



RCAAS

中央研究院
ACADEMIA SINICA

應用科學研究中心
Research Center for APPLIED SCIENCES

The multidisciplinary unit dedicated to application-driven research and technology development.

Green Technology



Intelligence Bioengineering



Quantum Photonics



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Introduction

Mission

RCAS employs cutting-edge science and technology to conduct interdisciplinary applied science research for achieving local impact and global excellence.

RCAS has three thematic centers: Intelligence BioEngineering, Green Technology and Quantum Photonics.

Cooperation outside Academia Sinica (MOU)

- 2012**
 - National Chiao Tung University
 - National Dong Hwa University
 - Department of Materials Science and Engineering
 - Department of Physics
 - The Hebrew University of Jerusalem in Israel
- 2013**
 - Molecular Imaging Center, National Taiwan University
 - National Sun Yat-sen University
 - Department of Photonics
 - Department of Materials and Optoelectronic Science
 - Department of Physics
 - Department of Mechanical and Electro-Mechanical Engineering
- 2014**
 - College of Engineering, Chang Gung University
 - College of Biomedical Science and Engineering, National Yang Ming University
 - Research Institute of Electronic Science, Hokkaido University, Japan
 - Graduate Institute of Applied Physics and Department of Physics, National Taiwan University
- 2015**
 - Department of Photonics, National Cheng Kung University
- 2016**
 - Department of Materials Science and Engineering, National Tsing Hua University
- 2020**
 - Department of Applied Science, National Taitung University
 - School of Engineering, The University of Tokyo
 - Abbe Center of Photonics, Friedrich Schiller University Jena
- 2021**
 - Leibniz Institute of Photonic Technology e. V.
- 2023**
 - Institute of Microelectronics Engineering, National Cheng Kung University
 - Program on Semiconductor Manufacturing Technology, Academy of Innovative Semiconductor and Sustainable Manufacturing, National Cheng Kung University
- 2024**
 - Exploratory Research Center on Life and Living Systems, National Institutes of Natural Sciences, Japan
 - Graduate Institute of Electro-Optical Science and Technology, National Taiwan Normal University

Elite Scholarship Program MOU

- Department of Photonics, National Yang Ming Chiao Tung University
- Department of Materials Science and Engineering, National Tsing Hua University
- Department of Electrophysics, National Yang Ming Chiao Tung University
- Department of Chemical Engineering, National Tsing Hua University
- Institute of Biophotonics, National Yang Ming Chiao Tung University
- College of Photonics, National Yang Ming Chiao Tung University
- College of Engineering, Chang Gung University
- Brain Research Center, National Tsing Hua University
- College of Life Science, National Tsing Hua University
- Department of Photonics, National Cheng Kung University
- Department of Materials Science and Engineering, National Yang Ming Chiao Tung University
- Ph.D.Program of Green Materials and Precision Devices, National Taiwan University
- Department of Chemistry, National Taiwan University
- College of Biological Science and Technology, National Yang Ming Chiao Tung University
- Institute of Applied Mechanics, National Taiwan University
- Department of Electrical Engineering, National Chung Hsing University
- Department of Biomechatronics Engineering, National Taiwan University
- Graduate Institute of Electro-Optical Science and Technology, National Taiwan Normal University



Prof. Chung-Yuan Mou
(Chair)

Professor Emeritus, Distinguished Chair Professor for Research, Department of Chemistry, National Taiwan University, Taiwan
國立台灣大學化學系名譽教授



Prof. Li-Chyong Chen

Chair Professor, Department of Physics, National Taiwan University, Taiwan
國立臺灣大學物理系講座教授



Prof. Tai Chang Chiang

Research Professor, Department of Physics, University of Illinois, USA
美國伊利諾伊大學香檳分校物理系名譽教授及研究教授



Prof. Hiroaki MISAWA

(Specially Appointed) Professor, RIES – Research Institute for Electronic Science, Hokkaido University, Japan
北海道大學電子科學研究所特任教授



Prof. Yu-Chong Tai

Anna L. Rosen Professor of Electrical Engineering and Mechanical Engineering, California Institute of Technology (Caltech), USA
加州理工學院電機及機械工程系 Anna L. Rosen 講座教授



Prof. Nai-Chang Yeh

Professor of Physics, California Institute of Technology (Caltech), USA
加州理工學院物理系教授



Prof. Jackie Y. Ying

Professor, King Faisal Specialist Hospital and Research Centre, Riyadh, Kingdom of Saudi Arabia
沙烏地阿拉伯 King Faisal 專科醫院暨研究中心教授

*Sorted in alphabetical order.

The Thematic Center for Intelligence Bioengineering is a premier research unit dedicated to pioneering advancements in biomedical engineering. Our thematic center is committed to transforming the landscape of biomedical applications through state-of-the-art developments in sensing, imaging, characterization, and fabrication technologies. Positioned at the forefront of bioengineering, our center aims to address industrial and clinical challenges by harnessing the power of cutting-edge technology and collaborative innovation.

Vision and Mission

Our mission is to drive significant advancements in biotechnology and clinical applications, focusing on innovative solutions that promise substantial potential for transformation. With a robust team of experts and strategic partnerships, we aim to push the boundaries of current medical technologies to create impactful and sustainable improvements in healthcare.

Our Team and Collaborative Spirit

Led by a team of eleven principal investigators—Dr. Peilin Chen, Dr. Pei-Kuen Wei, Dr. Ji-Yen Cheng, Dr. Fu-Liang Yang, Dr. Chau-Hwang Lee, Dr. Jung-Hsin Lin, Dr. Jing-Jong Shyue, Dr. Yi-Chung Tung, Dr. Chih-Yu Kuo, Dr. Bi-Chang Chen, and Dr. Yu-Jung Lin—the thematic center also includes two adept research specialists, Dr. Tung-Han Hsieh and Dr. Shu-Yi Hsieh. This team's combined expertise spans the entire spectrum of bioengineering, from molecular biology to nano-fabrication technologies, ensuring a comprehensive approach to research and development. The diverse expertise ensures a comprehensive and multi-disciplinary approach to our research projects. Collaboration is a key pillar of our operational philosophy, involving close ties with Academia Sinica's Life Science Division and medical institutes across Taiwan, facilitating a seamless integration of academic research and practical application.

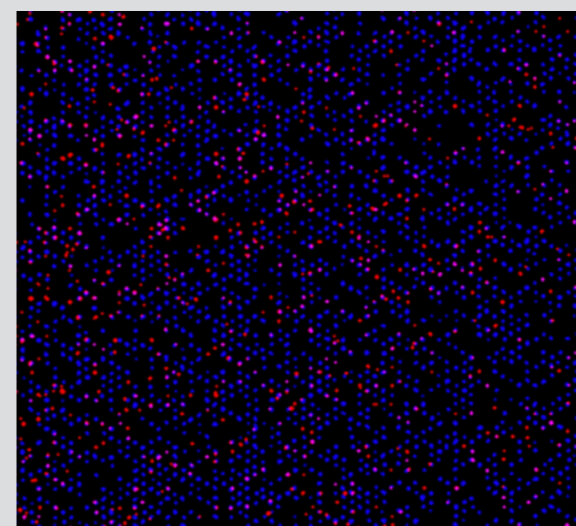
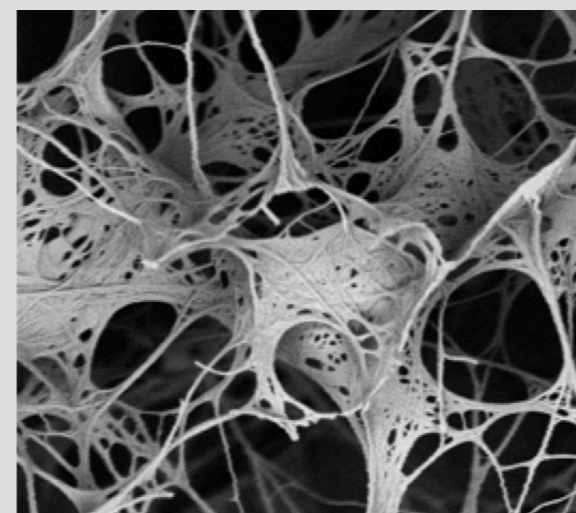
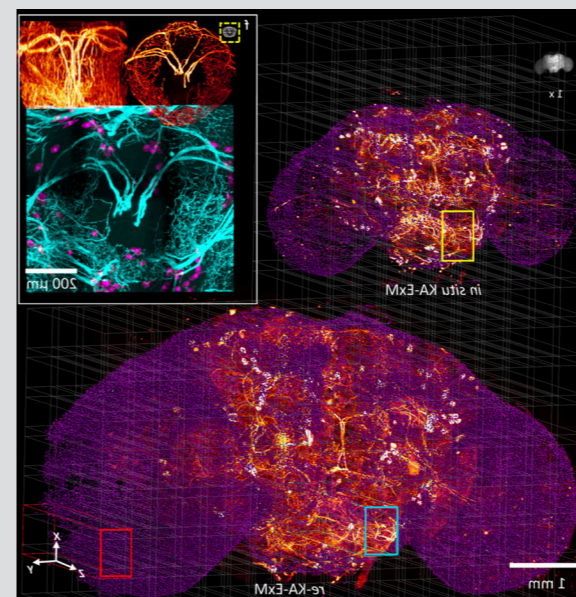
Research Focus and Strategic Initiatives

Our research is strategically divided into three primary areas:

Advanced Imaging and Sensing Technologies: We are leaders in developing sophisticated imaging methods such as lightsheet expansion microscopy, which provides resolutions comparable to electron microscopes, and the application of advanced mass spectrometry techniques for studying complex biological materials.

Artificial Intelligence in Bioengineering: Our center has developed groundbreaking AI applications, including an AI-driven non-invasive blood glucose meter, which has received several national recognitions. We also employ AI to enhance computational methods for biomolecular interaction analysis and drug discovery.

Innovative Drug Delivery Systems: We are pioneering new drug delivery methods, including hydrogel systems for the controlled release of therapeutic compounds, offering new approaches to treat chronic diseases like obesity.



Thematic Research Projects

To foster deeper collaboration and innovation among our principal investigators, we have established a thematic research program that concentrates on two pivotal projects:

Automated Intelligence-Empowered Biology Lab: This project aims to develop an automated, intelligent biological laboratory that streamlines early-stage drug discovery and testing before animal studies and clinical trials. By integrating AI-driven virtual screening, autonomous chemical synthesis, high-sensitivity biosensing, and patient-derived cell and organoid models, the platform will enable efficient identification, synthesis, and evaluation of drug candidates. The entire process—from compound selection to biological testing—will be automated to improve accuracy, reproducibility, and throughput while minimizing human bias and reducing the time and cost of drug development.

Development and Application of Multiscale Multimodal Biomedical Imaging Technologies: This project aims to develop advanced biomaterials and high-resolution single-molecule imaging technologies to enhance the precision and efficiency of biomedical diagnostics and therapeutics. By integrating cutting-edge instruments such as volumetric electron microscopes and sub-nanometer optical microscopes, we seek to build a robust research platform that accelerates clinical translation and fosters innovation. Through close collaboration with medical institutions and international partners, the program also aims to strengthen Taiwan's biomedical industry and establish a leading global research hub.

The Thematic Center for Intelligence Bioengineering is not just a place of scientific inquiry but a beacon of innovation in the biomedical field. Our commitment to developing groundbreaking technologies and fostering collaborative projects positions us to lead the next wave of biomedical advancements. As we continue to explore and expand the frontiers of bioengineering, we anticipate creating revolutionary solutions that promise to redefine the standards of medical technology and healthcare.

The objective of this thematic center is to explore innovative manufacturing and emerging materials in order to expedite the development and implementation of sustainability technologies for realization carbon neutral society: The key research interests include: (1) Energy-efficient and Energy Generation Devices, (2) Next-Generation Batteries, (3) Advanced Energy Material Simulation. Currently, the thematic center comprises seven principal investigators (PIs): Chih Wei Chu, Chun-Wei Pao, Mu-Huai Fang, Tzung-Fang Guo, Yuh-Jen Cheng, Yu-Jung Lu, and Yun-Chong Chang.

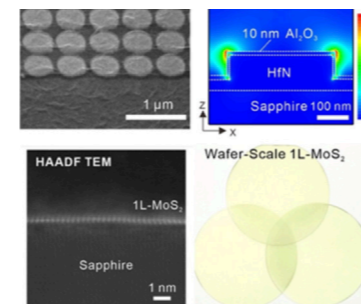
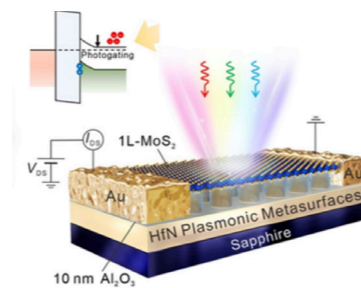
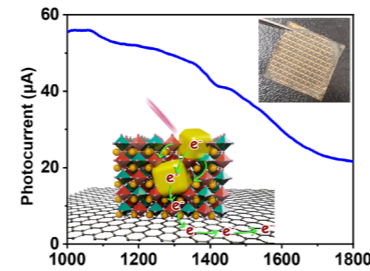
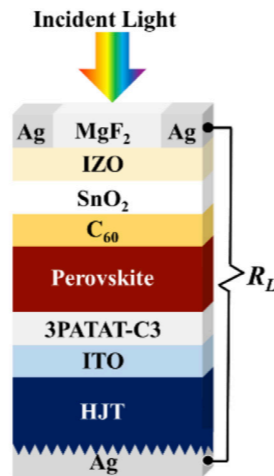
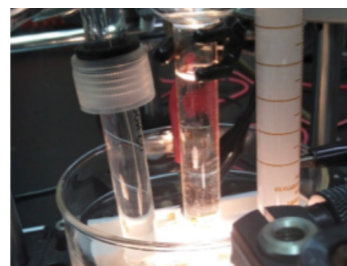
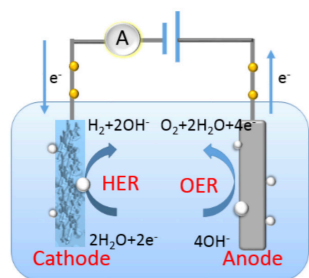
Energy-efficient and energy generation devices

We have developed a high-efficiency tandem perovskite/silicon solar cell by stacking a perovskite layer onto a silicon solar cell. This design integrates two light-absorbing cells, surpassing the Shockley-Queisser limit and achieving over 30% efficiency. Future efforts will focus on optimizing fabrication and interface engineering to enhance performance. Increasing power generation efficiency per unit area reduces reliance on coal-fired power and lowers greenhouse gas emissions, supporting the national net-zero goal.

We develop cooling-free, room-temperature-operable, and affordable infrared photodetectors (1000–1700 nm) with quantum dot nanocomposite and graphene field-effect transistors. The device shows responsivity and detectivity of 15000 A/W and $1.31 \times 10^{12} \text{ cm Hz}^{1/2} \text{ W}^{-1}$ at room temperature, respectively, with a response time of a few mini seconds. The photodetectors we develop have greater potential for application in our daily lives compared with traditional compound semiconductors (e.g. InGaAs), such as in wearable devices, smartphones, robots, and other fields.

We demonstrate wafer-scale integration of monolayer single-crystal MoS₂ photodetectors with a nitride-based resonant plasmonic metasurface to achieve a high detectivity with a record-low dark current and long-term stability. Upon comparison with control devices, we observe an overall enhancement factor of >100; this can be attributed to the local strong electromagnetic field enhanced photogating effect by the resonant plasmonic metasurface.

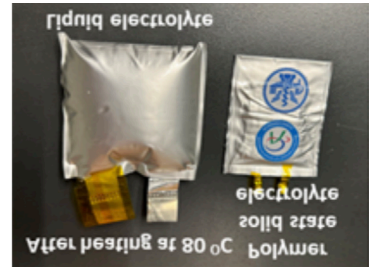
The aim is to study the use of renewable energy to generate green hydrogen, hydrocarbon fuel as well as other energy storage chemicals through electrolysis process. We have developed a highly active NiCr electrocatalyst, comparable with Pt/C, for hydrogen evolution reaction. We also developed an ultrasonic deposition method to synthesize NiFe oxyhydroxide electrocatalyst with highly dispersed surface-active sites for oxygen evolution reaction. These works pave the way as intermediate steps toward hydrocarbon and energy storage chemical generation.



Next-Generation Batteries

We have successfully developed a lightweight, low-cost, and easily synthesized polymer-based solid electrolyte. This electrolyte exhibits excellent ionic conductivity, reaching $10^{-3} \text{ S cm}^{-1}$, enabling the realization of safe, room-temperature-operable, and high-energy-density solid-state lithium metal batteries. Unlike conventional brittle oxide-based solid electrolytes, our polymer electrolyte is not only flexible but also self-healing, significantly enhancing battery lifespan and reliability. These properties make it particularly suitable for flexible electronic devices, with the potential to drive the advancement of next-generation flexible consumer electronics and electronic medical products.

We developed a novel synthetic method with the potential for automated large-scale production and controllable material structure to synthesize high ionic conductivity solid electrolytes. We demonstrate that this method can be used to synthesize Li₃InCl₆ with the high ionic conductivity of $1.42 \times 10^{-3} \text{ S/cm}$. We are now trying to fabricate the battery based on our-prepared Li₃InCl₆. We also utilize moisture- and atmospheric-dependent in-situ synchrotron X-ray powder diffraction techniques to track their structural evolution.



Advanced Energy Material Simulation

We leverage machine learning (ML) to investigate the microstructures and properties of chemically complex materials, including the phase behavior of mixed-ion and 2D perovskites, the thermodynamics and dislocation dynamics of high-entropy alloys/intermetallics, and the microstructural features and lithium diffusion pathways in solid-state electrolytes. Our ML-enabled models can efficiently explore the vast configurational spaces of these materials—up to 100,000 times faster than first-principles calculations—while maintaining comparable accuracy in energy predictions. This capability allows us to resolve atomic-scale microstructures and systematically establish process-structure-property (PSP) relationships, thereby accelerating the design and discovery of advanced materials for energy applications.

Core Project

The first core project aims to employ nitride-based metasurfaces and metamaterials as perfect absorbers to maximize the utilization of solar radiation for highly efficient thermal energy conversion. By leveraging their exceptional light absorption capabilities, these engineered nanostructures can concentrate and retain solar energy with minimal losses, significantly enhancing thermal-driven catalytic reactions. Specifically, by leveraging the strong light-matter interactions in metasurfaces, the system can generate highly localized, intense thermal fields that not only improve energy conversion efficiency but also create a high-temperature microenvironment (~2000 °C) ideal for photochemical synthesis. By precisely tuning the optical and thermal properties of nitride-based metasurfaces, the localized heating effect can dramatically increase the catalytic activity, boosting reaction rates by at least eight times compared to conventional methods ($\sim 10 \text{ mmole g}_{\text{cat}}^{-1} \text{ h}^{-1}$). This advancement not only optimizes solar energy utilization but also establishes a high-temperature microenvironment that is ideal for accelerating green fuel production, particularly ammonia synthesis. Beyond fundamental research, this project paves the way for industrial-scale solar-thermal catalytic processes, offering a transformative approach to renewable energy technologies.

The second core project aims to develop solid-state electrolytes to realize high-efficiency solid-state batteries. In the pursuit of solid-state electrolytes, the focus primarily lies on organic-inorganic composites and halides. For composite materials, our aim is to develop high-ion conductivity polymers and blend them with inorganic nanoparticles to mitigate the high interfacial resistance and poor mechanical properties associated with solid-state batteries. This endeavor will lead to the creation of solid-state batteries characterized by high stability, safety, and operability at room temperature. In the realm of halide solid-state electrolytes, we will employ an innovative liquid-phase synthesis method to fabricate safe halide solid-state electrolytes, thereby producing secure solid-state batteries. We will establish a chemistry synthesis system to demonstrate the automated synthesis and large-scale synthesis capabilities of this method. The research topic will also explore suitable anode and cathode materials to develop new high ionic conductivity solid-state batteries.

The main objective of the Thematic Center for Quantum Photonics is to develop key materials and devices for applications in photonic quantum technologies. We synergize the existing research strengths in RCAS, including material growth, spectroscopy measurements, device fabrications, and theoretical analysis. Collaborations with domestic and overseas leading research teams have also been established in order to leverage state-of-the-art techniques for tackling the technical barriers in materials and devices for applications in quantum photonics technologies. The Thematic Center currently involves 7 core members, including: Wen-Hao Chang, Min-Hsiung Shih, Shih-Yen Lin, Chao-Cheng Kaun, Shu-Wei Chang, Chi Chen and Yu-Chen Chen.

Research Areas

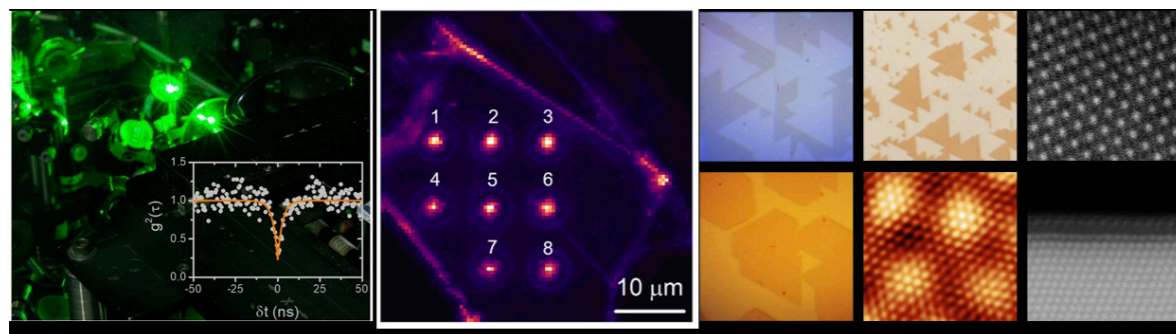
The research areas of the Thematic Center include: (1) Developing quantum light source and single-photon detectors; (2) exploring room-temperature quantum systems for applications in spin control and quantum sensing; (3) design and fabrication of nanophotonic structures; and (4) Developing emergent materials for new device architectures. We hope in the long term can achieve significant breakthroughs in photonic quantum computations and communications.

Focusing Projects

1. Improve the efficiency of quantum photonic devices and development of quantum photonic chip technology.

Project Summary: Quantum photonic devices—including single-photon sources and single-photon detectors—combined with quantum photonic chips for controlling photons are critical devices and technologies for quantum communications and photonic quantum computations. The key technologies proposed to be developed in this project include: (1) High-efficiency single-photon sources operating at communication wavelengths, (2) Infrared superconducting single-photon detectors, and (3) Quantum photonic chips. The project will utilize optical cavity design and theoretical simulations to determine the optimal structures, aiming to enhance the efficiency of single-photon sources and detectors, achieve greater photon indistinguishability, improve the fidelity of entangled photon pairs, and optimize both the sensitivity and response speed of the detectors. Additionally, the project seeks to develop quantum optoelectronic chip technology by integrating single-photon sources with detectors to enable the control and readout of photonic quantum states. Furthermore, through new materials research (including SiO₂/SiN, hBN, and SiC), the project aims to develop single-photon sources that can be operating at room temperature in the telecom wavelength bands.

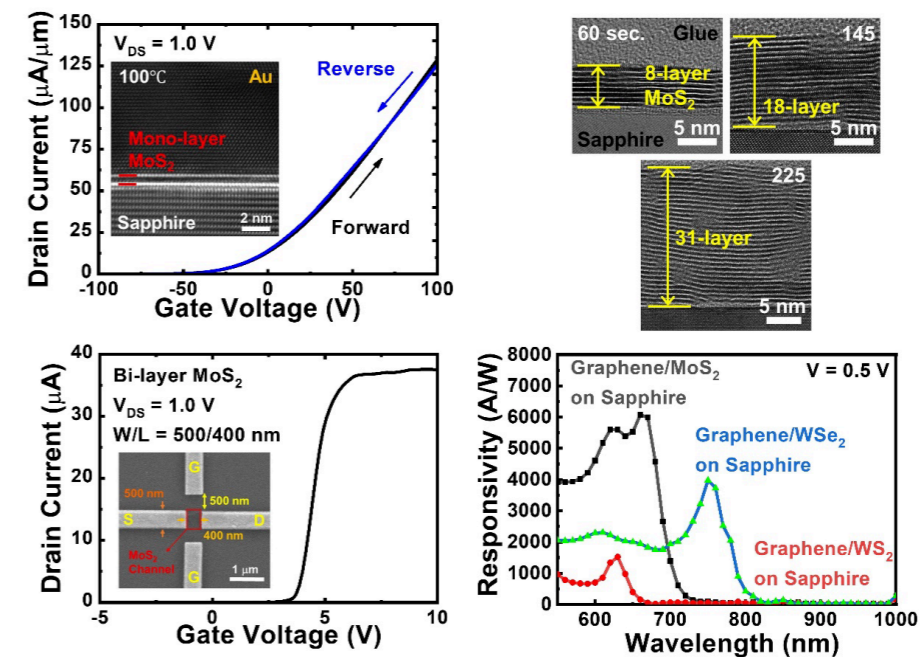
Expected Outcomes: Enhance the efficiency of single-photon sources and single-photon detectors, develop quantum optoelectronic chips, and utilize novel materials to realize single-photon sources operating in the telecom band at room temperature.



2. Development of Technology for Electronic and Optoelectronic Devices based on Two-Dimensional Materials

Project Summary: Two-dimensional materials have extensive applications in next-generation electronic and optoelectronic devices. However, they also face numerous challenges. Our team has developed high-performance two-dimensional transistor technology, including devices that utilize few-layer MoS₂ as the channel material. With shorter channel widths and a passivation layer, these devices can achieve a drain current of 100 μA/μm and a carrier mobility exceeding 100 cm² · V⁻¹ · s⁻¹. Based on our expertise in device technology, this project will further develop WSe₂ transistor technology. Due to the significant environmental impact on WSe₂ materials, device performance still needs improvement. By material quality improvement and process optimization, the project aims to achieve WSe₂ transistors with a field-effect mobility of 10 cm² · V⁻¹ · s⁻¹. For optoelectronics, our team has developed a large-area multilayer MoS₂ thin film growth technique to be used as a light-absorbing layer, combined with single-layer graphene as the carrier transport layer. This approach has enabled photodetectors with high responsivity and short response times. This project also aims at integrating two-dimensional materials with traditional semiconductors to develop heterojunction photodetectors. By leveraging the short carrier transit times characteristic of two-dimensional materials alongside the broad range of bandgaps available in conventional semiconductors, we aim to achieve long-wavelength photodetection at room temperature. Furthermore, due to their ultrafast carrier response and atomic-scale thickness, two-dimensional materials are ideal candidates for high-speed optical modulation devices integrated into photonic chips. This project intends to combine two-dimensional materials with miniature optical nanocavities to enable exciton-cavity coupling. By modulating the cavity emission intensity via an external voltage, our goal is to realize high-speed optical modulators based on two-dimensional semiconductors, which can be applied in future integrated photonic and quantum optoelectronic chips.

Expected Outcomes: Achieve high-performance two-dimensional WSe₂ transistor devices with carrier mobility of 10 cm² · V⁻¹ · s⁻¹; develop heterojunction photodetectors that can detect wavelengths > 1.55 μm with response times < 10 ms; and develop two-dimensional semiconductor optical modulators for use in future integrated photonic and quantum optoelectronic chips.





Intelligence Bioengineering

| Faculty Members |

Yi-Chung Tung

Executive Officer of TCIB/Research Fellow

Ph.D. Mechanical Engineering, University of Michigan, Ann Arbor, USA (2005)

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Narrative CV

Dr. Yi-Chung Tung is a Research Fellow at the Research Center for Applied Sciences, Academia Sinica, where he has been conducting interdisciplinary biomedical research since 2009. Previously, he was a postdoctoral fellow in the Department of Biomedical Engineering at the University of Michigan, Ann Arbor (2006–2009), where he also earned his Ph.D. in Mechanical Engineering in 2005. His contributions have been widely recognized with numerous prestigious awards, including the 2020–2022 Scientist with Top 2% Single Year Impact, the 2018 Project for Excellent Junior Research Investigators (Ministry of Science and Technology, Taiwan), the 2016 Career Development Award (Academia Sinica), and the 2014 Ta-You Wu Memorial Award (Ministry of Science and Technology, Taiwan). He was also named a Top 10% Highly Cited Author in the Analytical Portfolio of Royal Society of Chemistry Journals in 2016. His research focuses on microfluidic cell culture and analysis, biomedical instrumentation, and advanced micro/nano-fabrication techniques, driving innovations in biomedical technology. Dr. Tung has established domestic and international collaborations, including with Ohio State University and Boston University, to advance biomedical research. His lab is currently developing automated, intelligence-embedded instrumentation to enhance biomedical investigations, with a particular focus on cancer and neuro-related studies.

Selective Publications

- 1 Y.-H. Liu, M.-T. Chung, H.-C. Lin, T.-A. Lee, Y.-J. Cheng, C.-C. Huang, H.-M. Wu*, and Y.-C. Tung*, “Shaping Early Neural Development by Timed Elevated Tissue Oxygen Tension: Insights from Multiomic Analysis on Human Cerebral Organoids,” *Science Advances*, Vol. 11, ado1164, March 2025.
- 2 H.-H. Hsu, P.-L. Ko, C.-C. Peng, Y.-J. Cheng, H.-M. Wu, and Y.-C. Tung*, “Studying Sprouting Angiogenesis under Combination of Oxygen Gradients and Co-Culture of Fibroblasts Using Microfluidic Cell Culture Model,” *Materials Today Bio*, Vol. 21, 100703, August 2023.
- 3 C.-W. Chang, H.-C. Shih, M. Cortes-Medina, P. E. Beshay, A. Avendano, A. J. Seibel, W.-H. Liao, Y.-C. Tung*, and J. W. Song*, “ECM-Derived Biophysical Cues Mediate Interstitial Flow-Induced Sprouting Angiogenesis,” *ACS Applied Materials & Interfaces*, Vol. 15, pp. 15047-15088, March 2023.
- 4 P.-L. Ko, C.-K. Wang, H.-H. Hsu, T.-A. Lee, and Y.-C. Tung*, “Revealing Anisotropic Elasticity of Endothelium under Fluid Shear Stress,” *Acta Biomaterialia*, Vol. 145, pp. 316-328, June 2022.
- 5 H.-H. Hsu, P.-L. Ko, H.-M. Wu, H.-C. Line, C.-K. Wang, and Y.-C. Tung*, “Study Formation of Three-Dimensional Endothelial Cell Network under Various Oxygen Microenvironment and Hydrogel Composition Combinations Using Upside-Down Microfluidic Device,” *Small*, Vol. 17, Issue 15, 2006091, April 2021. (Featured as the inside back cover image)

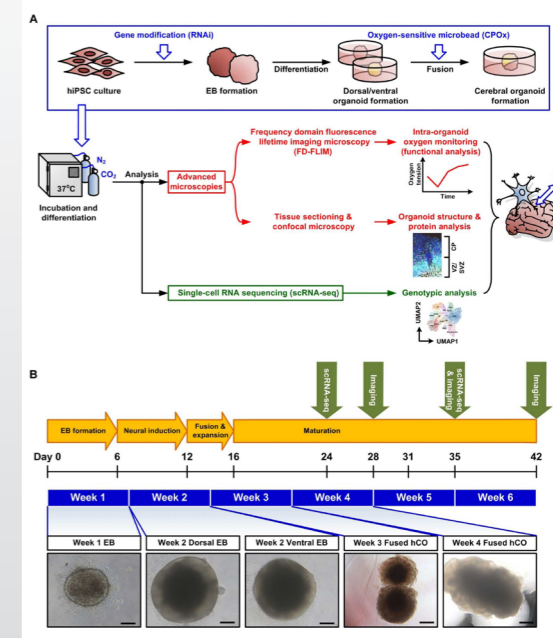
Research Focus

Shaping early neural development by timed elevated tissue oxygen tension: Insights from multiomic analysis on human cerebral organoids

Yuan-Hsuan Liu, Meng-Ting Chung, His-Chieh, Lin, Tse-Ang, Lee, Ya-Jen Cheng, Chien-Chang Huang, Hsiao-Mei Wu,* and Yi-Chung Tung*

Academic Sinica, Research Center for Applied Sciences
Science Advances 2025, DOI: 10.1126/sciadv.ado1164

Oxygen is critical for early brain development, especially before full vascularization, but has been understudied due to technical challenges. This study uses human cerebral organoids with advanced microscopies and single-cell RNA sequencing to monitor tissue oxygen during neurodevelopment. A key window between weeks 4 and 6 shows elevated intra-organoid oxygen, altered energy metabolism, and rapid neurogenesis. This oxygen increase is suppressed by hypoxia or neuroglobin gene silencing. The findings reveal oxygen's functional, genotypic, and proteomic roles in early neurogenesis and highlight the importance of timed oxygen elevation. The study also implicates neuroglobin in neural development, offering insights relevant to neurodegenerative diseases and potential therapeutic strategies.

