



ISPE 2025

NOV. 7-9, 2025

The 6th INTERNATIONAL SYMPOSIUM
ON PRECISION ENGINEERING

ORGANIZERS



CO-ORGANIZERS



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Organizers



National Chung Hsing University
<http://www.nchu.edu.tw>



National University of Singapore
<https://www.nus.edu.sg>

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精密工程

研究所 Graduate Institute
of Precision Engineering

Graduate Institute of Precision Engineering, GIPE
National Chung Hsing University
<https://www.ipe.nchu.edu.tw>



SCIENCE and Engineering Institute, SCIEI
<http://sciei.org>



NCHU GIPE Alumni Association
<http://alumnigipe.nchu.edu.tw>



Flexible MiCAtronics Industry University
Alliance
<https://sites.google.com/view/mica-platform>



Advanced Industry Technology and Precision
Processing Center
National Chung Hsing University
<http://rcaitpp.nchu.edu.tw>



National Science and Technology Council
<https://www.nstc.gov.tw/>

General Information

The 6th International Symposium on Precision Engineering 2025 (ISPE 2025) will be held at Sun Moon Lake Youth Activity Center, Yuchi, Nantou County, during November 7 ~ 9, 2025. The main objective of the ISPE 2025 is to provide a major international platform for knowledge exchange and an interactive forum in integrated technologies, mechanical engineering, optics, electronics, electrical engineering and material engineering into precision manufacturing, precision measurement, precision inspection, MEMS, semiconductor and precision environmental control, etc. These are all fascinating topics related to future needs. On behalf of the ISPE 2025 organizing committee, we sincerely welcome you for participating this symposium to share your experience and research results. ISPE 2025 welcomes authors to submit papers on any branch of precision engineering and its applications, and other subjects.

Plenary Speakers

- Chair Prof. and Department Chair Ying-Hao Chu
Department of Materials Science & Engineering
College of Semiconductor Research (joint)
National Tsing Hua University, Taiwan
- GlobalFoundries Chair Prof. Cheng-Kuo Lee
Center for Intelligent Sensors and MEMS
Department of Electrical and Computer Engineering
National University of Singapore, Singapore

Keynote Speakers

- Prof. Hieng-Kiat Jun
Department of Mechanical and Material Engineering
University Tunku Abdul Rahman, Malaysia
- Prof. Chang-Fu Dee
Institute of Microengineering and Nanoelectronics (IMEN)
National University of Malaysia, Malaysia

Invited Speakers

- Prof. Uma N. Dulhare
Computer Science & Artificial Intelligence Department
Muffakham Jah College of Engineering & Technology, India
- Assoc. Prof. Wei-Sea Chang
Department of Materials Science and Engineering
National Yang Ming Chiao Tung University, Hsinchu, Taiwan
- Prof. Chao-Cheng Kaun
Research Center for Applied Sciences, Academia Sinica, Taiwan
- Prof. Ngoc Dang Khoa Tran
Faculty of Mechanical Engineering
Industrial University of Ho Chi Minh City, Vietnam
- Assoc. Prof. Jyoti Jaiswal
Department of Physics, Rajiv Gandhi University
Rono-Hills, Doimukh, Arunachal Pradesh, India

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National Chung Hsing University, Taiwan
- Dean Ming-Der Yang
Department of Civil Engineering
National Chung Hsing University, Taiwan

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Graduate Institute of Precision Engineering
National Chung Hsing University, Taiwan
- GlobalFoundries Chair Prof. Chengkuo Lee
Department of Electrical and Computer Engineering
National University of Singapore, Singapore

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Publication Chair

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University of New Mexico, USA

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Indian Institute of Technology Delhi, New Delhi, India
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Department of Materials Engineering
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- Prof. Po-Liang Liu
Graduate Institute of Precision Engineering
National Chung Hsing University, Taiwan

- Distinguished Prof. Ming-Tzer Lin
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- Prof. and Head Cheng-Mu Tsai
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- Prof. Congo Tak-Shing Ching
Graduate Institute of Biomedical Engineering
National Chung Hsing University, Taiwan
- Prof. Cheng-Chung Chang
Graduate Institute of Biomedical Engineering
National Chung Hsing University, Taiwan
- Prof. Hui-Min David Wang
Graduate Institute of Biomedical Engineering
National Chung Hsing University, Taiwan
- Assoc. Prof. Fu-Yuan Hsu
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National United University, Taiwan
- Assoc. Prof. Sheng-Fang Huang
Mechanical Engineering Department
China University of Science and Technology, Taiwan
- Assoc. Prof. Kuo-Chih Liao
Graduate Institute of Biomedical Engineering
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- Assist. Prof. Che-Hao Liao
Department of Electronic Engineering
National Yunlin University of Science and Technology, Taiwan
- Prof. Shih-Hung Lin
Department of Electronic Engineering
National Yunlin University of Science and Technology, Taiwan
- Prof. Chil-Chyuan Kuo
Department of Mechanical Engineering
Ming Chi University of Technology, Taiwan
- Assist. Prof. Chi-Pin Hsu
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Symposium Secretary

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Sun Moon Lake Youth Activity Center, Nantou

Country Map



Symposium Agenda

All academic events will be held at Sun Moon Lake Youth Activity Center, Taiwan

Time	Activity		
7 November, 2025 - Only Registration			
15:00~17:00	Registration & Welcome Reception		
8 November, 2025 - Symposium Day			
08:00~08:30	Registration		
08:30~10:00	Invited Talk & Oral Session (1)	Poster Exhibition	
10:00~10:20	Group Photo & Coffee Break		
10:20~10:30	Opening Ceremony		
10:30~11:15	Plenary Speech (1) Cheng-Kuo Lee		Moderator: Dung-An Wang
11:15~12:00	Keynote Speech (1) Hieng-Kiat Jun		
12:00~13:00	Lunch Time		
13:00~13:45	Plenary Speech (2) Ying-Hao Chu		Moderator: Wei-Sea Chang
13:45~14:30	Keynote Speech (2) Chang-Fu Dee		
14:30~14:50	Coffee Break		
14:30~15:30	Poster Session		
14:50~16:05	Invited Talk & Oral Session (2)		
16:05~17:20	Invited Talk & Oral Session (3)		
17:20~18:20	Invited Talk & Oral Session (4)		
18:20~18:25	Closing & Poster Awards		
18:30	Banquet		
9 November, 2025 - Academic Visit			
09:00~13:30	Explore Sun Moon Lake – Optional Self-Paid Excursion		

Plenary Speaker 1



Chair Prof. and Department Chair Ying-Hao Chu

*Department of Materials Science & Engineering
College of Semiconductor Research (joint)
National Tsing Hua University, Taiwan*

Title of Plenary Speech

A New Platform for Flexible Electronics: Exploiting Muscovite Mica Heterostructures and Intercalation

Abstract of Plenary Speech

Muscovite mica is a layered silicate mineral that underpins MICAtronics, a platform essential for developing flexible electronics. It has an atomically flat surface after cleavage, enabling van der Waals heteroepitaxy, which is highly beneficial as it accommodates large lattice mismatches (up to 60%) and reduces epitaxial strain and substrate clamping. Mica shows high mechanical flexibility and optical transparency, along with excellent thermal and chemical stability. In this talk, I will first discuss the mechanical properties of muscovite. Then, I will demonstrate how to modify muscovite's mechanical and physical properties. The gaps within the mica structure act as two-dimensional confined cavities, creating an intrinsic interlayer static pressure on inserted materials (intercalants). This spatial restriction directs oriented growth, making it possible to fabricate well-ordered 3D mesocrystals, including superconductive MgB_2 , antiferromagnetic NiO , ferromagnetic Fe_3O_4 , and Ag nanocrystals for SERS. Additionally, a new method for flexible crystal growth will be shown through mobility and piezoresistive sensors. In the final part of the presentation, I will focus on our recent advances in thermal actuators and sensors.

Plenary Speaker 2



GlobalFoundries Chair Prof. Cheng-Kuo Lee

*Center for Intelligent Sensors and MEMS
Department of Electrical and Computer Engineering
National University of Singapore, Singapore*

Title of Plenary Speech

Wearable AI Sensors and CMOS Photonics for Future Edge AI Applications

Abstract of Plenary Speech

With the growing demand for energy-efficient AI applications, the rapid development of self-powered sensors together with edge computing and edge AI technology at the sensor nodes has led to the new era of AI sensors. Traditional sensors and sensing systems can no longer meet the demands for real-time multimodal sensing and large-scale data processing, leading to a shift towards a new paradigm of AI Sensors and Artificial Intelligence of Things (AIoT) sensing systems with integrated computational intelligence. Self-powered wearable sensors have promoted low-power or battery-free sensing platforms for applications including human-machine interaction, soft robotics, and electronic skin (e-Skin). Tactile sensors featuring artificial neuron like self-generated zero-biased signals are developed to realize synergistic sensing of multimodal information (vibration, material, texture, pressure, and temperature) in a single device will be discussed first. On the other hand, aiming at smart farming, various AIoT sensing systems have been developed recently. A multifunctional hydrogel is developed as a stable energy harvester that continuously generates direct current (DC) output with an average power density of $1.9 \text{ W} \cdot \text{m}^{-3}$ for nearly 60 days of operation in normal environments (24°C, 60% RH). Moreover, this hydrogel enables non-invasive and self-powered monitoring of leaf relative water content (RWC), providing critical data on evaluating plant health, previously obtainable only through invasive or high-power

consumption methods. The e-skin sensors for indoor and outdoor farming applications will be discussed in this talk as well.

In addition, the development of AlN/Si-based CMOS Photonics have been developed as a near-sensor edge computing (NSEC) platform pushes the boundary of real-time AI by combining electro-optic microring resonators (MRRs) and thermo-optic interferometers (MZIs) to achieve low-latency neural computation directly at the sensing layer. Demonstrated with high accuracy in multimodal gesture and gait classification tasks (96.77% and 98.31%, respectively), and achieving latency under 10 ns with energy consumption below 0.34 pJ, such platforms are paving the way for privacy-preserving, always-on AI hardware for healthcare, robotics, and immersive interaction systems. Overall, the fusion of AI-enhanced photonic sensing, on-chip neuromorphic computing, and flexible sensor integration represents a paradigm shift for future AIoT systems. As optical edge computing continues to mature, it will become a cornerstone in the transition from centralized cloud AI to energy-efficient, responsive, and context-aware edge intelligence. Looking ahead, the convergence of AI, photonic integration, and edge computing will catalyze the next wave of intelligent systems that are no longer confined to centralized data centers or limited by power and latency bottlenecks. Future AIoT architectures will evolve toward ultra-distributed networks of smart, self-powered, and self-learning sensor nodes, each capable of perception, inference, and adaptation in real time. Ultimately, the long-term vision is a world where every object, environment, and human interaction is seamlessly sensed, interpreted, and enhanced in real time.

Keynote Speaker 1



Prof. Hieng-Kiat Jun

*Department of Mechanical and Material Engineering
University Tunku Abdul Rahman, Malaysia*

Title of Keynote Speech

Some Insights on PEMA-based Solid Polymer Electrolytes for EDLC Application

Abstract of Keynote Speech

Electric double-layer capacitors (EDLCs) are promising energy storage devices due to their high power density, long cycle life, and reliability. Polymer electrolytes play a key role in their performance, and further improvements can be achieved through suitable additives. In this work, poly(ethyl methacrylate) (PEMA) solid polymer electrolytes incorporating sodium perchlorate (NaClO_4) and 1-butyl-3-methylimidazolium thiocyanate ([BMIM][SCN]) were prepared via solution casting. The addition of [BMIM][SCN] enhanced amorphicity, polymer-ion interactions, and thermal stability up to $\sim 270^\circ\text{C}$. The optimized composition containing 25 wt% [BMIM][SCN] achieved an ionic conductivity of $3.15 \times 10^{-4} \text{ S/cm}$ at ambient temperature. To further enhance performance, graphene was introduced into the optimized electrolyte. The resulting EDLC exhibited a specific capacitance of $5.09 \times 10^{-3} \text{ F/g}$, outperforming the graphene-free system. These findings provide insights into the synergistic effects of ionic liquid and graphene in PEMA-based electrolytes, highlighting their potential for advanced EDLC applications.

Keynote Speaker 2



Prof. Chang-Fu Dee

*Institute of Microengineering and Nanoelectronics (IMEN)
National University of Malaysia, Malaysia*

Title of Keynote Speech

Low-Dimensional Materials: Synthesis, Characterization, Applications, and Computational Studies

Abstract of Keynote Speech

Low-dimensional materials are fundamental semiconductor building blocks for nanoelectronics and have attracted significant research attention over the past decade. Non-volatile memory devices based on graphene quantum dots (GQDs) and two-dimensional molybdenum disulfide (MoS_2) were fabricated and characterized. Current-voltage (I-V) measurements revealed multi-stage bi-stable and tri-stable switching behaviors, demonstrating their potential as two-terminal memory elements. The devices exhibited ON/OFF current ratios with stable retention of up to 1×10^4 seconds. Additionally, a ZnO nanorod-based field-effect transistor (FET) was developed as a human serum albumin (HSA) biosensor. A TiO_2 -based interdigitated electrode (IDE) amperometric biosensor was also fabricated for detecting HSA and *E. coli* O157:H7. The TiO_2 nanoparticle platform enabled detection of HSA concentrations ranging from 1 mg/mL down to 1 pg/mL. Multiple devices were tested to assess stability, sensitivity, and reproducibility. After surface cleaning, the sensors demonstrated reusability with consistent I-V profiles across five devices, confirming reliable performance.

