



# 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.

Intelligence  
Bioengineering

Green Energy  
Technologies

Quantum  
Photonics

## Contents

<b>Introduction</b>	1
<b>Cooperation outside Academia Sinica (MOU)</b>	1
<b>Elite Scholarship Program MOU</b>	2
<b>Academic Advisory Committee</b>	3
<b>Research Directions</b>	
Thematic Center for Intelligence Bioengineering	4
Thematic Center for Green Technology	6
Thematic Center for Quantum Photonics	8
<b>Faculty Members</b>	
<b>Thematic Center for Intelligence Bioengineering</b>	
Peilin Chen	10
Pei-Kuen Wei	12
Fu-Liang Yang	14
Ji-Yen Cheng	16
Chau-Hwang Lee	18
Jung-Hsin Lin	20
Jing-Jong Shyue	22
Yi-Chung Tung	24
Chih-Yu Kuo	26
Bi-Chang Chen	28
Yu-Jung Lin	30
Tung-Han Hsieh	32
Shu-Yi Hsieh	34
<b>Thematic Center for Green Technology</b>	
Chih Wei Chu	36
Chun-Wei Pao	38
Tzung-Fang Guo	40
Yun-Chorng Chang	42
Yuh-Jen Cheng	44
Yu-Jung Lu	46
Mu-Huai Fang	48
<b>Thematic Center for Quantum Photonics</b>	
Wen-Hao Chang	50
Min-Hsiung Shih	52
Chao-Cheng Kaun	54
Shih-Yen Lin	56
Shu-Wei Chang	58
Chi Chen	60
Yu-Chen Chen	62
<b>Honors and Awards</b>	64
<b>Major Equipemnt &amp; Core Facilities</b>	65
<b>Adminstration Staffs</b>	67

## 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)

<i>January 1<sup>st</sup>, 2012</i>	National Chiao Tung University (Academic Cooperation Agreement on Optoelectronic Technology)
<i>December 3<sup>rd</sup>, 2012</i>	Department of Materials Science and Engineering, National Dong Hwa University
<i>December 3<sup>rd</sup>, 2012</i>	Department of Physics, National Dong Hwa University
<i>July 31<sup>st</sup>, 2012</i>	The Hebrew University of Jerusalem in Israel
<i>January 24<sup>th</sup>, 2013</i>	Molecular Biomedical Imaging Center, National Taiwan University
<i>August 14<sup>th</sup>, 2013</i>	Department of Photonics/ Materials and Optoelectronic Science/ Physics/ Mechanical and Electromechanical Engineering, National Sun Yat-sen University
<i>February 18<sup>th</sup>, 2014</i>	College of Engineering, Chang Gung University
<i>February 18<sup>th</sup>, 2014</i>	College of Biomedical Science and Engineering, National Yang Ming University
<i>December 22<sup>nd</sup>, 2014</i>	Research Institute of Electronic Science, Hokkaido University, Japan
<i>July 17<sup>th</sup>, 2014</i>	Graduate Institute of Applied Physics and Department of Physics, National Taiwan University
<i>May 1<sup>st</sup>, 2015</i>	Department of Photonics, National Cheng Kung University
<i>August 26<sup>th</sup>, 2016</i>	Department of Materials Science and Engineering, National Tsing Hua University
<i>March 25<sup>th</sup>, 2020</i>	Department of Applied Science, National Taitung University
<i>July 27<sup>th</sup>, 2020</i>	School of Engineering, The University of Tokyo, Japan
<i>August 1<sup>st</sup>, 2020</i>	Abbe Center of Photonics, Friedrich Schiller University Jena
<i>January 1<sup>st</sup>, 2021</i>	Leibniz Institute of Photonic Technology e. V.
<i>December 20<sup>th</sup>, 2023</i>	Institute of Microelectronics Engineering, National Cheng Kung University
<i>December 20<sup>th</sup>, 2023</i>	Program on Semiconductor Manufacturing Technology, Academy of Innovative Semiconductor and Sustainable Manufacturing, National Cheng Kung 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 Biomechanics Engineering, National Taiwan University

### 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,  
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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. Chung-Yuan Mou (Chair)



Professor Emeritus,  
Distinguished Chair  
Professor for Research,  
Department of  
Chemistry, National  
Taiwan University,  
Taiwan

國立臺灣大學化學系名譽教授

### 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

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. This 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 numerous 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.

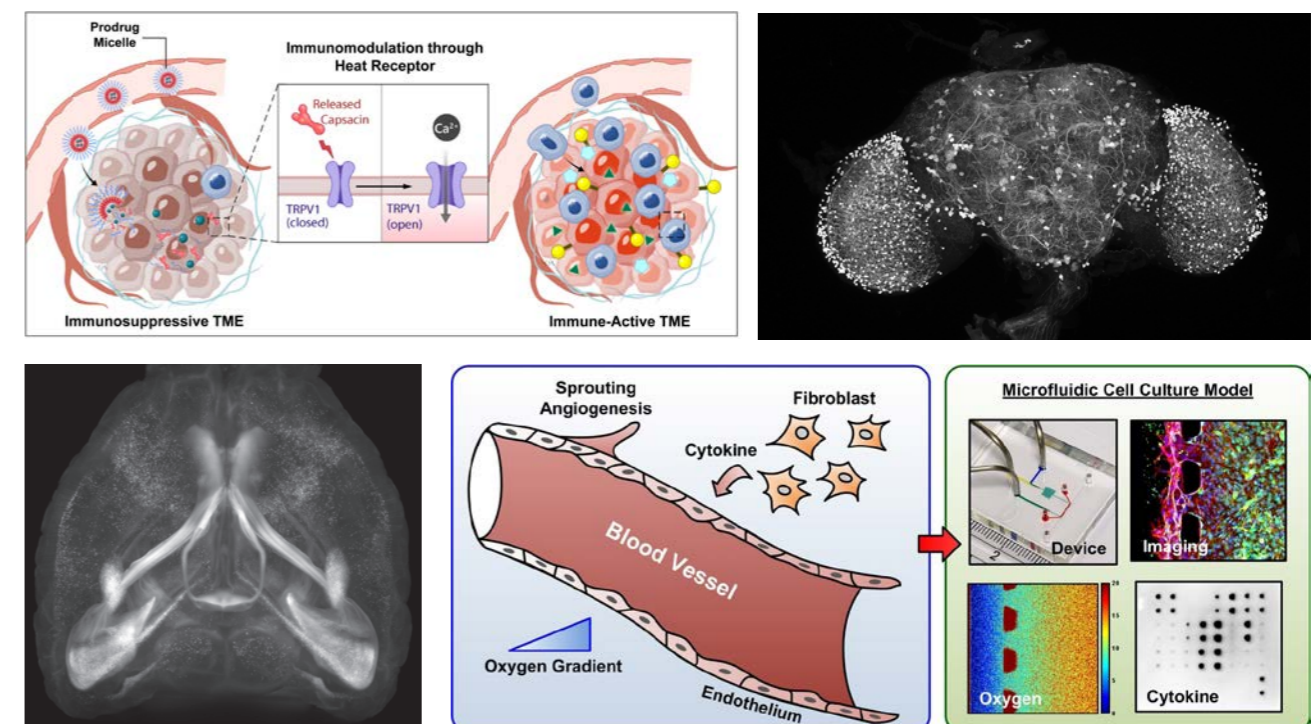
## Focusing Research Program

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

**Automatic Drug Synthesis and Screening Platform:** This project aims to develop an automated platform for drug synthesis and screening, utilizing AI-driven models for predicting drug targets. This initiative represents a significant leap forward in streamlining the drug development process, making it faster and more efficient.

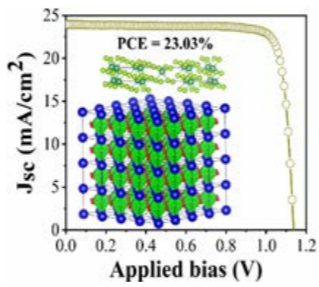
**Integrated 3D Imaging for Biological Samples:** We are combining multiple advanced imaging techniques—such as super-resolution microscopy, expansion microscopy, electron microscopy, and focused ion beam microscopy—with AI-powered image analysis to create detailed 3D images of biological samples. This project aims to identify key biomarkers across various model systems, enhancing our understanding of complex biological processes.

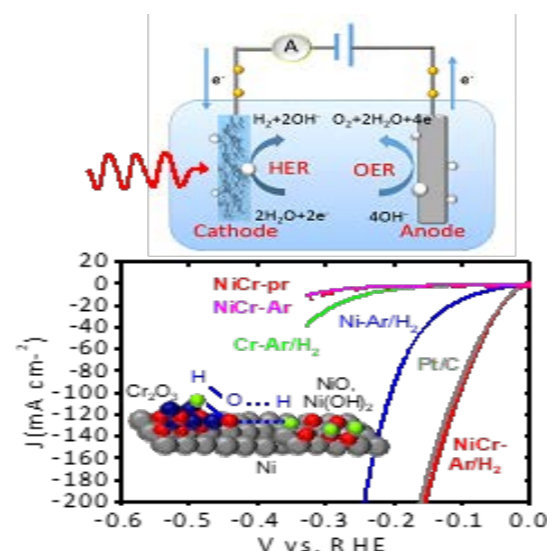
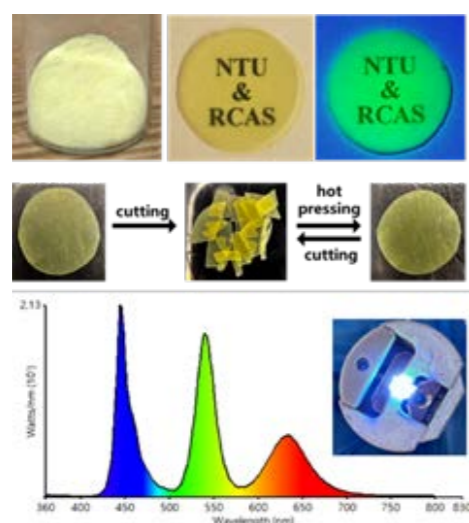
The Thematic Center for Intelligence Bioengineering is not just a place of scientific inquiry but a beacon of innovation in the biomedical field. Our commitment to developing groundbreaking technologies and fostering collaborative projects positions us to lead the next wave of biomedical advancements. 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-Chorng Chang.

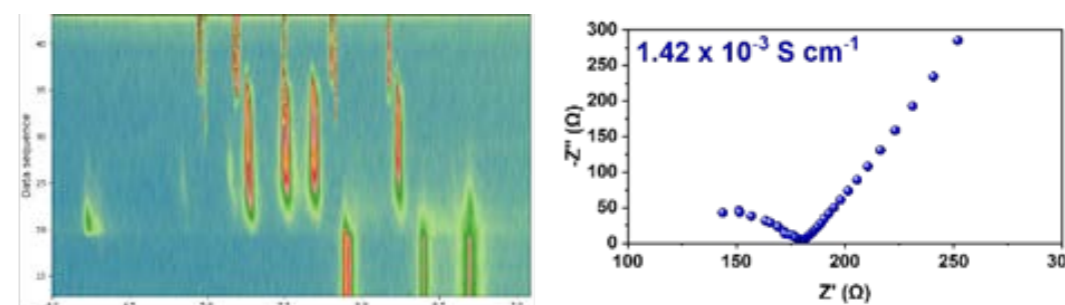
## Energy-efficient and energy generation devices

- Perovskite solar cells show photovoltaic hysteresis and stability issues, which need improvement to meet commercial standards. We will study strategies such as using additives to reduce defects, controlling grain growth, and minimizing defects at grain boundaries and interfaces. These approaches aim to enhance the stability and efficiency of perovskite solar cells.
- 
- We have developed a robust Quantum-dot@Vitrimer thin film composite for backlighting LED that can be physically and chemically recycled. The recycled compound can also be reused, making it a sustainable material. We have also synthesized near-infrared and short-wave infrared fluorescent materials and made them into energy-saving broadband infrared LEDs.
  - The research aims to study the use of sunlight to drive water splitting for green hydrogen generation. The key research subjects include developing semiconductor structure for efficient electron-hole generation, developing non-noble metal composite catalysts, and designing electrode structure for efficient gas-liquid separation. Through the integration of these results, the goal is to achieve highly efficient solar to hydrogen conversion.



