related descriptors from first-principles phonon calculations along with 16 descriptors related to the structure and electronic properties. Our logistic regression classifiers exhibit an accuracy of 93%, while the random forest regression model yields a root-mean-square error for log(σ) of 1.179 S/cm and R2 of 0.710. Notably, phonon-related features are essential for estimating the ionic conductivities in both models. Furthermore, we applied our prediction model to screen 264 Li-containing materials and identified 11 promising candidates as potential superionic conductors.

Tech 5-2(5)

## Quantum phenomena manipulated by chemical potential

**Prof. Choonkyu Hwang**

Busan National University, South Korea

Chemical potential provides a powerful methodology to explore rich physics in exotic materials. Energy landscape in the electron band structure in conjunction with charge carrier density are tuned by the chemical potential, which allows us to access to the quantum critical point in cuprates, colossal magnetoresistance in manganites, and chiral spin-density wave even in graphene with a simple geometric structure. In this presentation, angle-resolved photoemission spectroscopy studies on layered transition-metal chalcogen compounds will be discussed to introduce two plausible ways of tuning physical properties of a solid material via chemical potential. Defect control in the bulk and thermal expansion modify chemical potential, leading to the manipulation of berry curvature dipole (1) and the enhanced thermoelectric effect (2).

REFERENCES

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(2) J. Lee et al., Nano Converg. 10 (2023) 32.

Tech 5-2(6)

# Gate-Tunable Potential Barrier in a Single Graphene Layer on a Fluorocarbon Thin Film

**Prof. Haeyong Kang**

Busan National University, South Korea

To explore the electrical properties of various thin films or substrates, the field-effect transistor type device was fabricated using graphene as channel materials. Generally, graphene properties are modulated by doping and we tried surface charge transfer doping (SCTD) by surface contact with a fluorocarbon film. Since SCTD supplies a surface dopant that can perform as an acceptor in graphene, it provides a simple and high doping efficiency by preventing the defect problem. In addition, to understand the electrical properties of graphene or interface between graphene and substrates, several studies using dual-gate devices have been conducted. Owing to the conductive graphene induced by SCTD, the potential barrier height through the graphene channel can be effectively modulated by the additional gate voltage in the dual-gate structure without other defects or contact problems in heterojunction.

[1] Y. Yi, et al., Advanced Materials Interfaces, 2023, 10, 2201883

## Tech 5-3. Advanced Materials

**Chair: Prof. Yuljae Cho** (Shanghai Jiao Tong University, China)

Tech 5-3(1)

## Neuromorphic dendritic computation using multi-gate hybrid transistors

**Dr. Eunhye Baek**

Tsinghua University, China

Neuromorphic technologies often employ a point-neuron model, neglecting the spatiotemporal nature of neuronal computation. Dendritic morphology and synaptic organization are structurally tailored for spatiotemporal information processing, enabling various computations such as visual perception. This talk will introduce a neuromorphic computational model termed ‘dendristor’, which integrates synaptic organization with dendritic tree-like morphology. This model is based on the physics of ion-doped sol-gel film-covered Si nanowire transistors having multi gates. The dendristor presents bioplausible nonlinear integration of excitatory/inhibitory synaptic inputs and silent synapses with diverse spatial distribution dependency, emulating direction selectivity, which is the feature to react to signal direction on the dendrite. Silent synapses turn to be crucial in dendritic computation, enhancing direction selectivity. Finally, I will discuss a neuromorphic dendritic neural circuit which can be used as a building-block to design a multi-layer system that emulates 3D spatial motion perception in the retina. The proposed dendritic computation demonstrates unique capabilities compared to the current paradigms in electronic device engineering for neuromorphic computation, providing solutions to explore new frontiers in artificial intelligence, neurocomputation and brain-inspired computing.

Tech 5-3(2)

## Mechanical computing with metamaterials

**Prof. Jaehyung Ju**

Shanghai Jiao Tong University, China

tbd

Tech 5-3(3)

# The re-surging of hydrocarbon gas as early sign of battery rollover degradation

**Prof. Jongmyung Kim**

Shanghai Tech University, China

tbd

Tech 5-3(4)

## Environmental energy harvesting towards self-powered electronics

**Prof. Yuljae Cho**

Shanghai Jiao Tong University, China

tbd