Computational studies were conducted to complement the experimental findings. Molecular docking simulations were performed to analyze the structural and electrostatic characteristics of the antibody-antigen interface. The results confirmed that the APTES-functionalized TiO_2 IDE surface enhances antibody binding stability at pH 7, demonstrating the effectiveness of the TiO_2 platform for biosensor applications. These findings provide preliminary validation of the robust antibody immobilization on TiO_2 .

surfaces. Additionally, first-principles calculations were carried out to investigate defects in various 2D and bulk materials. Structural stability, electronic properties, and electron localization were systematically analyzed. Using density functional theory (DFT), different phases of 2D SnGe_2N_4 were evaluated for catalytic water-splitting reactions. The computed reaction pathways and free-energy profiles indicate that SnGe_2N_4 is a promising photocatalyst for the oxygen evolution reaction (OER).

Various synthesis and fabrication techniques for low -dimensional structures have been developed to achieve high quality and low-cost production. One promising approach is the synthesis of silicon nanowires using hot-wire chemical vapor deposition (HWCVD) with an indium catalyst. In HWCVD, a heated tungsten filament decomposes silane and hydrogen gases, resulting in high-crystallinity silicon nanowires. The use of indium as a catalyst enables growth at relatively low temperatures due to its low melting point (157 °C), compared to conventional metals such as gold or copper. Key growth parameters, including catalyst size, filament temperature, substrate-filament distance, and deposition time, were optimized for improved nanowire formation. Subsequently, zinc oxide (ZnO) nanostructures were integrated onto the silicon nanowires to form three-dimensional heterostructured nanowires. ZnO was synthesized via vapor transport condensation and hydrothermal methods. These Si / ZnO heterostructures enhance the optical, photocurrent, and field emission properties of silicon nanowires, overcoming their inherent limitations.

Invited Speaker 1



Prof. Uma N. Dulhare

*Computer Science & Artificial Intelligence Department
Muffakham Jah College of Engineering & Technology, India*

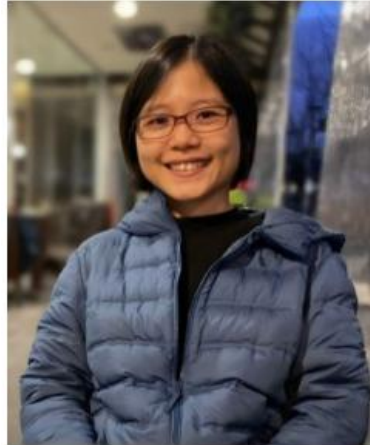
Title of Invited Talk

AIoT-Enabled Precision Diagnostics for Early Skin Cancer Detection: A Smart Sensing and Deep Learning Approach

Abstract of Invited Talk

The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) is redefining the boundaries of precision healthcare by enabling real-time, intelligent and patient-centric diagnostics. For early skin cancer detection, AIoT-enabled precision diagnostic framework designed to bridge the gap between clinical dermatology and smart engineering systems. The proposed architecture integrates miniaturized IoT-based sensing devices including portable dermoscopic imaging units and wearable skin sensors with a cloud-edge deep learning platform. These devices continuously acquire high-resolution images and physiological signals which are transmitted through secure IoT protocols to an AI-driven precision analytics engine. The system employs convolutional neural networks (CNNs) and attention-based fusion layers to automatically detect segment and classify skin lesions into malignant and benign categories achieving real-time inference and a communication adaptive learning. From an engineering perspective, the system's edge-cloud synergy, lightweight model optimization and energy-efficient IoT design make it highly scalable and deployable across healthcare ecosystems. By merging precision sensing hardware with AI-driven decision models this research exemplifies the future of intelligent biomedical systems where diagnostics evolve from static laboratory testing to continuous connected and adaptive healthcare environments.

Invited Speaker 2



Assoc. Prof. Wei-Sea Chang

*Department of Materials Science and Engineering
National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

Title of Invited Talk

Ferroelectric Material as Photoelectrode

Abstract of Invited Talk

It is important goal to develop a renewable means to generate hydrogen for clean energy. One potential solution serves as a method of producing green hydrogen is known as photoelectrochemical (PEC) system. We demonstrate ferroelectric materials as photoelectrode for PEC water splitting, focusing on bismuth ferrite (BiFeO_3). One of the most remarkable features of BiFeO_3 is the high ferroelectric polarization. We discuss the electrical interactions between a water-based electrolyte and BiFeO_3 , including the effectiveness of polarization switching procedure in a liquid environment, as well as the field-effect enhancement of water splitting performance with macroscopic spatial separation between anode and cathode.

Invited Speaker 3



Prof. Chao-Cheng Kaun

Research Center for Applied Sciences, Academia Sinica, Taiwan

Title of Invited Talk

Computational Modeling of Nanoelectronics and Emerging Materials

Abstract of Invited Talk

Using first-principles calculations, we investigate electronic transport through MoS₂-based heterojunctions for nanoelectronic applications. Effects of biasing and quantum interfering are addressed. We study the efficiencies of polymer-protected perovskite quantum dot films for LED backlighting and polymer-promoted superionic electrolyte for Mg-O₂ batteries. Effects of polymer-adsorbing and material-configuring are highlighted. Moreover, we explore the bandgap tuning of NiFeV layered double hydroxides for optoelectronic and catalytic devices. Effects of compositing and cation ordering are identified.

Invited Speaker 4



Prof. Ngoc Dang Khoa Tran

*Faculty of Mechanical Engineering
Industrial University of Ho Chi Minh City, Vietnam*

Title of Invited Talk

A compliant bistable mechanism based on stepped line profile

Abstract of Invited Talk

This study developed a new compliant bistable mechanism is formed based on the connection of horizontal and vertical bars in the up step line shape. The behavior of the mechanism is analyzed based on CBCM numerical method and compared with the finite element method. Both methods agree that the mechanism achieves two stable positions through compression and expansion of the beams. Relevant parametric investigations have been conducted to analyze the characteristics of the mechanism. A macro prototype with ABS material has been fabricated and tested to verify the theory with an error of 3%. The structure has simple properties and is convenient in manufacturing to meet the needs in aerospace, medicine and MEMS.

Invited Speaker 5



Assoc. Prof. Jyoti Jaiswal

*Department of Physics, Rajiv Gandhi University
Rono-Hills, Doimukh, Arunachal Pradesh, India*

Title of Invited Talk

Tailored 2D-MoSe₂ Materials with Metal Dopants for Scalable Non-Enzymatic Biosensing Applications

Abstract of Invited Talk

Two-dimensional (2D) transition metal dichalcogenides (TMDs), particularly molybdenum diselenide (MoSe₂), have emerged as promising materials for next-generation electrochemical and optical biosensing owing to their tunable band structure, high surface-to-volume ratio, and chemical robustness. Nevertheless, the intrinsic conductivity and limited surface reactivity of pristine MoSe₂ necessitate further modification to enhance its sensitivity and selectivity toward specific biomolecules. In this context, MoSe₂ nanostructures were doped with Ag, Au, and Ni in varying concentrations (0.5–5%) using a scalable hydrothermal synthesis approach. The structural, chemical and electrochemical characterization revealed notable modifications in charge transfer, and electrochromic response as a function of dopant type and concentration. Among the tested compositions, 1% Ag–MoSe₂ exhibited superior non-enzymatic glucose sensing performance. Similarly, 2% Au–MoSe₂ demonstrated excellent selectivity and sensitivity toward dopamine. Furthermore, 1% Ni–MoSe₂ showed remarkable electrochemical response toward serotonin detection. These independent studies collectively highlight the potential of metal-doped MoSe₂ nanostructures as versatile, multifunctional, and composition-tunable sensing materials. The findings provide critical insights into structure–property–function correlations and open new avenues for the development of scalable, enzyme-free, and cost-effective biosensors for healthcare diagnostics and environmental monitoring.

Oral Sessions

Nov. 8, 2025

Session 1

Advanced Design and Intelligent Systems

Session Chair: Prof. Chao-Cheng Kaun

Research Center for Applied Sciences, Academia Sinica, Taiwan

08:30~10:00	I-2	Ferroelectric Material as Photoelectrode <i>Wei Sea Chang</i>[†] Department of Materials Science and Engineering, National Yang Ming Chiao Tung University
	I-4	Harnessing Deep Learning for Precision Diagnostics in Dermatology and Rheumatology <i>Ngoc Dang Khoa Tran</i>[†] Faculty of Mechanical Engineering Industrial University of Ho Chi Minh City, Vietnam
	O-4	Epitaxial 2D Bi₂O₂Te: An Emerging Material for the Next-Generation Semiconductor Industry <i>Yu-Ju Lin</i>^{1,†}, <i>Yu-Hao Tu</i>², <i>Jian-Wei Zhang</i>³, <i>Pai-Chun Wei</i>⁴, and <i>Ying-Hao Chu</i>^{2,*} ¹ Department of Materials Science & Engineering, National Yang Ming Chiao Tung University, Hsinchu, Taiwan ² Department of Materials Science & Engineering, National Tsing Hua University, Hsinchu, Taiwan ³ Key Laboratory of Polar Materials and Devices (MOE) and Department of Electronics, East China Normal University, Shanghai, China ⁴ Department of Materials Science & Engineering, National Cheng Kung University, Tainan, Taiwan

08:30~10:00	O-5	Bi₂O₂Se/PbHfO₃ Heteroepitaxy for Antiferroelectric Field-Effect Transistor <i>Ping-Li Huang[†] and Ying-Hao Chu[*]</i> Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan
	O-7	Study of the Micromechanical Properties of Synthetic Mica under Various Stress Angles via Nanoindentation <i>Yu-Hao Tu^{1,†}, Shou-Yi Chang^{1,2}, and Ying-Hao Chu^{1,2,*}</i> ¹ College of Semiconductor Research, National Tsing Hua University ² Department of Materials Science and Engineering, National Tsing Hua University
	O-8	Flexible High-Entropy Relaxor Ferroelectric for Sustainable Piezoelectric Sensors <i>Yu-En Pan^{1,†} and Ying-Hao Chu^{2,*}</i> ¹ College of Semiconductor Research, National Tsing Hua University, National Tsing Hua University, Hsinchu, Taiwan ² Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan

Session 2

Nano and Smart Sensor Technologies

Session Chair: Asst. Prof. Chun-Wei Tsai

Department of Electronic Engineering,

National United University, Taiwan

14:50~16:05	I-1	AIoT-Enabled Precision Diagnostics for Early Skin Cancer Detection: A Smart Sensing and Deep Learning Approach <i>Uma N. Dulhare</i>[†] Computer Science & Artificial Intelligence Department, Muffakham Jah College of Engineering & Technology, Hyderabad, India
	I-5	Tailored 2D-MoSe₂ Materials with Metal Dopants for Scalable Non-Enzymatic Biosensing Applications <i>Jyoti Jaiswal</i>[†] Department of Physics, Rajiv Gandhi University Rono-Hills, Doimukh, Arunachal Pradesh, India
	O-9	Fabrication and Structural Evolution of Non-Polar and Semi-Polar AlN Thin Films on AAO Nanoporous Structures Using Microwave Annealing <i>He-Han Wu</i>^{1,†}, <i>Yi-Tang Lin</i>¹, <i>Basheer Baba</i>¹, <i>Chien-Sheng Huang</i>¹, <i>Shih-Hung Lin</i>¹, <i>Xiao Tang</i>², and <i>Che-Hao Liao</i>^{1,*} ¹ Department of Electronic Engineering, National Yunlin University of Science and Technology, Yunlin 64002, Taiwan ² School of Electrical, Electronic and Mechanical Engineering, University of Bristol, Bristol BS8 1QU, UK

14:50~16:05	O-10	Enhancing ZnO UV Photodetector Performance Using Polystyrene Nanoparticles and RF-Sputtered Films from Custom Powder Target <i>Yo-Xiang Chen^{1,†}, Wei-Cheng Pan¹, Che-Hao Liao¹, Chien-Sheng Huang¹, Kuang-Hui Li², and Shih Hung Lin^{1,*}</i> ¹ Department of Electronic Engineering, National Yunlin University of Science and Technology, Yunlin 64002, Taiwan ² Department of Materials and Optoelectronic Science, National Sun Yat-sen University, Kaohsiung 804201, Taiwan
	O-3	Design and Fabrication of IoT Sensor for online detection <i>Min-Feng Sung^{1,†,*} and Wei-Hsuan Chang²</i> ¹ Department of Mechanical Engineering, Ming Chi University of Technology ² Department of Artificial Intelligence and Computer Engineering, Chin-Yi University of Technology