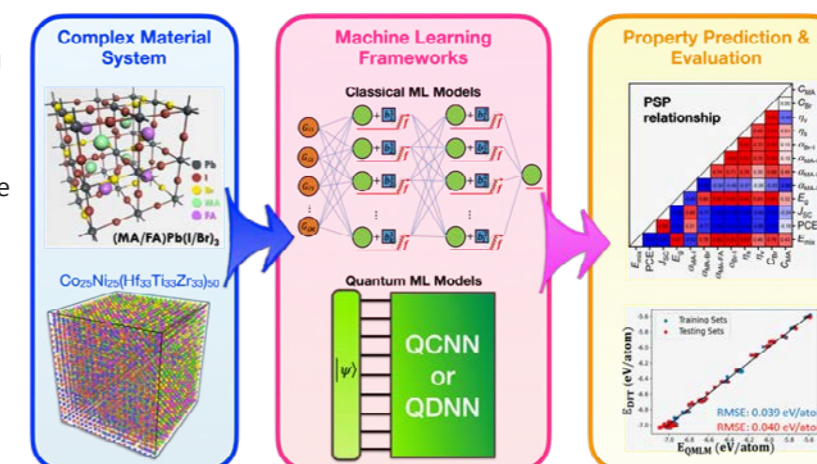
## Next-Generation Batteries

- We have developed a new liquid chemical synthesis method for solid-state electrolytes with high ionic conductivity, simultaneously achieving mass production and structural control. We also utilize moisture- and atmospheric-dependent in-situ synchrotron X-ray powder diffraction techniques to track their structural changes. We will eventually apply them to solid-state batteries.



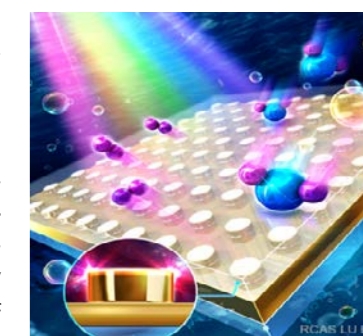
## Advanced Energy Material Simulation

- We actively developed machine learning frameworks investigating properties of complex structural and energy materials, including complex perovskites materials, high entropy alloys, and solid state electrolytes. We are also actively involved in exploring applications of AIGC and quantum machine learning in predicting material properties.

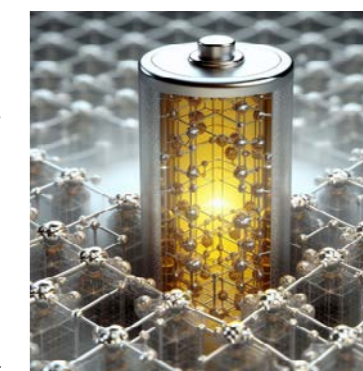


## Focusing Project

The first focusing project aims to employ metasurfaces and metamaterials as perfect absorbers to effectively harness solar radiation for thermal energy conversion. The goal is to utilize this solar-thermal energy to enhance chemical catalytic reactions for synthesizing green energy, specifically to increase the production of green fuels such as ammonia. The use of photonic nanostructures as perfect absorbers in this project not only boosts energy conversion efficiency but also provides a high-temperature environment for efficient photochemical synthesis. This research will not only explore new avenues for efficient photochemical energy conversion using metasurfaces/metamaterials. Still, it will also pave the way for the industrial application of solar thermal processes in renewable energy technologies.



The second focusing 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. This method also holds promise for large-scale production, addressing the previous limitation of difficulty in scaling up the process for solid-state electrolytes.



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.

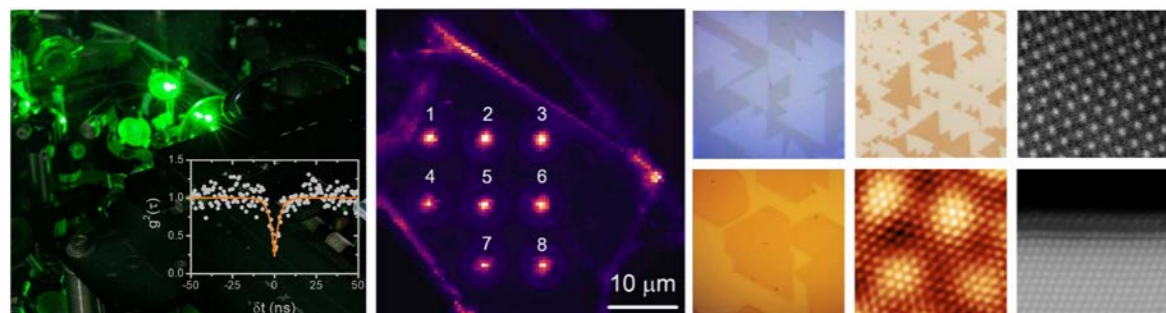
## Focusing Projects

### 1. Quantum Photonic Applications based on Emergent Materials

The emerging field of quantum technology has opened up new opportunities for the development of new optoelectronic devices. For future quantum technology, quantum photonic devices will play a crucial role in various aspects and bring revolutionary changes. This project aims at developing three critical areas including:

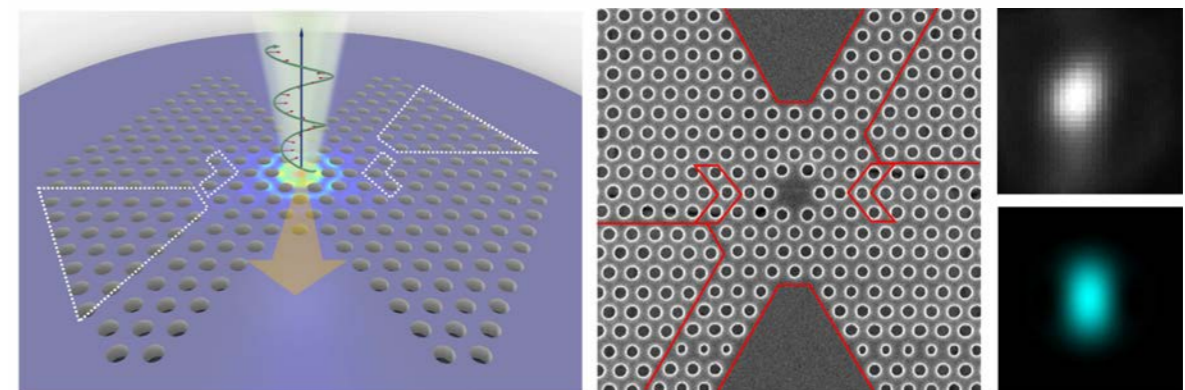
- (1) Single-photon emitters with high brightness, efficiency, and indistinguishability.
- (2) Superconducting single-photon detectors based on high-quality superconducting materials to achieve high sensitivity, fast response, high detection efficiency, and low noise.
- (3) Exploring room-temperature quantum systems for applications in spin control and quantum sensing.

The developed quantum photonic devices will be the foundation for future developments in quantum information technology.



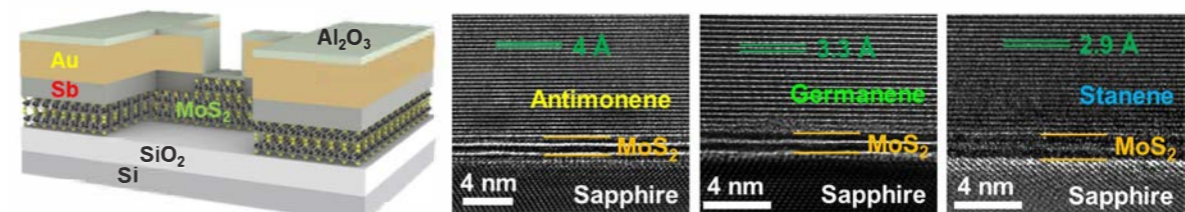
### 2. Photonic design for engineering single photon emissions

Once the generic properties of a single photon emitter are known, the next step is to tailor its emission characteristics so that the emitted single photon can be utilized for quantum applications in successive systems. A few key features of the single photon could be manipulated at the emission stage, including the emission rate, emission direction, and polarization state of single photons. This project aims at developing specialized photonic structures to control of single photon emissions, particularly focusing on the design of cavities, waveguide, and chiral structures that can enable manipulations of single photons. Our goal is to achieve efficient single-photon sources, controlling chiral polarization states, and routing single photons for coupling into photonic integrated chips.



### 3. Crystallinity of Electrodes: Extraction and Modelling of Contact Resistance on 2D Material Surfaces in the Nanometer Regime for Device Applications

The high contact resistance at electrodes and 2D material interfaces is one major bottleneck for 2D material devices. Our preliminary study has shown that the crystallinity of the contact electrodes may be the major issue influencing the contact resistance at the metal/2D material interfaces. This project aims at exploring the actual mechanism responsible for the reduced contact resistance at the metal/2D material interfaces with enhanced electrode crystallinity. We adopt conductive atomic force microscope to extract the actual contact resistance of different contact metals in the nanometer regime. First-principles modelling will be performed to gain deeper understanding. We also explore the opportunity to apply the low-resistance contacts to the compact light-emitting devices.



# Intelligence Bioengineering

| Faculty Members |



# Peilin Chen

Executive Officer of the TCIB and Research Fellow

**Education** | Education: Ph.D. Chemistry, University of California, Irvine (1998)

## Selected Publications

- Zih-An Chen, Cheng-Hsun Wu, Si-Han Wu, \* Chiung-Yin Huang, Chung-Yuan Mou, Kuo-Chen Wei, Yun Yen, I-Ting Chien, Sabiha Runa, Yi-Ping Chen, \* Peilin Chen\* "Receptor Ligand-Free Mesoporous Silica Nanoparticles: Streamlined Strategy for Targeted Drug Delivery Across the Blood-Brain Barrier" ACS Nano, 2024, 18, 12716.
- Chi-Shan Li, et al., "Cytosolic galectin-4 enchains bacteria, restricts their motility and promotes inflammasome activation in intestinal epithelial cells" Proc. Natl. Acad. Sci. U.S.A., 2023, 12, e2207091120.
- Yuan-Yuan Cheng, et al., "Metabolic changes associated with cardiomyocyte dedifferentiation enable adult mammalian cardiac regeneration." Circulation, 2022, 146, 1950.
- Wei-Chun Tang, Yen-Ting Liu, Cheng-Han Yeh, Chieh-Han Lu, Chiao-Hui Tu, Yi-Ling Lin, Yu-Chun Lin, Tsui-Ling Hsu, Liang Gao, Shu-Wei Chang, Peilin Chen\* and Bi-Chang Chen\* "Optogenetic Manipulation of Cell Migration with High Spatiotemporal Resolution Using Lattice Lightsheet Microscopy" Communications Biology, 2022, 5, 879.
- Chiung Wen Kuo, Feby Wijaya Pratiwi, Yen-Ting Liu, Di-Yen Chueh and Peilin Chen\* "Revealing the nanometric structural changes in myocardial infarction models by time-lapse intravital imaging" Frontiers in Bioengineering and Biotechnology, 2022, 10, 935415.
- San-Shan Huang, et al., "Immune cell shuttle for precise delivery of nanotherapeutics for heart disease and cancer" Science Advances, 2021, 7, eabf2400.
- Hung-Lin Chen, et al., "Galectin-7 downregulation in lesional keratinocytes contributes to enhanced IL-17A signaling and skin pathology in psoriasis" (2021) J. Clin. Invest. 131, e130704.
- Rong-Lin Chang, Feby Wijaya Pratiwi, Bi-Chang Chen, Peilin Chen,\* Si-Han Wu,\* Chung-Yuan Mou\* "Simultaneous Single-particle Tracking and Dynamic pH Sensing Reveal Lysosome-targetable Mesoporous Silica Nanoparticles Pathways", ACS Applied Materials & Interfaces, 2020, 12, 42472.
- Yi-Ping Chen, Chien-Tsu Chen, Tsang-Pai Liu, Fan-Ching Chien, Si-Han Wu\*, Peilin Chen\*, Chung-Yuan Mou\* "Catcher in the rel: Nanoparticles-antibody conjugate as NF- $\kappa$ B nuclear translocation blocker" Biomaterials. 2020, 246, 119997.
- Li-An Chu, et al., "Rapid single-wavelength lightsheet localization microscopy for clarified tissue" Nature Communications, 2019, 10, 4762.
- Chieh-Han Lu, Wei-Chun Tang, Yen-Ting Liu, Shu-Wei Chang, Frances Camille M. Wu, Chin-Yi Chen, Yun-Chi Tsai, Shun-Min Yang, Chiung-Wen Kuo, Yasushi Okada, Yeu-Kuang Hwu, Peilin Chen\*, & Bi-Chang Chen,\* "Lightsheet localization microscopy enables fast, large-scale, and three-dimensional super-resolution imaging" Communications Biology, 2019, 2, 177.