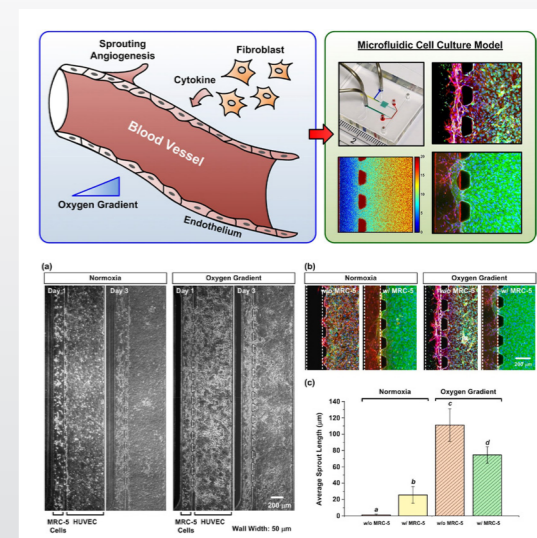


Studying sprouting angiogenesis under combination of oxygen gradients and co-culture of fibroblasts using microfluidic cell culture model

Heng-Hua Hsu, Ping-Liang Ko, Chien-Chung Peng, Ya-Jen Cheng, Hsiao-Mei Wu, and Yi-Chung Tung*

Academic Sinica, Research Center for Applied Sciences
Materials Today Bio 2023, DOI: 10.1016/j.mtbio.2023.100703

Sprouting angiogenesis is vital for vascular growth in various conditions. This study introduces a microfluidic device that supports 3D cell culture within a hydrogel matrix and generates stable oxygen gradients to study endothelial cell sprouting. Endothelial cells form a monolayer mimicking blood vessels, while adjacent hydrogels—with or without fibroblasts—serve as matrices for sprouting. Oxygen gradients are created using a spatially confined chemical reaction. Results show that oxygen gradients and fibroblast co-culture enhance endothelial sprouting by influencing cytokine levels and modifying the hydrogel's physical properties. This platform enables controlled simulation of in vivo-like microenvironments, allowing investigation of how biochemical and mechanical cues drive angiogenesis. The device serves as a versatile in vitro model for studying vascular development and disease mechanisms, with potential applications in drug screening and regenerative medicine.



Pei-Kuen Wei

Director and Research Fellow

Ph.D. Electrical Engineering, National Taiwan University (1994)

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Narrative CV

Dr. Pei-Kuen Wei is the Director and Full Research Fellow at RCAS, specializing in nano-photonics for biosensing applications. His current research focuses on digital nanoplasmonics, low-cost biosensing chips, and imaging technology for high-throughput screening (HTS) applications. He earned his Ph.D. in Electrical Engineering from NTU in 1994, specializing in integrated optics, and later conducted postdoctoral research at IAMS, Academia Sinica (AS), in the field of near-field optics. Since joining RCAS (AS) in 2000, Dr. Wei has dedicated his efforts to advancing nanoscience and engineering.

Dr. Wei has published over 180 journal papers in integrated optics, near-field optics, nano-photonics, and biosensors. His research has led to 12 patents, including 3 technology transfers. His novel sensing chips and imaging technology received the National Innovation Award (2024) and are currently being developed in collaboration with a TSMC subsidiary.

Dr. Wei's nanophotonic sensors are being developed in collaboration with domestic and international institutes, including Tokyo University (Mechanical Engineering Department) for fiber-based sensors, Hokkaido University (RIES) for nanostructured sensing chips, National Taiwan University (Institute of Applied Mechanics) for PCR product detection, and Academia Sinica (Institute of Physics) for high-throughput screening (HTS) of biomolecular interactions.

As a mentor, Dr. Wei has guided numerous graduate students from partner institutions, fostering new talent in nanofabrication, photonic devices, and biosensors. Additionally, he has served as a Member of the Academic Advisory Committee (AAC) at RCCI (AS), Conference Chair of OPTIC Taiwan (2024), and Review Panelist for the Silicon Photonics Project at NSTC.

Moving forward, Dr. Wei's research aims to translate biosensing chips and HTS imaging tools into real-world applications. These technologies will be applied to the detection of pesticide residues, environmental hormones, and infectious viruses, addressing critical challenges in public health and environmental monitoring.

Selective Publications

- 1 Ting-Wei Chang, Ting-Hao Chuang, Sheng-Hann Wang, Wing Kiu Yeung*, Pei-Kuen Wei*, "Self-referenced Digital Spectral Chromatic Local Surface Plasmon Resonance in Ultrasensitive Severe Sepsis Interleukin-6 Detection", ACS Sens. 2025, 10, 2, 1178–1186
- 2 (Patents) Pei-Kuen Wei, Ming-Yang Pan, Kuang-Li Lee: METHOD AND APPARATUS FOR SURFACE PLASMON RESONANCE IMAGING, US Patent No.: US 12,099,009 B2, Sep. 24, 2024; European Patent No. EP3861325 04.12.2024
- 3 Ting-Wei Chang, Sheng-Hann Wang, Iuan-Sheau Chin, Pei-Zhen Li, Shu-Cheng Lo, Shu-Yi Hsieh, Jung-Hsin Lin*, Pei-Kuen Wei*, "Biomimetic affinity sensor for the ultrasensitive detection of neonicotinoids", Biosens. & Bioelectron. 239, 2023, 115630
- 4 Shu-Cheng Lo, Sheng-Hann Wang, Ting-Wei Chang, Kuang-Li Lee, Ruey-Lin Chern, and Pei-Kuen Wei*, "Dual Gold-Nanoslit Electrodes for Ultrasensitive Detection of Antigen–Antibody Reactions in Electrochemical Surface Plasmon Resonance", ACS Sensors 2022 7 (9), 2597-2605
- 5 Sheng-Hann Wang; Chia-Wen Kuo; Shu-Cheng Lo; Wing Kiu Yeung; Ting-Wei Chang; Pei-Kuen Wei*, "Spectral Image Contrast-Based Flow Digital Nanoplasmon-metry for Ultrasensitive Antibody Detection", Journal of Nanobiotechnology. 2 20, (2022)

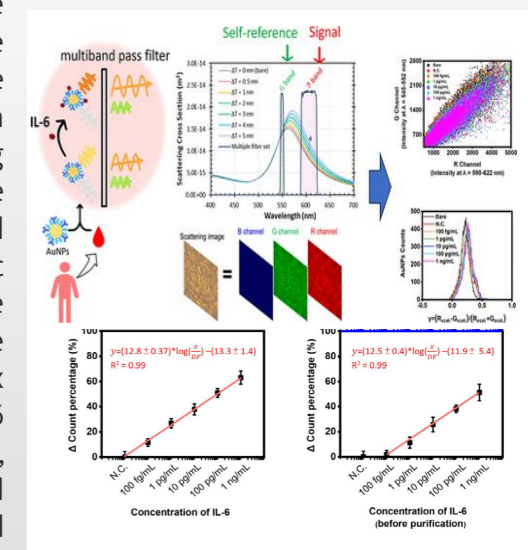
Research Focus

Self-referenced Digital Spectral Chromatic Local Surface Plasmon Resonance in Ultrasensitive Severe Sepsis Interleukin-6 Detection

Ting-Wei Chang, Ting-Hao Chuang, Sheng-Hann Wang, Wing Kiu Yeung, Pei-Kuen Wei

Academic Sinica, Research Center for Applied Sciences
ACS Sens. 2025, 10, 2, 1178–1186/j.bios.2023.115630

Interleukin-6 (IL-6) is a cytokine that mediates a range of physiological functions. It plays a crucial role in immune responses by regulating leukocyte activity and tissue inflammation and is also implicated in energy metabolism regulation. In this study, we employed a contrast imaging method to detect changes in the localized surface plasmon resonance of gold nanoparticles (AuNPs) induced by biomolecular binding. By digitally analyzing chromatic image contrast across numerous individual AuNPs, we significantly enhanced signal output, enabling sensitive detection even at low IL-6 concentrations in complex human blood plasma. The platform effectively detects IL-6 within 45 minutes, using only 0.5 mL of a 10-fold diluted, label-free sample. It achieved a limit of detection (LOD) and limit of quantification (LOQ) of less than 19.2 fg/mL and 87.8 fg/mL, respectively, with a recovery rate of 96%. This platform demonstrates strong potential as a rapid and efficient tool for clinical biomarker monitoring.

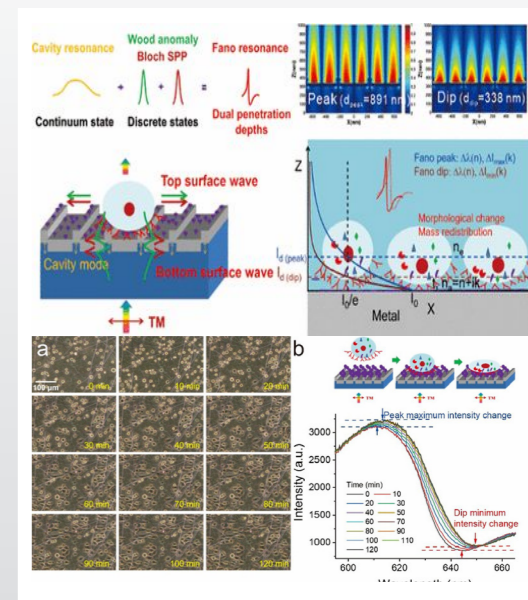


Aluminum-Coated Nanoridge Arrays with Dual Evanescent Wavelengths for Real-Time and Label-Free Cellular Analysis

Kuang-Li Lee, Hsien-San Hou, Xu Shi, Meng-Lin You, Ming-Yang Pan, Yasutaka Matsuo, Yasutaka Matsuo, Ji-Yen Cheng, Hiroaki Misawa, Pei-Kuen Wei

Academic Sinica, Research Center for Applied Sciences
J. Phys. Chem. C 2024, 128, 8, 3384–3392/acs.jpcc.3c08016

We introduced the concept of Fano resonances with dual evanescent lengths in aluminum-coated nanoridge arrays for real-time, label-free analysis of cellular adhesion. This approach enables dual-range sensing and utilizes four-parameter plots to characterize both short-range and long-range adhesion behaviors. The shorter evanescent length of the Fano dip is sensitive to the cell–substrate adhesion interface, while the longer evanescent length penetrates deeper into the cellular medium, capturing broader cellular interactions such as cell–cell adhesion. When integrated with a hyperspectral imaging system, the aluminum-coated nanoridge arrays support multiplexed sensing of cell adhesion, offering a powerful tool for high-throughput cell biology research, immunotherapy, and drug discovery.





Ji-Yen Cheng

Deputy Director and Researcher

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Narrative CV

Dr. Ji-Yen Cheng's Ph.D. training prompted him to build an OPO laser and an automatic data acquisition system for studying the vibrational spectra of DNA binding molecules. During his post-doctoral training, Dr. Cheng integrated microfluidic techniques with automation to construct a 1,536-channel oligonucleotide synthesizer. In his own lab, Dr. Cheng and his team harness laser microfabrication techniques to develop various types of microfluidic devices for biological studies.

Dr. Cheng's lab has developed culturing devices for cells (including mammalian cell lines and stem cells) and organisms (such as zebra fish and coral fragments). These devices allow the introduction of physical stimulations such as electric fields, temperature, and optical stimulation to the cultured cells for long-term (up to several weeks) studies. The zebra fish device provides life support for the specimens and enables cellular-level observation, assisting a collaborating biological lab with wound healing studies. The coral chip assists another biological lab in selecting temperature-resistant corals for coral restoration applications.

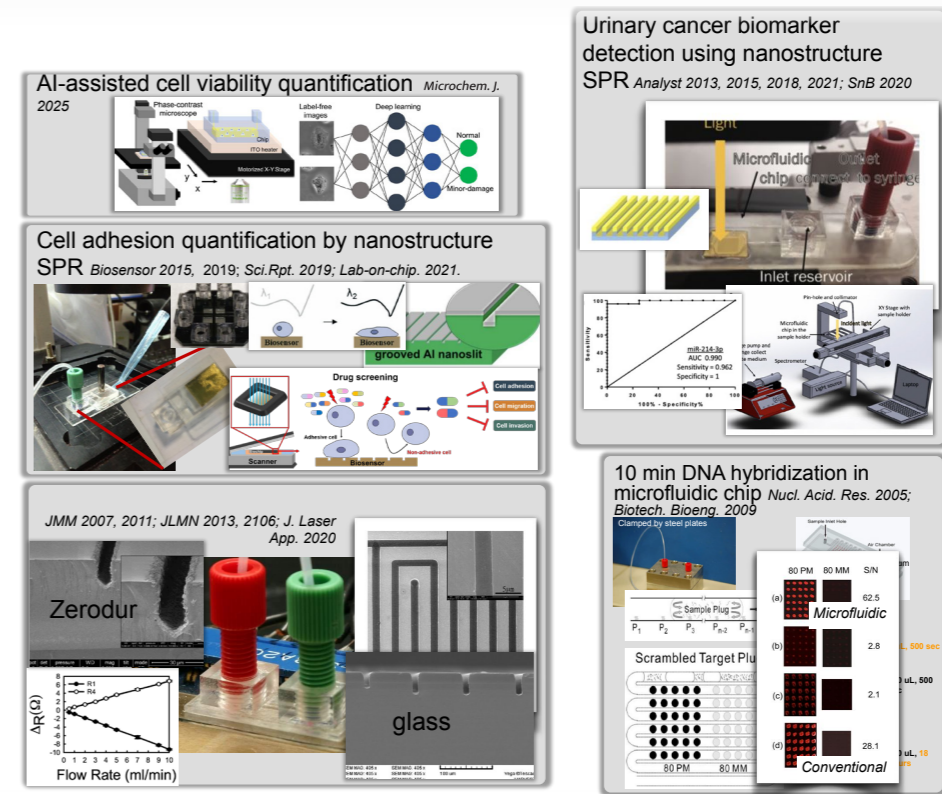
Dr. Cheng's team is able to obtain a large number of cell images and spectra needed for AI analysis. Recently, they have successfully applied AI for label-free cell viability quantification. Moving forward, Dr. Cheng plans to integrate AI process control with lab automation to develop single-lab automatic cell passage systems.

Selective Publications

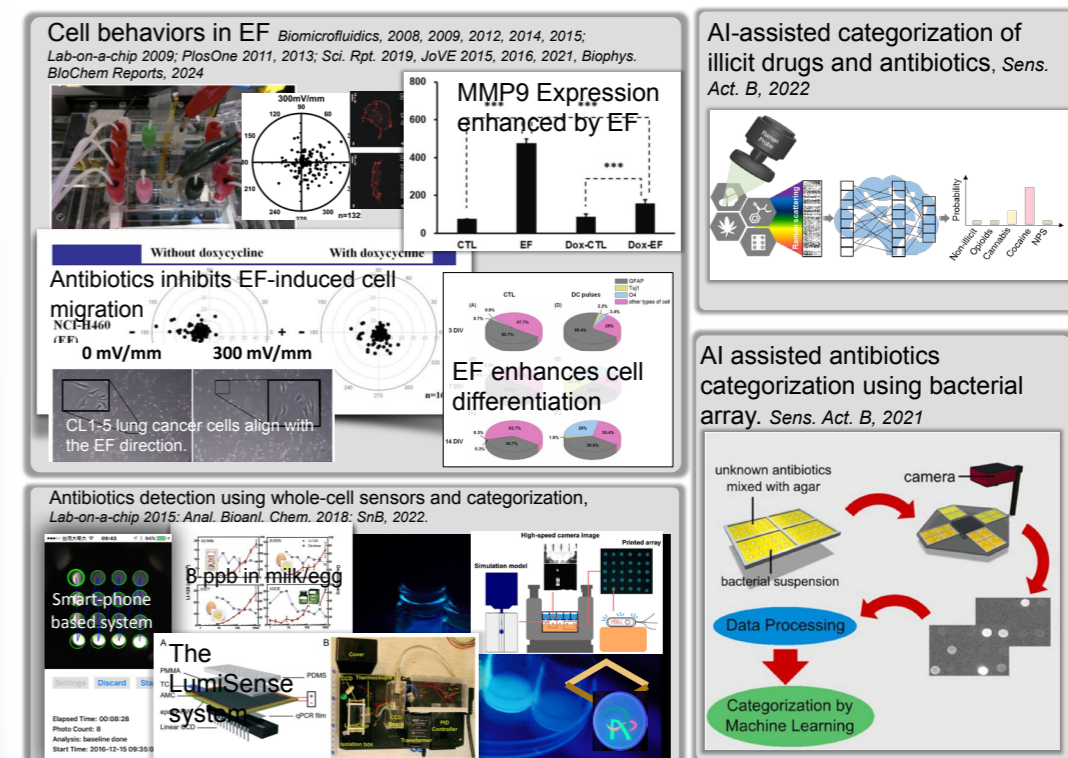
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- Tseng, T.Y., Chang, T.C. and Cheng, J.Y. (2024) A correlation of polymorphic G-quadruplex formation in vitro and in the lysosomes of live cancer cells. *Int J Biol Macromol*, **290**, 138899.
- Santoso, F., De Leon, M.P., Kao, W.C., Chu, W.C., Roan, H.Y., Lee, G.H., Tang, M.J., Cheng, J.Y. and Chen, C.H. (2024) Appendage-resident epithelial cells expedite wound healing response in adult zebrafish. *Curr Biol*, **34**.
- Lai, Y.T., Wei, P.K., Kuo, C.Y. and Cheng, J.Y. (2023) Inference detection and classification of illicit drugs by a modest Raman spectrometer with a convolutional neural network analyzer. *Sensor Actuat B-Chem*, **375**.
- Chou, S.E., Lee, K.L., Wei, P.K. and Cheng, J.Y. (2021) Screening anti-metastasis drugs by cell adhesion-induced color change in a biochip. *Lab Chip*, **21**, 2955-2970.

Research Focus

Ji-Yen Cheng Research Highlight -1/2



Ji-Yen Cheng Research Highlight -2/2



Fu-Liang Yang

Distinguished Research Fellow /
Professor

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Narrative CV

Dr. Fu-Liang YANG is a Distinguished Research Fellow/Professor specializing in Non-invasive Blood Glucose (NIBG) Measurements via Photoplethysmography. His research interest on physical treatments of cardio/cerebral vascular diseases has been ceased simply due to exclusive technology transfer. Before 2013, he has contributed as TSMC 5nm CMOS exploratory program manager and director general of National Nano Device laboratories.

His major research achievements and impacts are

- 2024 National Innovation Award: A Novel Earbud-Type Multifunctional Physiological Device Comprising Blood Pressure Measurement for Smart Home Healthcare Applications, non-exclusive technology transfer in process
- 2022 National Innovation Award: AI Deduction Learning Non-Invasive Blood Glucose Meter, non-exclusive technology transfer
- 2020 National Innovation Award: Helix External Counter Pulsation System, exclusive technology transfer and spin off

The current iteration of NIBG technology developed by Fu-Liang, Yang and his team has been successfully applied on fasting blood glucose measurements but not well performed for post meal measurements. To overcome the challenges of post meal NIBG measurements, they will not only develop new AI algorithms, but also collaborate with Taipei Tzu Chi Hospital for ICU patients' data collection. First common interest with the hospital is detecting hypoglycemia.

Selective Publications

- Bitewulign Kassa Mekonnen, Wei-Ru Lu, Tung-Han Hsieh, Justin Chu, & Fu-Liang Yang*. **Accurate and 30-plus days reliable cuffless blood pressure measurements with 9-minutes personal photoplethysmograph data and mixed deduction learning.** Scientific Reports volume 14, Article number: 23722(2024). <https://doi.org/10.1038/s41598-024-75583-y>
- Wei-Ru Lu, Wen-Tse Yang, Justin Chu, Tung-Han Hsieh & Fu-Liang Yang*. **“Deduction learning for precise noninvasive measurements of blood glucose with a dozen rounds of data for model training”** Scientific Reports volume 12, Article number: 6506(2022), <https://doi.org/10.1038/s41598-022-10360-3>
- Chu, J.; Yang, W.-T.; Lu, W.-R.; Chang, Y.-T.; Hsieh, T.-H.; Yang, F.-L*. **“90% Accuracy for Photoplethysmography-Based Non-Invasive Blood Glucose Prediction by Deep Learning with Cohort Arrangement and Quarterly Measured HbA1c.”** Sensors 2021, 21, 7815. <https://doi.org/10.3390/s21237815>
- Justin Chu, Wen-Tse Yang, Yao-Ting Chang* and Fu-Liang Yang* **“Visual Reassessment with Flux Interval Plot Configuration after Automatic Classification for Accurate Atrial Fibrillation Detection by Photoplethysmography”** Diagnostics 2022, 12, 1304. <https://doi.org/10.3390/diagnostics12061304>
- Justin Chu, Wen-Tse Yang, Tung-Han Hsieh, Fu-Liang Yang*, Feb. 2021 **“One-Minute Finger Pulsation Measurement for Diabetes Rapid Screening with 1.3% to 13% False-Negative Prediction Rate”** Biomedical Statistics and Informatics 2021; 6(1):6-13, DOI:10.11648/j.bsi.20210601.12

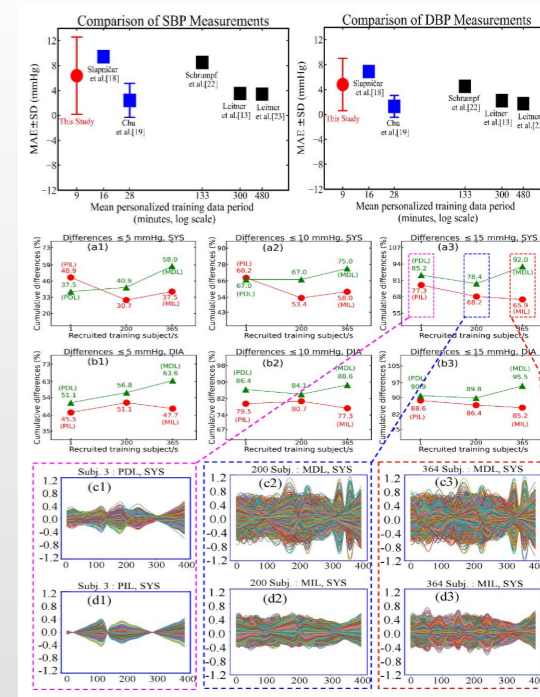
Research Focus

Accurate and 30-plus days reliable cuffless blood pressure measurements with 9-minutes personal photoplethysmograph data and mixed deduction learning

Bitewulign Kassa Mekonnen, Wei-Ru Lu, Tung-Han Hsieh, Justin Chu and Fu-Liang Yang

Scientific Reports volume 14, Article number: 23722 (2024)

To further meet the clinical accuracy requirements, PPG-only BP predictions with personalized modeling for overcoming personal deviations have been widely studied, but all required tens to hundreds of minutes of personal PPG measurements for training. Since our objective is commercial application and a substantial reduction in training data, we tailored our model training to closely mimic real-world usage. To achieve this, we developed a training approach that only requires 9-minutes of personal PPG signal recordings and mixed with other PPG data from our recruited 364 subjects. The modeling is conducted with two-channel paired inputs to the convolutional neural network (CNN)-based model, which we called Mixed Deduction Learning (MDL). The test results of 88 samples from 15 subjects, under testing period up to 30-plus days without extra calibration, revealed that MDL meets most of the standards of AAMI, BHS, and IEEE 1708–2014 (for static test only) for BP measurement devices, which indicates MDL's long-term stability and consistency. Furthermore, we found that the model with two-channel inputs presents a trend of improving performance as the pool of mixed training data increased, while the conventional one-channel input revealed degraded performance. The outperformance of MDL is attributed to many significant features remained in the first CNN layer even when mixing personal 9-minutes data with the other 364 subjects. Consequently, PPG-only with MDL introduces a new avenue for overcoming challenges in training due to personal physiological variations. Given our consideration of real-life usage, this technology can be seamlessly translated to commercial applications.

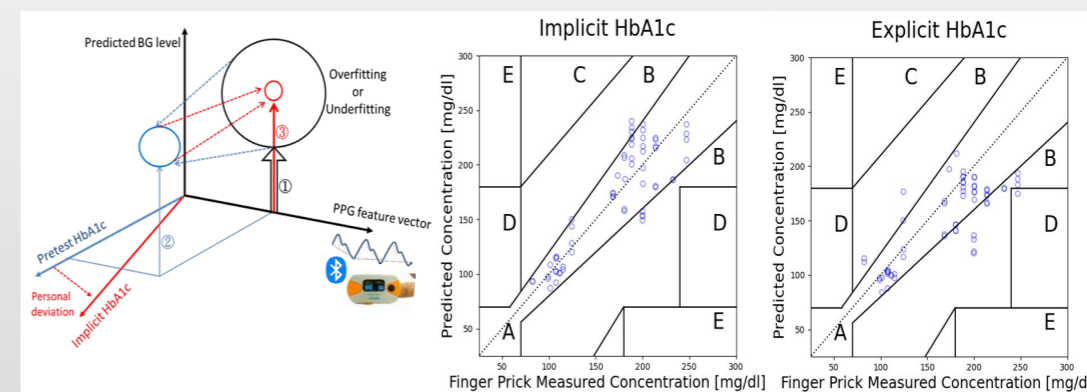


Implicit HbA1c Achieving 87% accuracy for Non-invasive Fasting Blood Glucose Measurements within 90 days by Photoplethysmography

Justin Chu, Yao-Ting Chang, Shien-Kuei Liaw and Fu-Liang Yang *

Bioengineering 2023, 10(10), 1207

To reduce the error induced by overfitting or underfitting in predicting non-invasive fasting blood glucose (NIBG) levels using photoplethysmography (PPG) data alone, we previously demonstrated incorporating HbA1c feature led to a notable 10 % improvement in NIBG prediction accuracy (the ratio in zone A of Clark's error grid). However, this enhancement came at the cost of requiring an additional HbA1c measurement, thus unfriendly to users. In this study, the enhanced HbA1c NIBG model (blood glucose level predicted from PPG and HbA1c) is trained with 1494 measurements, and we replaced the HbA1c measurement (explicit HbA1c) with “implicit HbA1c” which is reversely derived from pretested PPG and finger pricked blood glucose level.



Peilin Chen

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Narrative CV

Dr. Peilin Chen is a Research Fellow specializing in the development of biomaterials and bioimaging. His research interests focus on the field of nanomedicine, specifically the interactions between nanoparticles and tumors. His group has developed various nanoparticles and imaging tools to understand how nanoparticles reach and accumulate in tumors. Dr. Chen obtained his Ph.D. degree in Chemistry from the University of California, Irvine. Over the past few years, he has been invited to deliver more than 70 lectures, including plenary and keynote speeches, at international conferences. Additionally, Dr. Chen has organized over 20 international conferences and symposia.

The real-time two-photon intravital imaging tools developed by Dr. Chen's group are highly appreciated in the field. They help several medical doctors understand the disease mechanism in animal models and also benefit from the optimization of drug delivery efficiency through quantitative analysis of drug carrier distribution in various disease models.

In the past few years, Dr. Chen has coordinated more than four multidisciplinary projects. To promote the field of nanomedicine, Dr. Chen co-founded the Taiwan Nanomedicine Society and served as the executive supervisor. Regarding the commercialization of nanotechnology, Dr. Chen serves as Vice President of the Taiwan Nanotechnology Industry Development Association and an executive member of the Asia Nano Forum located in Singapore. As a mentor, Dr. Chen has guided 10 graduate students, fostering new talent in nanotechnology.

Selective Publications

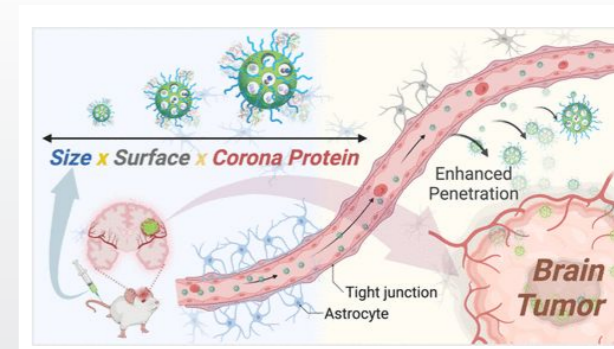
- 1 Zih-An Chen, et al., ACS Nano 2024, 18, 12716
- 2 Xuejiao Tian, et al., Nature Comm. 2024, 15, 10911
- 3 Yu-Tse Lee, et al., ACS Appl. Mater. Interfaces 2024, 16, 61787
- 4 Chi-Shan Li, et al., Proc. Natl. Acad. Sci. U.S.A., 2023, 12, e2207091120
- 5 Yu-Sheng Hsiao, et al., ACS Appl. Mater. Interfaces 2023, 15, 21953
- 6 Yuan-Yuan Cheng, et al., Circulation, 2022, 146, 1950.
- 7 Wei-Chun Tang, et al., Communications Biology, 2022, 5, 879
- 8 San-Shan Huang, et al., Science Advances, 2021, 7, eabf2400.
- 9 Hung-Lin Chen, et al., J. Clin. Invest. 2021, 131, e130704.
- 10 Yi-Ping Chen, et al., Biomaterials. 2020, 246, 119997.
- 11 Rong-Lin Chang, et al., ACS Applied Materials & Interfaces, 2020, 12, 42472
- 12 Li-An Chu, et al., Nature Comm. 2019, 10, 4762.
- 13 Po-Kai Chuang, et al., Proc Natl Acad Sci USA 2019, 116, 3518
- 14 Tony W.H. Tang, et al., Circulation, 2019, 139, 647
- 15 Zih-An Chen, et al., ACS Applied Materials & Interfaces, 2019, 11, 4790

Research Focus

Receptor Ligand-Free Mesoporous Silica Nanoparticles

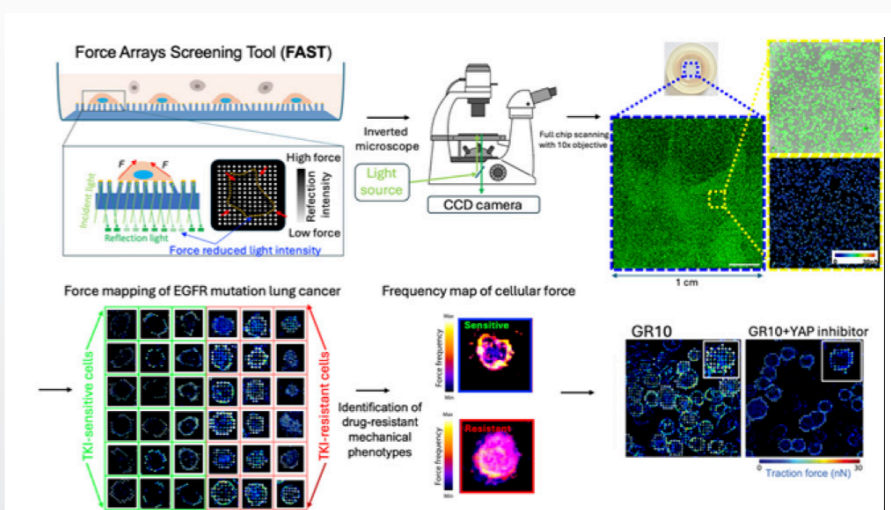
ACS Nano 2024, 18, 12716–12736

Mesoporous silica nanoparticles (MSNs) represent a promising avenue for targeted brain tumor therapy. However, the blood–brain barrier (BBB) often presents a formidable obstacle to efficient drug delivery. This study introduces a ligand-free PEGylated MSN variant (RMSN25-PEG-TA) with a 25 nm size and a slight positive charge, which exhibits superior BBB penetration. Utilizing two-photon imaging, RMSN25-PEG-TA particles remained in circulation for over 24 h, indicating significant traversal beyond the cerebrovascular realm. Importantly, DOX@RMSN25-PEG-TA, our MSN loaded with doxorubicin (DOX), harnessed the enhanced permeability and retention (EPR) effect to achieve a 6-fold increase in brain accumulation compared to free DOX. In vivo evaluations confirmed the potent inhibition of orthotopic glioma growth by DOX@RMSN25-PEG-TA, extending survival rates in spontaneous brain tumor models by over 28% and offering an improved biosafety profile. Advanced LC-MS/MS investigations unveiled a distinctive protein corona surrounding RMSN25-PEG-TA, suggesting proteins such as apolipoprotein E and albumin could play pivotal roles in enabling its BBB penetration.