Session 3

Modeling, Optoelectronics and Material Innovations

Session Chair: Asst. Prof. Che-Hao Liao

Department of Electronic Engineering

National Yunlin University of Science and Technology, Taiwan

16:05~17:20	I-3	Computational Modeling of Nanoelectronics and Emerging Materials <i>Chao-Cheng Kaun</i> [†] Research Center for Applied Sciences, Academia Sinica, Taiwan
	O-1	Developing an Artificial Intelligence-Based Real-Time Prediction System for the Quality of Rotary Friction Welded Joints <i>Chil-Chyuan Kuo</i> ^{1,2,*} and <i>Hong-Wei Chen</i> ^{3,†} ¹ Department of Mechanical Engineering, Ming Chi University of Technology ² Research Center for Intelligent Medical Devices, Ming Chi University of Technology ³ International Ph.D. Program in Innovative Technology of Biomedical Engineering and Medical Devices, Ming Chi University of Technology
	O-2	Tailored Interface Design for High-Performance Rotary Friction Welded Al/PEEK Joints in Lightweight Structural Applications <i>Chil-Chyuan Kuo</i> ^{1,2,*} , <i>Armaan Farooqui</i> ^{1,†} , and <i>Hong-Wei Chen</i> ³ ¹ Department of Mechanical Engineering, Ming Chi University of Technology ² Research Center for Intelligent Medical Devices, Ming Chi University of Technology ³ International Ph.D. Program in Innovative Technology of Biomedical Engineering and Medical Devices, Ming Chi University of Technology

16:05~17:20	O-11	Evaluation of Infrared Sensing Techniques with Copper Thermal Conductive Materials <i>Shu-Ting Chuang[†], Zhi-Xuan Liao, Yi-Hsuan Huang and Chun-Wei Tsai[*]</i> Department of Electronic Engineering, National United University, Miaoli 360302, Taiwan
	O-12	Simulation and Design of a Room-Temperature CO Sensor Using an SnO₂-Coated Microring Resonator <i>Kuan-He Chen[†], Ting-You Liao, Poo-Yu Lee, Yong-Zun Wang and Chun-Wei Tsai[*]</i> Department of Electronic Engineering, National United University, Miaoli 360302, Taiwan

Session 4

Precision Manufacturing and Sustainable Applications

Session Chair: Asst. Prof. Min-Feng Sung

Department of Mechanical Engineering

Ming Chi University of Technology, Taiwan

17:20~18:20	O-6	Substrate Effects on Anisotropic Lattice Thermal Expansion of Quasi-2D Semiconductors <i>Yu-Hsien Lee^{1,†}, Wei-Ting Chen², Yu-Ju Lin³, and Ying-Hao Chu[*]</i> ¹ Department of Materials Science and Engineering, National Tsing-Hua University ² College of Semiconductor Research, National Tsing-Hua University ³ Department of Materials Science and Engineering, National Yang Ming Chiao Tung University
	O-13	Study on Heterogeneous Joining of Thermoplastic Unidirectional Carbon Fiber Composites and Ti-6Al-4V Alloy <i>Ming-Yuan Shen^{1,*}, Chien-Hung Liu^{2,3}, and Shang-Ta Chiang^{1,†}</i> ¹ Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ² Department of Mechanical Engineering, National Chung Hsing University, Taichung 40227, Taiwan ³ Academy of Circular Economy, National Chung Hsing University, Taichung 40227, Taiwan
	O-14	Fabrication of Large-Scale Single-Crystal Metal Foils with Atomic-Scale Flatness via Muscovite <i>Tzu-Ming Chan^{1,†}, Evan Darius², Yu-Chuan Lin³, and Ying-Hao Chu^{1,*}</i> ¹ Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan ² Biomedical Engineering and Environmental Sciences, National Tsing Hua University, Hsinchu, Taiwan ³ Department of Materials Science and Engineering, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

	O-15	Designs of Synthetic Motions of Virtual Character for Human-Machine Gesture Interaction of Social Robots <i>Ing-Jr Ding and You-Zhe Lee^{†,*}</i> Department of Electronic Engineering, National United University
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Poster Session

Poster No.	Paper Title
P-1	First-Principles Study of $\text{LaAlO}_3(001)/\text{SrTiO}_3(001)$ Heterostructures <i>Jun-Kai Chyou</i>¹, <i>Chin-Chen Chen</i>^{1,†}, and <i>Po-Liang Liu</i>^{1,2,*} ¹ Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ² Department of Applied Materials and Optoelectronic Engineering, National Chi Nan University, Nantou 54561, Taiwan
P-2	Modulation of $\text{Bi}_2\text{O}_2\text{Se}$ and Heterogeneous Integration with Silicon Substrate <i>Wei-Ting Chen</i>^{1,†} and <i>Ying-Hao Chu</i>^{1,2,*} ¹ College of Semiconductor Research, National Tsing Hua University ² Department of Materials Science and Engineering, National Tsing Hua University
P-3	Wide-Angle Lens Aberration Correction Based on U-Net <i>Chun-Chen Yeh</i>[†] and <i>Cheng-Mu Tsai</i>[*] Graduate Institute of Precision Engineering, National Chung Hsing University, Taiwan
P-4	Combining machine learning techniques and kernel density estimation to construct a prediction model for chewing and swallowing disorders <i>Yu-Cheng Huang</i> and <i>Meng-Han Yang</i>^{†,*} Department of Computer Science & Information Engineering, National Kaohsiung University of Science and Technology
P-5	Multimodal Framework for Automated Pulmonary Fibrosis Report Generation from Chest CT Images <i>Bo-Han Tang</i>^{1,†}, <i>Cheng-Mu Tsai</i>^{2,*}, and <i>Chuan-Wang Chang</i>² ¹ Graduate Institute of Precision Engineering, National Chung Hsing University, Taiwan

	² Department of Computer Science and Information Engineering, Chin-Yi University of Technology, Taiwan
P-6	Dispersion Complementary Design of a Doublet Metalens: An Achromatic Simulation Study Centered at 587 nm <i>An-Sheng Chen[†]</i> and <i>Cheng-Mu Tsai[*]</i> Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung City 402, Taiwan, R.O.C
P-7	Photochromic Behavior of Molybdenum Trioxide Epitaxial Films on Muscovite <i>Yun-An Hsieh^{1,†}</i>, <i>Yu-Ju Lin¹</i>, and <i>Ying-Hao Chu^{2,*}</i> ¹ Department of Materials Science and Engineering, National Yang Ming Chiao Tung University, Hsinchu, Taiwan ² Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan
P-8	Optical design and simulation of collimated beam system for curved surface coating detection <i>Chia Wei Chang</i>, <i>Yin Yin Hu</i>, <i>Ju I Ding</i>, <i>Hung Yu Lai[†]</i>, and <i>Pin Han[*]</i> Graduate Institute of Precision Engineering, Nation Chung Hsing University, Taichung, Taiwan
P-9	<i>Ab-initio</i> Investigation of $\text{Bi}_2\text{O}_2\text{X}$ ($\text{X} = \text{Se}, \text{S}, \text{and Te}$)(001) Surface Terminations <i>Chun-Che Lee¹</i>, <i>Chin-Chen Chen^{1,†}</i>, <i>Yan-Cheng Lin¹</i>, <i>Kai-Chiao Yang²</i>, <i>Chi-Ho Cheng²</i>, and <i>Po-Liang Liu^{1,3,*}</i> ¹ Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ² Department of Physics, National Changhua University of Education, Changhua, 50007, Taiwan ³ Department of Applied Materials and Optoelectronic Engineering, National Chi Nan University, Nantou 54561, Taiwan

P-10	Photopolymerized Micro-Honeycomb Mold for Precision Micro-Well Fabrication <i>Tsung-Hung Lin^{†,*}</i> Department of Mechanical and Electro-Mechanical Engineering, National Ilan University, Ilan, Taiwan
P-11	Improved Design for Shelf-Based Automatic Chinese Medicine Dispenser <i>Yu-Chi Wu^{1,†,*}, Jun-Hsien Chiang¹, Jing-Yuan Lin¹, Hao-Pu Lin², and Chin-Chuan Han²</i> ¹ Department of Electrical Engineering, National United University ² Department of Computer Science and Information Engineering, National United University
P-12	NiCoFe Layered Double Hydroxide Anode Catalyst applied on Nickel paper for Anion Exchange Membrane Water Electrolysis <i>Fa-Cheng Su[†] and Hsiharng Yang[*]</i> Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung City 402, Taiwan
P-13	Robust Electroosmotic Touch: Design and Optimization for Enhanced Long-Term Durability <i>Chen-Yang Tsai^{1,†}, Yu-Chuan Su^{1,*}, and Chien-Hsun Chu²</i> ¹ National Tsing Hua University, Taiwan ² Industrial Technology Research Institute, Taiwan
P-14	Rapid Transient Liquid Phase Bonding of AlSiC/Graphene-Cu Composites Using Zn-Al-Cu Alloy <i>Yu-Cheng Ma^{1,†}, Yen-Tse Chiu¹, Chia-Chen Ku¹, Shih-Ying Chang^{1,*}, and Lung-Chuan Tsao²</i> ¹ Department of Mechanical Engineering, National Yunlin University of Science and Technology ² Department of Materials Engineering, National Pingtung University of Science and Technology

P-15	Effects of Laser Welding Parameters on the Microstructure and Mechanical Properties of 2205 Duplex Stainless Steel Joints <i>Hsuan-Ting Lin[†], Shang-Pu Tsai, Yu-Cheng Ma , and Shih-Ying Chang[*]</i> Department of Mechanical Engineering, National Yunlin University of Science and Technology
P-16	First-Principles Study of the Anomalous Hall Conductivity in Quaternary Heusler Compounds $XCuVZ$ ($X = \text{Fe, Co, Ni}$; $Z = \text{Sn, Sb}$) <i>Jen-Chuan Tung^{1,†}, Chun-Hsien Lee², and Po-Liang Liu^{2,3,*}</i> ¹ Center for General Education, Chang Gung University, Taoyuan 33302, Taiwan ² Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ³ Department of Applied Materials and Optoelectronic Engineering, National Chi Nan University, Nantou 54561, Taiwan
P-17	Theoretical Study of Gas Adsorption Driven Work Function Shifts on $\text{ZnGa}_2\text{O}_4(111)$ for Sensing Purposes <i>Jen-Chuan Tung^{1,†}, Guan-Yu Chen², and Po-Liang Liu^{2,3,*}</i> ¹ Center for General Education, Chang Gung University, Taoyuan 33302, Taiwan ² Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ³ Department of Applied Materials and Optoelectronic Engineering, National Chi Nan University, Nantou 54561, Taiwan
P-18	<i>Ab Initio</i> Theoretical Study of Rare-Earth-Based $RXVZ$ Equiatomic Heusler Compounds ($R = \text{Yb, Lu}$; $X = \text{Fe, Co, Ni}$; $Z = \text{Si, Ge, Sn}$) as Pure Spin-Polarized Current Sources <i>Jen-Chuan Tung^{1,†}, Yung-Yi Tseng², and Po-Liang Liu^{2,3,*}</i> ¹ Center for General Education, Chang Gung University, Taoyuan 33302, Taiwan ² Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung 40227, Taiwan ³ Department of Applied Materials and Optoelectronic Engineering, National Chi Nan University, Nantou 54561, Taiwan

Abstract Collections

No. O-1

TITLE: Developing an Artificial Intelligence-Based Real-Time Prediction System for the Quality of Rotary Friction Welded Joints

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ABSTRACT

This study develops an artificial intelligence (AI) model to predict temperature distribution and bending strength in rotary friction welding (RFW) of polymers. RFW offers energy-efficient joining but faces challenges in parameter optimization due to complex thermal–mechanical interactions. The rotational speed, welding time, and feed rate, which are three critical parameters, were tested in 96 combinations using a CNC lathe. Infrared thermography captured temperature profiles, while three-point bending tests evaluated joint strength. The data were normalized and used to train an artificial neural network with early stopping to prevent overfitting. The model achieved high prediction accuracy, with R^2 values of 0.89 for peak temperature and 0.92 for bending strength, and low mean squared error. Rotational speed had the strongest influence on temperature, while welding time and feed rate dominated strength outcomes. The neural network establishes a reliable numerical relationship between RFW parameters and joint properties, enabling real-time prediction of quality. This work provides a foundation for AI-driven process optimization in automated manufacturing, enhancing precision for high-performance polymer and composite applications.

Keyword: Artificial intelligence; Neural networks; Bending strength; Rotary friction welding

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No. O-2

TITLE: Tailored Interface Design for High-Performance Rotary Friction Welded Al/PEEK Joints in Lightweight Structural Applications

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ABSTRACT

The joining of metal and polymer has great potential in structural lightweighting. This study employed continuous drive friction welding to join aluminum (Al 6061) and polyetheretherketone (PEEK) through rotary friction melt fastening. Various interface geometries, including bore, dovetail, and turned structures, were fabricated on the aluminum surface to enhance mechanical interlocking. This study emphasizes the importance of interface geometry and process optimization in rotary friction welding of Al 6061-PEEK joints. The turned interface exhibited the highest bending strength of 92 MPa owing to superior mechanical interlocking and heat management. By optimizing the rotational speed of 4000 rpm, axial pressure, and preheating, thermal degradation was minimized, enhancing joint performance. The innovative approach integrates tailored interface designs and optimized parameters to produce lightweight, high-strength, and thermally stable joints. This advancement addresses key challenges in automotive, aerospace, and medical manufacturing, demonstrating the potential of rotary friction welding for high-performance applications.