## Positions and Career

- Research Fellow, RCAS, Academia Sinica, 2010-present
- Chief Executive Officer, Thematic Center for Intelligence Bioengineering, RCAS, 2023-present
- Joint Research Fellow, Institute of Physics, Academia Sinica, 2021-present
- Visiting Professor, Kyoto University, Kyoto, Japan, 2015
- Visiting Professor, RIKEN, Wako, Japan, 2012
- Chief Executive Officer, Thematic Center for Optoelectronic, RCAS, 2012
- Deputy Director, RCAS, Academia Sinica (2010 -2012)
- Associate Research Fellow, RCAS, Academia Sinica (2005-2010)
- Assistant Research Fellow, RCAS, Academia Sinica (2001-2005)
- Postdoctoral Fellow, University of California, Berkeley (1999-2001)
- Postdoctoral Fellow, University of California, Irvine (1998)

## Honors and Awards

- Research Award for Junior Research Investigators, Academia Sinica, Taiwan (2007)
- Ta-You Wu Memorial Award, National Research Council, Taiwan (2007)
- Career Development Award, Academia Sinica, Taiwan (2009)
- Fellow, the Royal Society of Chemistry (2019)
- Investigator Award, Academia Sinica, Taiwan (2021)

## Research Interests

- Advanced imaging: super-resolution, single molecules, intravital
- Bioelectronic and biomedical devices
- Multifunctional materials for Nanomedicine

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[https://www.rcas.sinica.edu.tw/pi\\_web/peilin.php](https://www.rcas.sinica.edu.tw/pi_web/peilin.php)

- Tony WH Tang, et. al., "Loss of Gut Microbiota Alters Immune System Composition and Cripples Post-Infarction Cardiac Repair" Circulation, 2019, 139, 647.
- Chiung Wen Kuo, Di-Yen Chueh, Peilin Chen\*, "Real-Time in vivo Imaging of Subpopulations of Circulating Tumor Cells Using Antibody Conjugated Quantum Dots" J. Nanobiotech, 2019, 17, 26.
- Po-Kai Chuang, et al., "Signaling pathway of globo-series glycosphingolipids and  $\beta$ 1,3-galactosyltransferase V ( $\beta$ GalT5) in breast cancer" Proc Natl Acad Sci USA 2019, 116, 3518-3523.

## Research Focus

### The Applications of Real-time Intravital Imaging

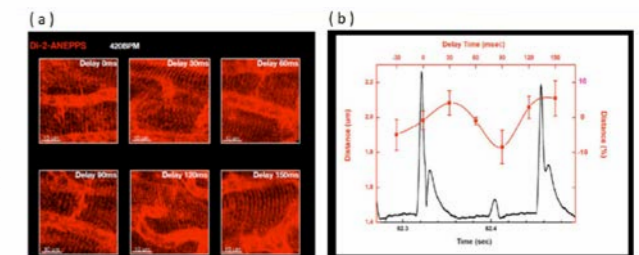
- Frontiers in Bioengineering and Biotechnology, 2022, 10, 935415
- Circulation, 2022, 146, 1950
- Science Advances, 2021, 7, eabf2400
- Circulation, 2019, 139, 647

- Science Translational Medicine 2016, 8, 365ra160
- J. Nanobiotech 2019, 17, 26
- J. Clin. Invest. 2021, 131, e130704
- PNAS, 2023, 12, e2207091120

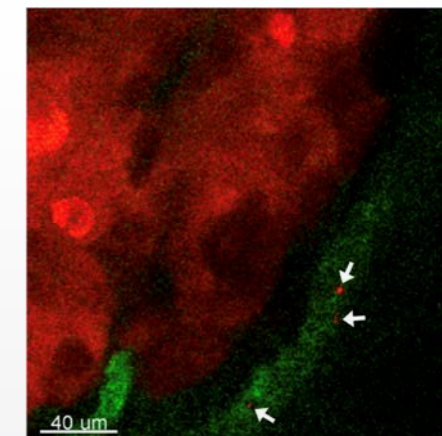
In our group, we have developed real-time intravital imaging for various disease models. Since the heart diseases and cancers are the top two leading causes of death in United State and Taiwan. We focus on the applications of real-time intravital imaging for these two disease models. In the heart disease model, the beating rate of mouse is about 6-8 Hz, which is about 6 times faster than human heartbeat. If we utilize two-photon microscope with a resonance scanner running at 30 Hz to image the beating heart in a living mouse, we will still get very blurry images. To minimize the influence of heart beating, we synchronized the scanner of confocal microscope to the beating heart. When the imaging system was synchronized with heartbeat, it allowed us to conduct detail analysis of individual cellular behavior in the blood vessels on the beating heart.

In the case of tumor imaging, we are interested in the real-time imaging of the circulating tumor cells (CTCs). The detection of circulating tumor cells (CTCs) is very important for cancer diagnosis. CTCs can travel from primary tumors through the circulation to form secondary tumor colonies via bloodstream extravasation. The number of CTCs has been used as an indicator of cancer progress. However, the population of CTCs is very heterogeneous. It is very challenging to identify CTC subpopulations such as cancer stem cells (CSCs) with high metastatic potential, which are very important for cancer diagnostic management.

We developed real-time CTC and CSC imaging in the bloodstreams of living animals using multi-photon microscopy and antibody conjugated quantum dots. When the cancer cells broke away from the solid tumor, CTCs with fluorescent proteins in the bloodstream at different stages of development could be monitored noninvasively in real time. The number of CTCs observed in the blood vessels could be correlated to the tumor size in the first month and reached a maximum value of approximately 100 CTCs/min after five weeks of tumor inoculation. To observe CTC subpopulations, conjugated quantum dots were used. It was found that cluster of differentiation (CD)24+ CTCs can move along the blood vessel walls and migrate to peripheral tissues.



(a) a section of the image from different time delay corresponding to a specific portion of the ECG cycle (b) the plot diagram of time delay and Sarcomere length displacement in one complete cardiac cycle



CTCs (red cells indicated by arrows) in the blood vessel near solid tumor expressing red fluorescent protein (RFP). The blood vessels (green) were stained with fluorescein isothiocyanate (FITC)-dextran. Tumor cells: BXP3-RFP.

# Pei-Kuen Wei

Director and Research Fellow

## Education

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

## Selected Publications

1. 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.
2. Yi-Ting Lai, Pei-Kuen Wei, Chih-Yu Kuo, Ji-Yen Cheng, "Inference detection and classification of illicit drugs by a modest Raman spectrometer with a convolutional neural network analyzer," *Sensors and Actuators B: Chemical*, 375, 132923, (2023).
3. Shu-cheng Lo, Chia-wei Lee, Ruey-lin Chern, and Pei-kuen Wei\*, "Hybrid modes in gold nanoslit arrays on Bragg nanostructures and their application for sensitive biosensors," *Opt. Express* 30, 30494-30506 (2022).
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. Yi-Ru Li, Kuang-Li Lee, Kuan-Ming Chen, Yun Cheng Lu, Pin Chieh Wu, Sy-Hann Chen, Jiun-Haw Lee, and Pei-Kuen Wei\*, "Direct detection of virus-like particles using color images of plasmonic nanostructures," *Opt. Express* 30, 22233-22246 (2022).
6. Chia-Wen Kuo, Sheng-Hann Wang, Shu-Cheng Lo, Wei-Han Yong, Ya-Lun Ho, Jean-Jacques Delaunay, Wan-Shao Tsai, and Pei-Kuen Wei\*, "Sensitive Oligonucleotide Detection Using Resonant Coupling between Fano Resonance and Image Dipoles of Gold Nanoparticles", *ACS Applied Materials & Interfaces*, 2022, 30:14012-14024.
7. Han-Yun Hsieh, Jia-Xian Luo, Yi-Hong Shen, Shu-Cheng Lo, Yi-Chiung Hsu, Hidetoshi Tahara, Yu-Jui Fan\*, Pei-Kuen Wei\*, Horn-Jiunn Sheen\*, "A nanofluidic preconcentrator integrated with an aluminum-based nanoplasmonic sensor for Epstein-Barr virus detection," *Sensors and Actuators B: Chemical*, 355, 2022, 131327.
8. 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).
9. Han-Yun Hsieh, Ray Chang, Yung-Yu Huang, Po-Han Juan, Hidetoshi Tahara, Kuan-Li Lee, Di Ngoc Kha Vo, Ming-Han Tsai, Pei-Kuen Wei\*, Horn-Jiunn Sheen\*, Yu-Jui Fan\*, "Continuous polymerase chain reaction microfluidics integrated with a gold-capped nanoslit sensing chip for Epstein-Barr virus detection", *Biosens. & Bioelectron.* 2022, 195, 113672.
10. Shu-Cheng Lo, Chun-Wei Yeh, Sheng-Hann Wang, Chia-Wen Kuo, Kuang-Li Lee, Ruey-Lin Chern, Pei-Kuen Wei\*, "Self-Referencing Biosensors Using Fano Resonance in Periodic Aluminium Nanostructures", *Nanoscale*, 2021, 13, 17775-17783.

## Positions and Career

- Director, Research Center for Applied Sciences, Academia Sinica (2023 – )
- Adjunct Professor, Institute of Applied Mechanics, National Taiwan University (2024 – ) Acting Director, Research Center for Applied Sciences, Academia Sinica (2022 – 2023)
- Deputy Director, Research Center for Applied Sciences, Academia Sinica (2012 – 2019)
- Adjunct Professor, Department of Photonics, National Sun Yat-sen University (2015 – )
- Adjunct Professor, Institute of Biophotonics Engineering, National Yang-Ming Chia-Tung University, (2011 – )
- Acting Executive Officer of the thematic center for Mechanics and Engineering Science, Academia Sinica (2009 – 2014)
- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2009 – )
- Adjunct Professor, Institute of Optoelectronic Sciences, National Taiwan Ocean University (2006 – 2021)
- Assistant Research Fellow, Institute of Applied Science and Engineering research (preparatory house), Academia Sinica (2000 – 2004)

## Honors and Awards

- 2021 Presidential scholars, Academia Sinica
- 2018 Industrial paper award (Champion), International Conference on Smart Sensors
- 2017 SPIE Senior Member, 2016 OSA Senior Member
- 1994 Doctoral Thesis Award, Optical Society of Taiwan

## Research Interests

- Nanophotonics & Nanoplasmonics
- Biosensors & Bioelectronics

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## Research Focus

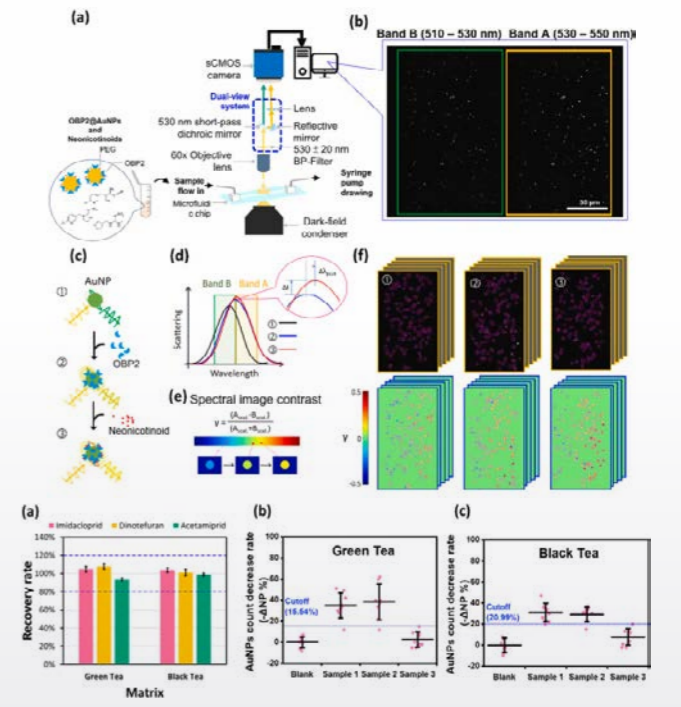
### Biomimetic affinity sensor for the ultrasensitive detection of neonicotinoids...