Spatial Force Distribution as a Biomarker for Cancer Cell Identification and Drug Resistance Detection

Force Arrays Screening Tool (FAST) provides a novel, high-throughput, label-free, user-friendly, and real-time approach to measure cellular traction forces at single-cell resolution. By rapidly screening cells based on mechanical properties, FAST enables detailed phenotypic characterization and efficient drug sensitivity testing. Its capability to simultaneously map traction forces across thousands of cells delivers unprecedented insights into dynamic cellular behaviors under physiological conditions. We demonstrate that spatial traction force distributions are potent biophysical biomarkers for distinguishing cellular phenotypes. Specifically, FAST identified distinct traction patterns that differentiate drug-sensitive from drug-resistant lung cancer cells. Importantly, these mechanical signatures correlate with key molecular regulators, YAP and β 1-integrin. Pharmacological inhibition of YAP and β 1-integrin successfully reverted drug-resistant mechanical phenotypes, restoring responsiveness to tyrosine kinase inhibitors (TKIs). FAST thus significantly advances cellular mechanobiology research and clinical applications, offering powerful opportunities for improved drug discovery, cancer diagnostics, and identification of therapeutic targets based on mechanical phenotype profiling.



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Ph.D. Physics, University of Duisburg, Germany (2000)

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Narrative CV

Dr. Jung-Hsin Lin is a Research Fellow of Research Center for Applied Sciences (RCAS). Dr. Lin did his PhD research in Forschungszentrum Jülich between 1996 and 2000, during which time his research area was molecular dynamics simulations of membrane proteins, and he was one of the pioneers in this area. After he received his PhD in January 2000, he worked as a Wissenschaftlicher Mitarbeiter at the John von Neuman Institute for Computing, at Forschungszentrum Jülich, and in 2000 September he moved to University of California at San Diego, worked as Bioinformatics Specialist in Howard Hughes Medical Institute, during which period his research areas were extended to computational drug design, and he was among the first to accommodate protein dynamics for structure-based drug design. He started his independent research career in early 2003 as assistant professor in School of Pharmacy, College of Medicine, National Taiwan University. He was recruited to RCAS in the mid of 2006. He is currently a jointly appointed professor in School of Pharmacy, College of Medicine, National Taiwan University.

The research focuses of Dr. Lin have been on the development of novel methods for computational drug discovery and structural bioinformatics, and their innovative applications for exploring new therapeutic candidates and biomolecular targets of natural product molecules and other pharmaceutical agents. As a recent example of such efforts, Dr. Lin's lab published a computational scheme for binding free energy calculations based on first principle of statistical mechanics, that can be applied to general biomolecular interactions, including proteins, peptides, and small chemical molecules. Besides, Dr. Lin's lab has committed in improving the accuracy of prediction of molecular docking methods, and their applicable domains. Examples of novel applications in this area include, MEDock, SLITHER and idTarget, and the last one was the first docking-based proteome-wide target prediction for a given small synthetic chemical molecule or a natural product compound. Deep learning algorithms and other artificial intelligence approaches have also been incorporated in the development of new computational methods for computational drug design. He is the inventor of 16 patents for the new drugs discovered from his collaborative teams. Two series of drug candidates on neurodegenerative diseases and cancer treatment were exclusively licensed to the companies in Taiwan in 2015 and 2016, respectively. Starting in the February of 2025, one small molecule drug for treating Alzheimer's disease is in the Phase I First in Human clinical trial.

Since Dr. Lin returned to Taiwan in 2003, he has been involved in many collaborative teams for the methodology development in structural bioinformatics, as well for drug discovery and development for several diseases. He served as the Chief Executive Officer of the Thematic Center for Biomedical Applications of RCAS between 2015 and 2020, and the Deputy Director of RCAS between 2019 and 2020. Since November of 2020, he has been serving as the Deputy Director of Biomedical Translation Research Center (BioTRC), and was the Chief Executive Officer of the Thematic Center for Intelligence Medicine of BioTRC between 2021 and 2024.

Selective Publications

- 1 Ting-Wei Chang, Sheng-Hann Wang, Iuan-Sheau Chin, Pei-Zhen Li, Shu-Cheng Lo, Shu-Yi Hsieh, **Jung-Hsin Lin***, Pei-Kun Wei* **Biomimetic affinity sensor for ultrasensitive detection of nicotinoids.** *Biosensors and Bioelectronics.* 239: 115630 (2023)
- 2 Dhananjay C. Joshi, Charlie Gosse, Shu-Yu Huang and **Jung-Hsin Lin***, **A curvilinear-path umbrella sampling approach to characterizing the interactions between rapamycin and three FKBP12 variants** *Front. Mol. Biosci.* 9: 879000 (2022)
- 3 Dhananjay Joshi and **Jung-Hsin Lin*** **Delineating protein-protein curvilinear dissociation pathways and energetics with multiple-walker umbrella sampling simulations.** *J. Comput. Chem.* 40: 1652-1663 (2019)
- 4 Jui-Chih Wang, Pei-Ying Chu, Chung-Ming Chen and **Jung-Hsin Lin*** **idTarget: a web server for identifying proteins targets of small chemical molecules with robust scoring functions and a divide-and-conquer docking approach.** *Nucleic Acids Res.* 40: W393-W399 (2012).
- 5 Po-Hsien Lee, Kuei-Ling Kuo, Pei-Ying Chu, Eric M. Liu, **Jung-Hsin Lin*** **SLITHER: a web server for generating contiguous conformations of substrate molecules entering into deep active sites of proteins or migrating through channels in membrane transporters.** *Nucleic Acids Res.* 37: W559-W564 (2009)

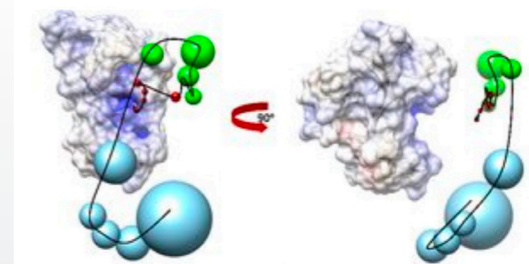
Research Focus

Delineating Protein-Protein Curvilinear Dissociation Pathways and Energetics with Naïve Multiple-Walker Umbrella Sampling Simulations

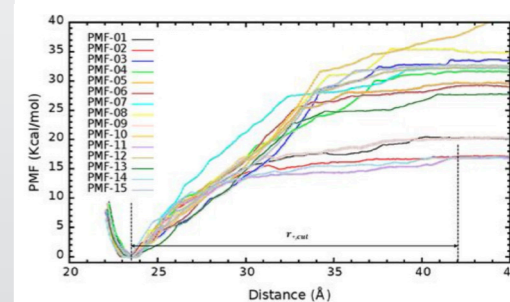
Dhananjay C. Joshi, **Jung-Hsin Lin***

Academic Sinica, Research Center for Applied Sciences
J. Comput. Chem., 2019, DOI: DOI:10.1002/jcc.25821

The protein-protein interaction energetics can be obtained by calculating the potential of mean force (PMF) from umbrella sampling (US) simulations, in which samplings are often enhanced along a predefined vector as the reaction coordinate. However, any slight change in the vector may significantly vary the calculated PMF, and therefore the energetics using a random choice of vector may mislead. A non-predefined curve path-based sampling enhancement approach is a natural alternative, but was relatively less explored. In this work, dissociation of the barnase-barstar complex is simulated by implementing non-predefined curvilinear pathways in US simulations. A simple variational principle is applied to determine the lower bound PMF, which could be used to derive the standard free energy of binding. Two major dissociation pathways, which include interactions with the RNA-binding loop and the Val 36 to Gly 40 loop, are observed. Further, the proposed approach was used to discriminate the decoys from protein-protein docking studies.



Traces of curvilinear physical transitions for barnase-barstar from sequential US MD simulations.



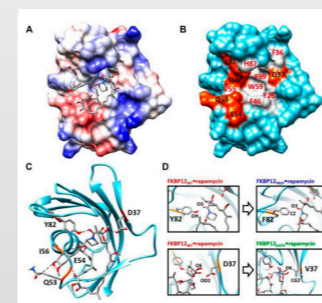
A variational principle-based approach was adopted to selected the PMF.

A Curvilinear-Path Umbrella Sampling Approach to Characterizing the Interactions Between Rapamycin and Three FKBP12 Variants

Dhananjay C. Joshi, Charlie Gosse, Shu-Yu Huang and **Jung-Hsin Lin***

Academic Sinica, Research Center for Applied Sciences
Front. Mol. Biosci. 9: 879000 (2022) DOI: 10.3389/fmol.2022.879000

Rapamycin is an immunosuppressant macrolide that exhibits anti-proliferative properties through inhibiting the mTOR kinase. Despite the availability of structural and thermodynamic information on the interaction of FKBP12 with rapamycin, the energetic and mechanistic understanding of this process is still incomplete. In the present paper, we extend our investigations to a protein-small molecule duo, the FKBP12-rapamycin complex. We estimate the binding free energies of rapamycin with wild-type FKBP12 and two mutants in which a hydrogen bond has been removed, D37V and Y82F. On one hand, removing the carboxylate group of D37 strongly destabilizes the association; on the other hand, the hydroxyl group of Y82 is nearly unnecessary for the stability of the complex because some nonconventional, cryptic, indirect interaction mechanisms seem to be at work.



Structure of the FKBP12-rapamycin complex as determined in PDB 1FKB.

(A) Coulombic surface representation

(B) Surface representation of the protein alone with the hydrogen-bond forming residues in orange and the hydrophobic residues in gray.

(C) The five hydrogen bonds formed between FKBP12 and rapamycin are shown as dashed lines.

(D) Close-up view on the Y82 and D37 residues and resulting starting conformation obtained after either the Y82F or the D37V substitution.

Chau-Hwang Lee

Research Fellow

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Narrative CV

Dr. Chau-Hwang Lee received his Ph.D. in Electrical Engineering from National Taiwan University in 1997 and conducted postdoctoral research at the Institute of Atomic and Molecular Sciences, Academia Sinica. Since 2000, he has been with the Research Center for Applied Sciences, Academia Sinica, where he was promoted to Research Fellow in 2010. His work focuses on optical microscopy, cell-microenvironment interactions, and biomedical applications of microfluidic devices.

Dr. Lee is the primary inventor of several nanometer-scale optical measurement technologies, including Differential Confocal Microscopy and Non-interferometric Wide-field Optical Profilometry. Since 2008, he has used microfluidics to study how cancer cells respond to changes in their environment, confirming a paracrine feedback loop with fibroblasts. He also developed 3D cell culture platforms for studying drug resistance and exploring neural cell regeneration.

Since 2004, Dr. Chau-Hwang Lee has held a joint appointment at the Institute of Biophotonics, National Yang Ming Chiao Tung University, where he also served as Director from 2011 to 2014. In addition, he has engaged in extensive interdisciplinary research with biological and medical experts. In 2016, he was appointed as the Deputy Executive Secretary of the Central Academic Advisory Council, where he manages academic administrative tasks for the Division of Mathematical and Physical Sciences. Starting in 2024, Dr. Lee assumed the position of inaugural Director of the newly established Research Center for Critical Issues (RCCI).

Dr. Lee will continue to investigate the motility of cancer cells in 3D environments and their responses to multiple drugs and therapeutic interventions. He will also study the regenerative potential of neural cells under external stimulation. Additionally, he is committed to developing the infrastructure and human resources of RCCI and carrying out mission-oriented projects aligned with Academia Sinica's strategic goals.

Selective Publications

- 1 C.-C. Kuo, W.-Y. Liao, Y.-J. Lin, and C.-H. Lee, "A 3D cell culture platform for evaluating macrophage-liposome conjugates in combination chemotherapy," *Journal of Biomedical Materials Research Part A* **113**, e37939 (2025).
- 2 H.-J. Pan, C.-W. Lee, L.-Y. Wu, H.-H. Hsu, Y.-C. Tung, W.-Y. Liao, and C.-H. Lee, "A 3D culture system for evaluating the combined effects of cisplatin and anti-fibrotic drugs on the growth and invasion of lung cancer cells co-cultured with fibroblasts," *APL Bioengineering* **7**, 016117 (2023).
- 3 Y.-C. Kao, G.-Y. Lin, J.-Y. Cheng, and C.-H. Lee, "Neurite growth induced by red light-caused intracellular production of reactive oxygen species through cytochrome c oxidase activation," *Journal of Photochemistry & Photobiology, B: Biology* **241**, 112681 (2023).
- 4 C.-W. Lee, C.-C. Kuo, C.-J. Liang, H.-J. Pan, C.-N. Shen, and C.-H. Lee, "Effects of the media conditioned by various macrophage subtypes derived from THP-1 cells on tunneling nanotube formation in pancreatic cancer cells," *BMC Molecular and Cell Biology* **23**, 26 (2022).
- 5 H.-H. Hou, H.-J. Pan, W.-Y. Liao, C.-H. Lee, and C.-J. Yu, "Autophagy in fibroblasts induced by cigarette smoke extract promotes invasion in lung cancer cells," *International Journal of Cancer* **147**, 2587-2596 (2020).

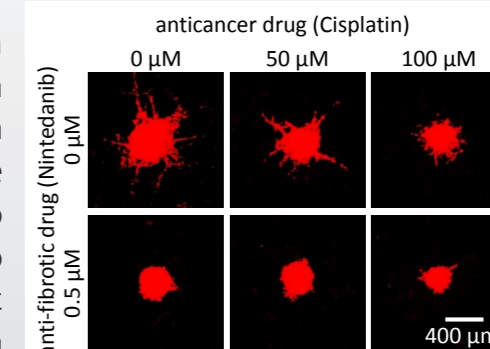
Research Focus

A 3D culture system for evaluating the combined effects of cisplatin and anti-fibrotic drugs on the growth and invasion of lung cancer cells co-cultured with fibroblasts

H.-J. Pan, C.-W. Lee, L.-Y. Wu, H.-H. Hsu, Y.-C. Tung, W.-Y. Liao, and C.-H. Lee

Research Center for Applied Sciences, Academia Sinica
APL Bioengineering **7**, 016117 (2023)

We developed a 3D co-culture system composed of the mixture of fibrin and Matrigel to mimic the tumor microenvironment for studying the impact of drug combinations on a tumor of lung cancer cells co-cultured with fibroblasts. The results demonstrated that an anti-fibrotic drug, nintedanib, could improve the effect of an anticancer drug, cisplatin, to reduce tumor growth and invasion. We also identified four genes in fibroblasts relevant to cell adhesion, invasion, or ECM degradation that were reduced by nintedanib in this co-culture system. This work was also reported by *Genetic Engineering & Biotechnology News*, March 29, 2023.

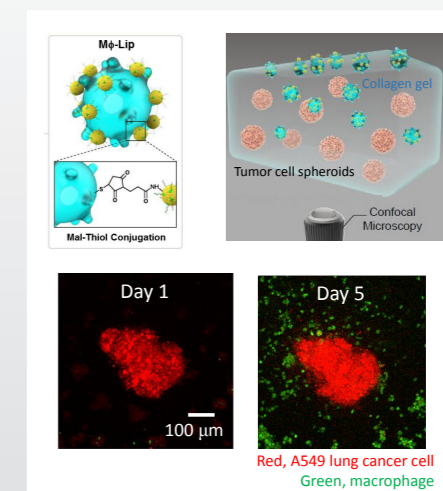


A 3D cell culture platform for evaluating macrophage-liposome conjugates in combination chemotherapy

C.-C. Kuo, W.-Y. Liao, Y.-J. Lin, and C.-H. Lee

Research Center for Applied Sciences, Academia Sinica
J. Biomed. Mater. Res. A **113**, e37939 (2025).

We collaborated with Dr. Yu-Jung Lin to assess the capability of macrophages delivering chemotherapy directly to tumor cells. We created a 3D cell culture system that closely mimicked real tumors, allowing us to watch how macrophages carrying drug-filled liposomes (called M ϕ -Lip) moved, invaded, and killed tumor cells. We tested the drug combination of cisplatin (CDDP) and paclitaxel (Taxol) at various concentrations, and found that the types and amounts of drugs affected how well the macrophages infiltrated into the collagen gel surrounding a tumor cell spheroid. The results suggest that Taxol could increase the diameters of liposomes and thus reduced the infiltration efficiency of the drug-carrying macrophages. This platform could help fine-tune targeted drug delivery and improve cancer treatment outcomes in the future.





Jing-Jong Shyue

Research Fellow

Ph.D. Materials Science and Engineering, Case Western Reserve University, Ohio, U.S.A. (2004)

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Narrative CV

Dr. Jing-Jong Shyue is a Research Fellow specializing in surface and interface analysis and sciences. His research interests encompass the utilization of cluster ion beams for the analysis of biological and organic-inorganic composites through surface electron spectroscopy and surface (tandem) mass spectroscopy. Additionally, he employs a quartz crystal microbalance equipped with energy dissipation to investigate the surface interaction of living cells and molecules at the solid-liquid interface. Dr. Shyue is committed to advancing knowledge and innovation within this field. He obtained his Ph.D. from the Department of Materials Science and Engineering at Case Western Reserve University and has contributed to multiple international research projects.

Dr. Shyue developed atomic and cluster ion cosputtering, now applied in x-ray photoelectron spectroscopy and secondary ion mass spectroscopy, impacting the interfacial analysis of materials such as organic light emitting diodes, organo-halide perovskite, and bulk-heterojunction composites.

Dr. Shyue has collaborated with several institutions including Peking University, Nanjing University of Posts & Telecommunications, Northwestern Polytechnical University, Raynergy Tek Incorporation, National Taiwan University, National Tsing Hua University, National Yang Ming Chiao Tung University, and National Cheng Kung University. His collaborative efforts focus on analyzing and understanding the changes in the internal structure of thin-film devices such as light-emitting diodes, solar cells, and memristors. Additionally, he serves as a co-editor for the Journal of Colloid and Interface Sciences and contributes as a committee member, organizer, or session chair in several prestigious international conferences, including the International Conference for Colloids and Interfaces in Spain, the Chemistry National Meeting in Taiwan, the Chemistry Discipline in the National Science and Technology Council, the Joint Meeting of Analytical Chemistry and Physical Chemistry Division, the East Asia Microscopy Conference, and the Scientific International Symposium on SIMS and Related Techniques Based on Ion-Solid Interactions. He is also a board member of the Microscopy Society of Taiwan.

Dr. Shyue's future research aims to deepen the understanding and application of cluster ion sputtering and enhance interdisciplinary collaboration. He strives to translate academic discoveries into real-world applications, ensuring a lasting impact on both academia and society.

Selective Publications

- 1 P Chen, Y Xiao, JT Hu, SD Li, DY Luo,* R Su, P Caprioglio, P Kaienburg, XH Jia, N Chen, JJ Wu, YP Sui, PYi Tang, HM Yan, TY Huang, MT Yu, QY Li, LC Zhao, CH Hou, YW You, JJ Shyue, DK Wang, XJ Li, Q Zhao, QH Gong*, ZH Lu*, HJ Snaith* and R Zhu* "Multifunctional Ytterbium Oxide Buffer for Perovskite Solar Cells" *Nature* **625** [7995] 516-522 (2024).
- 2 HY Tan, SC Lin, JL Wang, JH Chen, CJ Chang, CH Hou, JJ Shyue, TR Kuo and HM Chen* "Reversibly Adapting Configuration in Atomic Catalyst Enables Efficient Oxygen Electroreduction" *J of the Am. Chem. Soc.* **145** [49] 27054-27066 (2023).
- 3 YQ Yang, GD Li, LC Zhao, PJ Tan, Y Li,* SD Li, LN CH Chuang, TY Wang, CY Chou, SH Yi, JJ Shyue and MJ Chen* "Sharp Transformation Across Morphotropic Phase Boundary in sub-6 nm Wake-Up-Free Ferroelectric Films by Atomic Layer Technology" *Adv. Sci.* **10** [32] 2302770 (2023).
- 4 JY Li, YZ Qian, W Li*, SC Yu, YX Ke, HW Qian, YH Lin, CH Hou*, JJ Shyue, J Zhou, Y Chen, JP Xu, JY Zhu, MF Yi* and W Huang* "Polymeric Memristor Based Artificial Synapses with Ultra-Wide Operating Temperature" *Adv. Mater.* **35** [23] 2209728 (2023).
- 5 C Hanmandlu, R Paste, HH Tsai, SNS Yadav, KW Lai, YY Wang, CS Gantepogu, CH Hou, JJ Shyue, YJ Lu, TD Jadhav, JM Liao, HH Chou, HW Wong, TJ Yen, CS Lai, D Ghosh, S Tretiak, HJ Yen* and CW Chu* "3D Nanographene Precursor Suppress Interfacial Recombination in PEDOT:PSS Based Perovskite Solar Cells" *Nano Energy* **107** 108136 (2023).

Research Focus

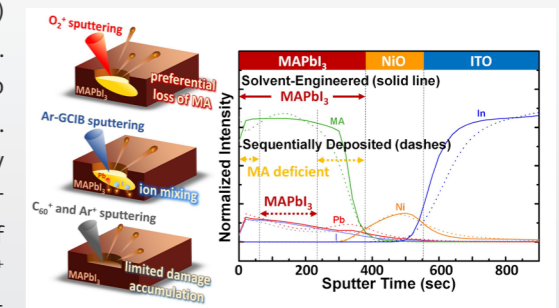
Validated Analysis of Component Distribution Inside Perovskite Solar Cells and Its Utility in Unveiling Factors of Device Performance and Degradation

Cheng-Hung Hou, Shu-Han Hung, Li-Ji Jhang, Keh-Jiunh Chou, Yu-Kai Hu, Pi-Tai Chou, Wei-Fang Su, Feng-Yu Tsai, Jay Shieh, and Jing-Jong Shyue*

Academic Sinica, Research Center for Applied Sciences

ACS Applied Materials & Interfaces **12** [20] 22730-22740 (2020) DOI:10.1021/acsami.9b22492

Time-of-flight secondary-ion mass spectrometry (ToF-SIMS) has been used for gaining insights into perovskite solar cells (PSCs). However, the importance of selecting ion beam parameters to eliminate artifacts in the resulting depth profile is often overlooked. In this work, significant artifacts were identified with commonly applied sputter sources, i.e., an O_2^+ beam and an Ar-gas cluster ion beam (Ar-GCIB), which could lead to the misinterpretation of the PSC structure. On the other hand, polyatomic C_{60}^+ and Ar^+ ion beams were found to be able to produce depth profiles that properly reflect the distribution of the components. Based on this validated method, differences in component distribution, depending on the fabrication processes, were identified and discussed. The solvent engineering process yielded a homogeneous film with higher device performance, but sequential deposition led to a perovskite layer sandwiched by methylammonium-deficient layers that impeded the performance. For device degradation, it was found that most components remained intact at their original position except for iodide. This result unambiguously indicated that iodide diffusion was one of the key factors governing the device lifetime. With the validated parameters provided, ToF-SIMS was demonstrated as a powerful tool to unveil the structure variation amid device performance and during degradation, which are crucial for the future development of PSCs.



Adsorption of Drug Guest Molecules in Metal-Organic Frameworks Studied by Quartz Crystal Microbalance with Dissipation (QCM-D)

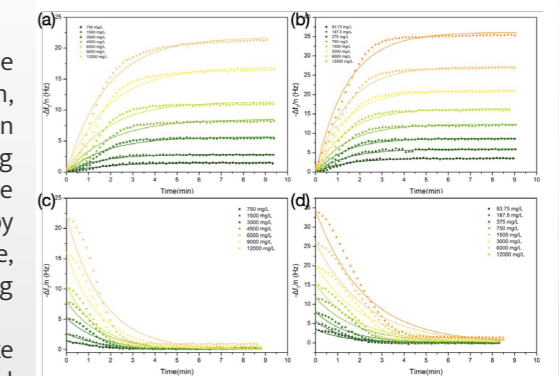
Wen-Yi Yu and Jing-Jong Shyue*

Academic Sinica, Research Center for Applied Sciences

Guest molecules absorption and desorption processes in the aqueous phase were examined by QCM-D, and Acetaminophen, Caffeine and Aspirin were chosen for this study. The preparation of UiO-66-coated quartz crystal chip was via the spin-coating method. It was found that the absorption process was repeatable and reproducible. Furthermore, the degree of absorption varied by the guest molecule, and in descending order were aspirin, caffeine, acetaminophen due to electric charge, polarity and π - π stacking interaction.

In order to study the effect of environment on guest uptake in MOF, the absorption and desorption processes were observed under different pHs. As pH value went down, the absorption of acetaminophen decreased due to the failure to form hydrogen bond with UiO-66 which was surrounded by more protons at lower pH. However, the caffeine absorption slightly increased, owing to the enhance of the electrostatic interaction caused by the increase of UiO-66 zeta potential at lower pH. For aspirin, the absorption first raised and then descended at pH 3. The increase resulted from the zeta potential of uiO-66 as well, while the decrease was caused by dissociated aspirin molecules getting back protons at lower pH. It led to molecular become neutral, and reduce the electrostatic interaction.

The drug absorption and desorption kinetics was also investigated, and the result showed that non-linear pseudo first order kinetic model was the most suitable one. There was good correlation between models and experiment data. Moreover, the interaction between MOF and guest would have an effect on absorption and desorption kinetics.



Chih-Yu Kuo

Research Fellow

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Narrative CV

Dr. Chih-Yu Kuo is a Research Fellow specializing in fluid mechanics, debris flow, and environmental mechanics. His research interests focus on debris flows, landslide monitoring, and slope stability analysis. Dr. Kuo is dedicated to advancing knowledge and innovation in these areas. He obtained his PhD from the Department of Engineering at Cambridge University, UK.

Dr. Kuo developed landslide volume estimation schemes, data analysis methods for multi-temporal Interferometric Synthetic Aperture Radar (MTInSAR) images, and landslide activity assessment indices. These methods have now been applied in long-term monitoring and hazard mitigation projects for deep-seated landslides by the Agency of Rural Development and Soil and Water Conservation, Ministry of Agriculture, in Taiwan.

Dr. Kuo has collaborated with National Taipei University of Technology, National Central University, and National Cheng-Kung University on landslides, MTInSAR data analysis, and underground water flows. As a mentor, he has guided students in geo-sciences, landslides, and fluid mechanics. He also serves as a reviewer for Engineering Geology, Remote Sensing, Granular Matters, Physics of Fluids, Energy, Journal of Sound and Vibrations, and other journals.

Dr. Kuo's future research aims to deepen landslide research and enhance interdisciplinary collaboration. He strives to translate academic discoveries into real-world applications, ensuring a lasting impact on both academia and society.

Selective Publications

- 1 Y. T. Lai, P. K. Wei, Chih-Yu Kuo, J. Y. Chen (2023) Inference detection and classification of illicit drugs by a modest Raman spectrometer with a convolutional neural network analyzer, *Sensors Actuators B: Chem.* 375, 132923.
- 2 S. Alexandrov, Y.-R. Jeng, Chih-Yu Kuo, C.-Y. Chen, (2022). Towards the theoretical/experimental description of the evolution of material properties at frictional interfaces in metal forming processes. *Trib. Intl.*, 171, 107518.
- 3 Chih-Yu Kuo, S.-E. Lin, R.-F. Chen, Y.-J. Hsu, K.-J. Chang, S.-P. Lee, R.-Y. Wu, C.-W. Lin and Y.-H. Chan (2021). Occurrences of Deep-Seated Creeping Landslides in Accordance with Hydrological Water Storage in Catchments. *Front. in Earth Sci.*, 9, doi:10.3389/feart.2021.743669.
- 4 Chih-Yu Kuo, P.-W. Tsai, Y.-C. Tai, Y.-H. Chan, R.-F. Chen, C.-W. Lin (2020). Application assessments of using scarp boundary-fitted, volume constrained, smooth minimal surfaces as failure interfaces of deep-seated landslides. *Front. in Earth Sci.*, 8, doi:10.3389/feart.2020.00211
- 5 Y. C. Chung, C.-W. Wu, Chih-Yu Kuo, S. S. Hsiau, (2019). A rapid granular chute avalanche impinging on a small fixed obstacle: DEM modeling, experimental validation and exploration of granular stress. *Appl. Math. Model.*, 70, 540-568.

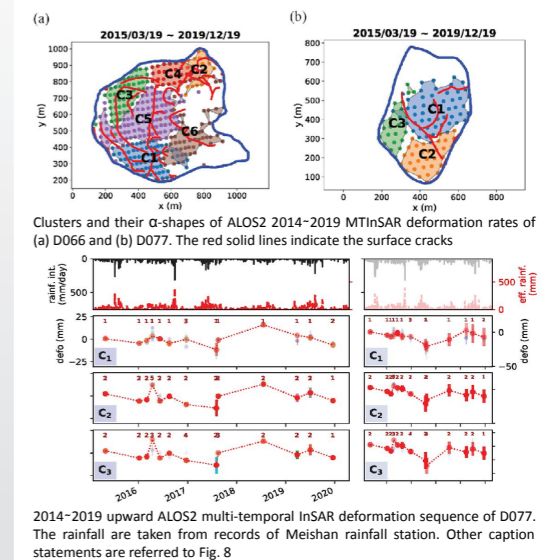
Research Focus

Application of statistical clustering to diagnose sub-zone activities in potential deep-seated landslide sites

Pi-Wen Tsai, Chih-Yu Kuo¹, Rou-Fei Chen

¹Academic Sinica, Research Center for Applied Sciences

Multi-Temporal Interferometric Synthetic Radar (MTInSAR) is a remote sensing technology, which can provide high accuracy and wide coverage of transient surface deformation through analyzing a sequence of radar interferograms. It has been applied to hazard mitigation planning for potential deep-seated landslides and long-term monitoring of the slope activities in Taiwan. In this study, a Gaussian mixture model is proposed to perform statistical clustering for the surface deformation data points, associated clusters are defined to connect multitemporal deformation clusters, and the time series of the deformation clusters can be composed. These techniques enable investigations on the relations among the time series of the deformation clusters, precipitations or other influential factors of the landslide activities. The results indicate that the method can be further deployed for wider deep-seated landslide applications.