Keyword: Polyetheretherketone; Aluminum; Continuous drive friction welding

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No. O-3

TITLE: Design and Fabrication of IoT Sensor for online detection

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ABSTRACT

This study explores the feasibility of using a wireless smart sensor, embedded within a tire, for real-time condition monitoring of production equipment. The proposed sensor module incorporates an integrated microprocessor and wirelessly transmits vibration data to the cloud at a sampling rate of 1000 Hz. While the current system is limited to data transmission, the collected vibration signals exhibit distinct patterns, suggesting a strong potential for future integration of embedded algorithms to enable online automated fault detection. The comparative analysis between the vibration data of conforming and nonconforming products revealed a notable distinction in the standard deviation values. For products classified as acceptable by the QC department, the standard deviation of the vibration signals consistently ranged from 0.04 to 0.07. In contrast, defective products exhibited significantly higher standard deviation values, ranging from 0.14 to 0.18. This more than twofold increase in variability suggests a substantial deviation in dynamic behavior during the manufacturing process.

Keyword: Vibration; IoT; MCU; online detection

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No. O-4

TITLE: Epitaxial 2D Bi₂O₂Te: An Emerging Material for the Next-Generation Semiconductor Industry

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ABSTRACT

2D materials have been extensively studied in recent years, primarily due to their anisotropic layered structure, which grants them unique optical and electronic properties and bandgap tunability. Bi₂O₂X (S, Se, Te), a member of the class of two-dimensional (2D) materials, is a compelling research topic that has been widely investigated in recent years. Their tunable bandgap, ultrahigh mobility, and strong orbit-coupling make them stand out among 2D materials. Among them, Bi₂O₂Te (BOTe) has been predicted using density functional theory to have a lower effective mass and even higher mobility compared to the others in the Bi₂O₂X family [1]. In this study, we deposited epitaxial BOTe on SrTiO₃ (STO) substrate with great crystallinity using pulsed laser deposition (PLD). Epitaxial growth of BOTe has been unexplored until now. In this study, we fabricated BOTe into an epitaxial thin film and conducted an in-depth investigation of its characteristics when synthesized epitaxially. Epitaxial growth of BOTe can minimize scattering centers, resulting in high mobility with a value of ~170 cm²/V · s at room temperature. Notably, oxidation of epitaxial BOTe results in the formation of epitaxial Bi₂TeO₆ that has the same structure as BOTe with four extra oxygen atoms connected to a tellurium atom. Bi₂TeO₆ is found to be a high-k material with a dielectric constant of ~22, and the dielectric strength value reaches ~75 kV/mm for a thickness of ~20nm, which can be directly used as a gate dielectric like silicon dioxide does. Furthermore, a high Seebeck coefficient and power factor are observed for BOTe at room temperature. These appealing properties make it a superior candidate for next-generation electronic and thermoelectric applications.

Keyword: epitaxial; Bi₂O₂Te; native oxide; Bi₂TeO₆; PLD

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No. O-5

TITLE: Bi₂O₂Se /PbHfO₃ Heteroepitaxy for Antiferroelectric Field-Effect Transistor

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ABSTRACT

Silicon-based components have been the dominant material in the semiconductor industry in recent years. According to Moore's Law, "the number of transistors on a microchip doubles every two years while maintaining minimal cost increases." However, difficulties such as decreased carrier mobility and increased short-channel effects arise when minimizing silicon-based electronics. To overcome these obstacles, two-dimensional (2D) materials, which possess properties such as atomic-scale thickness, flexibility, and dangling-bond-free surfaces, are considered suitable for next-generation electronics. Among all the 2D materials, Bi₂O₂Se (BOSE) exhibits exceptional properties, including high mobility, excellent stability, and a tunable bandgap. The bandgap of BOSe ranges from approximately 0.8 to 1 eV. Excess electrons filling the vacancies in the Se layer render BOSe a naturally n-type material. As the amount of BOSe increases, its semiconducting nature gradually transitions toward metallic behavior, attributed to variations in carrier concentration. Furthermore, field-effect transistors based on BOSe can achieve ultra-high mobility exceeding 20,000 cm²/V·s. The ultra-high field-effect mobility is anticipated to facilitate rapid data computing, thereby enhancing the performance of related applications. These advantages make BOSe stand out from other candidates for industrial applications.

In this work, PbHfO₃(PHO) is utilized as the antiferroelectric (AFE) oxide layer. PHO demonstrates superior high-temperature stability compared to other AFE materials due to its high Curie temperature and dielectric constant. A high dielectric constant allows for achieving the same capacitance without significantly reducing the thickness, thereby mitigating current leakage in the oxide layer. The dipoles in the AFE layer switch in response to the external electric field. After removing the external field, the switched dipoles depolarize quickly. During the switching process, the capacitance varies accordingly, influencing the band bending in the BOSe layer on the top. Additionally, changes in BOSe content modulate carrier concentrations, which subsequently affect the dynamic polarization response of the AFE layer. These phenomena impart this electronic component to nonlinear behavior and short-term memory. Besides, AFE transistors are renowned for reduced switching energy loss, subthreshold swing, and increased memory states compared to traditional transistors.

Keywords: transistors; antiferroelectric; epitaxy; BOSe; 2D semiconductor

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No. O-6

TITLE: Substrate Effects on Anisotropic Lattice Thermal Expansion of Quasi-2D Semiconductors

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ABSTRACT

Thermal expansion mismatch between quasi-2D semiconductor films and their substrates can induce strain, warping, or delamination during device fabrication, posing challenges for precision processing and device integration. Understanding the thermomechanical behavior of these films is therefore critical for ensuring structural stability and reliable performance in micro- and nano-fabricated devices. In this study, we use temperature-dependent X-ray diffraction reciprocal space mapping to quantify the in-plane and out-of-plane lattice thermal expansion of Bi₂O₂Se, Bi₂O₂S, and Bi₂O₂Te thin films under different substrates. These materials are selected as representative quasi-2D semiconductors due to their promising electric properties.

In the first part of the study, these materials are deposited on SrTiO₃ substrates by using pulsed laser deposition. For each material, we examine samples of varying thickness to understand how thermal strain evolves and relaxes with temperature under thickness gradients. We also compare different materials at the same thickness to evaluate composition-dependent expansion behaviour.

In the second part, we extend the investigation to silicon substrates, where both the films and the silicon substrate itself are analyzed simultaneously through the same temperature dependent reciprocal space mapping measurements. This approach enables direct extraction of effective thermal expansion coefficients of the substrate under identical experimental conditions, allowing a more accurate evaluation of strain transfer across the film/substrate interface. By comparing the thermal expansion behavior of Bi₂O₂X (X = Se, S, Te) films on SrTiO₃ and silicon, we reveal how substrate thermal expansion mismatch and interfacial coupling affect strain relaxation pathways.

For the results, we have obtained the in-plane and out-of-plane thermal expansion coefficients of the Bi₂O₂X series on SrTiO₃ under different thickness gradients as well as on silicon substrates. Preliminary results suggest that the thermal expansion behavior of Bi₂O₂X films on silicon differs from that on SrTiO₃, implying possible differences in interfacial stress and strain relaxation mechanisms.

These findings provide insight into how substrate choice and film thickness influence thermomechanical stability, which is critical for fabrication and structural stability. Understanding these substrate-driven effects can guide the selection of compatible substrates and the design of quasi-2D semiconductor devices, supporting the reliable production of micro- and nano-scale structures.

Keywords: Quasi-2D Semiconductors; RSM; Thermal Expansion; Substrate Effect; Silicon

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No. O-7

TITLE: Study of the Micromechanical Properties of Synthetic Mica under Various Stress Angles via Nanoindentation

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ABSTRACT

With the development of mobile networks and the Internet of Things, the demand for various wearable devices and sensors has also increased. To enhance the adaptability of these devices in different scenarios, replacing traditional rigid materials with flexible materials is an inevitable trend. Currently, the market commonly uses two types of flexible substrates: metal foils and polymer materials. Metal foils can withstand high temperatures but are relatively heavy and not transparent. They are prone to oxidation and diffusion problems on the surface. Polymers are lightweight and highly transparent but have low melting points and cannot be used in high-temperature working environments. To address these issues, a new substrate, mica, has been proposed, and various materials have been successfully grown on it [1]. Mica is a layered silicate compound with a two-dimensional structure along its [001] direction. At appropriate thicknesses, it exhibits excellent flexibility (bending radius < 5mm) and transparency (visible light transmittance > 85%). It is also heat-resistant (melting point > 1000°C), resistant to acids and alkalis, and exhibits good insulation properties. After proper exfoliation, its surface can achieve atomic-level flatness.

To further investigate the applicability of mica in wearable electronic devices, the mechanical properties of mica itself have become an important issue. In this study, we utilize nanoindentation [2] to investigate its deformation behavior [3] at the micron scale, aiming to provide further insights into the future applications of mica in wearable devices.

Micron-scale mica pillars are fabricated by a focused ion beam. Their size is controlled to about two microns in diameter and six microns in height. Initially, nanoindentation tests were conducted on mica pillars with a flat punch. We investigated the deformation behavior of mica pillars when the applied stress deviated from the perpendicular orientation to the mica (001) plane, with an offset angle from 0° to 45°. As the angle of inclination increased, the strength of the pillar decreased. Notably, a continuous drop in stress was observed for the pillars with 35° and 45° offset angles. After the indentation test, the remaining pillar was sent to a transmission electron microscope for further analysis. From the HRTEM image, it is clear that the slip plane is the mica (001) plane.

In this study, we successfully characterized the stress-strain behavior of mica pillars using nanoindentation, examining the influence of pillar inclination angle. The results obtained from mica pillars showed a clear trend. The 35° and 45°-tilted pillars show a constant drop in the curve, which results from the slip along the mica (001). However, the detailed behavior of mica pillars with different inclination angles remains unclear. Therefore, further experimentation and analysis are necessary to explain the actual behavior under varying inclination angles.

Keyword: synthetic mica; mechanical property; nanoindentation; micropillar compression

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No. O-8

TITLE: Flexible High-Entropy Relaxor Ferroelectric for Sustainable Piezoelectric Sensors

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ABSTRACT

In recent years, flexible devices have garnered widespread attention, with flexible sensors receiving particular interest due to the development of AI robots. The ferroelectric material PMN-PT has emerged as an excellent candidate for sensors or actuators due to its high sensitivity and strong piezoelectric response. However, its relatively low Curie temperature and brittle nature limit its applicability in flexible and high-temperature environments. On the other hand, current flexible piezoelectric materials, such as PVDF, black phosphorus, and bio piezoelectric materials, typically exhibit low d_{33} values and limited operating temperatures. To overcome the challenge of achieving both high thermal stability and strong piezoelectric performance, this study introduces a high-entropy system into a relaxor ferroelectric matrix and combines it with a flexible mica substrate to develop a material—PMNTHZO ($\text{Pb}_{1.1}(\text{Mg}_{0.15}\text{Nb}_{0.3}\text{Ti}_{0.05}\text{Hf}_{0.25}\text{Zr}_{0.25})\text{O}_3$)—that is both thermally stable and mechanically flexible. PMNTHZO thin films were fabricated via pulsed laser deposition (PLD), resulting in a single-crystalline film on STO/mica and a polycrystalline film on Pt/mica. Both film types exhibit high breakdown electric fields (>2.21 MV/cm) and excellent thermal stability ($>250^\circ\text{C}$), demonstrating the outstanding structural stability endowed by the high-entropy system. Moreover, bending results reveal the excellent flexibility of PMNTHZO, as PMNTHZO retains its ferroelectric property at a bending diameter of 3.5 mm. For piezoelectric applications, the results show that the output signal is highly sensitive to changes in curvature. Bending fatigue tests further verify the durability and sustainability of PMNTHZO in long-term use. Additionally, PMNTHZO was designed as a flexible body sensor, and tactile tests confirm its ability to detect varying magnitudes of applied force and bending deformation. In conclusion, this work highlights the great potential of high-entropy oxides in relaxor ferroelectric systems for the development of flexible and thermally stable piezoelectric sensors.

Keyword: high entropy; piezoelectric; flexible sensors; relaxor ferroelectric

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No. O-9

TITLE: Fabrication and Structural Evolution of Non-Polar and Semi-Polar AlN Thin Films on AAO Nanoporous Structures Using Microwave Annealing

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ABSTRACT

This study presents the fabrication and crystallographic evolution of non-polar and semi-polar aluminum nitride (AlN) thin films grown on Si(100) substrates using nanoporous anodic aluminum oxide (AAO) microstructure buffer layers and microwave annealing treatment. The introduction of a nanoporous AAO layer effectively reduces the lattice mismatch and interfacial stress between AlN and Si, thereby improving film crystallinity. The AAO buffer layer was prepared by anodizing an aluminum film deposited on Si(100) substrates using oxalic acid and sulfuric acid electrolytes. It was found that oxalic acid produced larger pore sizes and higher porosity compared with sulfuric acid. The pore size and distribution density were tunable through anodizing voltage and duration, where an increase in voltage resulted in larger and less densely distributed pores. Additionally, a near-linear relationship was observed between anodizing time and pore diameter, and subsequent phosphoric acid etching was employed to further enlarge and smooth the nanoporous surface.