Ting-Wei Chang, Sheng-Hann Wang, Iuan-Sheau Chin, Pei-Zhen Li, Shu-Cheng Lo, Shu-Yi Hsieh, Jung-Hsin Lin, and Pei-Kuen Wei.

Academic Sinica, Research Center for Applied Sciences

*Biosens Bioelectron.* 2023 Nov 1:239:115630. DOI:10.1016/j.bios.2023.115630

Multiple pesticides are often used in combination to protect crops from pests. This makes rapid on-site detection of pesticide contamination challenging. Herein, we describe a method for simultaneous detection of diverse neonicotinoid pesticides using a sensor that combines neonicotinoid-specific odorant-binding protein 2 (OBP2), which was cloned from an insect chemical sensing protein and modified gold nanoparticles with local surface plasmon resonance (LSPR)-based digital nanoplasmonometry (DiNM). Using this approach, we obtained excellent limits of detection (LODs) of 1.4, 1.5, and 4.5 ppb for the neonicotinoids imidacloprid, acetamiprid, and dinotefuran, respectively. Blind tests demonstrated high positive and negative rates for teas, approximately 85 and 100%, respectively. This method is highly selective and sensitive to neonicotinoids, making it practical for field use.



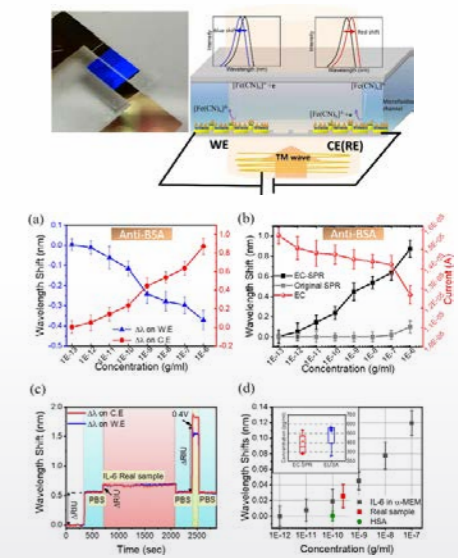
### Dual Gold-Nanoslit Electrodes for Ultrasensitive Detection of Antigen–Antibody Reactions in Electrochemical Surface Plasmon Resonance

Shu-Cheng Lo, Sheng-Hann Wang, Ting-Wei Chang, Kuang-Li Lee, Ruey-Lin Chern, and Pei-Kuen Wei

Academic Sinica, Research Center for Applied Sciences

*ACS Sensors* 2022 7, 2597-2605 DOI: 10.1021/acssensors.2c00850

We present the use of surface charges in dual gold-nanoslit electrodes to improve the surface plasmon resonance (SPR) detection limit by several orders of magnitude. The SPR is directly generated by gold-nanoslit arrays in the two electrodes. The SPR shifts for both nanoslit arrays are measured simultaneously with a simple hyperspectral setup. When biomolecules are captured by specific antibodies on the dual electrodes, the surface charge is changed during the electrochemical process due to the increase in surface impedance. The push-pull-type electrodes generate opposite surface charges. Using the differences in both spectral shifts, the change in surface charge is detected sensitively. We demonstrate that using a  $[\text{Fe}(\text{CN})_6]^{3-/4-}$  redox process after antigen-antibody interactions, the dual nanoslit electrodes show an enhancement of the detection limit from 1  $\mu\text{g}/\text{mL}$  to 10  $\text{pg}/\text{mL}$ .



# Fu-Liang Yang

Distinguished Research Fellow / Professor

## Education

Ph.D., Materials Science and Metallurgy,  
University of Cambridge, UK

## Selected Publications

- 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
- Bitewulign Kassa Mekonnen, Webb Yang, Tung-Han Hsieh, Shien-Kuei Liaw, and Fu-Liang Yang\*, May. 2020 **"Accurate Prediction of Glucose Concentration and Identification of Major Contributing Features from Hardly Distinguishable Near-Infrared Spectroscopy"** Biomedical Signal Processing and Control, Volume 59. DOI: 10.1016/j.bspc.2020.101923
- 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; <https://doi.org/10.3390/diagnostics11040685>
- Yann-Wen Lan1\*, Po-Chun Chen, Yun-Yan Lin, Ming-Yang Li, Lain-Jong Li, Yu-Ling Tu, **Fu-Liang Yang**, Min-Cheng Chen, Kai-Shin Li, Jan. 2019 **"Scalable fabrication of a complementary logic inverter based on MoS2 fin-shaped field effect transistors"** Nanoscale Horizons, DOI: 10.1039/C8NH00419F
- I-Fang Cheng, Hsien-Chang Chang, Tzu-Ying Chen, Chenming Hu, **Fu-Liang Yang**, Aug. 2013, **"Rapid (<5min) Identification of Pathogen in Human Blood by Electrokinetic Concentration and Surface-Enhanced Raman Spectroscopy"**, Scientific Reports, 2365(3),1-8. DOI: 10.1038/srep02365(SCI) (IF: 2.927; SCI ranking: 15.1%)

## Positions and Career

- Distinguished Research Fellow/Professor Research Center for Applied Sciences, Academia Sinica (2013.08-Present)
- Director, Division of Intellectual Property and Technology Transfer, Academia Sinica (2013.08-2016.09)
- Distinguished Research Fellow, National Nano Device Laboratories(NDL), National Applied Research Laboratories(Narlabs) (2008.08-2013.08)
- Director General, National Nano Device Laboratories (2008.08-2013.05)
- TSMC, all in R&D Organization. Deputy Director, 2008; Department Manager, 2002; TSMC Academician, TSMC Academy, 2004; Section Manager, 2000 (2000.03-2008.07)
- Vanguard International Semiconductor Corporation (VIS) Section Manager, Dept. of Device Development, 1998 Principal Integration Engineer, 1996 Senior Process Engineer, 1994 (1994.12-2000.03)

## Honors and Awards

- 2022, "AI Deduction Learning Non-Invasive Blood Glucose Meter" awarded National Innovation Award.
- 2020, "Helix External Counter Pulsation System" awarded National Innovation Award.
- 2012, "A Label-Free Method for the Rapid Identification of Rare-Pathogens from Human Blood (<5min)" awarded National Innovation Award.
- 2004, Outstanding Young Engineer Award from the Chinese Institute of Engineering
- 2004, TSMC Academician of TSMC Academy.
- 2004, TSMC Innovation Award (for <100> boosted PMOS)
- 2006, TSMC Best Invention Disclosures Award(for an outstanding transistor structure invention)

## Research Interests

- Wearable Devices, Pulsation Waveform Characterization and Modulation
- Noninvasive Blood Glucose Measurements via AI Deduction Learning

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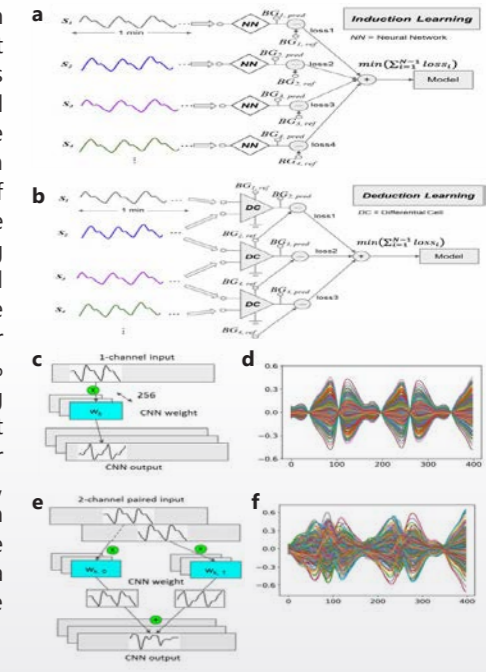
<http://www.rcas.sinica.edu.tw/faculty/flyang.html>

## Research Focus

### Deduction learning for precise noninvasive measurements of blood glucose with a dozen rounds of data for model training

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

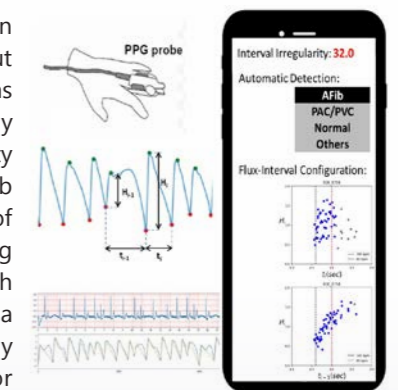
Personalized modeling has long been anticipated to approach precise noninvasive blood glucose (NIBG) measurements, but challenged by limited data for training personal model and its unavoidable outlier predictions. We recently significantly enhanced the training efficiency with the limited personal data by an innovative Deduction Learning (DL), instead of the conventional Induction Learning (IL). DL method involves the use of paired adjacent rounds of finger pulsation Photoplethysmography (PPG) signal recordings as the input to a convolutional-neural-network (CNN) based deep learning model. Our study reveals that CNN filters of DL model generated extra and non-uniform feature patterns than that of IL models. The DL model achieved 80% of test prediction in zone A of Clarke Error Grid (CEG) for model training with 12 rounds of data, which was 20% improvement over IL method. With only a dozen rounds of training data, DL with automatic screening achieved a correlation coefficient ( $R_p$ ) of 0.81, an accuracy score ( $R_A$ ) of 93.5, a root mean squared error (RMSE) of 13.93 mg/dl, a mean absolute error (MAE) of 12.07 mg/dl, and 100% predictions in zone A of CEG. The nonparametric Wilcoxon paired test on  $R_A$  for DL versus IL revealed near significant difference with p-value 0.06. These significant improvements indicate that a very simple and precise noninvasive measurement of blood glucose concentration is achievable.



### Visual Reassessment with Flux-Interval Plot Configuration after Automatic Classification for Accurate Atrial Fibrillation Detection by Photoplethysmography

Justin Chu, Wen-Tse Yang, Yao-Ting Chang\*, and Fu-Liang Yang\*

Atrial fibrillation (AFib) is a common type of arrhythmia that is often clinically asymptomatic, which increases the risk of stroke significantly but can be prevented with anticoagulation. The photoplethysmogram (PPG) has recently attracted a lot of attention as a surrogate for electrocardiography (ECG) on atrial fibrillation (AFib) detection, with its out-of-hospital usability for rapid screening or long-term monitoring. Previous studies on AFib detection via PPG signals have achieved good results, but were short of intuitive criteria like ECG p-wave absence or not, especially while using interval randomness to detect AFib suffering from conjunction with premature contractions (PAC/PVC). In this study, we newly developed a PPG flux (pulse amplitude) and interval plots-based methodology, simply comprising an irregularity index threshold of 20 and regression error threshold of 0.06 for the precise automatic detection of AFib. The proposed method with automated detection on AFib shows a combined sensitivity, specificity, accuracy, and precision of 1, 0.995, 0.995, and 0.952 across the 460 samples. Furthermore, the flux-interval plot configuration also acts as a very intuitive tool for visual reassessment to confirm the automatic detection of AFib by its distinctive plot pattern compared to other cardiac rhythms. The study demonstrated that exclusive 2 false-positive cases could be corrected after the reassessment. With the methodology's background theory well established, the detection process automated and visualized, and the PPG sensors already extensively used, this technology is very user-friendly and convincing for promoted to in-house AFib diagnostics.