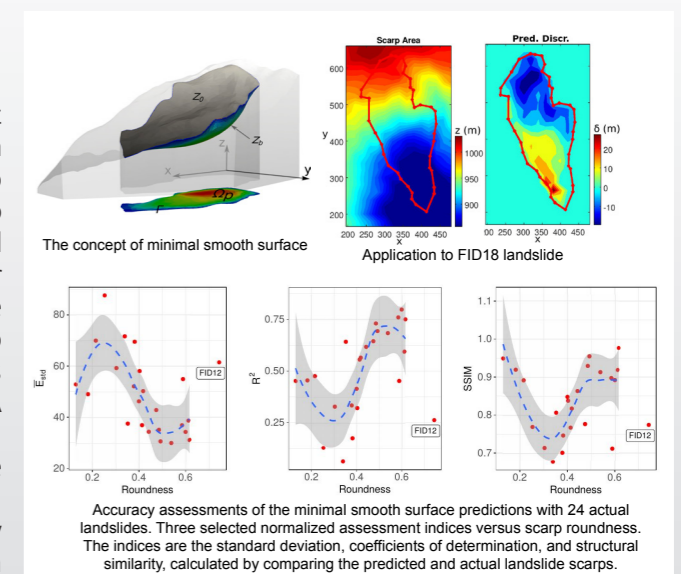


Application assessments of using scarp boundary-fitted, volume constrained, smooth minimal surfaces as failure interfaces of deep-seated landslides

Chih-Yu Kuo¹, P.W. Tsai, Y. C. Tai, Y. H. Chan, R. F. Chen, C. W. Lin

¹Academic Sinica, Research Center for Applied Sciences
Front. In Earth Sci., 2020, DOI: 10.3389/feart.2020.00211

More than 9,000 potential deep-seated landslide sites in the mountain ranges of Taiwan have been identified by a series of governmental hazard mitigation initiatives after the 2009 Morakot typhoon. Among them, 186 sites have protection targets where thorough mitigation strategies are to be implemented. One of the important tasks is to estimate the volume, failure interface and related quantities of each landslide site. With this number of sites, an automated tool is needed to generate predictions at low operational costs. We propose to use volume-constrained smooth minimal surfaces to approximate the landslide failure interfaces. A volume-constrained smooth minimal surface in the current context is defined as a differentiable surface that encloses a given landslide volume with the minimal surface area. Although the stratigraphy and geological structures are omitted, the smooth minimal surface method is verified with 24 known landslides and is shown to be able to generate acceptable, approximated failure interfaces. A collection of assessment indices is employed to measure the fitness of the predictions



Accuracy assessments of the minimal smooth surface predictions with 24 actual landslides. Three selected normalized assessment indices versus scarp roundness. The indices are the standard deviation, coefficients of determination, and structural similarity, calculated by comparing the predicted and actual landslide scarps.

Bi-Chang Chen

Research Fellow

Ph.D. Chemistry and Biochemistry, The University of Texas at Austin, Texas, U.S.A.(2011)

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Narrative CV

Bi-Chang Chen, an Research Fellow specializing in lightsheet microscopy. His research interests focus on superresolution lightsheet imaging in cleared and expanded tissues. He obtained Ph.D. degree in chemistry at the University of Texas at Austin and have contributed to multiple international research projects.

He developed lightsheet localization microscopy for clarified tissue and potassium acrylate expansion lightsheet microscopy, now applied for most of the model organisms, impacting neuroscience and developmental biology.

He has collaborated with Institute of Cellular and Organismic Biology, Institute of Molecular Biology and Biodiversity Research Center on expanded fly/mouse brain neuroscience and plant tissue clearing leading to the whole mouse brain imaging, coral-associated microbial aggregates in the cleared coral imaging and cleared imaging on fungus-cyanobacterium biosystem. As a mentor, he has guided 10 graduate students, fostering new talent in imaging techniques in biological applications and also serve as a reviewer for Cell, Science Advance, Nature Methods, Nature Communications, Scientific Reports, Biomedical Optical Express, Cell Report Method, SPIE journal, Optica, ACS photonics and contribute to Biophysical Society Annual Meetings.

His future research aims to deepen the increase of optical spatial resolution approaching the electron microscopy's power and enhance interdisciplinary collaboration.

Selective Publications

- 1 Tian, X.; Lin, T.-Y., L; Lin, P.-T., Tsai; M.-J., Chen, H.; Chen, W.-J.; Lee, C.-M.; Tu, C.-H.; Hsu, J.-C.; Hsieh, T.-H.; Tung, Y.-C.; Wang, C.-K.; Lin, S.; Chu, L.-A.; Tseng, F.-G.; Hsueh, Y.-P., Lee, C.-H.; Chen, P.; Chen, B.-C.* "Rapid lightsheet fluorescence imaging of whole Drosophila brains at nanoscale resolution by potassium acrylate-based expansion microscopy", *Nature Communications*, 15, 10911 DOI:10.1038/s41467-024-55305-8 (2024)
- 2 Wang, U.-T. T.; Tian, X.; Liou, Y.-H.; Lee, S.-P.; Hu H.-T.; Lu, C.-H.; Lin, P.-T.; Cheng, Y.-J.; Chen P. and Chen, B.-C.* "Protein and lipid expansion microscopy with trypsin and tyramide signal amplification for 3D imaging", *Scientific Reports*, 13, 21922 DOI:10.1038/s41598-023-48959-9 (2023)
- 3 Tang, W.-C.; Liu, Y.-T.; Yeh, C.-H.; Lin, Y.-L.; Lin, Y.-C.; Hsu, T.-L.; Gao, L.; Chen*, P. and B.-C. Chen*, "Optogenetic Manipulation of Cell Migration with High Spatiotemporal Resolution Using Lattice Lightsheet Microscopy" *Communications Biology*, 5, 879, DOI:10.1038/s42003-022-03835-6 (2022)
- 4 Chu, L.-A., Lu, C.-H., Yang, S.-M., Liu, Y.-T, Feng, K.-L., Tsai, Y.-C., Chang, W.-K., Wang, W.-C., Chang, S.-W., Chen, P.; Lee, T.-K., Hwu, Y.-K., Chiang, A.-S. *, and Chen, B.-C.* "Rapid single-wavelength lightsheet localization microscopy for clarified tissue" *Nature Communications*, 10, 4762, DOI: 10.1038/s41467-019-12715-3 (2019)
- 5 Lu, C.-H.; Tang, W.-C.; Liu, Y.-T.; Wu, F. C. M.; Chen, C. Y.; Tsai, Y. C.; Yang, S.-M; Kuo, C.-W.; Okada, Y.; Hwu, Y.-K.; Chang, S.-W.; Chen, P. * and Chen, B.-C.* "Lightsheet localization microscopy enables fast, large-scale, and three-dimensional super-resolution imaging." *Communications Biology*, 2, 177 DOI:10.1038/s42003-019-0403-9 (2019)

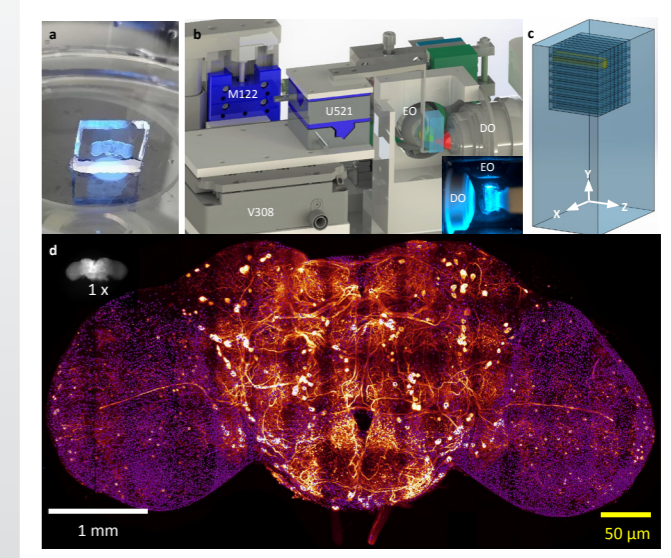
Research Focus

Rapid lightsheet fluorescence imaging of whole Drosophila brains at nanoscale resolution by potassium acrylate-based expansion microscopy

Tian, X.; Lin, T.-Y., L; Lin, P.-T., Tsai; M.-J., Chen, H.; Chen, W.-J.; Lee, C.-M.; Tu, C.-H.; Hsu, J.-C.; Hsieh, T.-H.; Tung, Y.-C.; Wang, C.-K.; Lin, S.; Chu, L.-A.; Tseng, F.-G.; Hsueh, Y.-P., Lee, C.-H.; Chen, P.; Chen, B.-C.*

Academic Sinica, Research Center for Applied Sciences
Nature Communications, 15, 10911
DOI:10.1038/s41467-024-55305-8 (2024)

To extend the resolution of optical microscopy towards that achievable by electron microscopy, whilst allowing colorful visualization of tissues in 3D, we have developed a potassium (poly) acrylate-based expansion microscopy (ExM) platform with an axicon-based Bessel lightsheet microscope equipped with long-working distance objectives and long travelling distance voice-coil stages. The good mechanical strength of our hydrogels could be mounted and translated in 3D for sample scanning via lightsheet imaging, resulting in a 40x plus increased resolution



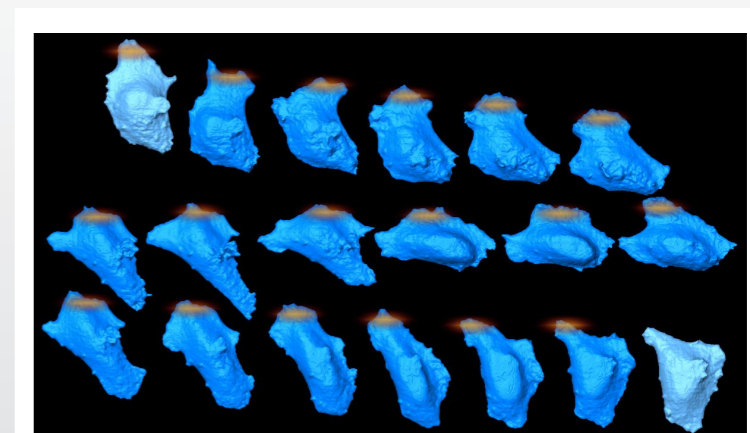
Optogenetic Manipulation of Cell Migration with High Spatiotemporal Resolution Using Lattice Lightsheet Microscopy

Tang, W.-C.; Liu, Y.-T.; Yeh, C.-H.; Lin, Y.-L.; Lin, Y.-C.; Hsu, T.-L.; Gao, L.; Chen, P.* , and Chen, B.-C.*

Academic Sinica, Research Center for Applied Sciences
Communications Biology, 5, 879
DOI:10.1038/s42003-022-03835-6 (2022)

Integration of the stimulation light source into lattice lightsheet microscopy allows us to conduct optogenetic experiment with precisely three-dimensional activation for a long time with no noticeable phototoxicity. We also show that the membrane ruffling with EGFR-CRY2olig-mApplex3 can be triggered at different locations within the same cell sequentially with subcellular resolution, where the activated cell can recover

after 30 minutes for next stimulation. We can continuously guide the cell migration for up to 6 hours, where 463 imaging volumes are collected, without noticeable damage to the cell. In summary, the 3D activation capability of our approach opens the opportunity for optogenetic activation of single cells in small animal models.



Yu-Jung Lin

Assistant Research Fellow

Ph.D. Physiology, National Yang-Ming University (2014)

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Narrative CV

Dr. Yu-Jung Lin received her Ph.D. degree in Physiology from National Yang-Ming University in 2014 and subsequently joined the Department of Chemical Engineering at National Tsing Hua University as a Postdoctoral Fellow. Since 2020, Dr. Lin has served as an independent Principal Investigator at the Research Center for Applied Sciences, Academia Sinica. Her research group focuses on engineering advanced drug delivery systems to reprogram pathological tissue microenvironments, aiming to improve therapeutic outcomes. Recent work has resulted in several publications in leading journals such as *ACS Nano*, *Biomaterials*, and *Chemical Engineering Journal*. Key achievements include a menthol-based platform for inducing adipocyte browning to treat metabolic disorders, hydrogen-generating systems to modulate inflammation, and nanoparticle systems designed to enhance cancer immunotherapy. Lin's Lab also developed electroactive dressings that accelerate wound healing process while enabling non-invasive monitoring. These research activities are supported by competitive funding, including the NSTC 2030 Cross-Generation Young Scholars Program, and have been recognized by Young Investigator Award from Prof. Chau-Jen Lee Biomedical Engineering Development Foundation. Looking ahead, Lin's team aims to explore the potential of nerve-immune interactions in tumor microenvironment remodeling, expand their research into the field of regenerative medicine, and strengthen interdisciplinary collaboration to accelerate clinical translation of research outcomes.

Selective Publications

- 1 Ngo, T. L. H., Wang, K. L., Pan, W. Y., Ruan, T.*; **Lin, Y. J.*** Immunomodulatory prodrug micelles imitate mild heat effects to reshape tumor microenvironment for enhanced cancer immunotherapy. *ACS Nano* 2024, 18, 5632–5646.
- 2 Ruan, T., Fu, C. Y., Lin, C. H., Chou, K. C., **Lin, Y. J.*** Nanocontroller-mediated dissolving hydrogel that can sustainably release cold-mimetic menthol to induce adipocyte browning for treating obesity and its related metabolic disorders. *Biomaterials* 2023, 297, 122120.
- 3 Wu, C. Y., Mac, C. H., Yang, T. H., Nguyen, K., Lo, S. K., Chang, Y., Lai, P. L., Sung, H. W.*; **Lin, Y. J.*** Nanoscale photocatalytic hydrogen production system mitigates inflammation by harnessing glycolysis waste. *Chemical Engineering Journal* 2023, 476, 146614.
- 4 Chou, C. W., Chia, W. T., Mac, C. H., Wu, C. Y., Chen, C. C., Song, H. L., Lin, Y. H., **Lin, Y. J.***, Sung, H. W.* Selective accumulation of ionic nanocrystal H₂ storage system as an in situ H₂/boric acid nanogenerator fights against ethanol-induced gastric ulcers. *Chemical Engineering Journal* 2023, 463, 142373.
- 5 Nguyen, N., Lin, Z. H., Barman, S. R. Korupalli, C., Cheng, J. Y., Song, N. X., Chang, Y., Mi, F. L., Song, H. L., Sung, H. W.*; **Lin, Y. J.*** Engineering an integrated electroactive dressing to accelerate wound healing and monitor noninvasively progress of healing. *Nano Energy* 2022, 99, 107393.

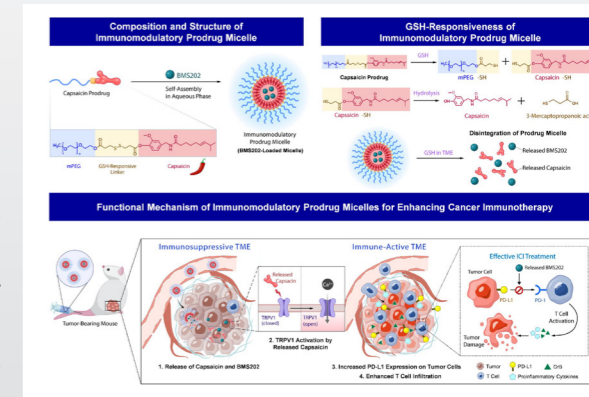
Research Focus

Immunomodulatory Prodrug Micelles Imitate Mild Heat Effects to Reshape Tumor Microenvironment for Enhanced Cancer Immunotherapy

Thi-Lan-Huong Ngo, Kuan-Lin Wang, Wen-Yu Pan, Ting Ruan* and Yu-Jung Lin*

Research Center for Applied Sciences, Academia Sinica
ACS Nano 2024, 18, 5632–5646.

This study employs capsaicin to chemically stimulate TRPV1, imitating immunomodulatory benefits akin to those induced by mild heat. This involves developing a glutathione (GSH)-responsive immunomodulatory prodrug micelle system to deliver capsaicin and an immune checkpoint inhibitor (BMS202) concurrently. Within the GSH-rich tumor microenvironment (TME), the micelles disintegrate and release capsaicin and BMS202. The released capsaicin activates TRPV1 expressed in the TME, enhancing PD-L1 expression on tumor cell surfaces and promoting T cell recruitment into the TME, rendering it more immunologically active. Meanwhile, the liberated BMS202 blocks immune checkpoints on tumor cells and T cells, activating the recruited T cells and ultimately eradicating the tumors. This innovative strategy represents a comprehensive approach to fine-tune the TME, significantly amplifying the effectiveness of cancer immunotherapy.

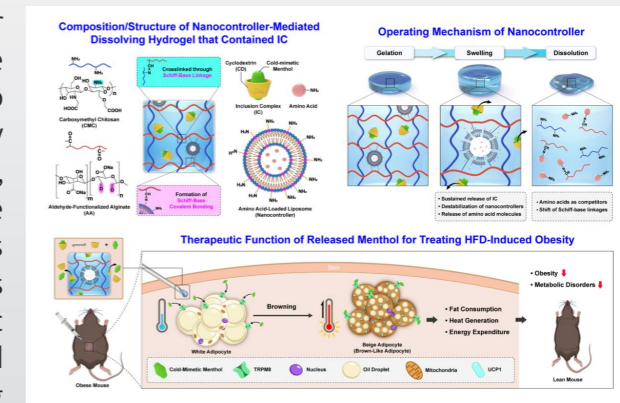


Nanocontroller-Mediated Dissolving Hydrogel that Can Sustainably Release Cold-Mimetic Menthol to Induce Adipocyte Browning for Treating Obesity and Its Related Metabolic Disorders

Ting Ruan, Chih-Yu Fu, Chih-Hung Lin, Kun-Chi Chou, and Yu-Jung Lin*

Research Center for Applied Sciences, Academia Sinica
Biomaterials 2023, 297, 122120.

An injectable hydrogel is developed to sustainably deliver cold-mimetic menthol for adipocyte browning. It contains carboxymethyl chitosan and aldehyde-functionalized alginate crosslinked with dynamic Schiff-base linkages, loaded with menthol-cyclodextrin inclusion complexes. Amino acid-loaded liposomes, functioning as nanocontrollers, are grafted onto the hydrogel to make it soluble after the payload release. When injected into obese mice, the hydrogel gradually releases menthol to induce adipocyte browning and increase energy expenditure. The hydrogel networks expand, triggering the grafted liposomes to release amino acids that dissolve the hydrogel. This nanocontroller-mediated dissolving hydrogel is effective for treating obesity and related metabolic disorders without leaving exogenous hydrogel materials inside the body, and thereby preventing any undesired adverse effects.



Tung-Han Hsieh

Research Specialist

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Narrative CV

Tung-Han Hsieh is a Research Specialist specializing in computational physics, HPC system development, and IoT maintenance. His research interests focus on biomedical image processing and machine learning, and dedicated to advancing knowledge and innovation in this area. He obtained his Ph.D. from Department of Physics, National Taiwan University and have contributed to multiple international research projects.

He developed a HPC system for RCAS, now applied in the first principle calculations and machine learning, impacting the researches of RCAS.

He has collaborated with Dr. Fu-Liang Yang on Deduction Learning model, leading to non-invasive blood glucose and cuffless blood pressure estimations. As a mentor, he has guided 1 graduate student, fostering new talent in machine learning. He also served as a reviewer for NSTC projects, Diagnostics, Photonics, and Sensors (MDPI) journals, and contribute to the organization of OPTIC2024 international conference.

His future research aims to deepen biomedical image processing with machine learning and enhance interdisciplinary collaboration. He strives to translate academic discoveries into real-world applications, ensuring a lasting impact on both academia and society.

Selective Publications

- Bitewulign Kassa Mekonnen, Wei-Ru Lu, Tung-Han Hsieh, Justin Chu and Fu-Liang Yang, "Accurate and 30-plus days reliable cuffless blood pressure measurements with 9-minutes personal photoplethysmograph data and mixed deduction learning", *Scientific Reports* 14, 23722 (2024).
- Wei-Ru Lu, Wen-Tse Yang, Justin Chu, Tung-Han Hsieh, and Fu-Liang Yang, "Deduction learning for precise noninvasive measurements of blood glucose with a dozen rounds of data for model training", *Sci. Rep.* 12, 6506 (2022).
- Wei-Che Huang, Chin-Dian Wei, Shimshon Belkin, Tung-Han Hsieh, and Ji-Yen Cheng, "Machine-learning assisted antibiotic detection and categorization using a bacterial sensor array", *Sensors and Actuators B: Chemical*, 355 (2022) 131257.
- Bitewulign Kassa Mekonnen, Tung-Han Hsieh, Dian-Fu Tsai, Shien-Kuei Liaw, Fu-Liang Yang, and Sheng-Lung Huang, "Generation of Augmented Capillary Network Optical Coherence Tomography Image Data of Human Skin for Deep Learning and Capillary Segmentation", *Diagnostics* 2021, 11(4), 685.
- Hsien-San Hou, Kuang-Li Lee, Chen-Hung Wang, Tung-Han Hsieh, Juan-Jie Sun, Pei-Kuen Wei, and Ji-Yen Cheng, "Simultaneous assessment of cell morphology and adhesion using aluminum nanoslit-based plasmonic biosensing chips", *Sci. Rep.* 9, 7204 (2019).

Research Focus

PPG signal pattern analysis via deduction learning

Wei-Ru Lu, Wen-Tse Yang, Justin Chu, Tung-Han Hsieh, Fu-Liang Yang

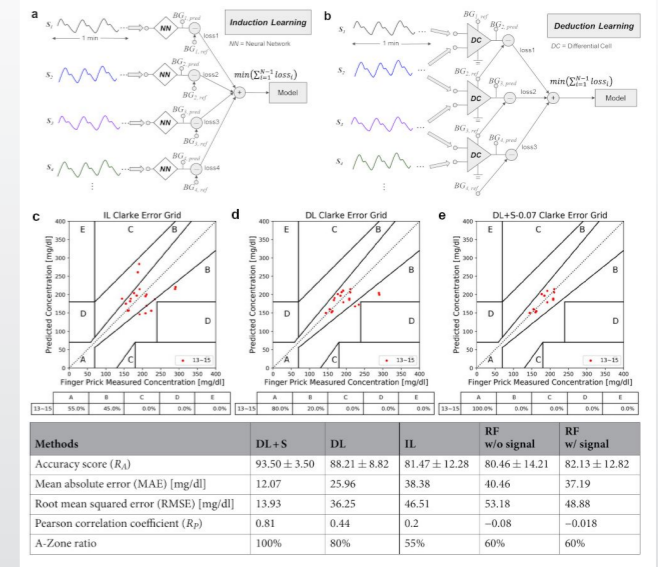
Research Center for Applied Sciences, Academia Sinica
(A part of work in *Scientific Report* (2022) 12:6506)

Diabetes mellitus (DM) is a chronic condition of abnormally elevated blood glucose level (BGL), which leads to various complications. Currently, reliable BGL measurement utilize invasive methods.

In this work, an attempt of noninvasive blood glucose (NIBG) prediction via correlating photoplethysmo-graphy (PPG) to BGL using deduction learning (DL) was developed. Unlike the traditional induction learning (IL), DL has rules based on our domain knowledge being imposed in the model to guide the learning. For PPG based NIBG, the rule imposed is the assumption of the relation between predicted BGL with its precede BGL, and also the measured PPG signals.

$$DL \leftarrow \sum_{i=2}^N f(S_i, S_{i-1}, BGL_{i-1})$$
$$BGL_k \leftarrow DL(S_k, S_N, BGL_N)$$

Using DL, we successfully trained our model with only a dozen of rounds (1 - 12) of training data, and gave good predictions on BGL for rounds 13 - 15.

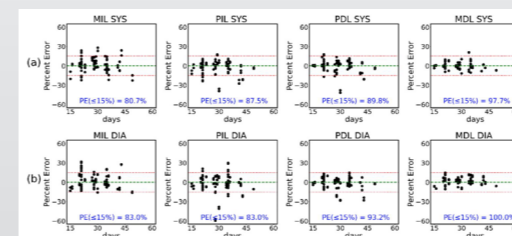
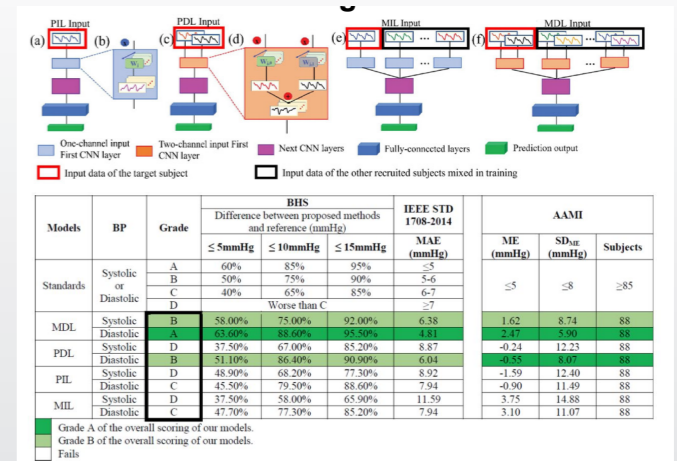


Reliable Cuffless Blood Pressure Measurements with 9-mins Personal PPG data and Mixed Deduction Learning

Bitewulign K. Mekonnen, Wei-Ru Lu, Tung-Han Hsieh, Justin Chu, Fu-Liang Yang

Research Center for Applied Sciences, Academia Sinica
(*Scientific Reports* 14, 23722 (2024))

Cuffless blood pressure (BP) measurements have long been anticipated. In this work, we developed the Mixed Deduction Learning (MDL) model that only requires 9-mins of personal PPG data and mixed with other PPG data collected from our recruited subjects for training, to attend a 30-plus days of reliable BP prediction without further calibrations. Given our consideration of real-life usage, this technology can be seamlessly translated to commercial applications.



Comparison between Mixed Deduction Learning (MDL), Personalized Deduction Learning (PDL), and traditional Personalized Induction Learning (PIL) and Mixed Induction Learning (MIL). We have demonstrated that MDL attained the best performance and can meet grade A for diastolic and grade B for systolic BP predictions, for BHS, IEEE 1708-2014, and AAMI standards.

Shu-Yi Hsieh

Assistant Research Specialist

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Narrative CV

Dr. Shu-Yi Hsieh is an Assistant Research Specialist specializing in chemical synthesis. Her research interests focus on the synthesis of small molecule drugs and nanoparticles, and she is dedicated to advancing knowledge and innovation in this area. She obtained her Ph.D. degree from the Department of Chemistry at National Tsing Hua University and has contributed to multiple research projects. In addition to her professional skills, she is also responsible for the construction and maintenance of RCAS's core facilities, providing excellent component manufacturing and analysis services. Moreover, she manages the experimental safety of her colleagues at the center and ensures safety measures are implemented in all laboratories.

She is developing an automated chemical synthesis system, with the main goal of applying it to small molecule drug research and having a significant impact on drug development.

She actively collaborates with researchers across various disciplines and has made contributions to several interdisciplinary projects.

In the future, she will continue to strengthen the operations and maintenance of core facilities to provide effective micro- and nano-fabrication services. Her future research will focus on advancing automated chemical synthesis and fostering interdisciplinary collaborations. She is committed to translating academic discoveries into real-world applications, ensuring a lasting impact on both academia and society.

Selective Publications

- 1 S. H. Wang, S. C. Y. J. Tung, C. W. Kuo, Y. H. Tai, S. Y. Hsieh, K. L. Lee, S. R. Hsiao, J. F. Sheen, J. C. Hsu and P. K. Wei. "Multichannel Nanoplasmonic Platform for Imidacloprid and Fipronil Residues Rapid Screen Detection Biosensors and Bioelectronics or its open access mirror" *Biosens. Bioelectron.* 2020, 170, 112677.
- 2 S. H. Wang, C. W. Lee, M. Y. Pan, S. Y. Hsieh, F. G. Tseng, and P. K. Wei. "Chromatogram analysis on revealing aggregated number and location of gold nanoparticles within living cells." *Plasmonics*, 2015, 10(4), 873-880.
- 3 W. H. Lin, T. K. Yeh, W. T. Jiaang, K. J. Yen, C. H. Chen, C. T. Huang, S. C. Yen, S. Y. Hsieh, L. H. Chou, C. P. Chen, C. H. Chiu, L. C. Kao, Y. S. Chao, C. T. Chen, and J. T. A. Hsu. & Chiu, C. H. "Evaluation of the antitumor effects of BPR1J-340, a potent and selective FLT3 inhibitor, alone or in combination with an HDAC inhibitor, vorinostat, in AML cancer." *PloS one*, 2014, 9(1), e83160.
- 4 S. H. Wu, S. Y. Hsieh, K. L. Lee, R. H. Weng, A. Chiou, and P. K. Wei, "Cell viability monitoring using Fano resonance in gold nanoslit array." *Applied Physics Letters*, 2013, 103(13), 133702.
- 5 W. H. Lin, J. T. A. Hsu, S. Y. Hsieh, C. T. Chen, J. S. Song, S. C. Yen, T. Hsu, C. T. Lu, C. H. Chen, L. H. Chou, Y. N. Yang, C. H. Chiu, C. P. Chen, Y. J. Tseng, K. J. Yen, C. F. Yeh, Y. S. Chao, T. K. Yeh, and W. T. "Discovery of 3-phenyl-1H-5-pyrazolylamine derivatives containing a urea pharmacophore as potent and efficacious inhibitors of FMS-like tyrosine kinase-3 (FLT3)." Jiaang, *Bioorganic & medicinal chemistry*, 2013, 21(11), 2856-2867.

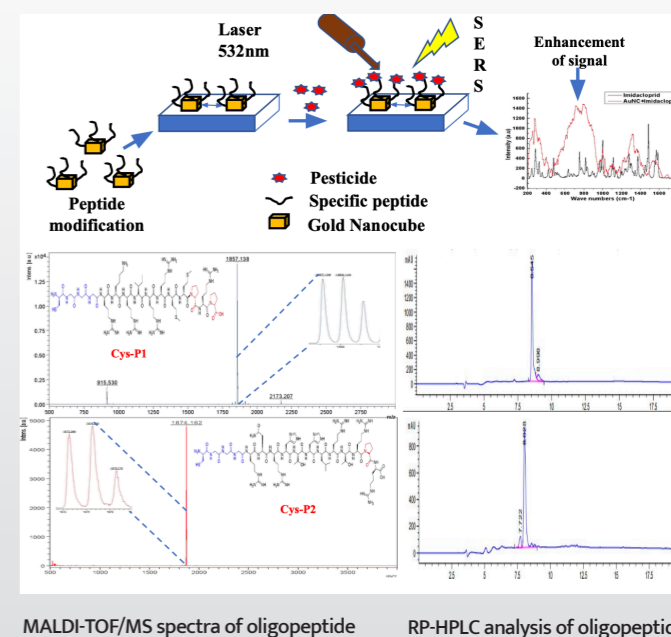
Research Focus

Multiple Pesticides Detection by Integrating Synthetic Peptides and Gold Nanoparticles

Tran Thi Anh Hong, Sheng-Hann Wang, Ting-Wei Chang, Pei-Kuen Wei, Shu-Yi Hsieh*

Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan

In this study, we attempt to develop a detection system by integrating self-synthesized peptides and gold nanoparticles (AuNPs) that is time-saving and enhances specificity as well as a simple technique. Principally, the surface-enhanced Raman scattering (SERS) technique is applied for pesticide detection, herein, AuNPs can be used as SERS substrate due to its roughened surfaces induces Raman signal enhancement. In addition, oligopeptide sequences CGGGRKRIRMMPRPS (Cys-P1) and CGGGRNRHTLRTPR (Cys-P2) were found for specific binding with thiocloprid and imidacloprid, respectively, whereas the CGGG fragment helps to bind with AuNPs forming peptide-modified AuNPs. Therefore, Raman signal from the captured pesticides is enhanced, and an improved specificity is also achieved by decreasing non-specific signals. For oligopeptide Cys-P1 and Cys-P2, Rink amide resin was used for Fmoc solid phase peptide synthesis. The purity of Cys-P1-CONH₂ and Cys-P2-CONH₂ was estimated to be about 90% and 92% by reverse phase HPLC (RP-HPLC). Together, Matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometry (MS) analysis shows the m/z value of Cys-P1-CONH₂ to be 1857.14 and 1858.13; Cys-P2-CONH₂ to be 1873.27 and 1874.26 which contained cis-Proline and trans-Proline isomers in sequence. In future work, we will continuously optimize the peptide-pesticides binding conditions in SERS analysis.