After the formation of the AAO layer, AlN films were deposited by RF sputtering and subjected to microwave (MW) annealing under various powers and durations. X-ray diffraction (XRD) analysis revealed that AlN films on both Si and AAO templates exhibited a dominant non-polar AlN(100) orientation after annealing at 3000 W for 600 s, corresponding to the m-plane structure. In contrast, at lower MW power or shorter annealing durations, the AlN films grown on AAO templates initially showed semi-polar AlN(101) orientations. Extending the annealing time caused a gradual transition from semi-polar (101) to non-polar (100) orientation.

The calculated domain sizes indicated that excessive MW power degraded the crystal quality of AlN films on bare Si but improved that on AAO templates. The largest non-polar AlN(100) domain size of 14.3 nm was achieved using an RF sputtering power of 150 W followed by 3000 W/600 s MW annealing. Meanwhile, the highest semi-polar AlN(101) domain size of 28.8 nm was obtained at 3000 W/300 s. These findings demonstrate that the crystallographic orientation and quality of AlN films can be effectively tuned through MW annealing parameters in combination with AAO-assisted growth, offering a promising route for high-quality AlN-based optoelectronic and piezoelectric devices.

Keyword: Aluminum nitride; anodic aluminum oxide; microwave annealing; non-polar AlN; semi-polar AlN

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No. O-10

TITLE: Enhancing ZnO UV Photodetector Performance Using Polystyrene Nanoparticles and RF-Sputtered Films from Custom Powder Target

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ABSTRACT

Ultraviolet (UV) photodetectors have become indispensable across various domains, including medical diagnostics, environmental monitoring, water purification, and military applications, owing to their ability to detect UV radiation with high sensitivity. Zinc oxide (ZnO) is widely recognized as a promising material for UV photodetectors due to its favorable properties, including a wide bandgap, low fabrication cost, excellent chemical stability, and strong resistance to radiation. In this study, we explore the enhancement of ZnO-based UV photodetectors by incorporating polystyrene nanoparticles (PSNP) into the sensing region to boost their performance. ZnO thin films were deposited on sapphire substrates using radio frequency (RF) magnetron sputtering [1], a method chosen for its compatibility with the polycrystalline structure of ZnO and the ability to achieve high-quality films. The ZnO sputtering targets were custom-fabricated by sintering powder targets at 900°C, facilitating the potential for future doping with additional materials to improve film properties.

The ZnO thin films, with a thickness of 500 nm, were deposited under varying argon-to-oxygen gas flow ratios, and sputtering power was adjusted between 40 W and 100 W, with the substrate temperature maintained at 400°C. Post-deposition annealing was conducted in an ambient atmosphere at temperatures ranging from 500°C to 1000°C for 4 hours, and the resulting films were characterized to identify optimal fabrication parameters [2]. To fabricate the UV photodetector devices, interdigitated electrode patterns were defined on the ZnO films using photolithography, followed by RF sputtering of aluminum to form the metal electrodes.

The performance of the ZnO UV photodetectors was evaluated in terms of photoresponsivity and sensitivity under UV illumination [3]. The incorporation of PSNP into the sensing region significantly enhanced the photodetectors' optoelectronic performance, improving UV absorption and carrier transport. These functional materials contributed to a substantial increase in both the photoresponsivity and sensitivity of the devices, with the integrated devices demonstrating enhanced electrical performance compared to those without the additional materials. The findings highlight the potential of ZnO-based UV photodetectors, particularly those enhanced with PSNP, for a wide range of applications, from daily used consumer products to specialized technological systems. The results suggest that such advancements could lead to significant improvements in the efficiency and functionality of UV photodetection systems, enabling broader utilization in both commercial and industrial settings. Our study underscores the importance of material integration in improving the performance of UV photodetectors and suggests a promising avenue for future research and development in the field of optoelectronics.

Keyword: ZnO; Polystyrene Nanoparticles; Ultraviolet photodetector; powder target

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No. O-11

TITLE: Evaluation of Infrared Sensing Techniques with Copper Thermal Conductive Materials

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ABSTRACT

Thermopile infrared sensors play an important role in temperature detection, and their sensitivity and response time are affected by thermal resistance and thermal mass [1]. According to the literature, the thermal conductivity of pure copper foil can be increased from about $340 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$ to about $415 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$ by redox-reducing graphene oxide into graphene as a coating material [2]. Therefore, the thermal conductivity and thermal diffusion characteristics of the sensing element are improved from the material side to reduce thermal resistance, speed up thermal response rate, and thus enhance sensitivity and reduce time constant.

This study used a thermopile infrared sensor as a substrate, depositing copper material on its surface. The nano-super copper contained graphene components, and then compared the performance of the sensor element before and after the use of the copper material. By integrating the nano-super copper into the infrared sensor element, the sensitivity, response time, and thermal conductivity were further improved. This research aims to improve the performance of thermopile infrared sensors by combining nanostructured copper with thermopile infrared sensors, demonstrating that sensor sensitivity and response characteristics can be enhanced through material design. This achievement can also serve as an experimental reference in the design of thermopile infrared sensors.

Keywords: Thermopile Infrared Sensor; Copper; Thermal Conductivity; Response Time; Sensitivity

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No. O-12

TITLE: Simulation and Design of a Room-Temperature CO Sensor Using an SnO₂-Coated Microring Resonator

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ABSTRACT

This study addresses the need for sensitive and real-time detection of indoor carbon monoxide (CO), a colorless and odorless gas that may cause mild headaches after 2–3 hours of exposure at approximately 200 ppm, which represents the target warning concentration [1]. A microring resonator (MRR) coated with a SnO₂ functional layer was employed, where CO adsorption induces a refractive index change, leading to a measurable shift in the resonant wavelength. MRRs offer advantages such as compact structure, high sensitivity to refractive index changes, fast measurement, and easy integration with other photonic components [2].

During the simulation and design process, trade-offs were optimized to achieve a high Q factor, a measurable resonance shift ($\Delta\lambda$), and acceptable optical losses [3]. To enhance low-temperature performance, the SnO₂ functional layer was doped with platinum (Pt), enabling effective CO detection at 80 °C. Simulation results indicate a sensitivity of approximately 0.5 pm/ppm, a conservative limit of detection (LOD) of 15–20 ppm, and response/recovery times of 1–2 min and 2–4 min, respectively, demonstrating measurable resonance shifts and practical feasibility. Sensor performance was further evaluated by comparison with a commercial MOS CO sensor, focusing on sensitivity, response time, and recovery behavior. The results suggest that the proposed optical sensor is feasible under typical laboratory conditions and holds potential for indoor CO detection and early-warning applications.

Keyword: carbon monoxide; microring resonator; SnO₂; gas sensor; optical detection

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No. O-13

TITLE: Study on Heterogeneous Joining of Thermoplastic Unidirectional Carbon Fiber Composites and Ti-6Al-4V Alloy

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ABSTRACT

(1) Background: Thermoplastic carbon fiber composites offer high strength, stiffness, impact resistance, and recyclability, making them ideal for sustainable lightweight structures. In this study, polycarbonate (PC) carbon fiber prepregs were hot-press molded and joined with Ti-6Al-4V (64Ti) alloy. The titanium surface was treated with three concentrations of modification agents to improve interfacial bonding. Single-lap shear tests (ASTM D3165) were performed to evaluate bonding strength. Results identified the optimal surface treatment, providing guidance for developing high-performance, eco-efficient fiber/metal laminates.;

(2) Methods: Carbon fiber prepregs with a polycarbonate (PC) thermoplastic matrix were used to form heterogeneous joints with Ti-6Al-4V (64Ti) alloy. Titanium substrates were machined to mold dimensions while accounting for thermal expansion, and laser surface treatment was applied to remove the oxide layer and generate suitable roughness for bonding. Parameters such as scanning speed, power, frequency, and passes were optimized to produce a clean surface without re-oxidation. After laser roughening, the alloy was immersed in surface modification agents with three different concentrations to enhance interfacial adhesion. The treated substrates were then joined with preformed PC-based carbon fiber laminates via hot-press molding at 270 °C. Mechanical performance was evaluated through ASTM D3165 single-lap shear testing, with specimens conditioned at 23 ± 3 °C and 50 ± 5% RH for 48 h before testing.;

(3) Results: Optimized laser parameters produced uniform surface roughness that enhanced bonding between titanium and resin while avoiding re-oxidation. The application of surface modification agents further improved adhesion. Lap shear tests demonstrated that modified specimens exhibited higher shear strength than untreated ones. Among the three concentrations, one condition yielded the highest bonding strength, confirming the synergistic enhancement from combining laser roughening with chemical modification. This approach effectively improved the interfacial properties of PC-based carbon fiber composites joined with 64Ti alloy, providing a promising pathway for developing high-performance fiber/metal laminates.;

(4) Conclusions: Optimized laser parameters and the appropriate concentration of surface treatment agent effectively enhanced the adhesion between Ti-6Al-4V and the polycarbonate matrix, resulting in superior lap shear strength. Future studies may explore a wider range of laser conditions and modifier concentrations to further improve the interfacial and mechanical performance of heterogeneous fiber/metal joints.

Keywords: Thermoplastic composites; Ti-6Al-4V alloy; Fiber–metal laminates; Laser surface treatment; Surface modification

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No. O-14

TITLE: Fabrication of Large-Scale Single-Crystal Metal Foils with Atomic-Scale Flatness via Muscovite

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ABSTRACT

The rapid advancement of nanotechnology has significantly increased the demand for high-quality substrates, which are essential for developing low-dimensional materials. Recent research has focused on innovative materials such as two-dimensional (2D) hexagonal boron nitride (hBN), graphene, and one-dimensional (1D) quantum dots, which exhibit outstanding electronic, optical, and thermal properties. “The choice of substrate plays a crucial role in determining the structural integrity, crystallinity, and overall performance of these materials.” Numerous studies have shown that low-dimensional materials achieve optimal performance when grown on metal substrates, particularly copper [1,2]. Copper’s low carbon solubility and catalytic properties make it an ideal candidate for synthesizing high-quality 2D materials. However, conventional copper foils are often limited by grain boundaries, surface defects, and insufficient crystallinity, restricting their use in advanced material fabrication [3]. In this study, we present a novel muscovite-assisted method for fabricating large-scale metal substrates with exceptional crystallinity and atomic-level flatness. The resulting substrates exhibit surface roughness on the order of a few angstroms and a single-crystal Cu(111) orientation, for example. This versatile approach has also been successfully extended to other metal substrates, including platinum (Pt), silver (Ag), and high-entropy alloys (HEAs). With this advanced method, we can significantly improve the quality of substrate fabrication while leveraging naturally abundant muscovite to reduce production costs substantially. The combination of high performance and economic efficiency makes this technique highly attractive for large-scale applications. Moreover, the compatibility of muscovite with various metals and its reusability further enhance the sustainability and scalability of the process. These advantages collectively position our approach as a powerful enabler for the practical realization of next-generation low-dimensional materials and flexible electronic systems. Building on this achievement, we further utilized the high-quality single-crystal copper substrates as a growth platform for two-dimensional graphene. Owing to the atomically flat surface and superior crystallinity of the copper substrate, the resulting graphene exhibited significantly improved structural uniformity and reduced defect density. This advancement effectively overcomes the limitations imposed by conventional polycrystalline copper foils, enabling the synthesis of high-performance graphene with enhanced electrical and mechanical properties. Our results demonstrate that muscovite-assisted metal substrates provide a promising pathway toward the scalable fabrication of next-generation two-dimensional materials and high-precision electronic devices.

Keyword: Ultra-flat; copper substrate; muscovite; 2D materials; Graphene

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No. O-15

TITLE: Designs of Synthetic Motions of Virtual Character for Human-Machine Gesture Interaction of Social Robots

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ABSTRACT

With the rapid development of artificial intelligence (AI) and deep learning, virtual agents and digital humans have been widely applied in fields such as smart homes, interactive entertainment, healthcare, and smart assistants. However, most virtual agent designs on the market currently rely primarily on voice interaction, focusing mainly on the dialogue level of voice input and response. In contrast, agent systems capable of natural interaction through body postures or gestures are still relatively insufficient, and there is a significant gap in applications related to emotional expression and nonverbal communication. To address this issue, this study develops a scheme to generate virtual character motions for human-computer gesture interaction in social robots. The gesture synthesis design contains two phases, model training and inference. In the phase of model training, the translation work between text and gestures consists of three main training modules, the vector quantized variational auto-encoder (VQ-VAE)-based gesture quantization module for converting continuous gesture sequences into discrete code vectors, the gesture-to-text module to enhance the semantic consistency between actions and text, and the text-to-gesture module to generate corresponding virtual gestures based on emotionally charged text descriptions. In the inference phase, only the established text-to-gesture module, acting as the type of sequence-to-sequence (Seq2Seq), is used for generate natural actions based on the understood text from social action with emotion. To analyze the naturalness and expressiveness between the generated and the real action, this study will use five different evaluation metrics including matching score, R-Precision, Frechet inception distance (FID), diversity score, and multimodality index.