# Ji-Yen Cheng

Deputy Director and Researcher

## Education

Ph.D. Department of Chemistry, National Taiwan University (1998)

## Selected Publications

- 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**. ARTN 132923 10.1016/j.snb.2022.132923.
- Belkin, S. and Cheng, J.Y. (2023) Miniaturized bioluminescent whole-cell sensor systems. *Current Opinion in Biotechnology*, **82**. ARTN 102952 10.1016/j.copbio.2023.102952.
- Huang, W.-C., Wei, C.-D., Belkin, S., Hsieh, T.-H. and Cheng, J.-Y. (2022) Machine-learning assisted antibiotic detection and categorization using a bacterial sensor array. *Sensors and Actuators B: Chemical*, **355**, 131257.
- Chien, T.Y., Marin-Benavides, R., Belkin, S. and Cheng, J.Y. (2022) Rapid printing of a Bacterial array for a Solid-Phase Assay (BacSPA) of heavy metal ions. *Sensor Actuat B-Chem*, 359.
- 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.
- Chang, H.F., Chou, S.E. and Cheng, J.Y. (2021) Electric-Field-Induced Neural Precursor Cell Differentiation in Microfluidic Devices. *Jove-J Vis Exp*.
- Yeung, W.K., Li, H.-F., Chung, C.-L., Lee, K.-L., Wei, P.-K., Lin, H., Chen, H.-H. and Cheng, J.-Y. (2020) Promising urinary miRNA biomarkers t-SPR profiling for urothelial cell carcinoma. *Sensors and Actuators B: Chemical*, **322**, 128605.
- Tsai, H.-F., Tsai, Y.-C., Yagur-Kroll, S., Palevsky, N., Belkin, S. and Cheng, J.-Y. (2015) Water pollutant monitoring by a whole cell array through lens-free detection on CCD. *Lab Chip*, **15**, 1472-1480.
- Wang, C.-C., Ka, Y.-C., Chi, P.-Y., Huang, C.-W., Lin, J.-Y., Chou, C.-F., Cheng, J.-Y. and Lee, C.-H. (2011) Asymmetric cancer-cell filopodium growth induced by electric-fields in a microfluidic culture chip. *Lab Chip*, **11**, 695-699.
- Hsu, T.-H., Yen, M.-H., Liao, W.-Y., Cheng, J.-Y. and Lee, C.-H. (2009) Label-free quantification of asymmetric cancer-cell filopodium activities in a multi-gradient chip. *Lab Chip*, **9**, 884-890.
- Cheng, J.-Y., Yen, M.-H., Kuo, C.-T. and Young, T.-H. (2008) A transparent cell culture microchamber with variably controlled concentration gradient generator and flow field rectifier. *Biomicrofluidics*, **2**, 024105.
- Wei, C.-W., Cheng, J.-Y., Huang, C.-T., Yen, M.-H. and Young, T.-H. (2005) Using a microfluidic device for 1 microliter DNA microarray hybridization in 500 seconds. *Nucleic Acids Research Methods*, **33**, e78.

## Positions and Career

Deputy Director, RCAS, Academia Sinica Taiwan, 2023  
Executive Officer of the TCBMA (Thematic Center of Bio & Medical Applications) 2021 ~  
Executive Officer of the TCMEs (Thematic Center of Mechanics and Engineering Sciences) 2015 ~  
Research Fellow, RCAS, Academia Sinica Taiwan, 2013  
Associate Research Fellow, RCAS, Academia Sinica Taiwan, 2007  
Assistant Research Fellow, RCAS, Academia Sinica Taiwan, 2001  
Postdoctoral Fellow, Institute of Biomedical Sciences, Academia Sinica Taiwan, 1998

Adjunct Professor, National Taiwan Ocean University  
Adjunct Professor, National Yang Ming Chiao Tung University

## Honors and Awards

- Cell-based micro analysis: cell responses in weak DC EF, cell-cell interaction co-culture chip, cellular chemotaxis, electrotaxis and metastasis, affinity binding and separation.
- Microfluidic biochip and their applications in biosensing.
- Microarray technologies: flexible in-situ array synthesis, rapid hybridization, mRNA labeling chip, and portable DNA amplification chip.

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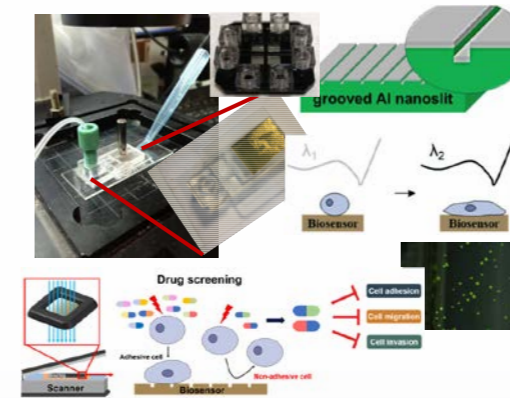
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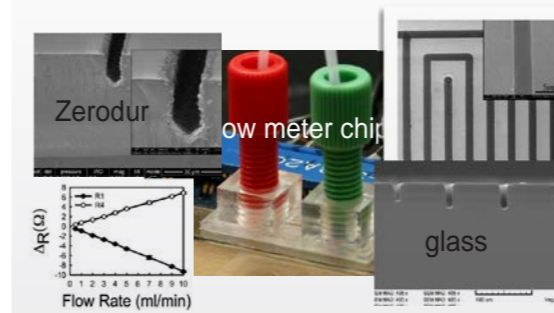
## Research Focus

### Research Highlight -1/2

**Cell adhesion quantification by nanostructure SPR**  
*Biosensor 2015, 2019; Sci.Rpt. 2019; Lab-on-chip. 2021.*

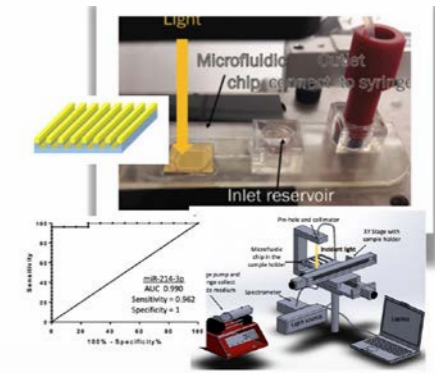


**Laser microfabrication/Microfluidic flow sensor**  
*JMM 2007, 2011; JLMN 2013, 2106; J. Laser App. 2020*

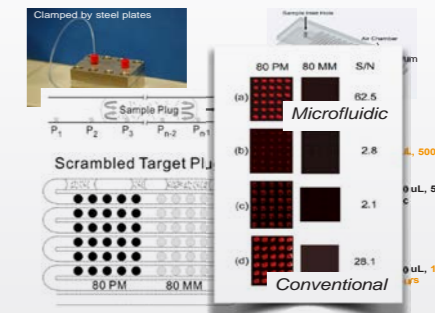


**Urinary cancer biomarker detection using nanostructure SPR**

*Analyst 2013, 2015, 2018, 2021; SnB 2020*



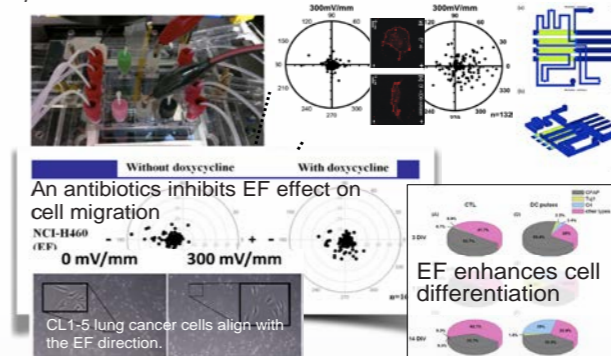
**10 min DNA hybridization in microfluidic chip**  
*Nucl. Acid. Res. 2005; Biotech. Bioeng. 2009*



### Research Highlight -2/2

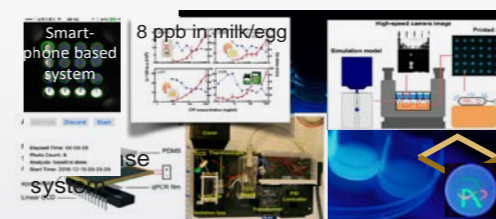
**Migration and differentiation of adherent cells in EF**

*Biomicrofluidics, 2008, 2009, 2012, 2014, 2015; Lab-on-a-chip 2009; PlosOne 2011, 2013; Sci. Rpt. 2019, JoVE 2015, 2016, 2021*



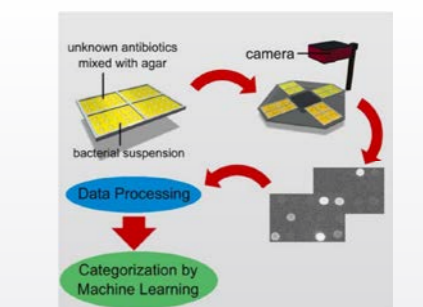
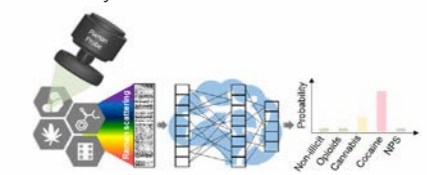
**Antibiotics detection and characterization using whole-cell biosensor,**

*Lab-on-a-chip 2015; Anal. Bioanl. Chem. 2018; SnB, 2022.*



**AI-assisted categorization of illicit drugs and antibiotics,**  
*SnB, 2021; 2022*

Portable Raman spectral imaging system and machine-learning model assists in predicting different illicit drugs with high accuracy.



AI assisted antibiotics categorization using bacterial array.

# Chau-Hwang Lee

Research Fellow

Education | Ph.D. Electrical Engineering, National Taiwan University (1997)

## Selected Publications

- 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).
- 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).
- 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).
- Y.-C. Kao, Z.-H. Chen, W.-Y. Wang, C.-H. Lee, and P.-L. Kuo, "Hydrostatic pressure promotes migration and filamin-A activation in fibroblasts with increased p38 phosphorylation and TGF- $\beta$  production," *Biochemical and Biophysical Research Communications* **568**, 15-22 (2021).
- 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).
- Y.-C. Kao, Y.-C. Liao, P.-L. Cheng, and C.-H. Lee, "Neurite regrowth stimulation by a red-light spot focused on the neuronal cell soma following blue light-induced retraction," *Scientific Reports* **9**, 18210 (2019).
- C.-W. Lee, Y.-L. Chiang, J.-T. Liu, Y.-X. Chen, C.-H. Lee, Y.-L. Chen, and I.-S. Hwang, "Emerging roles of air gases in lipid bilayers," *Small* **14**, 1802133 (2018).
- Y.-C. Kao, J.-R. Jheng, H.-J. Pan, W.-Y. Liao, C.-H. Lee, and P.-L. Kuo, "Elevated hydrostatic pressure enhances the motility and enlarges the size of the lung cancer cells through aquaporin upregulation mediated by caveolin-1 and ERK1/2 signaling," *Oncogene* **36**, 863-874 (2017).
- C.-H. Chang, H.-H. Lee\*, and C.-H. Lee, "Substrate properties modulate cell membrane roughness by way of actin filaments," *Scientific Reports* **7**, 9068 (2017).
- C.-W. Lee, C.-C. Wang, and C.-H. Lee, "Mechanoprofiling on membranes of living cells with atomic force microscopy and optical nano-profilometry," *Advances in Physics: X* **2**, 608-621 (2017).

## Positions and Career

- Director, Research Center for Critical Issues, Academia Sinica (2024–Present)
- Deputy Executive Secretary, Central Academic Advisory Committee, Academia Sinica (2016–Present)
- Deputy Director, Research Center for Applied Sciences, Academia Sinica (2014–2016)
- Chairman, Institute of Biophotonics, National Yang Ming Chiao Tung University (2011–2014)
- Joint-appointment Professor, Institute of Biophotonics, National Yang Ming Chiao Tung University (2011–Present)
- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2010–Present)
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2004–2010)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2000–2004)
- Postdoctoral Research Associate, Institute of Atomic and Molecular Sciences, Academia Sinica (1997–2000)

## Honors and Awards

- 2012 Academia Sinica Junior Investigator Award.
- 2010 Dr. Ta-You Wu Memorial Award, National

## Research Interests

- Optical microscopy and related techniques
- Cell–cell and cell–microenvironment interactions
- Biomedical applications of microfluidic devices

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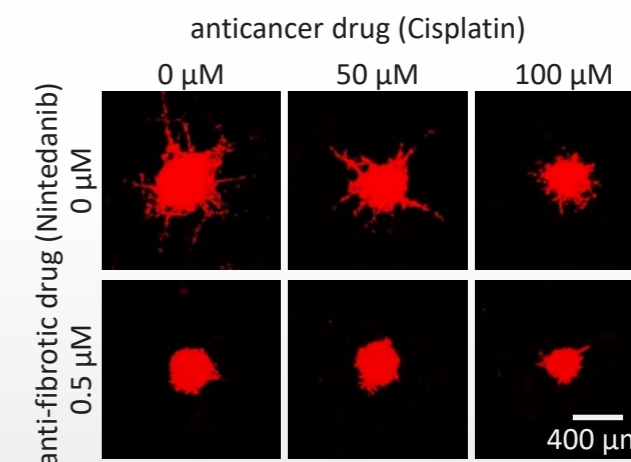
## Research Focus

### 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, 2023, DOI: 10.1063/5.0115464

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.