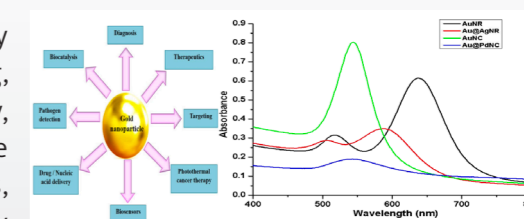


Various Gold Nanoparticles Synthesis: Property, Morphology and Applications

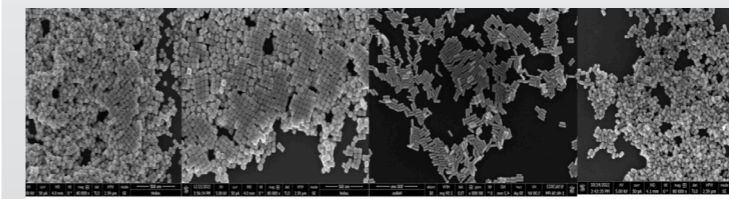
Tran Thi Anh Hong, Shu-Yi Hsieh*

Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan

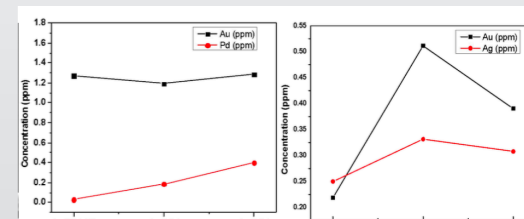
Gold nanoparticles (NPs) have been used in a variety of applications such as diagnosis, therapeutics, targeting, photothermal cancer therapy, biosensors, drug delivery, pathogen detection, and biocatalysis. In RCAS, we synthesize the various AuNPs including AuNCs, Au@Pd NCs, AuNRs, and Au@Ag NRs and provide it to research. Furthermore, by employing the surface-enhanced Raman scattering technique, AuNCs and AuNRs are used as sensitive probes as well as an enhanced signal in SERS. Core-shell Au@Ag NRs with different shell thicknesses of silver will enhance the chemical interface damping (CID) effect. In addition, bimetallic core-shell Au@Pd nanoparticles were applied in enhanced catalytic activity. The particles of AuNPs were characterized by scanning electron microscopy (SEM) and UV-visible spectroscopy, and ICP-OES determined the Au/Ag/Pd mass concentration.



Application of AuNPs



SEM image of the AuNPs immobilized on Si wafer



ICP-OES measurement of Au@PdNC and Au@AgNR

A stylized, light blue graphic of a plant with two large, rounded leaves and a vertical stem, positioned on the left side of the slide. The background is a gradient of dark blue to light blue.

Green Technology

| Faculty Members |

Chih-Wei Chu

Executive Officer of the TCGT and Research Fellow

Ph.D. Materials Science and Engineering, University of California, Los Angeles (2006)

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Narrative CV

Dr. Chih Wei Chu is a Research Fellow specializing in sustainable energy research. His work focuses on next-generation solar cells with high conversion efficiency and high-energy-density batteries, driving innovation in energy materials. He earned his Ph.D. in Materials Science and Engineering from UCLA. With over 250 peer-reviewed publications and more than 23,000 citations (H-index: 70), his research has made a significant impact in photovoltaics and energy storage.

Dr. Chu leads two major research initiatives aimed at transforming the future of renewable energy and energy storage. The first focuses on developing high-efficiency perovskite/Si tandem solar cells to surpass the Shockley-Queisser efficiency limit. By overcoming critical interfacial challenges, his team recently achieved an efficiency exceeding 31%, paving the way for more cost-effective and scalable solar energy solutions. The second project advances solid-state battery technology by designing high-ion-conductivity polymers with superior thermal stability. These breakthroughs are now being applied in real-world battery systems, enhancing safety and energy density, and accelerating the transition to a sustainable energy future.

Dr. Chu's future research aims to further advance high-efficiency solar energy and next-generation energy storage solutions while fostering interdisciplinary collaboration. By bridging fundamental research with practical applications, he strives to develop scalable, sustainable technologies that drive the global transition to clean energy. His work will continue to address critical challenges in renewable energy and battery safety, ensuring a lasting impact on both academia and society by accelerating the adoption of innovative energy solutions for a more sustainable future.

Selective Publications

- 1 Chintam Hanmandlu, Rohan Paste, Hsinhan Tsai, Shyam Narayan Singh Yadav, Kuan-Wen Lai, Yen-Yu Wang, Chandra Shekar Gantepogu, Chen-Hung Hou, Jing-Jong Shyue, Yu-Jung Lu, Tushar Sanjay Jadhav, Jian-Ming Liao, Hsien-Hsin Chou, Hui Qi Wong, Ta-Jen Yen, Chao-Sung Lai, Dibyajyoti Ghosh, Sergei Tretiak, Hung-Ju Yen*, Chih Wei Chu*, "3D Nanographene Precursor Suppress Interfacial Recombination in PEDOT: PSS based Perovskite Solar Cells" Nano Energy, 107, 108136 (2023).
- 2 Rohan Paste, Chintam Hanmandlu, Po-Yu Su, Cheng-Hung Hou, Hsin-An Chen, Chun-Wei Pao, Jing-Jong Shyue, Kuei-Hsien Chen, Heng-Liang Wu, Hong-Cheu Lin*, Chih Wei Chu*, "Intimate interaction of TFSI-anions with MoO₃-x oxygen vacancies boost ionic conductivity of cathode-supported solid polymer electrolyte" Chemical Engineering Journal, 452, 139088 (2023).
- 3 Syed Ali Abbas, Hsin-An Chen, Anisha Mohapatra, Anupriya Singh, Chun-Wei Pao, Chih Wei Chu*, "Sweetening Lithium Metal Interface by High Surface and Adhesive Energy Coating of Crystalline α -D-Glucose Film to Inhibit Dendrite Growth" Small, 18, 2201349 (2022).
- 4 Chintam Hanmandlu, Mamina Sahoo, Chi-Ching Liu, Yun-Chorng Chang, Chih Wei Chu*, Chao-Sung Lai*, "Few-layer fluorine-functionalized graphene hole-selective contacts for efficient inverted perovskite solar cells" Chemical Engineering Journal, 430, 132831 (2021).
- 5 Anupriya Singh, Po-Ting Lai, Anisha Mohapatra, Chien-Yu Chen, Hao-Wu Lin, Yu-Jung Lu, Chih Wei Chu*, "Panchromatic heterojunction solar cells for Pb-free All-Inorganic Antimony Based Perovskite" Chemical Engineering Journal, 419, 129424 (2021).

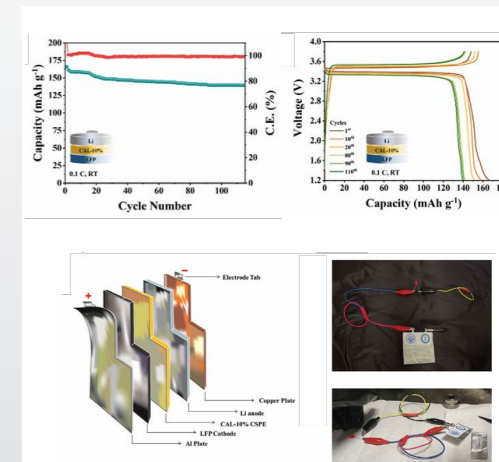
Research Focus

A-LLTO Nanoparticles Embedded Composite Solid Polymer Electrolyte for Room Temperature Operational Li-metal Batteries

Rohan Paste, Yu-Te Chen, Krishna Borde, Atul Dhage, Shih-Sheng Sun, Hong-Cheu Lin, and Chih Wei Chu

Academic Sinica, Research Center for Applied Sciences
Small, 2024, DOI: 10.1002/sml.202311382

Solid-state batteries (SSBs) are poised to revolutionize energy storage, particularly for electric vehicles and next-generation electronics. While lithium-ion batteries (LIBs) dominate today's market, future energy demands call for safer, more reliable alternatives. This study introduces a novel solid-state electrolyte composed of a self-healing composite solid polymer electrolyte (CSPE) matrix with aluminum-doped ($\text{Li}_{0.33}\text{La}_{0.56}\text{Ti}_{1.005}\text{Al}_{0.01}\text{O}_3$ (A-LLTO) nanofillers. The optimized CSPE (CAL-10%) achieves a room-temperature ionic conductivity of $1.1 \times 10^{-3} \text{ S cm}^{-1}$, facilitated by a percolation network formed by uniformly dispersed A-LLTO nanofillers, enhancing Li^+ ion transport. A $\text{LiFePO}_4 \parallel \text{CAL-10\%} \parallel \text{Li CR-2032}$ cell delivers an initial discharge capacity of $\approx 165 \text{ mAh g}^{-1}$ at 0.1C for 120 cycles with 98.85% coulombic efficiency, demonstrating excellent electrochemical performance. These findings highlight the potential of CSPE-based electrolytes to advance SSB technology for high-performance energy storage applications.

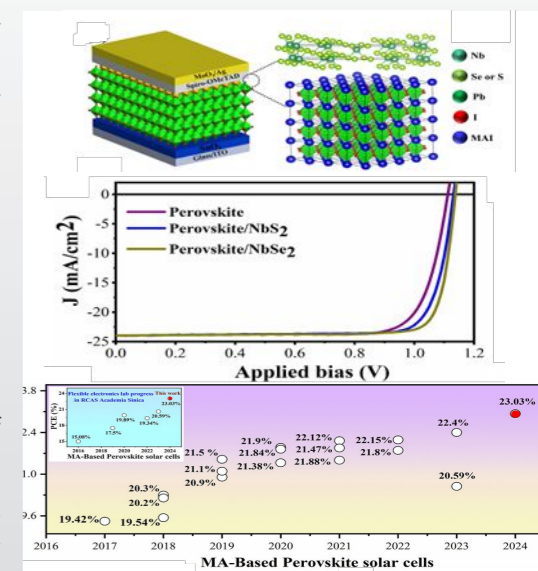


Ion mitigation and strain regulation with 2D Semi-Metals for MA-Based perovskite materials in highly efficient solar cells

Chintam Hanmandlu, Soumallya Banerjee, Abhishek Kumar, Zeeshan Alam Ansari, Ramesh Kumar, Yen-Yu Wang, Lin-Chyn Yuan, Shenghan Li, Raman Sanker, Chandra Shekar Gantepogu, You-Yun Wen, Shyam Narayan Singh Yadav, Sumangaladevi Koodathil, Po-Yu-Yang, Chun-Wei Pao, Yu-Jung Lu, Jing-Jong Shyue, Chao-Sung Lai, and ChihWei Chu

Academic Sinica, Research Center for Applied Sciences
Chemical Engineering Journal, 2025, DOI: 10.1016/j.cej.2024.158070

Achieving high efficiency and stability is crucial for commercializing perovskite solar cells (PSCs). Addressing recombination and voltage losses, particularly at the perovskite/hole-transport layer interface, remains a key challenge. This study introduces a simple surface modification strategy using 2D semi-metallic nanoparticles of NbSe₂ and NbS₂ to passivate surface defects. Their divalent anions (Se²⁻ and S²⁻) form strong coordination bonds, reducing trap densities and extending charge carrier lifetime. Additionally, hydrogen bond-like interactions with organic cations enhance film stability. PSCs incorporating NbSe₂ NP passivation achieved an efficiency of 23.03%, an open-circuit voltage (Voc) of 1.14 V, and a fill factor exceeding 84%, with significantly improved stability. This work demonstrates an effective inorganic passivation strategy for high-performance PSCs, advancing their commercial viability.



Chun-Wei Pao

Research Fellow

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Princeton University (2007)

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Narrative CV

Dr. Chun-Wei Pao is a Research Fellow at the Research Center for Applied Sciences, Academia Sinica, and adjunct professor at National Taiwan University, National Yang Ming Chiao Tung University, and National Dong Hwa University. He earned his Ph.D. in Mechanical and Aerospace Engineering from Princeton University, following M.S. degrees from Princeton and National Taiwan University, and a B.S. from National Tsing Hua University. He conducted postdoctoral research at the Theoretical Division of Los Alamos National Laboratory.

Dr. Pao is recognized for his contributions to computational materials science, particularly in multiscale modeling, molecular dynamics, and machine learning-enabled energy models. His recent research has enabled extensive computational exploration of complex materials, including 2D perovskites and high-entropy alloys. His 2022 Nature publication on ultraelastic chemically complex alloys laid the groundwork for his 2024 Nature Communications study, which introduced a machine learning-enabled potential for large-scale simulation of dislocation behaviors in these alloys.

A recipient of the 2025 NSTC Outstanding Research Award, Dr. Pao has also been honored with the Y.Z. Hsu Science Paper Award, Academia Sinica Investigator Award, Academia Sinica Career Development Award, and the IUPAC Distinguished Award for Novel Materials. He serves the international research community through editorial, symposium, and review roles.

Selective Publications

- H. Wang, Po-Yu Yang, W.J. Zhao, S.H. Ma, J.H. Hou, Q.F. He, C.L. Wu, H.A. Chen, Q. Wang, Q. Cheng, B.S. Guo, J. C. Qiao, W.J. Lu, S.J. Zhao, X.D. Xu, C.T. Liu, Y. Liu*, Chun-Wei Pao*, Yong Yang* (2024), "Lattice distortion enabling enhanced strength and plasticity in high entropy intermetallic alloy", *Nature Communications* 15, 6782.
- Quanfeng He, J.G. Wang, Hsin-An Chen, Z.Y. Ding, Z.Q. Zhou, L.H. Xiong, Junhua Luan, J.M. Pelletier, J.C. Qiao, Q. Wang, L.L. Fan, Yang Ren, Qiaoshi Zeng, Chain Liu, C.W. Pao*, David Srolovitz*, Yong Yang* (2022), "A Highly Distorted Ultra-Elastic Chemically Complex Elinvar Alloy", *Nature* 602, 251.
- Hsin-An Chen, Ping-Han Tang, Guan-Jie Chen, Chien-Cheng Chang*, Chun-Wei Pao* (2021), "Microstructure Maps of Complex Perovskite Materials from Extensive Monte Carlo Sampling Using Machine Learning-Enabled Energy Model", *Journal of Physical Chemistry Letters* 12, 3591.
- Cheng-Lun Wu, Fang-Cheng Li, Chun-Wei Pao*, David J. Srolovitz* (2017), "Folding Sheets with Ion Beams", *Nano Letters* 17, 249-254.
- Cheng-Kuang Lee, Chun-Wei Pao*, Chun-Wei Chen (2013), "Correlation of nanoscale organizations of polymer and nanocrystals in polymer/inorganic nanocrystal bulk heterojunction hybrid solar cells: insights from multiscale molecular simulations", *Energy & Environmental Science* 6, 307.

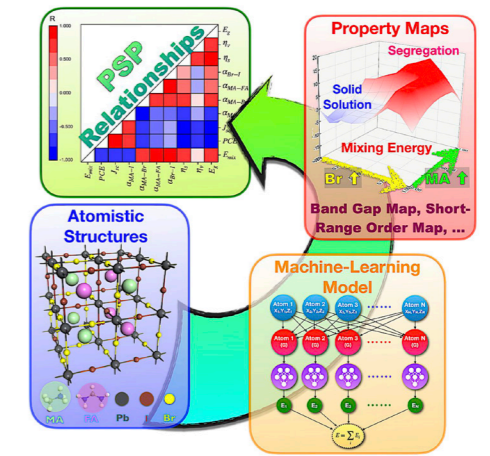
Research Focus

Microstructure Maps of Complex Perovskite Materials from Extensive Monte Carlo Sampling Using Machine Learning Enabled Energy Model

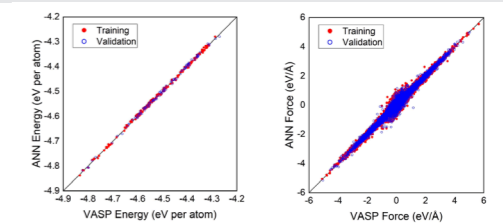
Hsin-An Chen, Ping-Han Tang, Guan-Jie Chen, Chien-Cheng Chang, Chun-Wei Pao*

Journal of Physical Chemistry Letters 12, 3591 (2021)

In this work, we trained an artificial neural network (ANN) potential energy model of the $MA_yFA_{1-y}Pb(Br_xI_{1-x})_3$ complex perovskite material and investigated the microstructure over the composition space using extensive Monte Carlo simulations. We sampled around 8.1×10^5 structures of different site permutations and compositions, identified low energy structures and mapped the structural properties - the mixing energy, SRO parameters, and lattice distortion - over the composition space. Subsequent Pearson correlation analysis revealed the process-structure-property relationship of complex perovskite materials, indicating that the composition lowering the lattice distortion would yield better efficiency because of formation of single solid solution phase.



Extensive Monte Carlo samplings allows mapping of structural properties

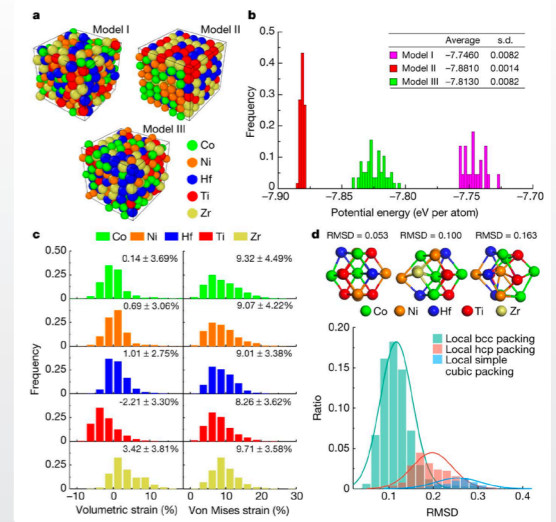


High fidelity of the ANN model to DFT calculations

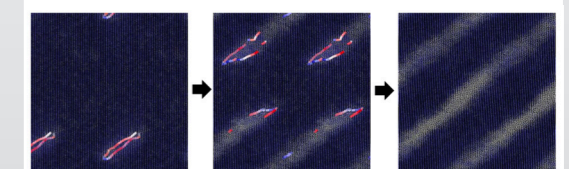
Multiscale Simulation of Microstructure of Ultra-elastic Complex Alloy

Nature 602, 251 (2022) and *Nature Communications* 15, 6782 (2024)

In this work, we collaborated with our experimental collaborators in Hong Kong and decoded the atomistic structure of $Ni_{25}Co_{25}(HfTiZr)_{50}$ chemically complex alloy using extensive DFT calculations. DFT calculation revealed the judicious chemical ordering at atomic scale helps retain the material stability while undergoing a 11% of atomic size mismatch, which was also confirmed by STEM-EDS experiments. Extensive DFT calculations indicate that each constituent elements is subjected to ~9% of distortion - several times more severe than other high entropy alloys, and is the primary factor leading to the ultraelasticity and Elinvar effect of this extraordinary alloy. A machine learning energy model for large-scale molecular simulation has been trained to further examine its exceptional plastic deformation properties, and we discovered the temperature-dependent microstructure upon loading beyond elastic limit.



Extensive DFT calculations reveal the structural stability and lattice distortion of complex alloy



Plastic deformation from MLMD simulations (Nature Comm, 2024)

Tzung-Fang Guo

Research Fellow

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University of California, Los Angeles (2002)

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Narrative CV

Dr. Tzung-Fang Guo is a Research Fellow specializing in organic electronics devices and hybrid organolead halide perovskite-based devices. His research interests focus on high-performance organic/polymer light-emitting diodes, polymer photovoltaics, *n*-type pentacene organic thin-film transistors, and the magnetic field effect of organic electronic devices. He obtained his Ph.D. from the Department of Materials Science and Engineering at the University of California Los Angeles. Dr. Guo has contributed to multiple international research projects.

Dr. Guo was the first to develop perovskite-based hybrid solar cells with a *p-i-n* device configuration and apply a *p*-type nickel oxide electrode interlayer in fabricating efficient perovskite solar cells and light-emitting diodes. His work has significantly impacted novel perovskite photovoltaic and solid-state lighting fields.

Dr. Guo has collaborated with Chi-Mei Optoelectronics Corporation on organic light-emitting diodes, leading to the development of novel organic oxide/Al cathode structures. As a mentor, he has guided 60 graduate students, fostering new talent in organic semiconductors. From 2012 to 2018, Dr. Guo served as Chairman of the Department of Photonics at National Cheng Kung University, Taiwan. He is currently a Fellow of SPIE and OPTICA.

Dr. Guo's future research aims to deepen the development of highly efficient perovskite/Si tandem solar cells, explore the unique interfacial properties in perovskite-based light-emitting diodes, investigate the magnetic field effect in organic electronic devices, and enhance interdisciplinary collaboration.

Selective Publications

- 1 Y. Lin, S. -H. Luo, C. -T. Li and T. -F. Guo*, "Visualizing the "hidden" triplet-triplet fusion process to fluorescence in typical organic/polymer light-emitting diodes" *Adv. Optical Mater.* **13**, 2402111 (2025).
- 2 M. -H. Li, H. -H. Yeh, Y. -H. Chiang, U -S. Jeng, C. -J. Su, H. -W. Shiu, Y. -J. Hsu, N. Kosugi, T. Ohigashi, Y. -A. Chen, P. -S. Shen, P. Chen*, and T. -F. Guo*, "Highly efficient 2D/3D hybrid perovskite solar cells via low-pressure vapor-assisted solution process" *Adv. Mater.* **30**, 1804801 (2018). (Highly cited papers in ESI)
- 3 Y. -K. Chih, J. -C. Wang, R. -T. Yang, C. -C. Liu, Y. -C. Chang, Y. -S. Fu, W. -C. Lai, P. Chen, T. -C. Wen, Y. -C. Huang, C. -S. Tsao, and T. -F. Guo*, "NiOx electrode interlayer and CH₃NH₂/CH₃NH₃PbBr₃ interface treatment to markedly advance hybrid perovskite-based light-emitting diodes", *Adv. Mater.* **28**, 8687 (2016).
- 4 J. -Y. Jeng, K. -C. Chen, T. -Y. Chiang, P. -Y. Lin, T. -D. Tsai, Y. -C. Chang, T. -F. Guo*, and P. Chen* "Nickel oxide electrode interlayer in CH₃NH₃PbI₃ perovskite/PCBM planar-heterojunction hybrid solar cells" *Adv. Mater.* **26**, 4107 (2014). (Highly cited papers in ESI)
- 5 J. -Y. Jeng, Y. -F. Chiang, M. -H. Lee, S. -R. Peng, T. -F. Guo*, P. Chen*, and T. -C. Wen "CH₃NH₃PbI₃ perovskite/fullerene planar-heterojunction hybrid solar cells" *Adv. Mater.* **25**, 3727 (2013). (*SPIE Newsroom highlighted*) (Highly cited papers in ESI)

Research Focus

Visualizing the "Hidden" Triplet-Triplet Fusion Process to Fluorescence in Typical Organic/Polymer Light-Emitting Diodes

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Adv. Optical Mater. **13**, 2402122 (2025)

Fluorescence emission of a typical poly(9,9-dialkylfluorene) derivative (PF GreenB)-based polymer light-emitting diodes (PLEDs) clearly demonstrates that it partially involves the contribution of triplet excitons by the triplet-triplet fusion (TTF) process through measuring the magneto electroluminescence (MEL) responses of devices at different bias conditions and temperatures. The TTF process to fluorescence intrinsically correlates with the concentration, lifetime, and polaron quenching of triplet excitons, as modulated by different bias regimes and conditions. The results in this work unveil the "hidden" component of fluorescence emission, which originates from the fusion of triplet excitons to singlet excitons in typical PLEDs. The results elucidate that TTF of triplet excitons to fluorescence emission can be a practicable mechanism that contributes to enhancing the performance of devices.

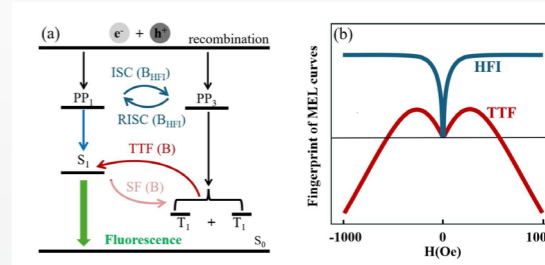


Figure 1. (a) The evolution channel and microscopic processes of ISC(BHFI), RISC(BHFI), SF, and TTF occurred in PF Green B-based devices. (b) Fingerprint MEL curves for HFI and TTF processes.

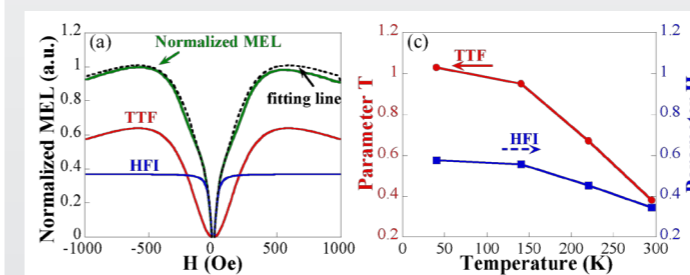
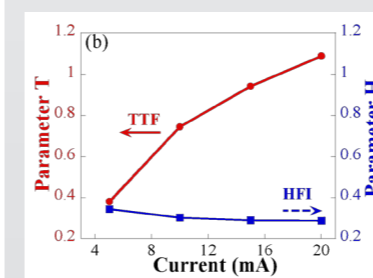


Figure 2. Illustrate the fitting results (a) based on the normalized MEL response measured at 295 K and 5 mA with respect to TTF and HFI intensities. (b) Display the intensity curves of the current-dependent TTF and HFI processes (Parameters T and H) at room-temperature. (c) Show the intensity curves of the temperature-dependent TTF and HFI processes at a fixed 5 mA current.



$$MEL(\text{normalized}) = T \left[A_1 \frac{B^2}{B^2 + B_{10}^2} - A_2 \frac{B^2}{(|B| + B_{20})^2} \right] + H \frac{B^2}{B^2 + B_{30}^2}$$

MEL fingerprint responses determined by the HFI process can be effectively fitted using Lorentzian functions, while MEL fingerprint responses dominated by the TTF process can be fitted using a combination of Lorentzian and non-Lorentzian functions, where defines the saturation fields of the TTF process at low and high magnetic fields as parameters B₁₀ (248.53 Oe) and B₂₀ (662.71 Oe), respectively. Similarly, B₃₀ (27 Oe) represents the saturation field of the HFI process. The parameters T and H represent the intensity of the TTF and HFI processes, respectively.

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Narrative CV

Dr. Yun-Chorng Chang, who received his Ph.D. degree from the Department of Electrical and Computer Engineering at North Carolina State University in USA, is currently a research fellow in RCAS.

His research interests focus on developing low-cost and high-throughput nanofabrication methods to enable the industrialization of Nanophotonic devices. His research team has developed and coined the Nanospherical-Lens Lithography, which is now capable of fabricating complex three-dimensional nanostructure arrays for commercial applications. His team is currently one of the world's leading groups in nanosphere-based fabrication techniques.

Dr. Chang collaborates with various research teams both domestically and internationally on diverse topics. He is also actively participating in various international societies. Currently, he is a senior member of SPIE and IEEE, and also serves as the Chair of the Education Committee of the Taiwan Photonics Society. He also serves as an Associate Editor of the Chinese Journal of Physics.

In the future, Dr. Chang will continue to focus on enabling the commercial application of nanodevices, with particular emphasis on developing next-generation green energy optoelectronic components and biosensing platforms.

Selective Publications

- 1 C. C. Liu, H. H. Hsiao, Y. C. Chang*, "Nonlinear Two-photon Pumped Vortex Lasing Based on Quasi-Bound States in the Continuum from Perovskite Metasurface", *Science Advances*, 2023/05, 9, eadf6649.
- 2 C. Y. Li, C. C. Liu, W. C. Lai, Y. -C. Lan*, and Y. C. Chang*, "Quantifying the Plasmonic Generation Rate of Non-Thermal Hot Carriers with an AlGaIn/GaN High-Electron-Mobility Transistor", *Advanced Science*, 2021/07, 8(13) 2100362.
- 3 C. Y. Lin, C. C. Liu, Y. Y. Chen, K. Y. Chiu, J. D. Wu, B. L. Lin, C. H. Wang, Y. F. Chen, S. -H. Chang*, and Y. C. Chang*, "Molecular chirality detection with periodic arrays of three-dimensional twisted metamaterials", *ACS Applied Materials & Interfaces*, 2021/01, 11(01), 1152–1157.
- 4 M. C. Chou, C. Y. Lin, B. L. Lin, C. H. Wang, S. H. Chang, W. C. Lai, K. Y. Lai, and Y. C. Chang*, "Polarization-Selecting III-Nitride Elliptical Nanorod Light-Emitting Diodes Fabricated with Nanospherical-Lens Lithography", *ACS Nano*, 2018/08, 12(08), 8748–8757.
- 5 Y. H. Chien, C. H. Wang, C. C. Liu, S. H. Chang, K. V. Kong, and Y. C. Chang*, "Large-scale nanofabrication of designed nanostructures using Angled Nanospherical-Lens Lithography for Surface Enhanced Infrared Absorption Spectroscopy", *ACS Applied Materials & Interfaces*, 2017/07, 9(29), 24917-24925.

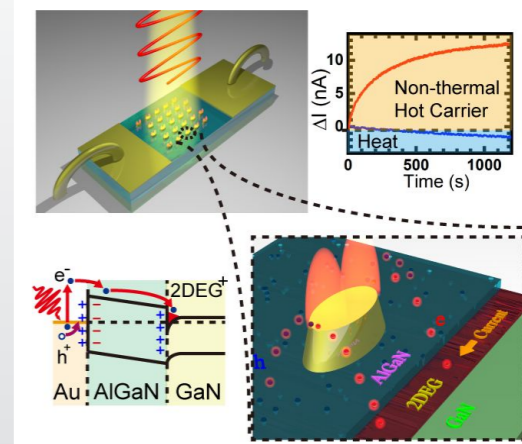
Research Focus

Quantifying the Plasmonic Generation Rate of Non-Thermal Hot Carriers with an AlGaIn/GaN High-Electron-Mobility Transistor

Chun-Yu Li, Chi-Ching Liu, Wei-Chih Lai, Yung-Chiang Lan*, and Yun-Chorng Chang*

Academic Sinica, Research Center for Applied Sciences
Advanced Sciences, 2021, DOI: 10.1002/advs.202100362

Plasmonic generation of hot carriers in metallic nanostructures has attracted much attention due to its great potential in several applications. However, it is highly debated whether the enhancement is due to the hot carriers or the thermal effect. Here, the ability to exclude the thermal effect and detect the generation of non-thermal hot carriers by surface plasmon is demonstrated using an AlGaIn/GaN high-electron-mobility transistor. This ultrasensitive platform, which demonstrates at least two orders of magnitude more sensitivity compared to the previous reports, can detect the hot carriers generated from discrete nanostructures illuminated by a continuous wave light. The quantitative measurements of hot carrier generation also open a new way to optimize the plasmonic nanoantenna design in many applications.