Keyword: deep learning; text-to-gesture; virtual agent; gesture naturalness; gesture generation

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No. P-1

TITLE: First-Principles Study of LaAlO₃(001)/SrTiO₃(001) Heterostructures

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ABSTRACT

In this work, *ab initio* calculations based on density functional theory were performed to investigate the structural and surface properties of LaAlO₃ films and SrTiO₃ substrates[1-6]. The optimized lattice parameters and angles for both materials are in close agreement with experimental reports, confirming the reliability of the computational approach. Surface energy calculations indicate that LaO-terminated and AlO₂-terminated LaAlO₃(001) surfaces possess energies in the ranges of 0.07 ~ 0.18 eV/Å² and 0.09 ~ 0.19 eV/Å², respectively, while SrO-terminated and TiO₂-terminated SrTiO₃(001) surfaces have energies of 0.03 eV/Å² and 0.06 eV/Å². The lower surface energies observed for LaO-terminated LaAlO₃(001) and SrO-terminated SrTiO₃(001), compared to the other surface terminations, are consistent with experimental findings. Furthermore, analysis of the heterointerface energies reveals that the LaO-polar LaAlO₃(001) film on SrO-terminated SrTiO₃(001) substrate yields the most stable configuration, with interface energies ranging from 0.0580 ~ 0.0525 eV/Å². This suggests that the AlO₂/SrO interface is favorable for heteroepitaxial growth, and the continuous interface structure corresponds to the lowest interface energy, in agreement with experimental observations.

Keyword: ab initio study; 2D-material; surface energy; heterostructure; interface energy

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No. P-2

TITLE: Modulation of Bi₂O₂Se and Heterogeneous Integration with Silicon Substrate

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ABSTRACT

As the size of semiconductor devices continues to shrink, the short channel effect, leakage current, and degradation in carrier transport performance have severely limited the further reduction of device size under Moore's Law. This has prompted people to urgently seek new channel materials that can continuously improve performance and break through the physical limits of traditional silicon-based transistors. Two-dimensional materials have become highly promising alternatives due to their atomically thin geometric structure, few dangling bonds, and excellent electrostatic control capabilities. Among them, Bi₂O₂Se is a quasi-2D semiconductor with a moderate and tunable bandgap (approximately 0.8–1 eV), high carrier mobility, and excellent thermal and environmental stability. Its unique crystal structure consists of alternating [Bi₂O₂]²⁺ layers and [Se]²⁻ layers bonded by van der Waals interactions, enabling heterogeneous integration with traditional substrates. This study aims to investigate the structural and electrical properties of Bi₂O₂Se films grown on silicon substrates and explore their potential as scalable high-performance channel materials for future logic and memory applications.

High-quality Bi₂O₂Se thin films were synthesized on silicon substrates using pulsed laser deposition (PLD) technology, with a SrTiO₃ buffer layer to promote epitaxial orientation and lattice matching. During the PLD process, a high-power pulsed laser ablates the target, and the resulting plasma plume condenses onto the heated substrate, forming a uniform crystalline layer. Structural characterization using X-ray diffraction (XRD) θ –2 θ and φ scans confirmed the epitaxial growth of Bi₂O₂Se with a 45° in-plane rotated orientation relative to the substrate. Rocking curve analysis revealed full-width at half-maximum (FWHM) values of 0.25–0.34°, indicating good crystallinity, while reciprocal space mapping (RSM) determined lattice constants of $a = b = 3.93$ Å and $c = 11.68$ Å, confirming excellent structural compatibility. To evaluate the electrical properties, dielectric and crystal measurements were performed. Capacitance-voltage analysis using HfO₂ as the dielectric exhibited characteristic depletion at negative bias, confirming effective semiconductor-dielectric coupling. The fabricated back-gate MOSFET exhibited stable n-type behavior, with a field-effect mobility of approximately 59.4 cm²/V·s, an on/off current ratio of roughly 10⁵, and a subthreshold swing (SS) of approximately 310 mV/dec. The output characteristics exhibited clear current saturation and an ohmic contact between the source/drain electrodes and the Bi₂O₂Se channel. Overall, these results demonstrate the ability of PLD to grow highly crystalline and functionally stable Bi₂O₂Se films, suitable for integration into silicon-based devices.

This study successfully achieved the heterogeneous integration of quasi-two-dimensional Bi₂O₂Se on a silicon substrate, resulting in high structural quality and stable transistor operation. The combination of epitaxial growth, 45° in-plane rotation, narrow full width at half maximum (FWHM), and consistent lattice parameters confirmed its excellent film crystallinity and interface coherence. Electrical properties further verified its reliable n-type conductivity, efficient charge modulation, and robust semiconductor-dielectric coupling. These findings establish Bi₂O₂Se as a promising candidate material for next-generation logic and storage devices, providing a practical method to extend Moore's Law by integrating quasi-two-dimensional semiconductors with traditional silicon platforms.

Keywords: Bi₂O₂Se; silicon substrate; heterogeneous integration; quasi-2D semiconductor

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No. P-3

TITLE: Wide-Angle Lens Aberration Correction Based on U-Net

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ABSTRACT

Wide-angle lenses offer expansive fields of view by virtue of their optical architecture, but they also suffer from pronounced inherent distortion. In this work, we first model and design a wide-angle lens in Zemax OpticStudio operating in the visible spectrum, with a maximum field of view of 180° and plastic optical elements. Using the software's built-in image simulation tools, we generate system images and synthesize captures of diverse scenes by inputting multiple test images. The simulated outputs are then compiled into a dataset to train a U-Net deep learning model, with the goal of restoring images to an aberration-free form. The loss curve looks good: the train and validation losses decrease together with a small gap, showing no clear signs of overfitting. The drop is fast early on and then tapers off; the model basically converges around epochs 35–40, with only minor improvements afterward.

Keyword: wide-angle lens; Zemax; optical design; deep learning

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No. P-4

TITLE: Combining machine learning techniques and kernel density estimation to construct a prediction model for chewing and swallowing disorders

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ABSTRACT

According to population projections from the National Development Council, Taiwan's average life expectancy was 81.75 years by 2023. As the proportion of the elderly (aged 65 and older) in the total population continues to rise, it is projected to exceed 20% by 2025, marking the beginning of a super-aged society [1]. According to a report from the Health Promotion Administration, 21.8% of Taiwanese residents aged 65 and older experience choking at least three times per week, and 12.8% have been assessed for swallowing disorders [2]. This disorder occurs when food cannot pass smoothly from the mouth, through the pharynx, and into the esophagus, causing choking. Chewing and swallowing disorders can have many different causes, such as esophageal disease causing narrowing or compression caused by enlarged organs outside the esophagus. Alternatively, malfunctioning nerves or muscles may interfere with coordinated swallowing. Finally, any pathology in the structures of the mouth, pharynx, and larynx can also lead to decreased chewing and swallowing function. These factors negatively impact the physiological mechanisms of nutrient intake and negatively impact health outcomes, such as aspiration pneumonia, malnutrition, and decreased quality of life [3-5].

Based on the concept of "knowledge distillation" [6], this study attempts to combine machine learning techniques with kernel density estimation (KDE) to construct a predictive model for chewing and swallowing disorders. Unlike traditional invasive tests (such as FEES and VFSS), this model requires only medical records. Using the MIMIC (Medical Information Mart for Intensive Care) database, this study selected ICD (International Classification of Diseases) coded diagnosis data from patient samples. The study dataset contained 262,814 records, including 11,685 patients with chewing and swallowing disorders. Each patient's ICD diagnosis codes were first converted into an embedding vector (dimension = 10) using the Word2Vec method. Then, extreme gradient boosting (XGB) and artificial neural network (ANN) were used respectively to develop a binary predictive model for chewing and swallowing disorders. Using a 10-fold cross-validation training mechanism, the prediction model built using ANN achieved average accuracies of 0.980-0.987 and mean F1-scores of 0.744-0.841 (average execution time = 39,713.3-47,252.8 seconds). The prediction model built using XGB achieved average accuracies of 0.987-0.992 and mean F1-scores of 0.852-0.896, but the average execution time were significantly reduced to 166.6-238.3 seconds. If KDE was used to construct the probability distribution function of the input data and perform dimensionality reduction, the prediction model built using XGB achieved average accuracies of 0.985-0.989 and mean F1-scores of 0.836-0.872 (average execution time = 55.4-89.0 seconds). In summary, this study combined machine learning methods with medical record diagnostic data to effectively predict the risk of chewing and swallowing disorders. Future work will examine the impact of data dimensionality reduction using the KDE method on predictive performance. We hope to develop a practical clinical decision support system and contribute to the development of the long-term care industry in our country.

Keyword: chewing and swallowing disorders; machine learning; kernel density estimation; Medical Information Mart for Intensive Care

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No. P-5

TITLE: Multimodal Framework for Automated Pulmonary Fibrosis Report Generation from Chest CT Images

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ABSTRACT

Chest computed tomography (CT) plays a crucial role in evaluating and monitoring pulmonary fibrosis by providing high-resolution visualization of lung parenchymal abnormalities. However, traditional manual interpretation and report writing are time-consuming, subject to inter-observer variability, and may lack consistency across different radiologists. To address these limitations, we propose a multimodal automated reporting framework that integrates both visual and textual information to generate structured, radiology-style diagnostic reports.

The proposed system leverages a Swin-Transformer-based image encoder to capture hierarchical contextual features from CT slices and a Bio_ClinicalBERT text encoder to represent domain-specific linguistic patterns from radiology descriptions. These representations are aligned through contrastive learning, while image augmentation and GPT-based text paraphrasing enhance robustness and generalization. At the reporting stage, a BioGPT-based decoder equipped with attention fusion synthesizes multi-slice image embeddings into a coherent case-level summary while maintaining the ability to produce fine-grained, slice-level findings.

Experimental results demonstrate that the model effectively captures fibrosis-related characteristics such as honeycombing, traction bronchiectasis, and ground-glass opacity, achieving high semantic alignment between generated and expert reports. This study highlights the feasibility and clinical potential of automated pulmonary fibrosis reporting systems, providing a promising foundation for future computer-aided diagnostic integration in radiology workflows.

Keyword: pulmonary fibrosis; chest CT; multimodal learning; report generation; deep learning

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No. P-6

TITLE: Dispersion Complementary Design of a Doublet Metalens: An Achromatic Simulation Study Centered at 587 nm

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ABSTRACT

Metasurface-based metalenses offer a compact alternative to multi-element refractive optics. However, large-scale fabrication and broadband chromatic correction remain challenging. We propose a doublet achromatic metalens in which two complementary metasurfaces provide dispersion compensation. Using COMSOL Multiphysics together with physical-optics analysis, numerical simulations verify wide-aperture achromatic focusing, supporting a feasible route toward compact, high-performance optical systems.

Keywords: achromatic metalens; metasurface doublet; dispersion compensation; broadband focusing; COMSOL Multiphysics; physical optics

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No. P-7

TITLE: Photochromic Behavior of Molybdenum Trioxide Epitaxial Films on Muscovite

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ABSTRACT

Nowadays, global warming and energy consumption are critical issues, creating an increasing demand for materials that can respond dynamically to light for energy-efficient applications. Molybdenum Trioxide (MoO₃) is a material exhibiting reversible photochromic behavior, making it a promising candidate for smart windows, UV-shielding coatings, and other energy-saving optical devices. Its ability to absorb UV light without additional energy input offers potential for reducing indoor temperatures and protecting against harmful UV exposure. In this work, artificial muscovite, a 2D material characterized by high transparency, flexibility, excellent mechanical stability, and ease of shape tailoring, was selected as the substrate to support the epitaxial growth of MoO₃ thin films, providing a controlled platform for studying their photochromic properties. MoO₃ thin films were deposited on muscovite substrates using pulsed laser deposition (PLD). After deposition, the films were annealed under different atmospheres, including pure nitrogen and nitrogen containing 5% hydrogen, to investigate their color change behavior. The films were also exposed to UV irradiation under ambient conditions to observe the light-induced response. For characterization, X-ray diffraction and UV-visible spectrophotometry are used.

The results show that the epitaxial MoO₃ thin films on muscovite have well-defined crystallographic orientation and high crystalline quality. Annealing under both nitrogen and hydrogen-containing atmospheres induced an apparent color change, suggesting that oxygen defect formation may play an essential role in the photochromic response, while hydrogen does not appear to be necessary. UV irradiation in air successfully induced a color change, suggesting that the photochromic response can be initiated by light, with oxygen defects likely playing a central role, and hydrogen not being required. In conclusion, this study demonstrates that high-quality epitaxial MoO₃ thin films can be reliably grown on transparent and flexible muscovite substrates, and that their color-change behavior can be influenced by both controlled annealing and UV exposure. This platform provides a well-defined system for further exploring the mechanisms behind MoO₃ photochromism, offering potential for energy-efficient optical and UV-protective applications. By combining controlled film growth with annealing and illumination treatments, this work lays a foundation for optimizing MoO₃ thin films for practical use while providing insight into the role of oxygen defects in reversible colorchange processes.