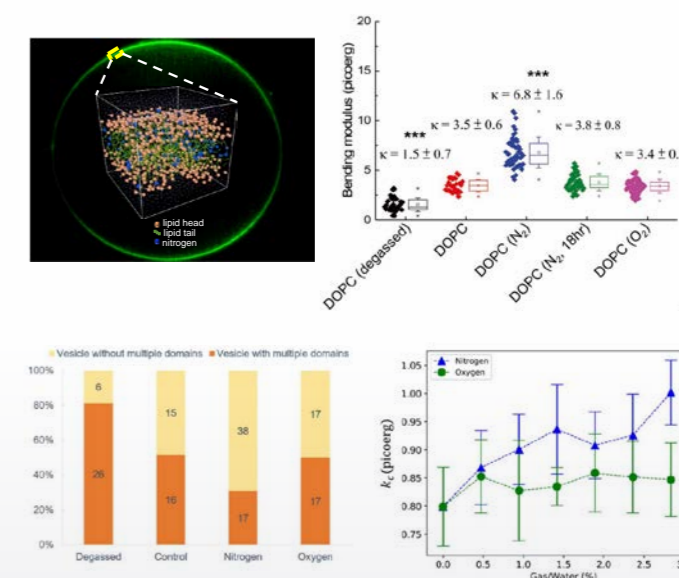


### Emerging roles of air gases in lipid bilayers

C.-W. Lee, Y.-L. Chiang, J.-T. Liu, Y.-X. Chen, C.-H. Lee, Y.-L. Chen, and I.-S. Hwang

Institute of Physics and Research Center for Applied Sciences, Academia Sinica  
Small, 2018, DOI: 10.1002/sml.201802133

We collaborated with Dr. Ing-Shouh Hwang and Dr. Yeng-Long Chen of Institute of Physics, Academia Sinica, to study the influences of dissolved air gases on lipid bilayers in aqueous solutions. Experimental measurements were based on differential confocal microscopy (DCM) and fluorescence microscopy on giant unilamellar lipid vesicles, as well as atomic force microscopy (AFM) on supported lipid bilayers. In comparison to lipid bilayers in ambient solutions (without gas control), the bilayers in degassed solutions are softer and less stable. High concentrations of  $N_2$  increase the bending moduli and stability of the lipid bilayers, and impede phase separation in ternary lipid bilayers. Molecular dynamic simulations found that  $N_2$  accumulates in the lipid bilayer, and higher  $N_2$  affinity to the lipid tails accounts for increased bending rigidity. The results imply that dissolved air gases may affect the properties of similar bilayer structures, such as cell membranes, in aqueous solutions.



# Jung-Hsin Lin

Research Fellow

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

## Selected Publications

1. 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) DOI: 10.3389/fmolb.2022.879000.
2. Dhananjay C. Joshi and Jung-Hsin Lin\*, "Delineating protein-protein curvilinear dissociation pathways and energetics with naïve multiple-walker umbrella sampling simulations", *J. Comput. Chem.* 40: 1652-1663 (2019) DOI:10.1002/jcc.25821
3. Yu-Hsuan Chen and Jung-Hsin Lin\*, "Can ligands of different functional types induce distinct dynamics in G protein-coupled receptors?" *Curr. Top. Med. Chem.* 17: 2370-2380 (2017)
4. Jung-Hsin Lin\*, "Structure- and dynamics-based computational design of anticancer drugs", *Biopolymers* 105: 2-9 (2016)
5. Nanlan Huang and Jung-Hsin Lin\*, "Recovery of the poisoned topoisomerase II for DNA religation: coordinated motion of the cleavage core revealed with the microsecond atomistic simulation", *Nucleic Acids Res.* 43: 6772-6786 (2015)
6. Nan-Lan Huang and Jung-Hsin Lin\*, "Drug-Induced conformational population shifts in topoisomerase-DNA ternary complexes". *Molecules* 15: 7415-7428 (2014)
7. Jhih-Bin Chen, Ting-Rong Chern, Tzu-Tang Wei, Ching-Chow Chen, Jung-Hsin Lin\*, and Jim-Min Fang\*. "Design and synthesis of dual-action inhibitors targeting histone deacetylases and HMG-CoA reductase for cancer treatment." *J. Med. Chem.* 56: 3645-3655 (2013)
8. Jui-Chih Wang and Jung-Hsin Lin\*, "Scoring functions for prediction of protein-ligand interactions", *Curr. Pharm. Des.* 19: 2174-2182 (2013)
9. Jung-Hsin Lin\*. "Target prediction of small molecules with information of key molecular interactions.", *Curr. Top. Med. Chem.* 12: 1903-1910 (2012)
10. 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)

## Positions and Career

- Chief Executive Officer, Thematic Center for Intelligence Medicine, Biomedical Translation Research Center, Academia Sinica (2021 - )
- Deputy Director, Biomedical Translation Research Center, Academia Sinica (2020 - )
- Editorial Board, *ChungHwa Pharmacopoeia*, Ministry of Health and Welfare, (2019 - )
- Review Panel, Division of Physics, Department of Natural Sciences and Sustainable Development, Ministry of Science and Technology (2019 - 2022)
- Delegate of Division of Mathematical and Physical Sciences, General Assembly of Academia Sinica (2017-2021)
- Deputy Director, Research Center for Applied Sciences, Academia Sinica (2019-2020)
- Chief Executive Officer, Thematic Center for Biomedical Applications, Research Center for Applied Sciences, Academia Sinica (2015-2020)
- Joint Appointment, College of Engineering Science, Chang Gung University (2015- )
- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2014- )
- Joint Appointment, School of Pharmacy, College of Medicine, National Taiwan University (2006 - )
- Joint Appointment, Institute of Biomedical Sciences, Academia Sinica (2004 - )
- Assistant Professor, School of Pharmacy, College of Medicine, National Taiwan University (2003 - 2006 )
- Bioinformatics Specialist, Howard Hughes Medical Institute, University of California at San Diego, U.S.A. (2000 - 2002)
- Postdoctoral Research, John von Neuman Institute of Computing, Forschungszentrum Jülich, Germany (2000 - 2000)

## Honors and Awards

- 2019 Investigator Award, Academia Sinica

## Research Interests

- Pharmacoinformatics
- Structural Biophysics
- Large-scale all-atom molecular dynamics simulations
- Computational drug discovery

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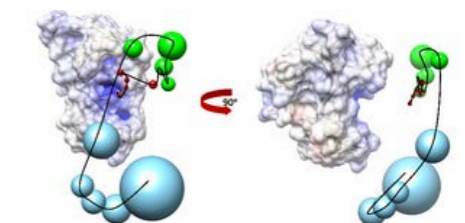
## Research Focus

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

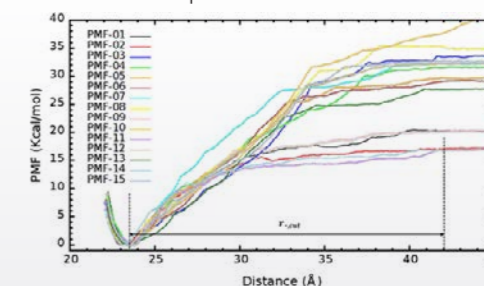
Dhananjay C. Joshi, Jung-Hsin Lin\*

Academia 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.



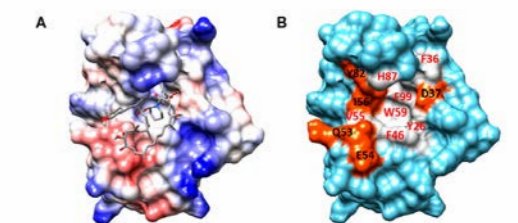
A variational principle-based approach was adopted to selected the PMF.

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

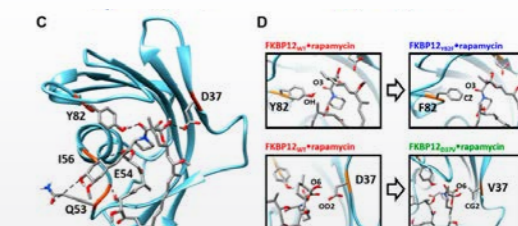
Dhananjay C. Joshi, Charlie Gosse, Shu-Yu Huang and Jung-Hsin Lin\*

Academia Sinica, Research Center for Applied Sciences  
*Front. Mol. Biosci.* 9: 879000 (2022) DOI: 10.3389/fmolb.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.



# Jing-Jong Shyue

Research Fellow

## Education

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

## Selected Publications

- 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).
- 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).
- 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).
- 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).
- 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).
- PH Ho,\* JR Chang, CH Chen, CH Hou, CH Chiang, MC Shih, HC Hsu, WH Chang, **JJ Shyue**, YP Chiu\* and CW Chen\* "Hysteresis-Free Contact Doping for High-Performance Two-Dimensional Electronics" *ACS Nano* **17** [3] 2653-2660 (2023).
- P Chen, Y Xiao, L Li, LC Zhao\*, MT Yu, SD Li, JT Hu, B Liu, YG Yang, DY Luo, CH Hou, XG Guo, **JJ Shyue**, ZH Lu, QH Gong, HJ Snaith\* and R Zhu\* "Efficient Inverted Perovskite Solar Cells via Improved Sequential Deposition" *Adv. Mater.* **35** [5] 2206345 (2023).
- CH Kuan, JM Chih, YC Chen, BH Liu, CH Wang, CH Hou, **JJ Shyue** and EWG Diau\* *ACS Energy Lett.* **7** 4436-4442 (2022).
- KW Tsai, G Madhaiyan, LH Lai, YT Hsiao, JL Wu, CY Liao, CH Hou\*, **JJ Shyue\*** and YM Chang\* *ACS Appl. Mater. Interfaces* **14** [33] 38004-38012 (2022).
- TK Su, WK Cheng, CY Chen, WC Wang, YT Chuang, GH Tan, HC Lin, CH Hou, CM Liu, YC Chang, **JJ Shyue**, KC Wu, and HW Lin\* *ACS Nano* **16** [8] 12979-12990 (2022).
- N Sun, BV Tran, ZS Peng, J Wang, C Zhang, P Yang, TX Zhang, J Widjaja, RY Zhang, WX Xia, A Keir, JW She, HH Yu, **JJ Shyue**, HG Zhu, VG Agopian, RJ Pei,\* JS Tomlinson, JA Toretzky, SJ Jonas, N Federman, SH Lu,\* HR Tseng,\* and YZ Zhu *Adv. Sci.* **9** [14] 2105853 (2022).
- HH Tsai,\* HH Huang, J Watt, CH Hou, J Strzalka, **JJ Shyue**, LY Wang and WY Nie\* *Adv. Sci.* **9** [14] 2105850 (2022).

## Positions and Career

- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2015–Present)
- Professor, Department of Materials Science and Engineering, National Taiwan University (2015–Present)
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2010–2015)
- Associate Professor, Department of Materials Science and Engineering, National Taiwan University (2011–2015)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2006–2010)
- Assistant Professor, Department of Materials Science and Engineering, National Taiwan University (2007–2011)
- Adjunct Assistant Professor, Department of Chemistry, National Taiwan University (2006–2007)

## Honors and Awards

- Research Project of Outstanding Young Scholar (優秀年輕學者研究計劃), Ministry of Science and Technology, 2014.
- Ta-You Wu Memorial Award (吳大猶先生紀念獎), National Science Council, 2013.
- Career Development Award (前瞻計劃), Academia Sinica, 2012-2016.

## Research Interests

- Functional materials (for electronic, chemical and biomedical applications).
- Synthesis and processing of materials (self-assembly, interface chemistry).
- Microcharacterization (surface analysis, electron/ion spectroscopy/microscopy).
- Computer programming, numerical simulation and scientific modeling.