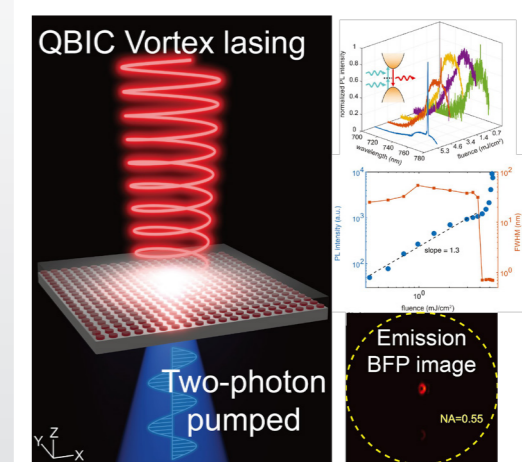
Schematic illustration of hot-electron generation and injection into the 2DEG of an AlGaIn HEMT device

Nonlinear Two-photon Pumped Vortex Lasing Based on Quasi-Bound States in the Continuum from Perovskite Metasurface

Chi-Ching Liu, Hui-Hsin Hsiao and Yun-Chorng Chang*

Academic Sinica, Research Center for Applied Sciences
Science Advances, 2023, DOI: 10.1126/sciadv.adf6649

The experimental observation of nonlinear two-photon pumped vortex lasing from perovskite metasurfaces is demonstrated for the first time. The vortex lasing beam is based on symmetry-protected quasi-bound states in the continuum (QBIC). The topological charge is estimated to be +1 according to the simulation result. The quality factor and lasing threshold is around 1100 and 4.28 mJ/cm², respectively. Theoretical analysis reveals that the QBIC mode originates from the magnetic dipole mode. The lasing wavelength can be experimentally designed within a broad spectral range by changing the diameter and periodicity of the metasurface. The finite array size effect of QBIC can affect the quality factor of the lasing and be used to modulate the lasing. Results shown in this study can lead to more complex vortex beam lasing from a single chip and new ways to obtain ultrafast modulation of the QBIC lasing via finite array size effect.



Schematic illustration of two-photon pumped vortex lasing based on QBIC

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Narrative CV

Yuh-Jen Cheng is currently an associate research fellow at RCAS, Academia Sinica. He received a doctorate degree from the Department of Applied Physics at Stanford University. His research interests span various areas, including III-nitride semiconductor growth, III-nitride LEDs and lasers in the past, and more recently, 2D material growth and photonic devices, and photoelectrochemical water splitting and electrocatalyst.

TMD semiconductor materials have self-terminating atomic surface structure with strong light interaction and excellent charge transport properties, making it a promising material for atomic scale electronic and photonic devices. The realization of such applications relies on the development of wafer scale crystal growth. Such growth has been challenging due to the weak van der Waals interaction with substrate that results in random nucleation orientation. His studies have developed growth conditions to achieve aligned nucleation orientation guided by substrate lattice, which paves the way for large scale crystal growth.

Water splitting is an attractive approach to generate green hydrogen from renewable energy. Its success highly depends on the development of electrocatalyst. Noble metal-based materials have been well known for their high efficiency. However, the high-cost limits practical use. His research has developed a transition metal composition and a sonochemical synthesis method to fabricate highly active electrocatalysts for water splitting with very low overpotential compatible with Pt/C.

Selective Publications

- 1 Pei-Xuan Long, Yung-Yu Lai, Pei-Hao Kang, Chi-Huang Chuang and Yuh-Jen Cheng*, "High photoresponsivity MoS₂ phototransistor through enhanced hole trapping HfO₂ gate dielectric", *Nanotechnology* 35, 025204 (2024).
- 2 Chi-Huang Chuang, Pei-Hao Kang, Yung-Yu Lai, Cheng-Hung Hou, Wei-Che Tseng, Yan-Jia Huang, Mu-Huai Fang, Jing-Jong Shyue, Chao-Cheng Kaun, and Yuh-Jen Cheng*, "Highly Active NiO-Ni(OH)²-Cr₂O₃/Ni Hydrogen Evolution Electrocatalyst through Synergistic Reaction Kinetics", *ChemSusChem* 2023, e202300820.
- 3 Chi-Huang Chuang, Pei-Hao Kang, Yung-Yu Lai, Cheng-Hung Hou, and Yuh-Jen Cheng*, "Junction Engineering in Si Photoanode for Efficient Photoelectrochemical Water Splitting", *ACS Appl. Energy Mater.* 2022, 5, 7, 8483–8491 (2022).
- 4 Yung-Yu Lai, Chi-Huang Chuang, Yen-Wei Yeh, Cheng-Hung Hou, Shih-Chieh Hsu, Yi Chou, Yi-Chia Chou, Hao-Chung Kuo, YewChung Sermon Wu, and Yuh-Jen Cheng*, "Substrate Lattice Guided MoS₂ Crystal Growth: Implications for van der Waals epitaxy", *ACS Appl. Nano Mater.* 4, 4930–4938 (2021).
- 5 Yung-Yu Lai, Yen-Wei Yeh, An-Jye Tzou, Yi-Yuan Chen, YewChung Sermon Wu, Yuh-Jen Cheng*, and Hao-Chung Kuo*, "Dependence of Photoresponsivity and On/Off Ratio on Quantum Dot Density in Quantum Dot Sensitized MoS₂ Photodetector", *Nanomaterials* 2020, 10, 1828.

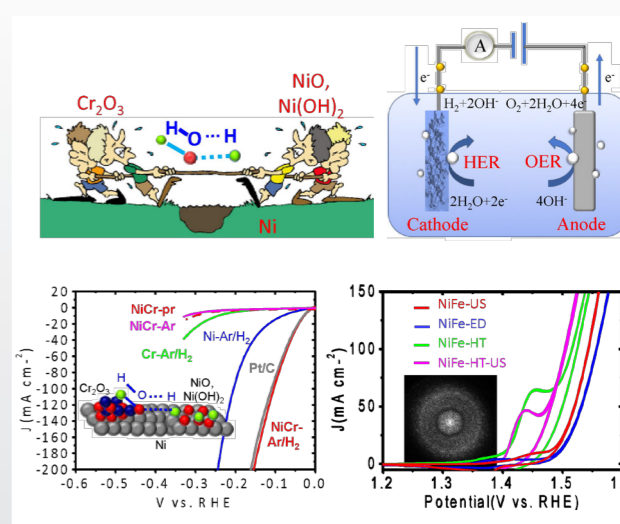
Research Focus

Noble-metal-free Electrocatalyst for Water Splitting

Chi-Huang Chuang, Pei-Hao Kang, Chao-Cheng Kaun, and Yuh-Jen Cheng

ChemSusChem 2023, e202300820, doi.org/10.1002/cssc.202300820

Electrocatalyst with high catalytic activity are crucial for converting renewable electricity to storable hydrogen fuel. Noble-metal-based materials, e.g. Pt, IrO₂, RuO₂, has been the well known highly efficient catalysts. This work focuses on developing noble metal free electrocatalysts for oxygen and hydrogen evolution reaction (OER and HER). This study has developed a HER electrocatalyst consisting of transition metal composition NiOx-Cr₂O₃/Ni, showing high activity comparable with Pt/C with low overpotential of -27, and -103, mV at current density of -10, -100 mA cm⁻². The high activity is attributed to the synergetic effect between NiOx/Ni and Cr₂O₃ in breaking OH-H bond and forming sites with low H* adsorption energy to promote H* to H₂ evolution. This study also developed an ultrasonic deposition to fabricate a NiFe OER electrocatalyst. Ultrasound irradiation in solution increases mixing, dispersion, and reaction, resulting in a well-mixed amorphous catalyst with highly dispersed active sites. Combining hydrothermal and ultrasonic deposition, this work demonstrated a OER electrocatalyst with low overpotential of 220 mV at 10 mA cm⁻² current density.

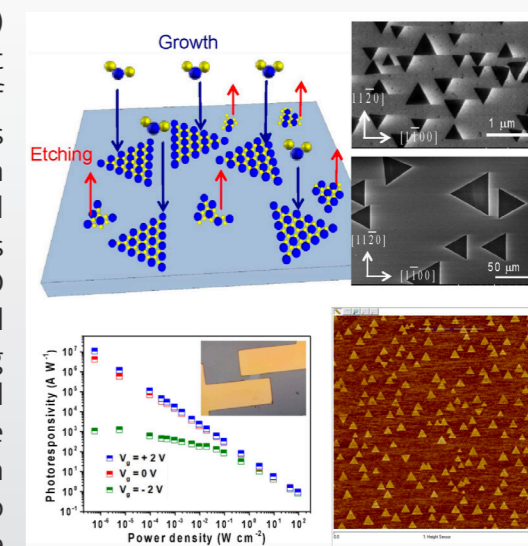


2D Semiconductor Crystal Growth and Photonic Devices

Chi-Huang Chuang, Yung-Yu Lai, Pei-Xuan Long, and Yuh-Jen Cheng

ACS Appl. Nano Mater. 2021, doi.org/10.1021/acsnm.1c00469

2D transition metal dichalcogenide (TMDC) semiconductor is an emerging material with great potential in novel device applications. The epitaxy of 2D crystal is challenging due to the weak van der Waals interaction with substrate, often resulting in random nucleation orientation and grain boundaries. Crystal growth is critically decided from nucleation. This studies the mechanism of 2D material nucleation on a 3D material substrate and the conditions to obtain aligned nuclei. Nucleation involves reactions not only among precursors but also with substrate surface that are full of unbounded dangling bonds. Proper intermediate steps can lead to a final 2D crystal nucleation with orientation guided by substrate lattice. This work also studies the device applications of 2D materials. Charge carriers in atomic layer thickness are highly sensitive to external electric field modulation yet protected by dangling bond free surface. This study demonstrated a field effect phototransistor with very large photoresponsivity of 1.1 x 10⁷ A W⁻¹ at low illumination intensity.



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Narrative CV

Dr. Yu-Jung Lu is an Associate Research Fellow at the Research Center for Applied Sciences, Academia Sinica, and an Associate Professor in the Department of Physics at National Taiwan University. She earned her Ph.D. in Physics from National Tsing Hua University in 2013 and later joined Caltech as a postdoctoral researcher from 2015 to 2017. Dr. Lu is a renowned materials physicist specializing in active plasmonics, nanophotonics, and metasurfaces. Her recent research has focused on developing novel ceramic plasmonic materials based on conductive nitrides. She has systematically explored their plasmonic behavior and engineered nanostructures to enhance light-matter interactions at the nanoscale, leading to significant advancements in energy conversion, sensing, and quantum photonic applications. The relevant research is currently conducted in collaboration with TSMC.

She has chaired, co-chaired, and served on committees for international symposiums. She has delivered over 50 invited talks at international nanophotonics conferences. As a mentor, she has guided more than 65 graduate students, research assistants, and postdocs, cultivating the next generation of researchers. She currently serves as an Associate Editor for APL Quantum, Advanced Photonics, and the Journal of Lightwave Technology. Her contributions have earned her numerous honors, including the Career Development Award (2018), the Youth Optical Engineering Medal (2020), SPIE Senior Member (2023), MRS Early Career Distinguished Presenters (2024), Future Tech Award (2024), IEEE Senior Member (2025) and iSPN Young Researcher Award (2025). Her research is widely published in high-impact journals such as Nature Communications, Nano Letters, ACS Nano, ACS Photonics, Nature Nanotechnology, and Science.

Selective Publications

- Yen-Yu Wang[#], Xing-Hao Lee[#], Chiung-Han Chen, Linchyn Yuan, Yin-Ti Lai, Tzu-Yu Peng, Jia-Wern Chen, Chu-Chen Chueh^{*}, and Yu-Jung Lu^{*}, Plasmon-Enhanced Exciton Re-localization in Quasi-2D Perovskites for Low-Threshold Room-Temperature Plasmonic Lasing. *Science Advances* 11, eadu6824 (2025)
- Tzu-Yu Peng[#], Jason Lynch[#], Jing-Wei Yang, Yen-Yu Wang, Xing-Hao Lee, Ben R. Conran, Clifford McAleese, Deep Jariwala^{*}, and Yu-Jung Lu^{*}, Polariton-Mediated Ultrafast Nonlinear Energy Transfer in a van der Waals Superlattice. *ACS Nano* 19, 8152–8161 (2025)
- Wei-Ren Syong, Jui-Han Fu, Yu-Hsin Kuo, Yu-Cheng Chu, Mariam Hakami, Tzu-Yu Peng, Jason Lynch, Deep Jariwala, Vincent Tung, and Yu-Jung Lu^{*}, Enhanced Photogating Gain in Scalable MoS₂ Plasmonic Photodetectors via Resonant Plasmonic Metasurfaces. *ACS Nano* 18, 5446–5456 (2024)
- Jing-Wei Yang, Tzu-Yu Peng, Daniel D. A. Clarke, Frank Daniel Bello, Jia-Wern Chen, Hao-Chen Yeh, Wei-Ren Syong, Chi-Te Liang, Ortwin Hess^{*}, and Yu-Jung Lu^{*}, Nanoscale Gap-Plasmon-Enhanced Superconducting Photon Detectors at Single-Photon Level. *Nano Letters* 23, 11387–11394 (2023)
- Hao-Yu Lan, Yu-Hung Hsieh, Zong-Yi Chiao, Deep Jariwala, Min-Hsiung Shih, Ta-Jen Yen, Ortwin Hess, and Yu-Jung Lu^{*}, Gate-Tunable Plasmon-Enhanced Photodetection in a Monolayer MoS₂ Phototransistor with Ultrahigh Photoresponsivity. *Nano Letters* 21, 3083–3091 (2021).

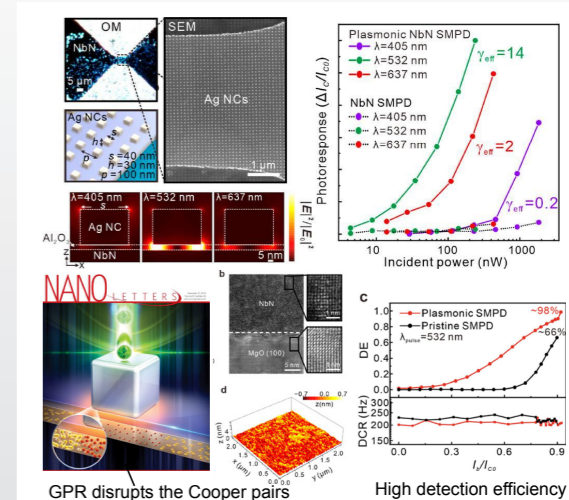
Research Focus

Nanoscale Gap-Plasmon-Enhanced Superconducting Photon Detectors at Single-Photon Level

Jing-Wei Yang, Tzu-Yu Peng, Daniel D. A. Clarke, Frank Daniel Bello, Jia-Wern Chen, Hao-Chen Yeh, Wei-Ren Syong, Chi-Te Liang, Ortwin Hess^{*}, and Yu-Jung Lu^{*}

Research Center for Applied Sciences, Academia Sinica
Nano Letters 23, 11387–11394 (2023)

With a growing demand for detecting light at the single-photon level in various fields, researchers are focused on optimizing the performance of superconducting single-photon detectors (SSPDs) by using multiple approaches. However, input light coupling for visible light has remained a challenge in the development of efficient SSPDs. To overcome these limitations, we developed a novel system that integrates NbN superconducting microwire photon detectors (SMPDs) with gap-plasmon resonators to improve the photon detection efficiency to 98% while preserving all detector performance features, such as polarization insensitivity. The optimized detection efficiency can be attributed to the gap plasmon mode that enhances the light-matter interaction, leading to the efficient disruption of Cooper pairs and the consequent breakdown of the superconducting state. These findings open new opportunities for ultrasensitive single-photon detection in areas like quantum information processing, quantum optics, imaging, and sensing at visible wavelengths.

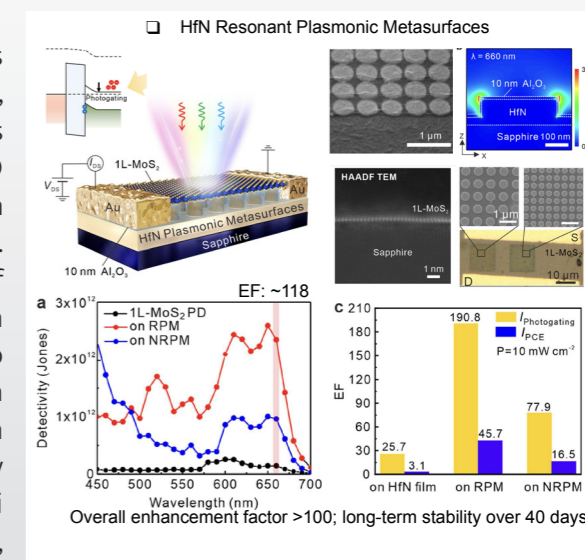


Enhancing Photogating Gain in Scalable MoS₂ Plasmonic Photodetectors via Resonant Plasmonic Metasurfaces

Wei-Ren Syong, Jui-Han Fu, Yu-Hsin Kuo, Yu-Cheng Chu, Mariam Hakami, Tzu-Yu Peng, Jason Lynch, Deep Jariwala, Vincent Tung, and Yu-Jung Lu^{*}

Research Center for Applied Sciences, Academia Sinica
ACS Nano 18, 5446–5456 (2024)

Absorption of photons in atomically thin materials has become a challenge in the realization of ultrathin, high-performance optoelectronics. While numerous schemes have been used to enhance absorption in 2D semiconductors, such enhanced device performance in scalable monolayer photodetectors remains unattained. Here, we demonstrate wafer-scale integration of monolayer single-crystal MoS₂ photodetectors with a nitride-based resonant plasmonic metasurface to achieve a high detectivity of 2.58×10^{12} Jones with a record-low dark current of 8 pA and long-term stability over 40 days. Considering the compatibility of 2D semiconductors and hafnium nitride with the Si CMOS process and their scalability across wafer sizes, our results facilitate the smooth incorporation of 2D semiconductor-based photodetectors into the fields of imaging, sensing, and optical communication applications.



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Narrative CV

Dr. Mu-Huai Fang is currently an Assistant Research Fellow at the Research Center for Applied Science, Academia Sinica. His research interests focus on material design for applications in solid-state batteries, short-wave infrared photodetectors, and infrared light-emitting diodes.

He developed a "Supersaturation-Driven Co-Precipitation" synthesis of halide solid-state electrolytes for solid-state batteries. This method has the potential to simultaneously achieve "chemical composition tuning" and "large-scale production", which not only focus on the academic research level but also consider stable mass production in the actual industrialization process. Besides, he collaborated with Dr. Shih-Yen Lin from the Research Center for Applied Science, Academia Sinica, to develop a graphene field-effect transistor based on quantum dot engineering. This device does not require cooling and can sense the 900–1700 nm infrared light at room temperature, with a detectivity of $\sim 10^{12} \text{ Hz}^{1/2} \text{ W}^{-1}$. He also collaborated with Prof. Man-kit Leung from the Department of Chemistry, National Taiwan University, to develop a sustainable quantum dot–vitrimers nanocomposite for light-emitting diodes. This composite can be recycled mechanically and chemically, separating cadmium elements by >99.9% without destroying the structure and optical properties of cadmium-containing quantum dots. The recycled polymers and quantum dots can be reused to achieve sustainable recycling.

His future research aims to strengthen the liquid synthesis method of halide solid-state electrolytes and prove that this method can achieve "chemical composition tuning" and "large-scale production". He will also improve the performance and chemical stability of quantum dot short-wave infrared photodetector through cross-disciplinary collaboration, and apply the above academic research to real life.

Selective Publications

- 1 Zhang, Y.-Y.; Lin, M.-Y.; Tsai, Y.-T.; Leung, M.-k.*; Fang, M.-H.* Sustainable Quantum Dot-Vitrimer Composites: A Synergy of Quantum Dots and Dynamic Covalent Bonds. *ChemSusChem* 2025, e202500464.
- 2 Bilo, J. A. V.; Chang, C.-K.; Chuang, Y.-C.; Fang, M.-H.* Coprecipitation Strategy for Halide-Based Solid-State Electrolytes and Atmospheric-Dependent In Situ Analysis. *ACS Appl. Mater. Interfaces* 2024, 16, 27394–27399.
- 3 Jhang, A.-T.; Tsai, P.-C.; Tsai, Y.-T.; Lin, S.-Y.*; Fang, M.-H.* Quantum-Dots-in-Double-Perovskite for High-Gain Short-Wave Infrared Photodetector. *Adv. Opt. Mater.* 2024, 12, 2401252.
- 4 Huang, P.-Y.; Zhang, Y.-Y.; Tsai, P.-C.; Chung, R.-J.; Tsai, Y.-T.; Leung, M.-k.; Lin, S.-Y.*; Fang, M.-H.* Interfacial Engineering of Quantum Dots–Metal-Organic Framework Composite toward Efficient Charge Transport for Short-Wave Infrared Photodetector. *Adv. Opt. Mater.* 2024, 12, 2302062.
- 5 Tsai, Y.-T.; Leśniewski, T.; Majewska, N.; Kamiński, M.; Barzowska, J.; Liu, E.-P.; Chen, W.-T.; Mahlik, S.*; Fang, M.-H.* Pressure/Temperature-Assisted Crystallographic Engineering—A Strategy for Developing the Infrared Phosphors. *Chem. Eng. J.* 2024, 490, 151596.

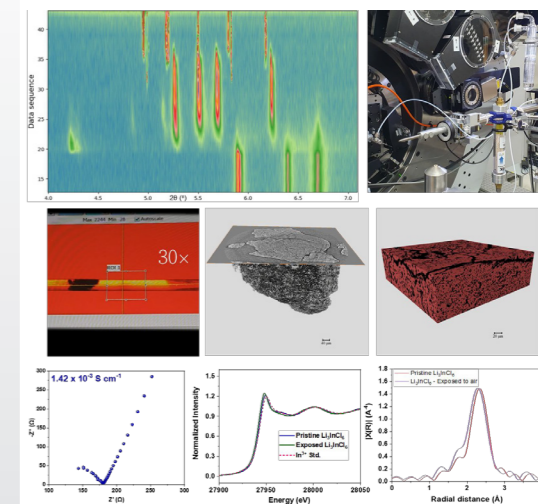
Research Focus

Pioneering Wet Chemical Synthesis Route for Halide Solid-State Electrolytes with In-situ Analyses

Josanelle Angela V. Bilo, Saddam Shaikh, and Mu-Huai Fang*

ACS Appl. Mater. Interfaces 2024, 16, 27394–27399.

Solid-state batteries have been pivotal in the development of energy-storage devices. In the continuous pursuit of an energy-efficient alternative to the energy-intensive mechanochemical process, we developed a modified solution-based synthesis strategy for synthesizing halide-based solid-state electrolytes (SSEs) that potentially warrant both structural control and commercial scalability. In this study, we utilize our method to synthesize Li_3InCl_6 SSE with high ionic conductivity of $1.42 \times 10^{-3} \text{ S cm}^{-1}$, comparable to traditionally prepared counterparts. We also use this method to first synthesize the pure phase Na_3InCl_6 SSE, which shows two orders of magnitude ($10^{-6} \text{ S cm}^{-1}$) higher than the ionic conductivity reported in the literature. Through the in-situ synchrotron X-ray diffraction technique, we unveil the stability mechanisms and rapid chemical reactions of these SSE under dry Ar, dry O_2 , and high-humidity atmosphere, which were not previously reported. These works addressed critical challenges in structural engineering and sustainable mass production and provided insights into chemical reactions under real-world conditions.



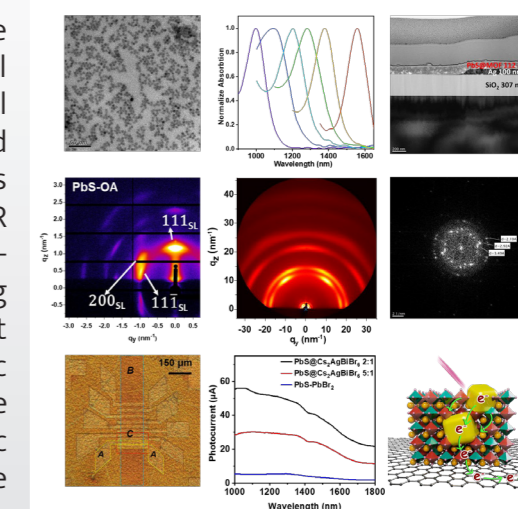
Cooling-Free Room-Temperature-Operable Short-Wave Infrared Photodetector

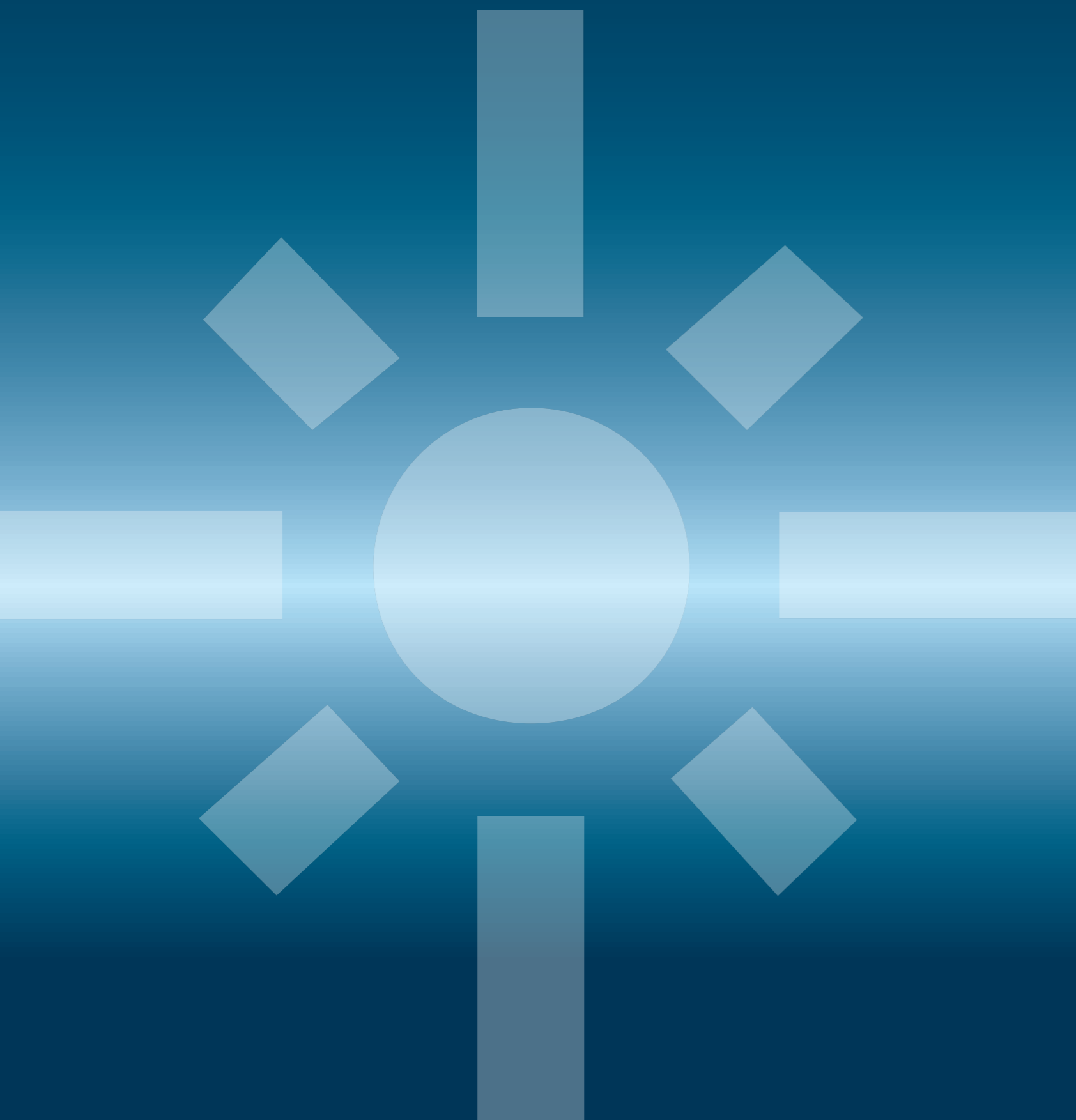
An-Ting Jhang, Po-Yu Huang, Po-Cheng Tsai, Shih-Yen Lin*, and Mu-Huai Fang*

Adv. Opt. Mater. 2024, 12, 2401252.

Adv. Opt. Mater. 2024, 12, 2302062.

Short-wave infrared (SWIR) photodetectors have attracted great attention in the fields of artificial intelligence, machine learning, food analysis, biological detection, etc. However, the cooling requirements and high production costs of compound semiconductors have hindered the practical application of these SWIR photodetectors. Here, we design a cooling-free room-temperature-operable SWIR photodetector by combining the SWIR quantum dots (QDs) and graphene field-effect transistors (FETs). The QDs in which the characteristic absorption peak can be tuned in 900–1700 nm. The composites that QDs hybrid with the metal-organic framework (MOF) and halide-based double perovskite (DP) are demonstrated. In QD@MOF, the responsivity and detectivity of the QD@MOF device are 301 A/W and $1.49 \times 10^{10} \text{ cm Hz}^{1/2} \text{ W}^{-1}$, respectively. The chemical stability is significantly enhanced compared to the non-hybrid one. By contrast, in the QD@DP, the responsivity and detectivity of QD@DP graphene FET are 15000 A/W and $1.31 \times 10^{12} \text{ cm Hz}^{1/2} \text{ W}^{-1}$, respectively, significantly promoted compared to the non-hybrid device. This research provides insight into developing energy-saving QD-based SWIR photodetectors.





Quantum Photonics

| Faculty Members |

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Narrative CV

Dr. Wen-Hao Chang is a Distinguished Research Fellow at Academia Sinica. He received his Ph.D. in Physics from National Central University (NCU) in 2001. Dr. Chang joined the Department of Electrophysics at National Yang Ming Chiao Tung University (NYCU) as an assistant professor in 2005 and became a full professor in 2012. In 2020, he joined the Research Center for Applied Sciences (RCAS) as the Acting Executive Officer of the Thematic Center for Quantum Photonics.

His research interests include light-matter interactions in low-dimensional semiconductor nanostructures, semiconductor quantum optics, and 2D layered materials. Dr. Chang has authored and co-authored more than 150 journal papers, with over 14,000 citations and an h-index of 53, according to Google Scholar (April 2025).

Dr. Chang has received several prestigious awards, including the Ta-Yu Wu Memorial Award (2010) and the Distinguished Research Award (2018) from the National Science and Technology Council (NSTC) of Taiwan. He also received the Academic Award (2018) from the Sun Yat-Sen Academic and Cultural Foundation and the Achievement in Asia Award (Robert T. Poe Prize, 2020) from the International Organization of Chinese Physicists and Astronomers (OCPA). In 2020, Dr. Chang was elected as a Fellow of the Physical Society of Taiwan.