Keyword: photochromism; oxygen defects; epitaxy

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No. P-8

TITLE: Optical design and simulation of collimated beam system for curved surface coating detection

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ABSTRACT

The importance of optical coating technology has long been valued. It can not only change the transmission or reflection of the substrate, but also achieve protective effects such as acid and alkali resistance. It has been widely used in optical, semiconductor and other fields. The current more accurate coating process monitoring methods include single-wavelength laser intensity turning method and wide spectrum interference method. However, they can only be used for flat substrate coating monitoring because when the collimated light of the light-emitting module is irradiated on a curved surface, the reflected light beam will be excessively divergent, thus affecting signal reception and judgment [1, 2].

Therefore, the main goal of this project is to jointly design and develop an optical system that can be used for arc surface coating detection [3, 4] with a cooperative enterprise (Turning Laser Company), and adjust the convergence of the incident beam through optical theoretical calculations and design simulations. The luminosity is such that the beam can still maintain considerable collimation after being reflected by different arcuate surfaces. The target is that the divergence angle increment is not greater than 20% of that when reflected by a flat substrate. This goal has been achieved successfully.

Keywords: Optical design; collimated beam system; curved surface coating

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No. P-9

TITLE: Ab-initio Investigation of Bi₂O₂X (X = Se, S, and Te)(001) Surface Terminations

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ABSTRACT

With the advancement of technology, the miniaturization of integrated circuits has accelerated. However, such miniaturization induces quantum tunneling effects, which can accelerate memory degradation and lead to data loss during power-off states. To address these challenges, two-dimensional bismuth oxychalcogenides, including Bi₂O₂Se, Bi₂O₂S, and Bi₂O₂Te, have attracted increasing attention as promising materials for storage devices. These materials possess tunable band gaps and can be directly integrated into nanoscale circuits, thereby mitigating the aforementioned limitations [1]. Q. Wei et al. used first-principles calculations to study the binding energy of Bi₂O₂Se and designed different surface chemical properties: Se-Se model (Se atoms are located on the top and bottom surfaces), Bi-O model (Bi or O atoms are located on the top and bottom surfaces) and Bi-Se model (Bi or Se atoms are located on the top and bottom surfaces) to study the binding energy. They determined that Se termination is the most promising configuration for the layered Bi₂O₂Se model [2]. Although the experimental research on two-dimensional layered Bi₂O₂Se thin films has been very in-depth, the research on Bi₂O₂S and Bi₂O₂Te is still relatively less. Therefore, it is necessary to systematically explore Bi₂O₂Se, Bi₂O₂S and Bi₂O₂Te thin films. In this study, the structures of Bi₂O₂Se, Bi₂O₂S and Bi₂O₂Te thin films were investigated using first-principles calculations based on density functional theory (DFT) [3-5]. The Bi₂O₂-terminated Bi₂O₂X (X = Se, S and Te)(001) thin films all exhibited relatively high surface energies of approximately 0.07 eV/Å². In contrast, the X-terminated (X = Se, S, and Te) surfaces exhibit lower surface energies: 0.06 eV/Å² for Se-terminated Bi₂O₂Se(001), 0.06 eV/Å² for S-terminated Bi₂O₂S(001), and 0.03 eV/Å² for Te-terminated Bi₂O₂Te(001). These results indicate that the X-terminated (X = Se, S, and Te) Bi₂O₂X(001) films are energetically more stable, which is consistent with previous research results [2].

Keyword: First-principles calculation; 2D-material; surface energy

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No. P-10

TITLE: Photopolymerized Micro-Honeycomb Mold for Precision Micro-Well Fabrication

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ABSTRACT

The concave microwell arrays with honeycomb geometry are widely used for reproducible 3D microtissue production and high-throughput biological assays. The traditional fabrication routes—photolithography to produce SU-8/silicon masters followed by PDMS replica molding or surface-tension mediated shaping[1-3]. Building on surface-tension PDMS approaches and viscoelastic lithography concepts[4].The study presents a practical that uses high-resolution photopolymerization 3D printing to fabricate master molds for PDMS micro-honeycomb concave microwell arrays.

The proposed process: (1) design honeycomb master geometry (hex cell pitch and wall thickness tuned for 500 μm pores/200 μm walls); (2) print master on a photopolymerization printer using a high-resolution resin; (3) post-process (wash + UV cure); (4) validate geometry by optical inspection. This approach untiled the design flexibility of 3D printing with established PDMS molding reproducible concave microwell without lithography.

Uniform honeycomb concave microwell arrays meeting the target dimensions were successfully fabricated, exhibiting smooth concave bottoms suitable for plane formation. In the future, the method enables rapid iteration of cell-culture microwell designs and reduces dependence on conventional photolithography, expanding accessibility for labs focused on organoid/spheroid assays and drug screening.

Keyword: concave microwell arrays; micro-honeycomb; fabrication

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No. P-11

TITLE: Improved Design for Shelf-Based Automatic Chinese Medicine Dispenser

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ABSTRACT

Traditional Chinese Medicine (TCM) is in demand in areas with significant Chinese populations worldwide. However, the current market lacks automated dispensing machines for the numerous types of scientific TCM powders, and dispensing is done manually. Due to the wide variety of scientific TCM powders, which all appear similar with close colors and scents, it is challenging to distinguish them. Moreover, manual dispensing faces issues such as slow dispensing speed, inaccurate medicine dispensing due to human negligence, difficulty in achieving precise powder weight, and a lack of effective automatic dispensing with digital records. Our previous research [1] proposed a shelf-based TCM powder automatic dispensing system to address these shortcomings. In this paper, we further introduce a novel modular powder canister base, a new rail platform design that removes the telescopic platform, and an improved lifting platform mechanism. Three types of motors are used in the system: stepper motors on the shelf rails and the lifting platform, servo motors for the medicine spoons to catch the discharged powder, and DC motors for stirring and discharging the powder in a canister. The main controller of the system is developed using a Raspberry Pi 4B. The distributed controller for each stepper motor is an ESP32. An STM32F031 is chosen for its low cost as the controller for each modular powder canister with two DC motors (one motor for stirring and the other for discharging the powder). Stepper motors are driven by TB6560 driver boards operating at DC 12 V. HX711 is used for the load cell. The servo motor is controlled by sending PWM pulse signals to set the stop position and rotation angle of the medicine spoon. These enhancements enable a powder dispensing speed of 1.6 g/s, with a weight error of less than ± 0.14 g, compared to the previous version of the dispensing machine, which had a speed of 0.22 g/s and a weight error of ± 0.14 g. Additionally, a simple greedy scheduling algorithm [2] has been designed for dispensing, achieving an average preparation time of less than 180 seconds for a prescription with six types of powders. This improved dispenser solves the pain point of manually preparing a prescription that takes 7 to 10 minutes. It easily achieves a 100% accuracy rate, saves labor, reduces patient waiting time, and enhances patient satisfaction. It meets the needs of three parties in the market: hospitals, TCM powder manufacturers, and TCM pharmacists.

Keyword: Traditional Chinese Medicine; Automatic Dispenser; Modular Powder Canister

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No. P-12

TITLE: NiCoFe Layered Double Hydroxide Anode Catalyst applied on Nickel paper for Anion Exchange Membrane Water Electrolysis

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ABSTRACT

This study aims to investigate the key components of the membrane electrode assembly (MEA), specifically the gas diffusion layers (carbon cloth, carbon paper, titanium paper, and nickel paper), and analyze the physical and chemical properties of the catalyst in alkaline anion exchange membrane water electrolysis (AEMWE). The experimental results show that titanium paper has the lowest resistivity; however, in electrochemical analysis, nickel paper exhibits the lowest overpotential and the lowest Tafel slope. X-ray diffraction analysis indicates that the NiCoFe-LDH after annealing has a face-centered cubic (FCC) structure and a higher degree of crystallinity compared to NiCoFe-LDH before annealing, which is confirmed by chemical analysis using electron spectroscopy for chemical analysis (ESCA) to verify the electronic configuration of the elements in NiCoFe-LDH. In electrochemical impedance, the R_{ct} value of NiCoFe-LDH after annealing on nickel paper is lower than the R_{ct} value of carbon paper after annealing. The specific surface area of nickel paper is larger than that of carbon paper, allowing nickel paper to have more active sites, resulting in a faster reaction compared to carbon paper. However, the pore volume of carbon paper is larger than that of nickel paper, indicating that carbon paper has better contact at active sites than nickel paper. In the comparison of power density at different KOH concentrations, the 1.5M KOH perform the highest power density. Furthermore, the optimal loading amount and performance tests indicate that a loading amount of 3 mg/cm² also achieves the highest power density. The results from Raman analysis indicate that the heat treatment annealing leads to changes in the LDH structure, resulting in the formation of different oxidation states and structures. Based on the above analysis conditions, the AEMWE parameters can utilize nickel paper as the gas diffusion layer, Sustainion® X37-50RT as the AEM, 1.5M KOH as the electrolyte, NiCoFe-LDH after annealing as the catalyst, a loading amount of 3 mg/cm², and an electrolyzer temperature of 50°C to achieve optimal AEMWE performance, with a maximum current density of 1.4 A/cm².

Keyword: Non-precious metal Alkaline Anion Exchange Membrane Water Electrolysis; Nano-petal NiCoFe-layered double hydroxide; Ultrasound preparation method; Gas diffusion layer; Nickel paper

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No. P-13

TITLE: Robust Electroosmotic Touch: Design and Optimization for Enhanced Long-Term Durability

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ABSTRACT

This study presents the design and optimization of a thin, low-voltage electroosmotic (EO) module tailored for wearable haptic devices, focusing specifically on enhancing force output and operational stability. EO pumps are versatile micropumps with no moving parts, essential for precise fluid control. They generate stable, high-pressure flow for miniaturized liquid chromatography, targeted drug delivery, electronics cooling, and efficient water management within fuel cell systems [1, 2]. Additionally, in haptics, EO pump arrays are embedded beneath flexible surfaces to create shape-changing displays. They can dynamically form tangible pop-up buttons and textures on flat screens, enabling silent, reconfigurable tactile feedback for user interfaces [3]. The primary challenge is the severely limited operating lifespan of existing EO actuators [4]. This study aims to optimize force output and establish a reliable, thin component architecture that supports long-term operational stability and maintenance.

To achieve enhanced long-term durability, we designed a novel modular structure with replaceable working fluid (Figure 1). This approach overcomes the “one-time use” constraint of conventional sealed EO devices, prioritizing component maintainability. We optimized the design by investigating various electrode materials (nickel-gold (Au), tin (Sn), and carbon) and working fluid compositions (ethylene carbonate (EC) and propylene carbonate (PC)). The results are shown in Figure 2. The EC content is critical, showing a monotonically increasing trend in force output as its mass percentage rises from 0% to 80%. Utilizing the optimal 80% EC working fluid at 150V, the Au electrode delivered a peak force feedback of 1138 mN, significantly surpassing the 450 mN achieved by the Sn electrode.

Crucially, our research identified working fluid degradation as the main failure mechanism. As shown in Figure 3, all three electrode types exhibit a consistent decline in force output during the first seven days of operation. On the 7th day, the module's working fluid was refreshed. This action caused a sharp, immediate increase in force output for all three electrodes, recovering 75% to 85% of the performance loss. After the working fluid was refreshed, the force output for all electrodes resumed a downward trend, similar to the degradation pattern observed in the first seven days. Throughout the experiment, the Au electrode consistently delivered the highest force output. This confirmed the viability of our modular design, offering a practical engineering solution for developing EO modules with significantly extended operational lifespan and reliable long-term performance.