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## Research Focus

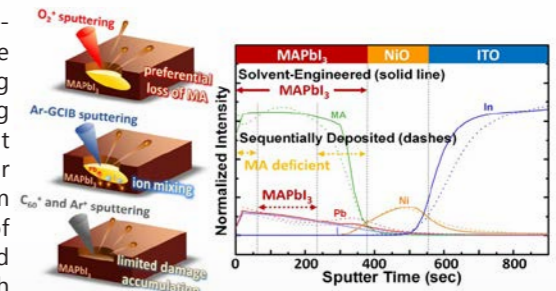
### Validated Analysis of Component Distribution Inside Perovskite Solar Cells and Its Utility in Unveiling Factors of Device Performance and Degradation

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/acsaami.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  $Ar^+$  ionbeams 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)

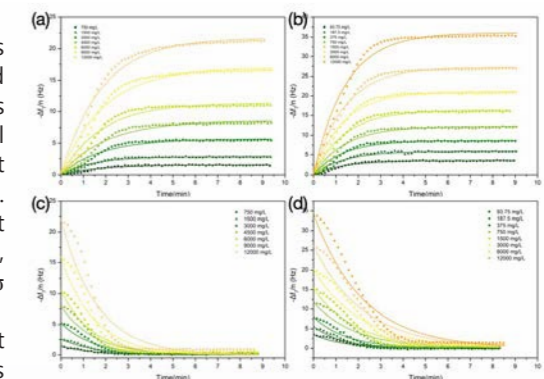
Wen-Yi Yu and Jing-Jong Shyue\*

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  $\pi$ - $\pi$  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.





# Yi-Chung Tung

Research Fellow

## Education

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

## Selected Publications

1. D.-M. Chang, H.-H. Hsu, P.-L. Ko, T.-H. Hsieh, H.-M. Wu\*, and Y.-C. Tung\*, "Rapid Time-Lapse 3D Oxygen Tension Measurement within Hydrogels Using Widefield Frequency Domain Fluorescence Lifetime Imaging Microscopy (FD-FLIM) and Image Segmentation," *Analyst*, Vol. 149, Issue 6, pp. 727-1737, March 2024. (Featured as the back cover image)
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. Y.-C. Tung, C.-K. Wang, Y.-K. Huang, C.-K. Huang, C.-C. Peng, B. Patra, H.-K. Chen, P.-N. Tsao\*, and T.-Y. Ling\*, "Identifying Distinct Oxygen Diffusivity through Type I Pneumocyte-Like Cell Layers Using Microfluidic Device," *Talanta*, Vol. 236, 122882, January 2022.
6. Y.-C. Chen, J.-J. Chen, Y.-J. Hsiao, C.-Z. Xie, C.-C. Peng, Y.-C. Tung\*, and Y.-F. Chen\*, "Plasmonic Gel Films for Time-Lapse LSPR Detection of Hydrogen Peroxide Secreted from Living Cells," *Sensors and Actuators B: Chemical*, Vol. 336, 129725, June 2021.
7. 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)
8. H.-C. Shih, T.-A. Lee, H.-M. Wu, P.-L. Ko, W.-H. Liao, and Y.-C. Tung\*, "Microfluidic Collective Cell Migration Assay for Study of Endothelial Cell Proliferation and Migration under Combinations of Oxygen Gradients, Tensions, and Drug Treatments," *Scientific Reports*, Vol. 9, 8234, June 2019.
9. H.-M. Wu, T.-A. Lee, P.-L. Ko, W.-H. Liao, T.-H. Hsieh, and Y.-C. Tung\*, "Widefield Frequency Domain Fluorescence Lifetime Imaging Microscopy (FD-FLIM) for Accurate Measurement of Oxygen Gradients within Microfluidic Devices," *Analyst*, Vol. 144, Issue 11, pp. 3494-3504, June 2019. (Featured as the inside back cover image)

## Positions and Career

- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2018 - )
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2013 - 2018)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2009 - 2013)
- Postdoctoral Research Fellow, Department of Biomedical Engineering, University of Michigan, Ann Arbor, USA (2006 - 2009)

## Honors and Awards

- 2020-2022 Scientist with Top 2% Single Year Impact
- 2018 Project for Excellent Junior Research Investigators, Taiwan Ministry of Science and Technology (MOST)
- 2016 Career Development Award, Academia Sinica
- 2016 Top 10% Highly Cited Author, Analytical Portfolio of Royal Society of Chemistry (RSC) Journals
- 2014 Ta-You Wu Memorial Award, Taiwan Ministry of Science and Technology (MOST)

## Research Interests

- Microfluidic Cell Culture and Analysis/Biomedical Instruments
- Advanced Micro/Nano Fabrication Techniques

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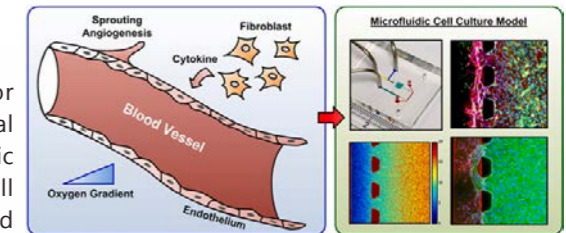
[https://www.rcas.sinica.edu.tw/web/mem\\_faculty/Tung\\_YiChung.html](https://www.rcas.sinica.edu.tw/web/mem_faculty/Tung_YiChung.html)

## Research Focus

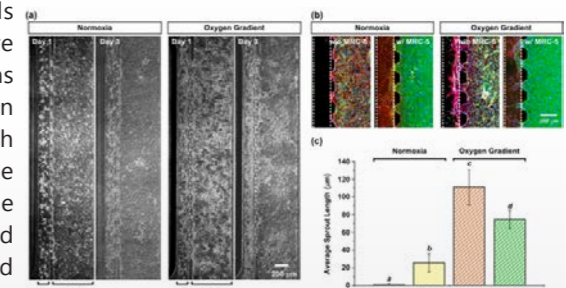
### Studying sprouting angiogenesis under combination of oxygen gradients and co-culture of fibroblasts using microfluidic cell culture model

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 an essential process for expanding vascular systems under various physiological and pathological conditions. In this paper, a microfluidic device capable of integrating a hydrogel matrix for cell culture and generating stable oxygen gradients is developed to study the sprouting angiogenesis of endothelial cells under combinations of oxygen gradients and co-culture of fibroblast cells. The endothelial cells can be cultured as a monolayer endothelium inside the device to mimic an existing blood vessel, and the hydrogel without or with fibroblast cells cultured in it provides a matrix next to the formed endothelium for three-dimensional sprouting of the endothelial cells. Oxygen gradients can be stably established inside the device for cell culture using the spatially-confined chemical reaction method. The results show that the oxygen gradient and the co-culture of fibroblast cells in the hydrogel can promote sprouting of the endothelial cells into the hydrogel matrix by altering cytokines in the culture medium and the physical properties of the hydrogel. The developed device provides a powerful in vitro model to investigate sprouting angiogenesis under various in vivo-like microenvironments.

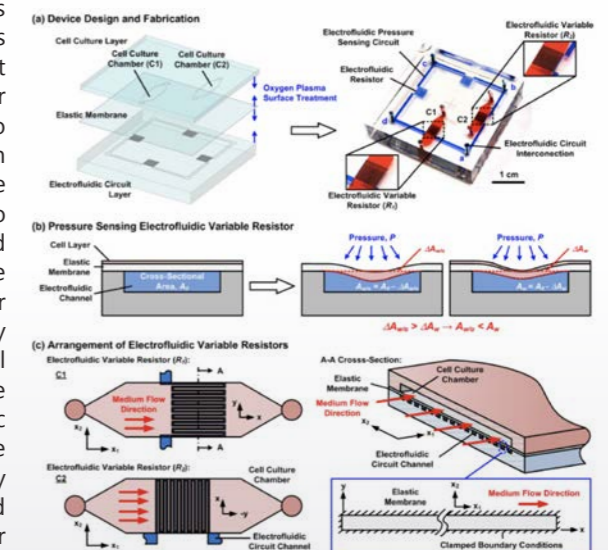


### Revealing anisotropic elasticity of endothelium under fluid shear stress

Ping-Liang Ko, Chien-Kai Wang, Heng-Hua Hsu, Tse-Ang Lee, and Yi-Chung Tung\*

Academic Sinica, Research Center for Applied Sciences  
*Acta Biomaterialia* 2022, DOI: 10.1016/j.actbio.2022.03.040

Endothelium lining interior surface of blood vessels experiences various physical stimulations *in vivo*. Its physical properties, especially elasticity, play important roles in regulating the physiological functions of vascular systems. An integrated approach is developed to characterize the anisotropic elasticity of the endothelium under physiological-level fluid shear stress. A pressure sensor-embedded microfluidic device is developed to provide fluid shear stress on the perfusion-cultured endothelium and to measure transverse in-plane elasticities in the directions parallel and perpendicular to the flow direction. Biological atomic force microscopy (Bio-AFM) is further exploited to measure the vertical elasticity of the endothelium in its out-of-plane direction. The results show the highly anisotropic physical properties of the endothelium. The quantitative measurement of the endothelium anisotropic elasticity in different directions at the tissue level under the fluid shear stress provides biologists insightful information for the advanced vascular system studies from biophysical and biomaterial viewpoints.





# Chih-Yu Kuo

Research Fellow

Education | Ph.D. Engineering, Cambridge University, UK (1998)

## Positions and Career

- Adjunct Professor, Department of Civil Engineering, National Taiwan University, (2021 – )
- Research Fellow, Research Center for Applied Sciences, Academia Sinica (20017 – )
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2013 – 2017)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2006 – 2013)
- Senior RD Engineer, Synopsys Co. (2005 – 2006)
- Senior RD Engineer, Nassda Co. (2000 – 2005)
- Research Associate, Department of Engineering, Cambridge University, UK (1998 – 2000)

## Honors and Awards

- 2020 research paper award, Journal of Chinese Soil Water Conservation
- 2018 research paper award, Journal of Chinese Soil Water Conservation
- 2013 research paper award, Journal of Mechanics

## Research Interests

- Slope stability monitoring
- Failure surface analysis and inversion
- Debris flow, fluid mechanics, granular flows, plasticity
- Wind resource assessments, Acoustics

## Selected 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. Hsiao, (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.
6. S. Alexandrov, Chih-Yu Kuo, Y. R. Jeng (2018). An accurate numerical solution for the singular velocity field near the maximum friction surface in plane strain extrusion. *Int. J. Solids and Struct.*, **150**, 107-116.
7. I. Luca, Y. C. Tai, Chih-Yu Kuo. *Shallow geophysical mass flows down arbitrary topography*. Switzerland: Springer, 2016.
8. Chih-Yu Kuo, K.-J. Chang, P.-W. Tsai, S.-K. Wei, R.-F. Chen, J.-J. Dong, C.-M. Yang, Y.-C. Chan, Y.-C. Tai (2015). Identification of co-seismic ground motion due to fracturing and impact of the Tsaoing landslide, Taiwan. *Eng. Geo.*, **196**, 268-279.
9. S. Alexandrov, Chih-Yu Kuo, Y.-R. Jeng (2015). A numerical method for determining the strain rate intensity factor under plane strain conditions, *Conti. Mech. Thermodyn.*, **28**, 977-992.
10. Chih-Yu Kuo, L.-T. Sheng, S.-Y. Chiu, Y.-Z. Yang, Y.-C. Tai, S.-S. Hsiao (2015). Measurement and discrete element simulation of a fixed-obstacle disturbed rapid granular chute flow. *Phys. Fluids*, **27**, 013305.
11. W. C. Chen, Chih-Yu Kuo, K.-M. Shyue, Y.-C. Tai (2013). Gas kinetic scheme for anisotropic Savage-Hutter model. *Comm. Comput. Phys.*, **13**, 1432-1454.