Selective Publications

- 1 Chien-Ju Lee, Hsin-Che Pan, Fatemeh HadavandMirzaee, Li-Syuan Lu, Fei Cheng, Tsing-Hua Her, Chih-Kang Shih, Wen-Hao Chang*, Exciton-Polariton Valley Hall Effect in Monolayer Semiconductors on Plasmonic Metasurface, *ACS Photonics* 12, 1351–1358 (2025)
- 2 Bo-Han Lin, Yung-Chun Chao, I-Ta Hsieh, Chih-Piao Chuu, Chien-Ju Lee, Fu-Hsien Chu, Li-Syuan Lu, Wei-Ting Hsu, Chun-Wei Pao, Chih-Kang Shih*, Jung-Jung Su*, Wen-Hao Chang*, Remarkably Deep Moiré Potential for Intralayer Excitons in MoSe₂/MoS₂ Twisted Heterobilayers, *Nano Letters* 23, 1306–1312 (2023).
- 3 Junho Choi, Wei-Ting Hsu, Li-Syuan Lu, Liuyang Sun, Hui-Yu Cheng, Ming-Hao Lee, Jiamin Quan, Kha Tran, Chun-Yuan Wang, Matthew Staab, Kayleigh Jones, Takashi Taniguchi, Kenji Watanabe, Ming-Wen Chu, Shangjr Gwo, Suenne Kim, Chih-Kang Shih, Xiaoqin Li*, and Wen-Hao Chang*, Moiré potential impedes interlayer exciton diffusion in van der Waals heterostructures, *Science Advances* 6, eaba8866 (2020)
- 4 Li-Syuan Lu, Guan-Hao Chen, Hui-Yu Cheng, Chih-Piao Chuu, Kuan-Cheng Lu, Chia-Hao Chen, Ming-Yen Lu, Tzu-Hung Chuang, Der-Hsin Wei, Wei-Chen Chueh, Wen-Bin Jian, Ming-Yang Li, Yu-Ming Chang, Lain-Jong Li*, Wen-Hao Chang*, Layer-Dependent and In-Plane Anisotropic Properties of Low-Temperature Synthesized Few-Layer PdSe₂ Single Crystals, *ACS Nano* 14, 4963-4972 (2020)
- 5 Tse-An Chen, Chih-Piao Chuu, Chien-Chih Tseng, Chao-Kai Wen, H-S Philip Wong, Shuangyuan Pan, Rongtan Li, Tzu-Ang Chao, Wei-Chen Chueh, Yanfeng Zhang, Qiang Fu, Boris I Yakobson*, Wen-Hao Chang*, Lain-Jong Li*, Wafer-scale single-crystal hexagonal boron nitride monolayers on Cu (111), *Nature* 579, 219–223 (2020)

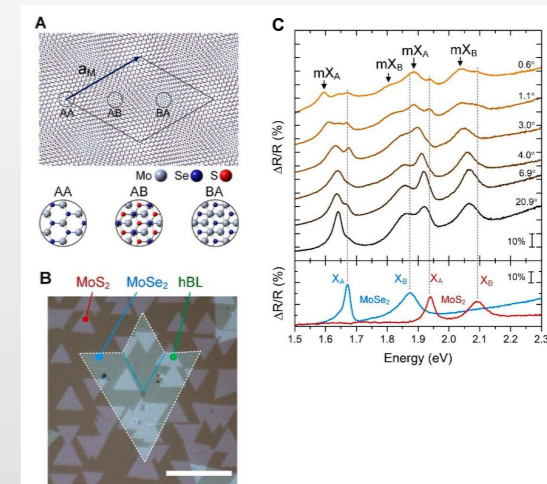
Research Focus

Remarkably Deep Moiré Potential for Intralayer Excitons in MoSe₂/MoS₂ Twisted Heterobilayers

Bo-Han Lin, Yung-Chun Chao, I-Ta Hsieh, Chih-Piao Chuu, Chien-Ju Lee, Fu-Hsien Chu, Li-Syuan Lu, Wei-Ting Hsu, Chun-Wei Pao, Chih-Kang Shih, Jung-Jung Su, and Wen-Hao Chang

Academia Sinica, Research Center for Applied Sciences
Department of Electrophysics, National Yang Ming Chiao Tung University
Nano Letters 2023, DOI:10.1021/acs.nanolett.2c04524

A moiré superlattice formed in twisted van der Waals bilayers can be a new tuning knob for creating new electronic and excitonic states in 2D materials. However, quantifying the moiré potential for excitons is nontrivial. By creating a large ensemble of MoSe₂/MoS₂ heterobilayers with a systematic variation of twist angles, we map out the minibands of interlayer and intralayer excitons as a function of twist angles, from which we determine the moiré potential for excitons. Surprisingly, the moiré potential depth for intralayer excitons is up to ~130 meV, comparable to that for interlayer excitons. The remarkably deep intralayer moiré potential is understood within the framework of structural reconstruction within the moiré unit cell.



A. Moiré pattern formed by MoSe₂ and MoS₂ heterobilayer. B. Optical microscope image of stacked heterobilayers grown by CVD. C. Reflectance spectra of intralayer moiré exciton states.

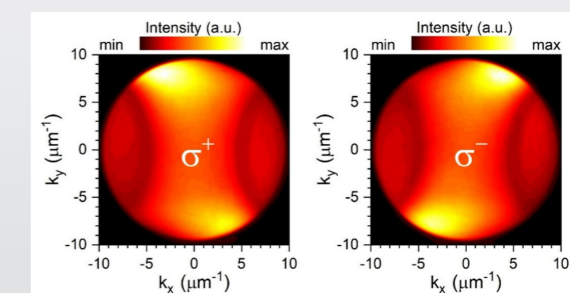
Exciton-Polariton Valley Hall Effect in Monolayer Semiconductors on Plasmonic Metasurface

Chien-Ju Lee, Hsin-Che Pan, Fatemeh HadavandMirzaee, Li-Syuan Lu, Fei Cheng, Tsing-Hua Her, Chih-Kang Shih and Wen-Hao Chang

Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan
Department of Electrophysics, National Yang Ming Chiao Tung University, Hsinchu 30010, Taiwan
ACS Photonics 2025, DOI: 10.1021/acsp Photonics.4c01554

Excitons in monolayer transition metal dichalcogenides (TMDs) possess the valley degree of freedom (DOF), which is regarded as a pseudospin (in addition to charge and spin DOF) and can be addressed optically by using polarized light. By placing monolayer TMDs on a plasmonic metasurface to enable strong coupling between excitons and surface plasmon polaritons (SPPs), we report here the observation of valley resolved polaritons in momentum space and a large separation in real space. The directional coupling of valley polaritons originated from the intrinsic spin-momentum locking associated with SPPs, resembling a photonic version of the valley Hall effect for polaritons.

The spatially routed valley polaritons provide a unique pathway for transporting and detecting the valley DOF through circular polarization of light for valleytronic applications.



Far-field separation of valley polariton emission in k-space. The k-space imaging of σ^+ (left) and σ^- (right) PL from WS₂ on nanogrooves.

Min-Hsiung Shih

Deputy Director and Research Fellow

Ph.D. Electrical Engineering, University of Southern California (USC), CA, U.S.A.(2006)

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Narrative CV

Dr. Min-Hsiung Shih is a research fellow specializing in nanophotonics and optoelectronic devices. Dr. Shih's research interests focus on photonic crystal lasers, two-dimensional material optical emitters and plasmonic devices. Dr. Shih obtained his PhD from the Department of Electrical Engineering, University of Southern California (USC).

Since joining RCAS, Dr. Shih's group has developed nanofabrication techniques for silicon and III-V semiconductor devices, and investigated photonic crystal microcavity lasers and nano-plasmonic emitters with III-V quantum dots, quantum wells, and 2-D materials to achieve different functionalities from UV to IR wavelength regimes.

Dr. Shih also serve as the organizing committee chair for Optics & Photonics Taiwan, the International Conference (OPTIC) 2024, the 8th International Conference on Surface Plasmon Photonics (SPP8) in 2017, and the 9th International Conference on Nanophotonics (ICNP) in 2016.

Selective Publications

- 1 Z-Z Chen, C-Y Chang, Y-T Tsai, P-C Tsai, S-Y Lin, M-H Shih*, "Sustained robust exciton emission in suspended monolayer WSe₂ within the low carrier density regime for quantum emitter applications", *APL Materials*, 12, 031125 (2024).
- 2 J. S. Konthoujam, Y-S Lin, Z-Z Chen, C-Y Chang, Y-W Zhang, S-Y Lin, D-H Lien, H-C Kuo, M-H Shih*, 2024, "Electrical control of electroluminescence in 2D semiconductor light emitting device through synchronous injection of electrons and holes", *Advanced Materials Technologies*, 2401743 (2024).
- 3 Y-H Chang, Y-S Lin, J. S. Konthoujam, H-T Lin, C-Y Chang, Z-Z Chen, Y-W Zhang, S-Y Lin, H-C Kuo, M-H Shih*, "AC-driven multicolor electroluminescence from a hybrid WSe₂ monolayer/AlGaInP quantum well light-emitting device", *Nanoscale*, 15(3), 1347 (2023).
- 4 H-T Lin, C-Y Chang, C-L Yu, A. B. Lee, S-Y Gu, L-S Lu, Y-W Zhang, S-Y Lin, W-H Chang, S-W Chang, M-H Shih*, "Boost Lasing Performances of 2D Semiconductor in a Hybrid Tungsten Diselenide Monolayer/Cadmium Selenide Quantum Dots Microcavity Laser", *Advanced Optical Materials*, 10, 2200799 (2022).
- 5 H-T Lin, Y-Y Hsu, P-J Cheng, W-T Wang, S-W Chang, M-H Shih*, "In situ tunable circular dichroism of flexible chiral metasurfaces composed of plasmonic nanorod trimers", *Nanoscale Advances*, 4(11), 2428 (2022).

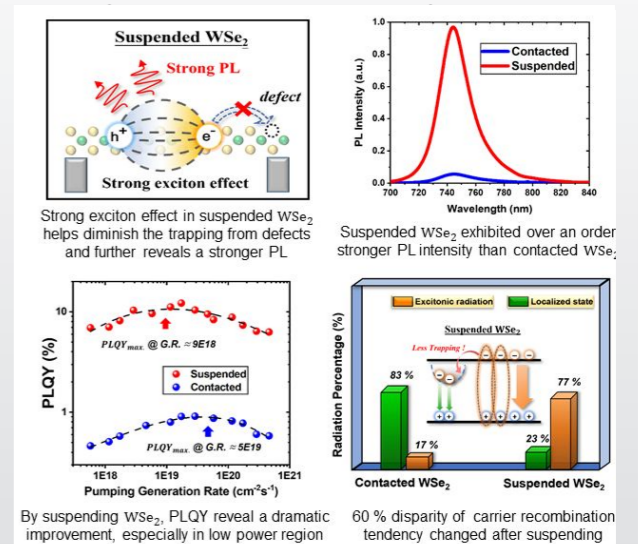
Research Focus

Sustained robust exciton emission in suspended monolayer WSe₂ within the low carrier density regime for quantum emitter applications

Zheng-Zhe Chen, Chiao-Yun Chang, Ya-Ting Tsai, Po-Cheng Tsai, Shih-Yen Lin, and Min-Hsiung Shih*

Research Center for Applied Sciences (RCAS), Academic Sinica
APL Materials (2024), DOI: 10.1063/5.0198072

In order to reduce the effect of carrier trapping and sustain a strong photoluminescence (PL) emission under low power pumping conditions, we investigated the influence of "suspending" a monolayer of tungsten diselenide (WSe₂). Not only PL intensity but also the photoluminescence quantum yield (PLQY) has exhibited a huge, order-scale enhancement through suspending. With its strong excitonic effect, suspended WSe₂ offers a solution to reduce carrier trapping. Moreover, in the low-power range, where SRH recombination dominates, suspended WSe₂ exhibited a remarkably higher percentage of excitonic radiation compared to contacted WSe₂. Herein, we quantitatively demonstrate the significance of the suspended WSe₂ monolayer in a low carrier density region, highlighting its potential for developing compact, low-power quantum emitters in the future.

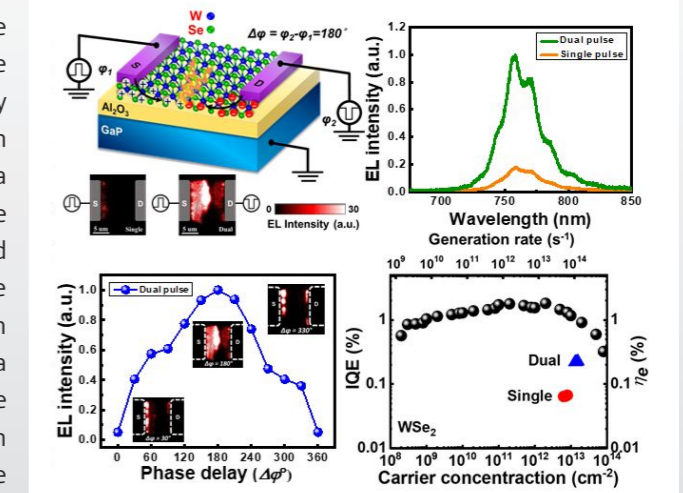


Electrical Control of Electroluminescence in 2D Semiconductor Light Emitting Device Through Synchronous Injection of Electrons and Holes

Konthoujam James Singh, Yen-Shou Lin, Zheng-Zhe Chen, Chiao-Yun Chang, Yu-Wei Zhang, Shih-Yen Lin, Der-Hsien Lien, Hao-Chung Kuo, and Min-Hsiung Shih*

Research Center for Applied Sciences (RCAS), Academic Sinica
Adv. Mater. Technol. (2025), <https://doi.org/10.1002/admt.202401743>

This study presents a method to enhance charge carrier injection in transition metal dichalcogenide (TMDC)-based light-emitting devices driven by alternating current (AC), utilizing a dual-pulse injection strategy. The dual-pulse configuration results in a significant enhancement of electroluminescence (EL) intensity, achieving approximately a sixfold increase compared to single-pulse operation. Phase delay-dependent EL behavior was observed, with the maximum integrated EL intensity occurring at a 180° phase delay. Furthermore, the dual-pulse device demonstrated an approximate 3.5-fold improvement in external EL efficiency (η_e) compared to the single-pulse configuration. These findings underscore the potential of controlled carrier recombination in TMDC-based LEDs to advance their performance for applications in display technologies, solid-state lighting, optical communication, and electrically tunable light sources.



Chao-Cheng Kaun

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Narrative CV

Chao-Cheng Kaun is a Research Fellow specializing in computational physics and materials. His research interests focus on computational modeling of nanoelectronics and emerging materials. He obtained his Ph.D. in Physics from McGill University and has been a postdoc at the Chemistry Department, Northwestern University.

He has been developing computational models to understand the contact resistance between two-dimensional materials and metal electrodes, the noncollinear interlayer exchange coupling in magnetic trilayers, the polymer-protected perovskite quantum dot films, the polymer-promoted superionic electrolyte and the plasmonic properties of complex transition metal nitrides, impacting nanoelectronics, spintronics, quasi-solid-state batteries, and photonics. He has awarded Future Tech Award on 2021 and 2022.

He guides six graduate students, fostering new talents in computational nanoelectronics and emerging materials. He also serves as Editors for Scientific Reports and Chinese Journal of Physics, and contribute to Journal Committee of Academia Sinica.

His future research aims to bridge the gap between theory and experiment in nanoelectronics and emerging materials, through enhanced interdisciplinary collaboration.

Selective Publications

- 1 C.-J. Chang, P.-Z. Huang, K.-B. Lin, T.-H. Chang, W.-C. Tu, C.-C. Kaun*, and S.-Y. Lin*, "High-performance transistors with polycrystalline 2D material channels: The influence of gold electrode crystallinity and the layer number of molybdenum disulfide channels", *Applied Surface Science* 693, 162795 (2025).
- 2 V. R. Dharmaraj, A. Sarkar, J.-Y. Huang, S.-C. Huang, C.-L. Kuo*, C.-C. Wu, W.-S. Chang, H.-C. Chen, Y.-P. Lin, C.-C. Kaun*, R.-J. Chung*, and R.-S. Liu*, "Superionic Quasi-Solid-State Electrolyte for Rechargeable Mg-O2 Batteries", *ACS Materials Letters* 7, 1440 (2025).
- 3 L. T. Ngo, W.-T. Huang, H. Verma, Y.-H. Lin, L.-W. Liang, C.-T. Fang, J.-C. Chang, W.-C. Chu, C. Su*, C.-C. Kaun*, and R.-S. Liu*, "Hybrid-Protected Perovskite Quantum Dot Films with Ultra-High Efficiency and Stability for LED Backlighting", *ACS Applied Materials & Interfaces* 16, 66262 (2024).
- 4 G.-W. Peng, H.-C. Wang, Y.-J. Zhong, C.-C. Kaun*, and C.-H. Chang*, "Driving noncollinear interlayer exchange coupling intrinsically in magnetic trilayers", *Materials Today Physics* 48, 101544 (2024).
- 5 M. U. Javed, J.-W. Yang, S. Kumari, M. Mustaqeem, T.-Y. Peng, L. C. Yang, Y.-J. Lu*, and C.-C. Kaun*, "Tailoring the plasmonic properties of complex transition metal nitrides: A theoretical and experimental approach", *Applied Surface Science* 641, 158486 (2023).

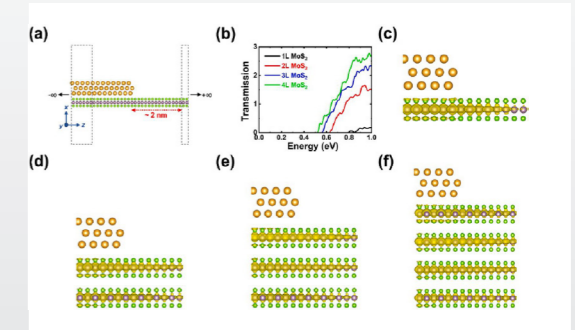
Research Focus

High-Performance Transistors with Polycrystalline 2D Material Channels: The Influence of Gold Electrode Crystallinity and the Layer Number of Molybdenum Disulfide Channels

C.-J. Chang, P.-Z. Huang, K.-B. Lin, T.-H. Chang, W.-C. Tu, C.-C. Kaun*, and S.-Y. Lin*

Applied Surface Science, 2025, DOI:10.1016/j.apsusc.2025.162795

Since two Au electrodes of MoS₂ transistors are well-separated in the experiment, only one Au (111)/MoS₂ and MoS₂ interface is considered in our two-probe model (a). The transmission spectra of Au/MoS₂ junctions at V_{DS} = 1.0 V show that the quad-layer Au/MoS₂ junction has the largest current and the smallest threshold voltage (b), aligning with our experiment data. The charge densities of Au/MoS₂ junctions at V_{DS} = 1.0 V show that the number of effective conduction channel increases as the number of MoS₂ layer increases, however, in a nonlinear fashion (c-f). Whereas the contact resistance is inversely proportional to the effective conduction channel number, it depends on the allocated electron density under the bias voltage.



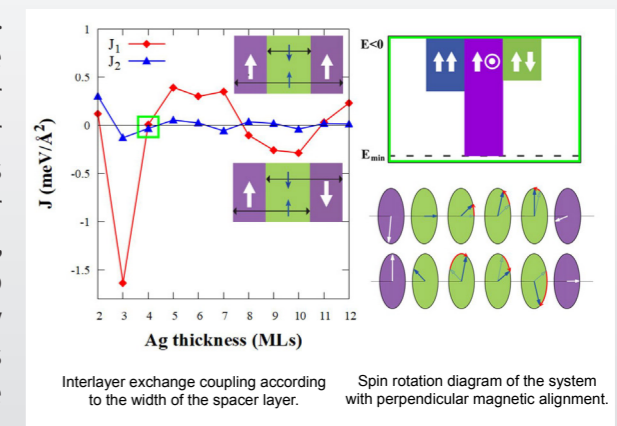
(a) Structure of the two-probe model. (b) Non-equilibrium transmission spectra and (c-f) charge distributions of Au/MoS₂ junctions at V_{DS} = 1.0 V with mono-, bi-, tri-, and quad-layer MoS₂, respectively.

Driving noncollinear interlayer exchange coupling intrinsically in magnetic trilayers

G.-W. Peng, H.-C. Wang, Y.-J. Zhong, C.-C. Kaun*, and C.-H. Chang*

Materials Today Physics, 2024, DOI:10.1016/j.mtphys.2024.101544

Recent experiments demonstrate that manipulating the width or the nature of conducting spacer induces noncollinear magnetic alignment between the side magnetic layers. Our theoretical analysis reveals that altering the width of spacer significantly affects the interlayer exchange coupling (IEC), resulting in noncollinear alignment. Through analytic and first-principles methods, our study on the Fe/Ag/Fe trilayer shows that at a specific width of the Ag spacer, the magnetic moments of side layers tend to be perpendicular. This alignment is mediated by Ag quantum well states, exhibiting spin spirals across the trilayer. Our results reveal that the noncollinear IEC offers a degree of freedom to control magnetic devices and boot spintronic technology with improved transport capabilities.



Interlayer exchange coupling according to the width of the spacer layer. Spin rotation diagram of the system with perpendicular magnetic alignment.

Shih-Yen Lin

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Narrative CV

Dr. Shih-Yen Lin obtained his PhD degree in Electrical Engineering, National Taiwan University at 2001. His current research focuses on the growth of 2D materials and their applications in electrical and optical devices.

Dr. Lin has collaborated with TSMC on the electronic device application of 2D materials for over 10 years. He has published over 150 journal papers and owns 15 US patents.

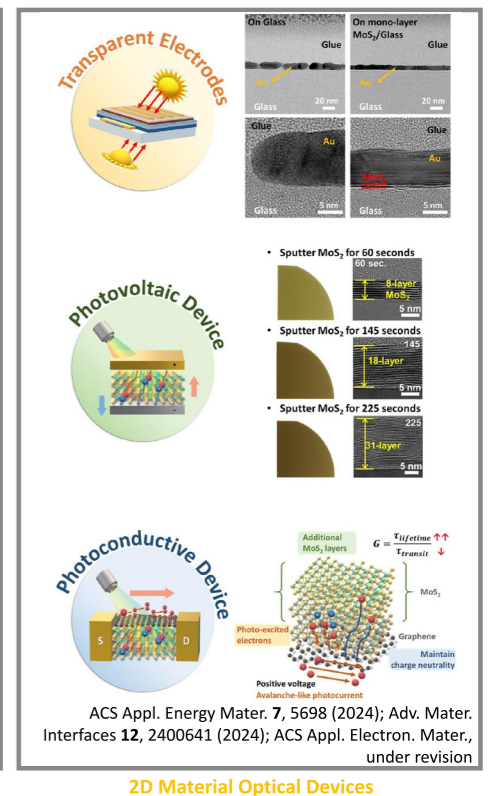
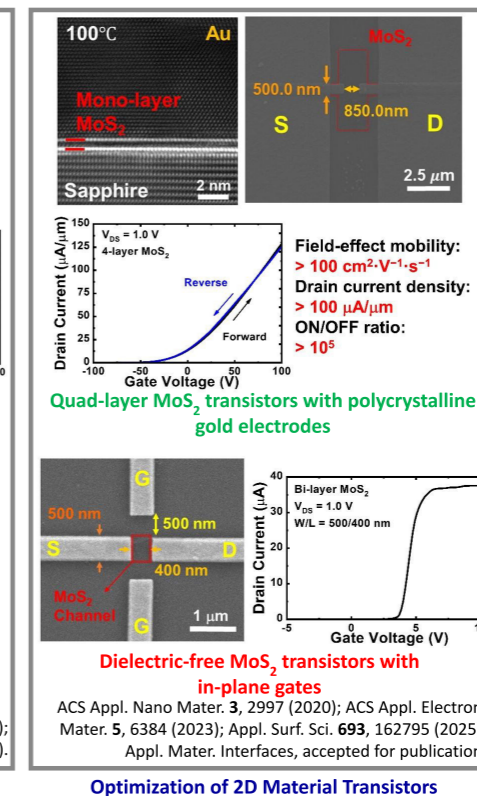
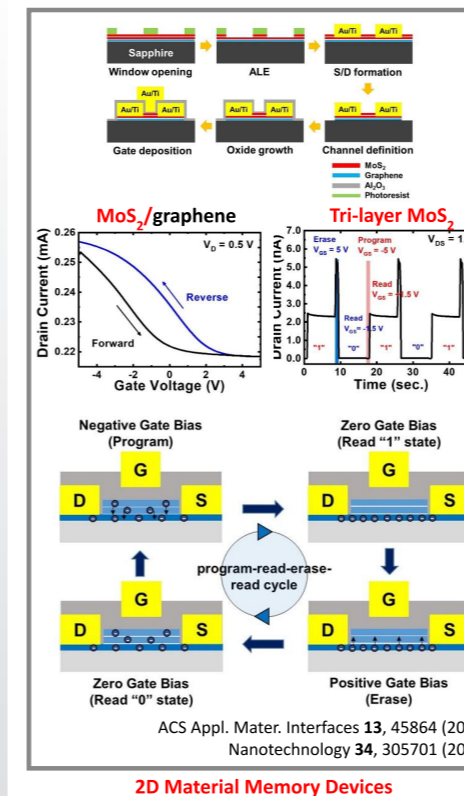
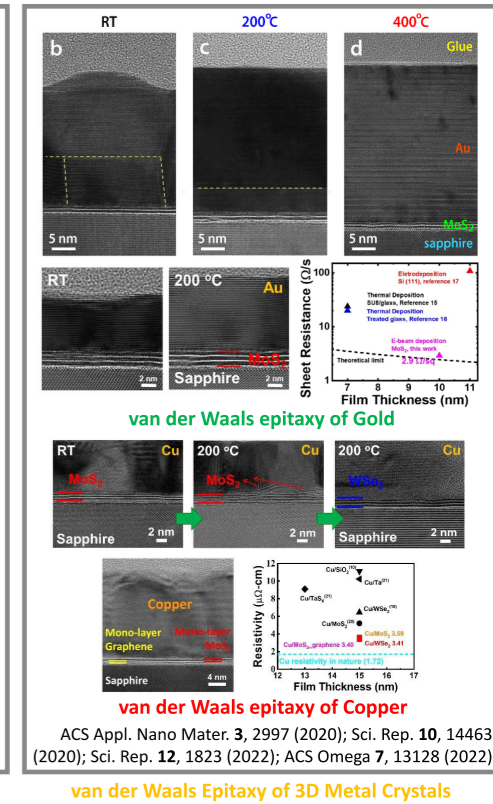
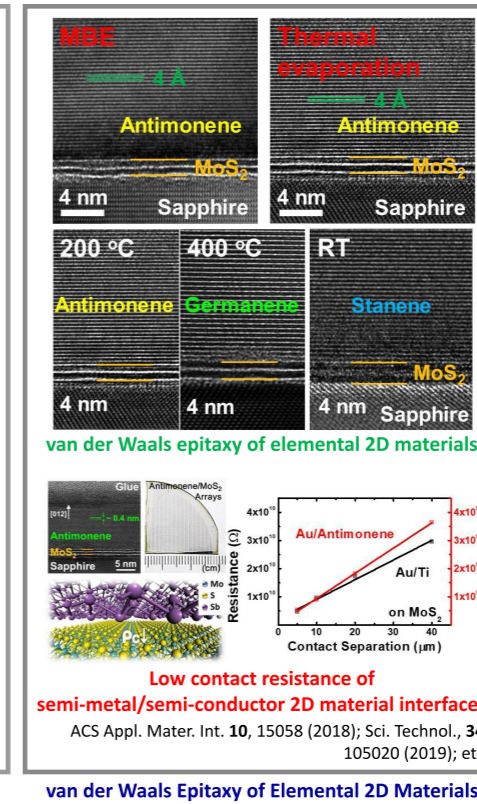
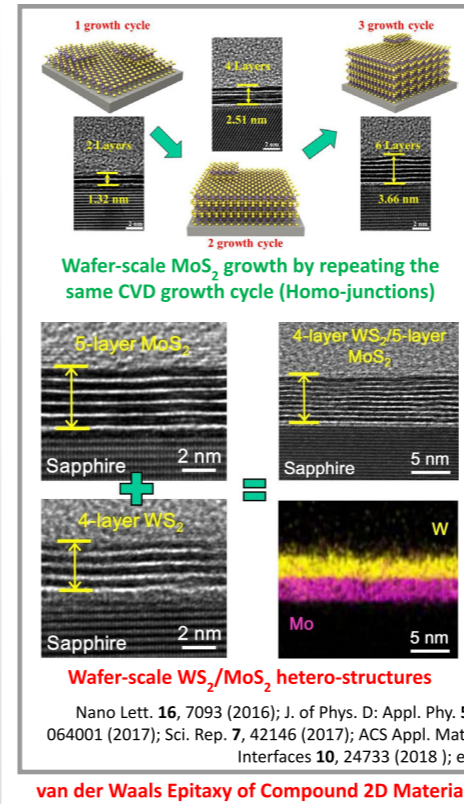
Dr. Lin is now adjunct professors at NTU, NCKU, NDHU, NCNU and NTTU. He has supervised over 50 master students and 11 PhD students from these universities. Besides his personal awards, his students have obtained over 30 awards with time. Dr. Lin has led a research team and earned Future Tech Award 2024.

Dr. Lin's research direction will still be focused on application-driven researches in the future.

Selective Publications

- 1 **Shih-Yen Lin***, Wei-Hsun Lin, Chi-Che Tseng, Kuang-Ping Chao, and Shu-Cheng Mai, "Voltage-Tunable Two-Color Quantum-Dot Infrared Photodetectors", *Appl. Phys. Lett.*, vol. 95, no. 12, pp. 123504, September 2009.
- 2 Wei-Hsun Lin, Kai-Wei Wang, Shu-Wei Chang, Min-Hsiung Shih and **Shih-Yen Lin***, "Type-II GaSb/GaAs Coupled Quantum Rings: Room-Temperature Luminescence Enhancement and Recombination Lifetime Elongation for Device Applications", *Appl. Phys. Lett.* vol. 101, no. 3, pp. 031906, July 2012.
- 3 Meng-Yu Lin, Wei-Ching Guo, Meng-Hsun Wu, Pro-Yao Wang, Te-Huan Liu, Chun-Wei Pao, Chien-Cheng Chang, Si-Chen Lee and **Shih-Yen Lin***, "Low-temperature grown graphene films by using molecular beam epitaxy", *Appl. Phys. Lett.* vol. 101, no. 22, pp. 221911, November 2012.
- 4 Chong-Rong Wu, Xiang-Rui Chang, Tung-Wei Chu, Hsuan-An Chen, Chao-Hsin Wu, and **Shih-Yen Lin***, "Establishment of 2D Crystal Heterostructures by Sulfurization of Sequential Transition Metal Depositions: Preparation, Characterization, and Selective Growth", *Nano Lett.*, vol. 16, no. 11, pp. 7093-7097, November 2016.
- 5 Hsuan-An Chen, Hsu Sun, Chong-Rong Wu, Yu-Xuan Wang, Po-Hsiang Lee, Chun-Wei Pao, and **Shih-Yen Lin***, "Single-Crystal Antimonene Films Prepared by Molecular Beam Epitaxy: Selective Growth and Contact Resistance Reduction of the 2D Material Heterostructure", *ACS Appl. Mater. Interfaces*, vol. 10, no. 17, pp. 15058-15064, May 2018.

Research Focus



Shu-Wei Chang

Associate Research Fellow

Ph.D., University of Illinois at Urbana-Champaign (2006)

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Narrative CV

Shu-Wei Chang is an associate research fellow specializing in theories, designs, and applications of photonics. His research interests focus on chiral modes of photonic-crystal cavities at the exceptional point and bound-state-in-continuum in integrated photonics or photonic crystals, mostly for lasers with novel features. In addition to these topics which are mainly aimed at device levels, he is also looking into integrated photonic circuits for both classical and quantum communication that are more system oriented. Dr. Chang obtained his PhD from University of Illinois at Urbana-Champaign and has contributed to multiple research projects within RCAS and with academic or industrial organizations in Taiwan.