Keyword: electroosmosis; wearable device; long-term durability; working fluid degradation; haptic feedback

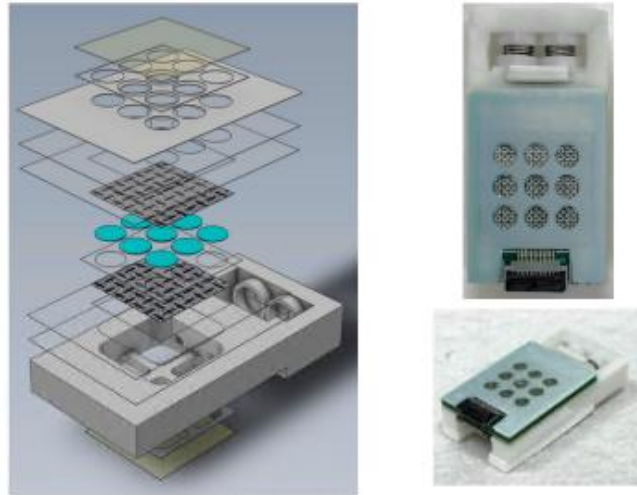


Fig. 1: Exploded-view diagram (left) and photographs (right) of robust electroosmotic module

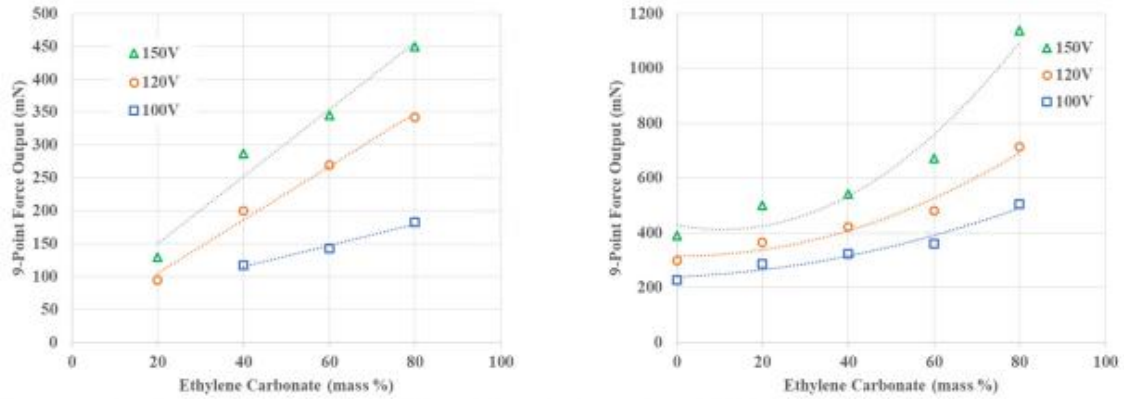


Fig. 2: 9-point force output of EO modules with Sn (left) and Au (right) electrodes with varying EC content

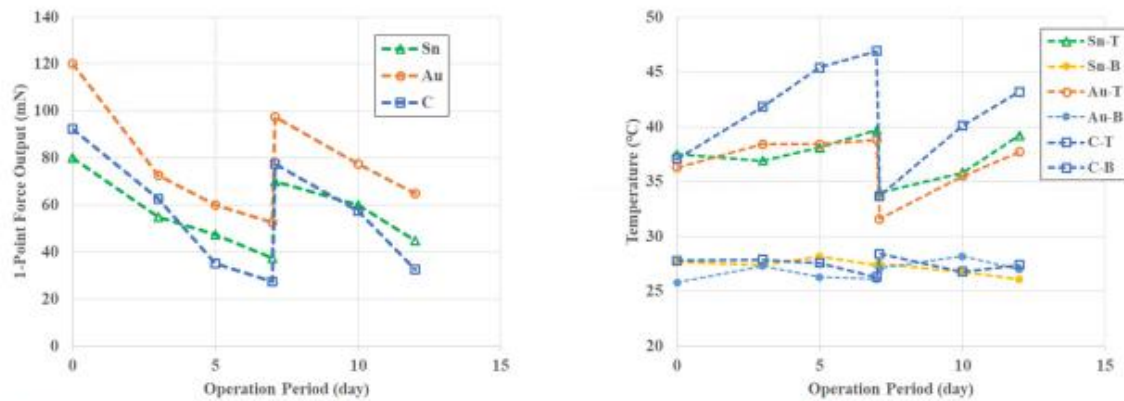


Fig. 3: 1-point force output (left) and temperature range (right) of EO module versus operation time

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No. P-14

TITLE: Rapid Transient Liquid Phase Bonding of AlSiC/Graphene-Cu Composites Using Zn-Al-Cu Alloy

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ABSTRACT

This study designed a Zn-14Al-2Cu filler alloy and developed a bonding technique capable of achieving rapid transient liquid-phase bonding with high thermal conductivity under an atmospheric environment. Experiments were conducted at bonding temperatures of 450 °C, 500 °C, and 550 °C, with ultrasonic activation times of 5, 10, and 30 seconds, to systematically investigate the effects of temperature and bonding duration on joint mechanical properties and interfacial diffusion behavior. The results showed that at a bonding temperature of 500 °C with an ultrasonic amplitude of 8 μm, an optimal shear strength of 26.97 MPa was obtained for the AlSiC/graphene-Cu joints after 30 seconds of ultrasonic application. The ultrasonic cavitation effect facilitated the extensive dissolution of aluminum into the Zn-14Al-2Cu filler alloy, enabling the rapid formation and isothermal solidification of a transient liquid phase, which eliminated the low-melting-point phase and produced a bonding interface exhibiting both high-temperature resistance and excellent thermal conductivity. High-temperature shear tests conducted at 500 °C, above the melting point of the filler alloy, revealed that the optimally bonded AlSiC/graphene-Cu joints maintained an average shear strength of 12.09 MPa, confirming that this bonding technology possesses high thermal stability and reliability, demonstrating strong potential for applications in high-power thermal management components.

Keyword: Rapid Transient Liquid Phase Bonding; Ultrasonics; Aluminum Silicon Carbide (AlSiC); Graphene-Copper; Zn-14Al-2Cu

No. P-15

TITLE: Effects of Laser Welding Parameters on the Microstructure and Mechanical Properties of 2205 Duplex Stainless Steel Joints

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ABSTRACT

This study investigated the effects of laser power, welding speed, and oscillation mode on the microstructure and mechanical properties of 2205 duplex stainless steel joints using a fiber laser. Continuous-wave laser welding was performed with a circular oscillation pattern at travel speeds of 200, 300, and 400 mm/s. The results showed that under a laser power of 600 W, a scanning speed of 300 mm/s, and an oscillation amplitude of 1.0 mm, a well-bonded weld interface was obtained with a maximum tensile strength of 869.54 MPa. When the laser power was increased to 800 W and the scanning speed was reduced to 200 mm/s, excessive heat input caused grain coarsening, leading to a significant decrease in ductility and strength. Conversely, at a lower laser power of 400 W and a higher scanning speed of 400 mm/s, insufficient heat input resulted in the formation of equiaxed grains and partially unmelted original structures at the center of the weld. After welding under various conditions, an increase in the δ -ferrite phase fraction was observed, resulting in an overall increase in hardness. However, under high heat input conditions, the joint exhibited reduced hardness due to grain coarsening and the presence of a higher proportion of austenite.

Keyword: 2205 duplex stainless steel; laser welding; oscillation mode; microstructure; mechanical properties

No. P-16

TITLE: First-Principles Study of the Anomalous Hall Conductivity in Quaternary Heusler Compounds XCuVZ ($\text{X} = \text{Fe}, \text{Co}, \text{Ni}$; $\text{Z} = \text{Sn}, \text{Sb}$)

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ABSTRACT

In this work, we carried out comprehensive first-principles calculations within the framework of density functional theory (DFT) to systematically explore the electronic and magnetic properties of the equiatomic quaternary Heusler (EQH) compounds RCuVZ ($\text{R} = \text{Fe}, \text{Co}, \text{Ni}$; Cu ; $\text{Z} = \text{Sn}, \text{Sb}$). These EQH compounds can crystallize in three possible atomic configurations, commonly referred to as type I, type II, and type III structures. To determine the energetically preferred phase for each composition, we first performed structural optimization and examined the equilibrium lattice parameters for all three configurations. Our results reveal that the type I configuration consistently exhibits the largest equilibrium lattice constants among the three structural types, indicating its distinct atomic coordination and bonding environment.

We then evaluated the magnetic ground states associated with each structure. For the type I configuration, all examined compounds display ferromagnetic (FM) ordering, suggesting that this structural phase energetically favors spin alignment. In contrast, the magnetic behavior of the type II configuration exhibits stronger material dependence: FeVCuSn and CoVCuSn are predicted to be nonmagnetic (NM), whereas CoVCuSb is found to be a half-metallic ferromagnet with a total magnetic moment of $2.00 \mu\text{B}$ per formula unit. Notably, CoVCuSb also features an indirect band gap of approximately 0.42 eV for one spin channel, highlighting its potential as a promising candidate for spintronic devices. For the type III configuration, FeCuSnV and CoCuSnV remain nonmagnetic, while the remaining compounds exhibit ferromagnetic metallic characteristics, further emphasizing the key role of atomic arrangement in governing magnetic ordering.

In addition, we incorporated spin-orbit coupling (SOC) to calculate the anomalous Hall conductivity (AHC) of the ferromagnetic systems. Among them, CoVCuSb , which is half-metallic in its ground state, demonstrates a notable AHC value of -195.29 S/cm . This result suggests that the interplay between half-metallicity and strong spin polarization may give rise to sizable Berry curvature contributions, rendering CoVCuSb a particularly promising material for future applications in spintronic and Hall-effect-based electronic devices.

Keyword: Heusler alloys; rare alloys; elastic constants; magnetic semiconductor; first-principles calculation

No. P-17

TITLE: Theoretical Study of Gas Adsorption Driven Work Function Shifts on $\text{ZnGa}_2\text{O}_4(111)$ for Sensing Purposes

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ABSTRACT

In the present study, first-principles calculations based on density functional theory (DFT) were conducted to comprehensively investigate the adsorption behavior and sensing response of the $\text{ZnGa}_2\text{O}_4(111)$ (ZGO(111)) surface toward a series of target gas molecules, including NO , CO , CO_2 , NO_2 , H_2S , and O_3 . Both single-molecule adsorption and binary co-adsorption configurations were systematically examined to gain deeper insight into the surface and molecule interaction mechanisms and the potential cooperative or competitive effects when multiple gas species are present simultaneously an aspect highly relevant to realistic sensing environments.

For single-gas adsorption, the results show that O_3 plays a particularly dominant role among the examined gas molecules. Specifically, O_3 adsorption on top of surface Ga atoms leads to a significant work function increase of 0.97 eV, implying strong charge redistribution and enhanced surface dipole formation. Meanwhile, O_3 adsorption on Zn sites yields the strongest adsorption energy of -1.90 eV, indicating robust chemical interaction and stable surface binding. These observations clearly suggest that O_3 induces pronounced electronic modulation on the ZGO(111) surface, making it highly detectable by ZGO based gas sensing devices.

In the case of binary co-adsorption, synergistic effects were found for certain gas combinations. Notably, the co-adsorption of NO_2 and O_3 , two strong oxidizing gases, on Ga atoms produces the largest work function modulation of 1.88 eV, while the same pair on Zn sites exhibits the most energetically favorable configuration with an adsorption energy of -3.98 eV. These results indicate that the cooperative presence of highly electronegative species may significantly enhance electron transfer, thereby amplifying the sensing signal and improving surface sensitivity.

Conversely, combinations containing one oxidizing and one reducing gas, such as the (NO_2 , H_2S) pair, show an opposite trend. In this case, the work function change is largely suppressed to -0.02 eV, suggesting partial charge compensation between the adsorbates and a diminished modulation of surface electronic states. This finding implies that competitive redox interactions between co-adsorbed species may weaken surface charge perturbation, potentially reducing the overall sensor response in mixed-gas environments.

Overall, the present work establishes a detailed theoretical understanding of gas- surface interactions on ZGO(111), and provides valuable guidance for optimizing ZnGa_2O_4 based gas sensors under single- and multi-gas exposure conditions.

Keyword: Gas Sensor; Density Functional Theory; Work Function

No. P-18

TITLE: Ab Initio Theoretical Study of Rare-Earth-Based RXVZ Equiatomic Heusler Compounds (R = Yb, Lu; X = Fe, Co, Ni; Z = Si, Ge, Sn) as Pure Spin-Polarized Current Sources

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ABSTRACT

In this study, we perform first-principles calculations within the framework of density functional theory (DFT) to comprehensively examine the structural, electronic, magnetic, and mechanical properties of rare-earth-based equiatomic quaternary Heusler (EQH) alloys with the chemical formula RXVZ (R = Lu, Yb; X = Fe, Co, Ni; Z = Si, Ge, Sn). To identify the most thermodynamically stable configurations and elucidate the correlation between crystal structure and physical properties, three possible atomic arrangements, which referred to as type I, type II, and type III, are systematically evaluated based on distinct atomic ordering schemes.

The calculated results reveal that most RXVZ quaternary Heusler alloys possess ferromagnetic ground states, indicating strong exchange interactions between transition metal atoms. In type II structures, YbFeVSi, YbFeVGe, YbCoVSi, YbCoVGe, YbNiVSi, YbNiVGe, LuCoVSi, LuCoVGe, and LuNiVSi exhibit ferromagnetic half-metallic behavior with integer magnetic moments, suggesting full spin polarization at the Fermi level. A half-metal is a material that behaves as a conductor in one spin channel while remaining insulating in the opposite one, making such compounds promising candidates for spintronic applications. In contrast, within the type III structure, LuCoVSi is identified as a rare magnetic semiconductor, characterized by an integer magnetic moment of 3.00 μ_B and an indirect band gap of 0.21 eV.

In addition, the elastic constants (C_{11} , C_{12} , and C_{44}) are calculated to evaluate the mechanical stability and related parameters such as bulk, shear, and Young's moduli, Poisson's ratio, and Pugh's ratio. The results confirm that most compounds satisfy the mechanical stability criteria and display elastic anisotropy, demonstrating their structural robustness and potential applicability in spintronic and functional materials design.

Keyword: Heusler alloys; rare alloys; elastic constants; magnetic semiconductor; first-principles calculation

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