Dr. Chang used to develop a source-based frequency-domain method in the form of generalized eigenvalue problems for modeling generic laser cavities. This method can directly and unambiguously provide the threshold gain, modal volume, and confinement factor of the cavity, which are not well-defined through conventional numerical integration of modal distribution.

Dr. Shu-Wei Chang has collaborated with Dr. Min-Hsiung Shih and Shih-Yen Lin in RCAS on novel semiconductor lasers and electronic devices based on two-dimensional materials. With the former, he has developed chiral lasers at chip level. He was also involved in a joint-development project of TSMC on silicon photonics through National Yang-Ming Chiao-tung University. As a mentor, he has guided 2 masters, 2 PhDs, and 2 post Docs, fostering new talent in photonics.

Dr. Chang's future research aims to develop active and passive components in integrated photonic systems for quantum applications. Also, more attention will be put on the practicality of these applications from system point of views. He tends to find a balance between the novelty and feasibility of academic discoveries, trying to address the pivotal problem of generic systems or turn useful results into real-world products.

Selective Publications

- 1 G. R. Lin, W. C. Miao, P. L. Chen, P. W. Ho, Y. H. Hong, S. W. Chang, C. H. Wu, and H. C. Kuo, "Nearly collimated 940-nm buried-photonic-crystal surface-emitting laser for lens-free discrete multitone transmission at 22 Gbit/s over 20 m," *Photon. Res.* 13, 649-660 (2025) [DOI: <https://doi.org/10.1364/PRJ.531738>]
- 2 J. T. Tsai, C. T. Hsieh, C. C. Cheng, M. H. Shih, and S. W. Chang, "Circularly-polarized laser equivalent to two phase-shifted linearly-polarized sources," *Laser Photon Rev.* 18, 2300574 (2024). [DOI: <https://doi.org/10.1002/lpor.202300574>]
- 3 C. C. Cheng, P. J. Cheng, T. W. Huang, W. T. Wang, J. T. Tsai, M. H. Shih, and S. W. Chang, "Realization of spinning mode with maximum chirality in photonic-crystal defect cavity at exceptional point," *Optica* 10, 732-739 (2023). [DOI: <https://doi.org/10.1364/OPTICA.481825>]
- 4 W. C. Tang, Y. T. Liu, C. H. Yeh, C. H. Lu, C. H. Tu, Y. L. Lin, Y. C. Lin, T. L. Hsu, L. Gao, S. W. Chang, P. Chen, and B. C. Chen*, "Optogenetic manipulation of cell migration with high spatiotemporal resolution using lattice lightsheet microscopy," *Commun. Biol.*, 5 879 (2022) [DOI: [10.1038/s42003-022-03835-6](https://doi.org/10.1038/s42003-022-03835-6)]
- 5 H. T. Lin, C. Y. Chang, C. L. Yu, A. B. Lee, S. Y. Gu, L. S. Lu, Y. W. Zhang, S. Y. Lin, W. H. Chang, S. W. Chang, and M. H. Shih*, "Boost lasing performances of 2D semiconductor in a hybrid tungsten diselenide monolayer/cadmium selenide quantum dots microcavity laser," *Adv. Optical Mater.* 2200799 (2022) [DOI: [10.1002/adom.202200799](https://doi.org/10.1002/adom.202200799)]

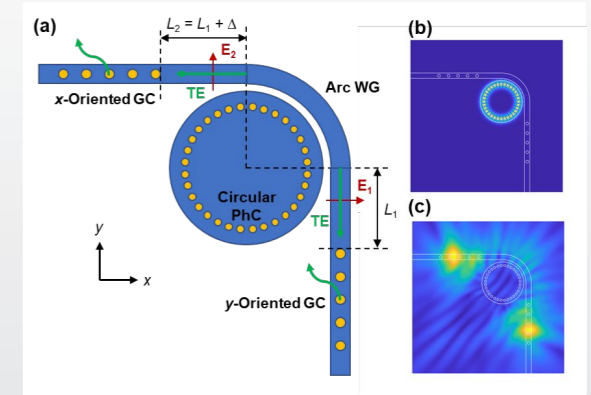
Research Focus

Circularly-Polarized Laser Equivalent to Two Phase-Shifted Linearly-Polarized Sources

Jui-Tse Tsai, Chi-Ti Hsieh, Chao-Chieh Cheng, Min-Hsiung Shih, Shu-Wei Chang

Academic Sinica, Research Center for Applied Sciences

The CP light is conventionally generated by passing the linearly-polarized (LP) one through quarter wave plates which are too thick for packed integrations. In this work, the in-plane submicron phase shifter substitutes the quarter-wave plate in the creation of CP light. After the lasing field of a holed microdisk is coupled into the nearby waveguide and phase shifter, it is guided into two grating couplers that output orthogonally LP waves vertically. The two LP waves are phase-shifted by $\pi/2$ and combine into the coherent CP radiation in the far-field zone. Experimentally, the fabricated devices exhibit a degree of circular polarization as high as 74%. This device scheme is simple and effective in that it relies on no extrinsic materials, large-area auxiliary structures, or specialized operation conditions critical for CP radiation.



The schematic of a microdisk coupled to two linearly-polarized scatters. The output phases of two scattered fields are phase-shifted by segments with different lengths.

The field profiles on the planes inside and on the top of microdisk.

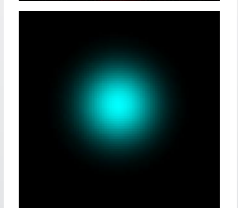
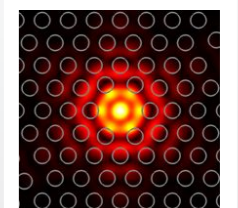
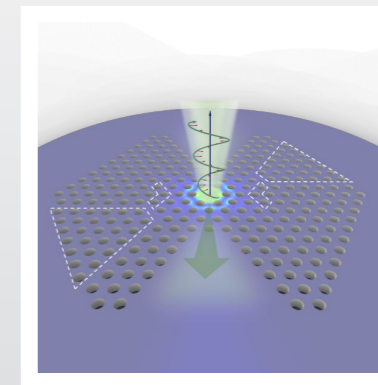
Spinning Mode with Maximum Chirality in Photonic Crystal Defect Cavity at Exceptional Point

Chao-Chieh Cheng, Pi-Ju Cheng, Tzu-Wei Huang, Wei-Ting Wang, Jui-Tse Tsai, Min-Hsiung Shih, and Shu-Wei Chang

Academic Sinica, Research Center for Applied Sciences

Optical modes spinning with maximum chirality in cavities at chip level are essential for quantum and biomedical applications. The coalescent chiral mode at the exceptional point (EP) due to non-hermicity is the one in demand. In this work, we realize circularly-polarized-like lasing modes with maximum chirality at the EP of photonic-crystal one-hole cavities. We adopt the in-plane tunneling loss that is well controlled with the layer number of air holes in photonic-crystal slab. By removing and relocating holes in blocks, we systematically elevate the chirality of radiation field. The collective variations of holes render the EP robust against the uncertainty in fabrications. Without auxiliary non-Hermitian and chiral structures, our works promote coherent chiral light sources at chip level.

The schematic of non-Hermitian but chiral H1 cavity. Some of air holes are collectively removed or relocated (enclosed in white dashed lines) when approaching the EP.



The near-field and far-field patterns of modes at the chiral exceptional point.

Chi Chen

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Narrative CV

Dr. Chi Chen is dedicated to integrating atomic force microscopy (AFM) and scanning tunneling microscopy (STM) with optical techniques, utilizing near-field optics (SNOM) to resolve spectroscopic properties of various materials at the nanoscale.

Dr. Chen's work spans the development of near-field optical instruments, fundamental principles of near-field optics, and spectroscopic imaging/analysis of both hard and soft matter materials. Throughout her career, she has successfully implemented all near-field optical modalities-including a-SNOM, s-SNOM, STM-EL, and TERS -achieving optical resolutions and image quality ranked among the highest reported in the literature.

Since joining RCAS in 2013, Dr. Chen's laboratory has succeeded in establishing three highly stable near-field optical systems operating in ambient air, nitrogen glove boxes, and aqueous environments. These systems enable advanced near-field fluorescence/absorption spectroscopy and imaging, serving as powerful tools for studying excitonic properties of 2D materials and nanoscale spectroscopic investigations.

Recently, Dr. Chen has further incorporated electrical circuitry into AFM/SNOM platforms. Beyond measuring microscopic conductive properties of materials, her work focuses on electroluminescence and nanoscale photocurrent imaging, aiming to extend near-field optical-electrical integration for studying microscale optoelectronic conversion in low-dimensional materials.

Selective Publications

- 1 P.-W. Tang, S.-Y. Shiau, H.-C. Chou, J.-R. Yu, X.-Q. Zhang, C.-T. Sung, Y.-H. Lee*, and C. Chen* Visualization of bandgap evolution and bilayer coupling in $W_xMo_{1-x}S_2$ alloy by near-field broadband absorption microscopy. *ACS Nano*, **16**, 5, 7503–7511(2022)
- 2 H.-C. Chou, X.-Q. Zhang, S.-Y. Shiau, C.-H. Chien, P.-W. Tang, C.-T. Sung, Y.-C. Chang, Y.-H. Lee*, and C. C. Chen* Near-Field Spectroscopic Imaging of Exciton Quenching at the Atomically Sharp MoS_2/WS_2 Lateral Heterojunction. *Nanoscale* **14**, 6323 – 6330 (2022)
- 3 S. Luo, P. P. Lin, L.-Y. Nieh, G.-B. Liao, P.-W. Tang, C. Chen, and J. C. Liao* A cell-free self-replenishing CO_2 fixing system. *Nature Catalysis* **5**, 154–162 (2022)
- 4 H.-C. Chou, C.-K. Fang, P.-Y. Chung, J.-R. Yu, W.-S. Liao, S.-H. Chen, P. Chen, I.-S. Hwang, J.-T. Chen*, and C. Chen* Structural and Optical Identification of Planar Side-Chains Stacking P3HT Nanowires. *Macromolecules* **54**, 23, 10750–10757 (2021)
- 5 J.-R. Yu, H.-C. Chou, C.-W. Yang, W.-S. Liao, I.-S. Hwang, and Chi. Chen* A Horizontal-type Scanning Near-Field Optical Microscope with Torsional Mode Operation Toward High-Resolution and Non-destructive Imaging of Soft Materials. *Rev. Sci. Instrum.* **91**, 073703 (2020)

Research Focus

Scanning Near-Field Optical Microscopy in Various Environments for Nanoscale Molecular and 2D Material Assemblies

J.-R. Yu, S.-Y. Weng, S.-M. Lai, H.-C. Chou, P.-W. Tang, and Chi Chen*

P.-W. Tang *et al.*, *ACS Nano*, **16**, 5, 7503 (2022)

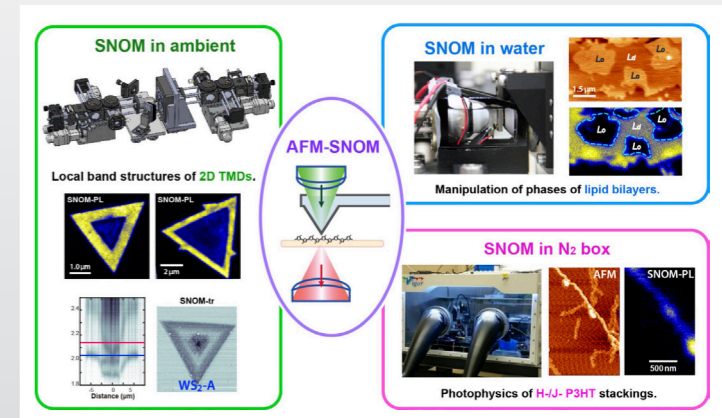
H.-C. Chou *et al.*, *Macromolecules* **54**, 10750 (2021)

H.-C. Chou *et al.*, *Nanoscale* **14**, 6323 (2022)

J.-R. Yu *et al.*, *Rev. Sci. Instrum.* **91**, 073703(2020)

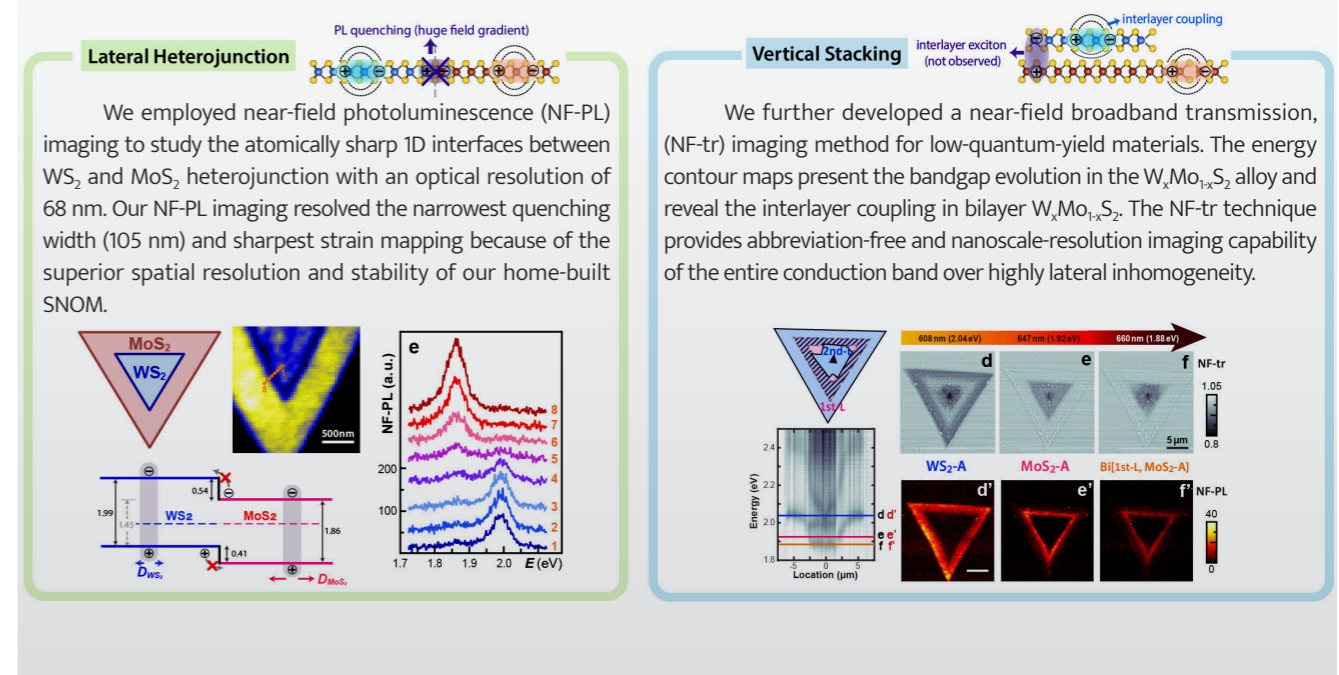
The primary tool developed in my lab is the home-built AFM-based scanning near-field optical microscopy (SNOM) with spectroscopic readout. Three horizontal-type aperture SNOM instruments in different environments have been successfully constructed and operated to investigate the stacking of 2D materials as well as soft molecular assemblies including polymer nanowires and lipid bilayers.

The SNOM instruments are highly-stable for reproducible topographic scan and optical signaling, which realized high-quality near-field absorption and PL microscopy. We also achieved small amplitude (< 2 nm) tapping mode in glove box and in water to avoid sample damages and to regulate tip-sample interaction. In addition, we have the full control of the near-field tip, including its design, fabrication, and operation.



Revealing the Local Band Structures of WS_2/MoS_2 Heterojunction $W_xMo_{1-x}S_2$ Alloy by Near-Field Optical Imaging

P.-W. Tang, H.-C. Chou, S.-Y. Shiau, J.-R. Yu, X.-Q. Zhang, Y.-H. Lee*, and Chi Chen* (RCAS & NTHU)



Yu-Chen Chen

Assistant Research Fellow

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Narrative CV

Yu-Chen Chen, an assistant research fellow specializing in single spin defects for quantum applications. His research interests focus on engineering and characterising single photon emitters in wide bandgap materials, such as diamond and SiC. He obtained his Master degree from NTHU in Taiwan. Then, He obtained his Ph. D degree from University of Oxford in UK.

He developed a method using femtosecond pulsed laser to generate single nitrogen-vacancy defects in diamond. This method is demonstrated to be able to generate minimum damage to the host materials. As a results, laser-generated nitrogen-vacancy centres' spin and optical coherence properties can reach its physics limit. Furthermore, he also demonstrated that this laser fabrication method can be used to generate silicon vacancy in silicon carbide.

His future research focuses on two topics. First, finding out new spin defects in the materials that are compatible with well-established, industrial-scale nano- or microfabrication of photonic structures, such as silica and SiN. Thus, the single spin defects can be coupled to on-chip photonic device to realise scalable quantum devices. His second research focus is engineering single spin defect with telecom band emission. This type of defects has great potential on the applications of quantum communication.

Selective Publications

- 1 Y. C. Chen, S. C. Lin, J. P. Chou, Y. C. Tsai, C. T. Huang, C. J. Lee, W. H. Chang. Stable Single Photon Emitters with Large Debye–Waller Factor in Silica. ACS Photonics 12, 3, 1461–1469 (2025).
- 2 N. Chejanovsky, A. Mukherjee*, J. Geng, Y. C. Chen, Y. Kim, A. Denisenko. A. Finkler, T. Taniguchi, K. Watanabe, D. B. R. Dasari*. P. Auburger, A. Gali, J. H. Smet, and J. Wrachtrup. Single-spin resonance in a van der Waals embedded paramagnetic defect. Nature Materials 20, 1079-1084 (2021).
- 3 M. Niethammer*, M. Widmann, T. Rendler, N. Morioka, Y. C. Chen, R. Stöhr, J. Ul Hassan, S. Onoda, T. Ohshima, S. Y. Lee, A. Mukherjee, J. Isoya, N. T. Son, and J. Wrachtrup. Coherent electrical readout of defect spins in silicon carbide by photo-ionization at ambient conditions. Nature Communications 10, 5569 (2019).
- 4 C. J. Stephen, B. L. Green, Y. N. D. Lekhai, L. Weng, P. Hill, S. Johnson, A. C. Frangeskou, P. L. Diggle, Y. C. Chen, J. Strain, E. Gu, M. E. Newton, J. M. Smith, P. S. Slater, and G. W. Morley*. Deep three-dimensional solid-state qubit arrays with long-live spin coherence. Physical Review Applied 12, 064005 (2019).
- 5 M. Widmann*, M. Niethammer, D. Y. Fedyanin, I. A. Khramtsov, T. Rendler, I. D. Booker, J. Ul Hassan, N. Morioka, Y. C. Chen, I. G. Ivanov, N. T. Son, T. Ohshima, M. Bockstedte, A. Gali, C. Bonato, S. Y. Lee*, and J. Wrachtrup. Electrical charge state manipulation of single silicon vacancies in a silicon carbide quantum optoelectronic device. Nano Letters 19, 10, 7173-7180 (2019).

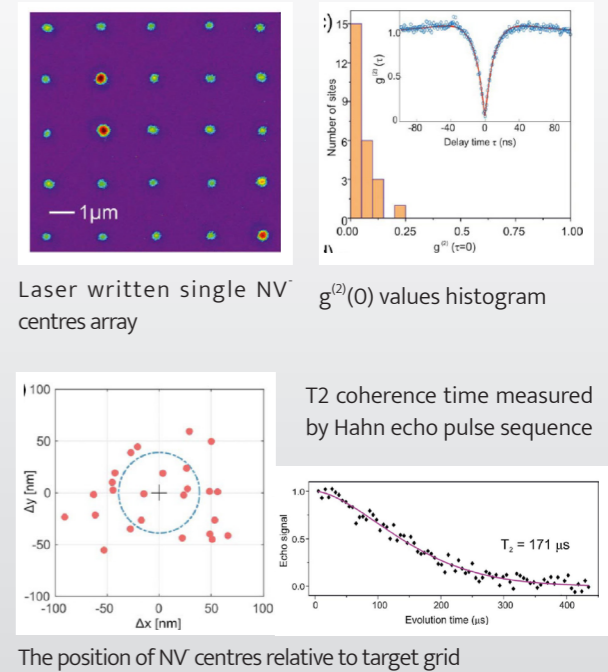
Research Focus

Laser writing of individual nitrogen-vacancy defects in diamond with near-unity yield

Yu-Chen Chen

Optica 6 (2019): 662-667

Spin defects in wide band gap materials show a great potential for various quantum applications. Nitrogen-vacancy (NV) centre in diamond is one of the most promising spin defect. In order to realise quantum applications, it is important to engineer the NV centre at desired location with high positioning accuracy and yield. Although the traditional single NV centre generation method can provide high position accuracy, the yield is lower than 50%. We developed a method which using femtosecond laser pulse sequence combined with fluorescence feedback to generate single NV centres array with yield of 96%. The positioning accuracy of single NV centres in the image plane is measured to be about 40 nm. Moreover, the laser written single NV centres still possess good spin coherence properties and the T_2 coherence time was measured up to 170 μ s by standard Hahn echo measurements.

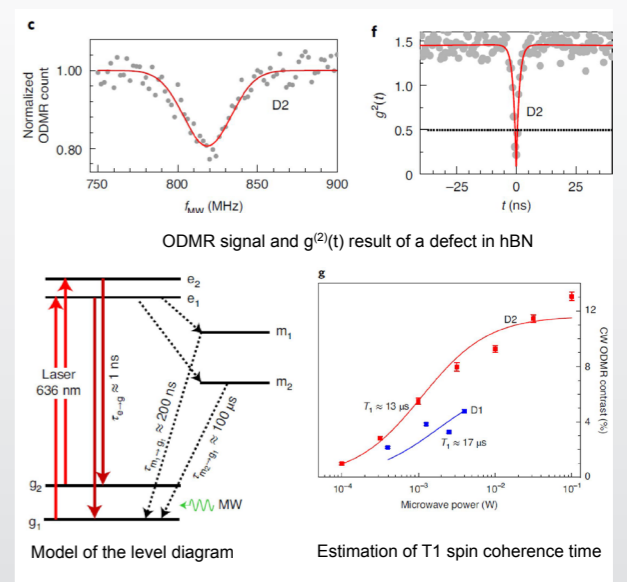


Spin readout and manipulation of single defect in hBN 2D material

Yu-Chen Chen

Nature Materials 20 (2021): 1079-1084

Single photon emitters in hexagonal boron nitride (hBN) have attracted many researchers' attentions, because it can be easily coupled into photonic structures. Moreover, some single photon emitters' zero-phonon line (ZPL) have been found to be Fourier transformed limited linewidth at room temperature. This property pave a way to realise the quantum repeater and quantum communication at room temperature. However, single spin defects was not discovered in the hBN. We have successfully found that some single defects show optically detected magnetic resonance (ODMR). Various laser and microwave pulse sequences were used to investigate the spin dynamics and we built a simple model to describe the results. We concluded that the magnetic resonance locates at the ground state. The g-factor of the defect was measured to be 2.06. The T_1 spin coherence time of the spin defects were estimated to be around 13~17 μ s.



Honors and Awards

| | | |
|-----------------|--------------------------|--|
| 2025 | Chun-Wei Pao | 2024 NSTC Outstanding Research Award |
| | Yu-Jung Lu | Young Researcher Award, iSPN 2025, Singapore |
| 2024 | Yu-Jung Lu, Shih-Yen Lin | Future Tech Award, National Science and Technology Council |
| | Tzung-Fang Guo | Fellow of OPTICA (formerly OSA) |
| | Fu-Liang Yang | 21st National Innovation Award |
| | Pei-Kuen Wei | 21st National Innovation Award |
| 2023 | Mu-Huai Fang | Career Development Award, Academia Sinica |
| | Chun-Wei Pao | Y. Z. Hsu Scientific Paper Award |
| | Yu-Jung Lu | SPIE Senior Members, USA |
| 2022 | Chun-Wei Pao | Investigator Award, Academia Sinica |
| | Chih Wei Chu | World's Top 2% Scientists |
| | Chih Wei Chu | SPIE Senior Member |
| | Yu-Jung Lin | Cross-Generation Young Scholars Program (Emerging Young Scholars), National Science and Technology Council, Taiwan |
| | Chi Chen | Academia Sinica Career Development Award |
| | Yi-Chung Tung | Scientist with Top 2% Single Year Impact |
| | Fu-Liang Yang | 19th National Innovation Award |
| | Tung-Han Hsieh | 19th National Innovation Award in the Academic Research Category |
| | Chao-Cheng Kaun | Future Tech Award, National Science and Technology Council |
| | 2021 | Yu-Jung Lu |
| Min-Hsiung Shih | | International Electron Devices & Materials Symposium (IEDMS), Excellent Paper Award |
| Min-Hsiung Shih | | Optics & Photonics Taiwan International Conference (OPTIC), Paper Award |
| Peilin Chen | | Investigator Award, Academia Sinica, Taiwan |
| Bi-Chang Chen | | Academia Sinica Early-Career Investigator Research Achievement Award |
| Pei-Kuen Wei | | Presidential scholars, Academia Sinica |
| 2020 | Chao-Cheng Kaun | Future Tech Award, Ministry of Science and Technology |
| | Yu-Jung Lu | Youth Photonics Award, Taiwan Photonics Society, Taiwan |
| | Yu-Jung Lin | Young Investigator Award, Prof. Chau-Jen Lee Biomedical Engineering Development Foundation, Taiwan |
| | Tzung-Fang Guo | Fellow of SPIE (International Society for Optics and Photonics) |
| | Bi-Chang Chen | 18th Y. Z. Hsu Science Paper Award, Optoelectronics Science & Technology Category |
| | Chih-Yu Kuo | Research Paper Award, Journal of Chinese Soil Water Conservation |
| | Fu-Liang Yang | 17th National Innovation Award |

Major Equipment & Core Facilities

The core facilities in Research Center of Applied Sciences (RCAS) provide service to the researchers of RCAS and Academia Sinica. All instruments are located on 6th, 4th and B2 floors in Interdisciplinary Research Building for Science and Technology (IRBST). The RCAS core facilities can be divided into three categories by features: Microscope, Materials Analysis and Micro Fabrication.

Table 1. The information of core facilities

| Type | Instruments | Features | Brand Model | Location |
|--------------------|--|---|-------------------------------|-------------|
| Microscope | MINIFLUX localization microscopy | Cell imaging analysis | Abberior | IRBST 6B06 |
| | Atomic force microscope | Material surface analysis | Bruker DM-CAFM | NCTU TKP506 |
| | Laser scanning Confocal Spectral Microscope | Bio and fluorescent sample detection | Leica TCS-SP5 | IRBST 4B20 |
| | Atomic force microscope | Bio materials and nano components detection | JPK Nano Wizard II & III | IRBST B2C01 |
| | High resolution Raman microscope | Fluorescence and crystallization analysis | Jobin Yvon HR800 | IRBST 6B08 |
| | Field emission scanning electron microscope | Analysis of surface morphology and elemental analysis | Nova 200 NPE 44/D8187 | IRBST 4C05 |
| Materials Analysis | X-ray photo-electron spectroscope | Surface and Depth Analysis of Elementals | ULVAC-PHI PHI-5000 Versaprobe | IRBST 4C05 |
| | Scanning Ion Microscope | Surface and Depth Analysis of Molecules and Atoms | ULVAC-PAI TRIFTV | IRBST 4C05 |
| | Time-resolved confocal microscope for single molecule spectrometer | Multi-Channel time resolve spectroscopy | PicoQuant Micro Time 2000 | IRBST 6B10 |
| | Color 3D Laser Scanning Microscope | Surface profile and roughness detection | Keyence VK9710K S/N 2190011 | IRBST 4C01 |
| Micro Fabrication | Specimen Preparation Equipment | Thin-film growth and etching | Gated Sted SKE104005 | IRBST 6A02 |
| | Focus Ion Beam | Structure production of nano components | FEI NanoLab660 | IRBST 4B19 |
| | Inductively coupled plasma etching system | Dry and wet etching of nano components | OXFORD ICP65 | IRBST B2C02 |
| | Benchtop maskless lithography system | Structure production of photoresist on components | Heidelberg uPG501 | IRBST B2C02 |
| | Mask Aligner with nanoimprint lithography | Structure production of photoresist on components | EVG620 NT | IRBST B2C02 |

Administration Staffs

The core facilities provide assistances for the researchers to conduct various experiments in bio-image detection, material surface analysis, components structure production and micro sample fabrication. Furthermore, several public laboratories on 6th, 4th and B2 floors in IRBST are established for our members to do researches in fabrication, imaging, cell and protein.

Every user should pass the safety course of Academia Sinica. After finishing the training of instruments, users could get the license. However, toxic chemicals (as defined by EPA and regardless if it is under controlled by EPA), volatile, radio-active and explosive substances are prohibited. Biological-active materials should be remarked on usage record. Based the requirement of each instrument, administrators can disallow additional types of samples such as (include, but not limited by) magnetic, powder, etc. For all facilities, users should make reservations on the web site (<http://scheduler.rcas.sinica.edu.tw/>) in advance and fill in usage records indeed.

In addition to routine maintenance every year, we would upgrade the facilities and improve the laboratory configuration. Moreover, we have suitable plan and management for every lab and instrument in safety considerations of research.



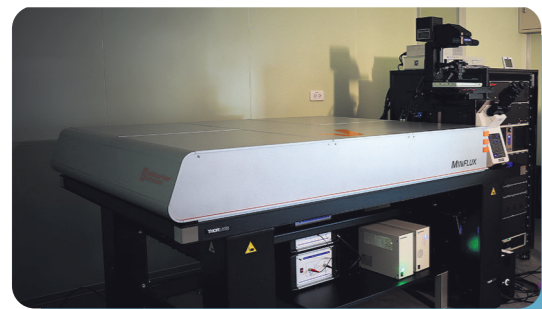
Specimen Preparation Equipment

試片準備機一套



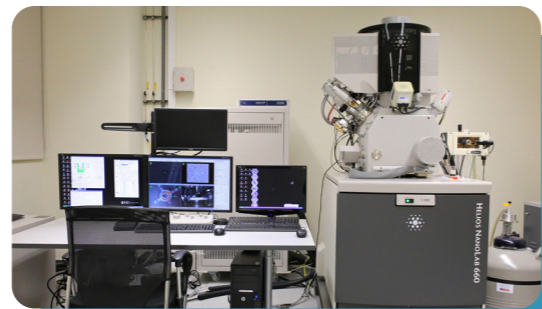
Inductively Coupled Plasma etching system

電感耦合電漿蝕刻機



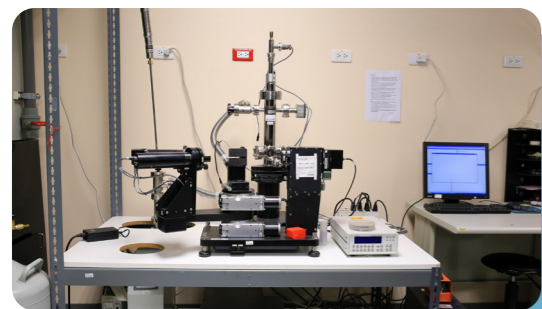
MINIFLUX (MINimal photon FLUXes)

MINIFLUX (最小光子通量定位顯微鏡)



Focus Ion Beam

高解析高精密雙束聚焦離子系統



Variable angle spectroscopic ellipsometer

可變角度陀螺儀



Color 3D Laser Scanning Microscope

奈米及雷射非接觸式 3D 表面量測儀



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