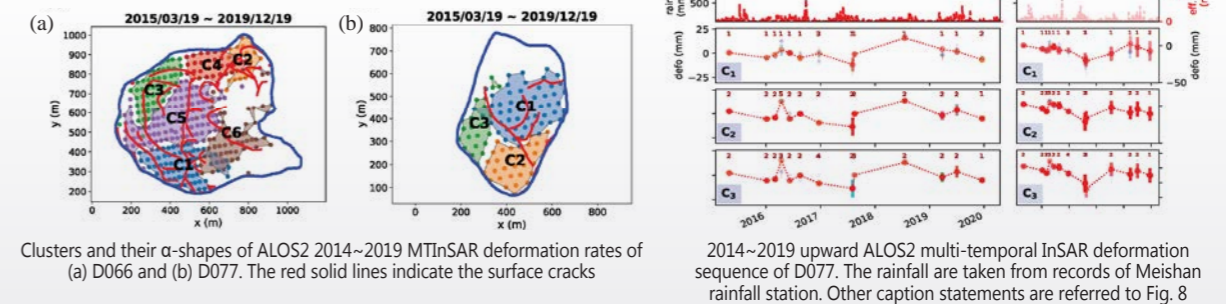
## Research Focus

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

Pi-Wen Tsai, Chih-Yu Kuo<sup>1</sup>, Rou-Fei Chen

<sup>1</sup>Academic 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.



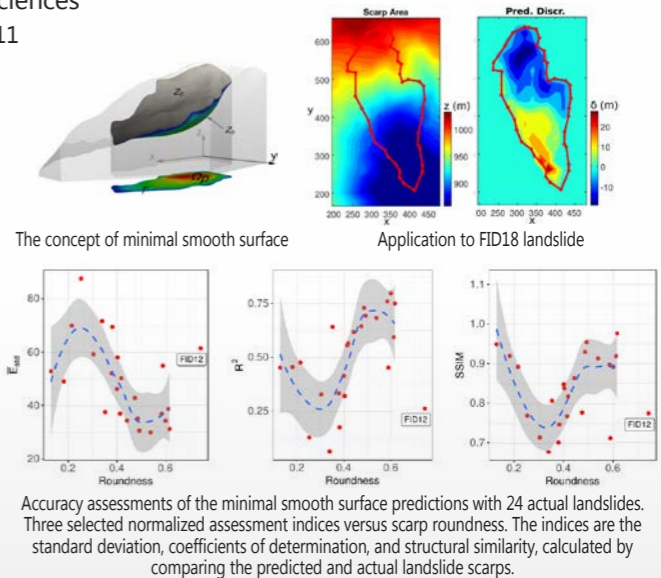
### Application assessments of using scarp boundary-fitted, volume constrained, smooth minimal surfaces as failure interfaces of deep-seated landslides

Chih-Yu Kuo<sup>1</sup>, P.W. Tsai, Y. C. Tai, Y. H. Chan, R. F. Chen, C. W. Lin

<sup>1</sup>Academic 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.



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# Bi-Chang Chen

Associate Research Fellow

## Education

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

## Selected Publications

1. W.-C. Tang, Y.-T. Liu, C.-H. Yeh, Y.-L. Lin, Y.-C. Lin, T.-L. Hsu, L. Gao, P. Chen\*, 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)
2. Fan, Y.-J.\*; Hsieh, H.-Y.; Huang, Y.-R.; Tsao, C.; Lee, C.-M.; Tahara, H.; Wu, Y.-C.; Sheen, H.-J.\*; **Chen, B.-C.\***, "Development of a water refractive index-matched microneedle integrated into a light sheet microscopy system for continuous embryonic cell imaging", *Lab on a chip*, 22, 584-591 DOI:10.1039/D1LC00827G (2022)
3. Lin, M.-H., Chen, J.-C., Tian, X., Lee, C.-M., Yu, I.-S., Lo, Y.-F., Uchida, S., Huang, C.-L., **Chen, B.-C.\***; Cheng, C.-J.\*, "Impairment in renal medulla development underlies salt wasting in Clc-k2 channel deficiency", *JCI Insight*, 9:151039 ; DOI:10.1172/jci.insight (2021) selected as the cover image
4. Fan, Y.-J.\*; Hsieh, H.-Y., Tsai, S.-F., Wu, C.-H., Lee, C.-M., Liu, Y.-T., Lu, C.-H., Chang, S.-W.\*; **Chen, B.-C.\***, "Microfluidic channel integrated with a lattice lightsheet microscopic system for continuous cell imaging" *Lab on a chip*, 21, 344 DOI: 10.1039/d0lc01009j (2021)
5. Tsai, Y.-C.; Tang, W.-C.; Low, C. S. L.; Liu, Y.-T.; Wu, J.-S.; Lee, P.-Y.; Lin, Y.-L.; Kanchanawong, P.; Gao, L, and **Chen, B.-C.\*** "Rapid High Resolution 3D Imaging of Expanded Biological Specimens with Lattice Lightsheet Microscopy", *Methods*, 174, 11-19 DOI:10.1016/j.jymeth.2019.04.006 (2020)
6. 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)
7. 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)
8. Gao, L. \*; Tang, W.-C.; Tsai, Y.-C.; **Chen, B.-C.\*** "Lattice light sheet microscopy using tiling lattice light sheets" *Opt. Express*, 27 1497-1506 DOI:10.1364/OE.27.001497. (2019)

## Positions and Career

- Associate Research Fellow, Research Center for Applied Sciences Academia Sinica (2020–Present)
- Assistant Research Fellow, Research Center for Applied Sciences Academia Sinica (2014–2020)
- Postdoctoral Associate, Howard Hughes Medical Institute/Janelia Research Campus, USA (2011–2014)

## Honors and Awards

- The 2015 AAAS Newcomb Cleveland Prize
- 2020 18th Y. Z. Hsu Science Paper Award, Optoelectronics Science & Technology Category
- 2021 Academia Sinica Early-Career Investigator Research Achievement Award

## Research Interests

- Super-resolution fluorescence imaging
- Fast 3D live imaging
- Developing Lightsheet microscopy technique
- Imaging on the expanded clarified tissue

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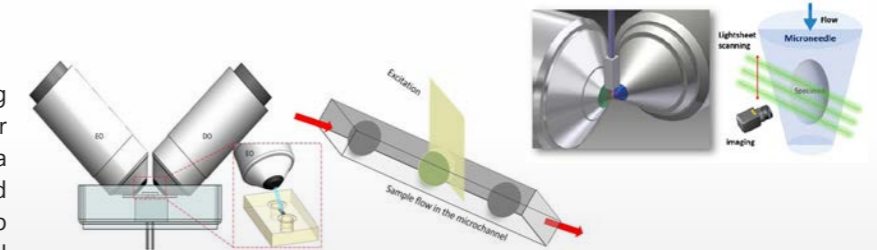
## Research Focus

### Microfluidic channel integrated with lightsheet microscopic system for continuous live 3D imaging

Fan, Y.-J.\* , Hsieh, H.-Y., Tsai, S.-F., Wu, C.-H., Lee, C.-M., Liu, Y.-T., Lu, C.-H., Chang, S.-W.\* , Chen, B.-C.\*

Academic Sinica, Research Center for Applied Sciences  
*Lab on a chip* **21**, 344 (2021)  
*Lab on a chip* **22**, 584 (2022)

A continuous live imaging system with subcellular resolution by integrating a water refractive index-matched microfluidic device was developed to achieve high spatiotemporal resolutions in 3D.

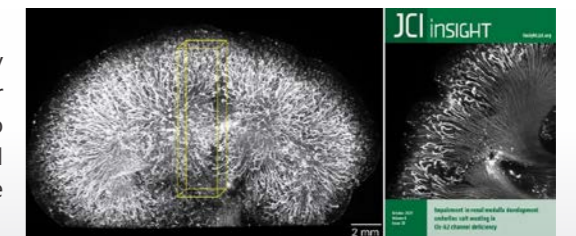


### Lightsheet expansion microscopy for 3D super-resolution imaging in the organ

Lin, M.-H., Chen, J.-C., ..., Chen, B.-C.\*; Cheng, C.-J.\*

*JCI Insight*, 9, 151039 (2021)

We have expanded isotropically the mouse kidney by 4x expansion microscopy and imaged such a centimeter sized sample at high speed by lightsheet microscopy to approach high spatial resolution of the immunolabeled thick ascending limb of Henle's loop within the whole organ.

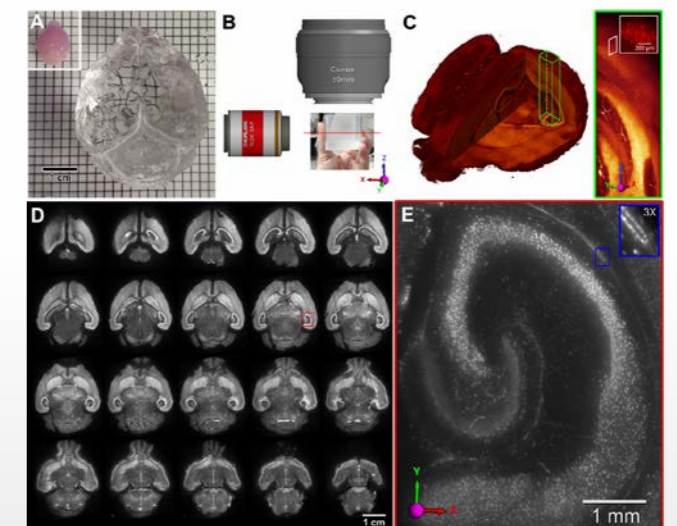


### Macro Photography with Lightsheet Illumination Enables Whole Expanded Brain Imaging with Single-cell Resolution

Lee, C.-M., Tian, X., Tsao, C., Chen, P. Huang, T.-N., Hsueh, Y.-P., Chen, B.-C.\*

Academic Sinica, Research Center for Applied Sciences  
*Discoveries Journals*, Jul-Sep, **9(3)**:e133  
DOI:10.15190/d.2021.12 (2021)

Macro photography allows direct visualization of enlarged whole mouse brain by a combination of lightsheet illumination and expansion microscopy with single-cell resolution. Taking advantage of the long working distance of a macro lens, we imaged a 3.7-cm thick, transparent, fluorescently-labeled expanded brain. In order to improve 3D sectioning capability, we used lightsheet excitation confined as the depth of field of the macro lens. Using 4x sample expansion and 5x optical magnification, macro photography enables imaging of expanded whole mouse brain with an effective resolution of 300 nm.





# Yu-Jung Lin

Assistant Research Fellow

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

## Positions and Career

- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica, Taiwan (2020-Present)
- Postdoctoral Fellow, Department of Chemical Engineering, National Tsing Hua University, Taiwan (2015-2020)

## Honors and Awards

- 2022 Cross-Generation Young Scholars Program (Emerging Young Scholars), National Science and Technology Council, Taiwan
- 2020 Young Investigator Award, Prof. Chau-Jen Lee Biomedical Engineering Development Foundation, Taiwan
- 2019 Best Research Paper Award for Postdoctoral Fellows, Ministry of Science and Technology, Taiwan

## Research Interests

- Development of drug delivery systems
- Development of therapeutic gas-generating systems

## Selected 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 H<sub>2</sub> storage system as an in situ H<sub>2</sub>/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.
6. Mac, C. H., Chan, H. Y., Lin, Y. H., Sharma, A. K., Song, H. L., Chan, Y. S., Lin, K. J., **Lin, Y. J.\***, Sung, H. W.\* Engineering a biomimetic bone scaffold that can regulate redox homeostasis and promote osteogenesis to repair large bone defects. *Biomaterials* 2022, 286, 121574.
7. Miao, Y. B.†, **Lin, Y. J.†**, Chen, K. H.†, Luo, P. K., Chuang, S. H., Yu, Y. T., Tai, H. M., Chen, C. T., Lin, K. J., Sung, H. W. Engineering nano- and microparticles as oral delivery vehicles to promote intestinal lymphatic drug transport. *Advanced Materials* 2021, 33, e2104139. (†Equal Contribution)
8. Korupalli, C., Li, H., Nguyen, N., Mi, F. L., Chang, Y., **Lin, Y. J.\***, Sung, H. W.\* Conductive materials for healing wounds: their incorporation in electroactive wound dressings, characterization, and perspectives. *Advanced Healthcare Materials* 2021, 10, 2001384.
9. **Lin, Y. J.**, Chen, C. C., Nguyen, D., Su, H. R., Lin, K. J., Chen, H. L., Hu, Y. J., Lai, P. L., Sung, H. W. Biomimetic engineering of a scavenger-free nitric oxide-generating/delivering system to enhance radiation therapy. *Small* 2020, 16, e2000655. (Selected as Inside Cover)
10. **Lin, Y. J.**, Chen, C. C., Chi, N. W., Nguyen, T., Lu, H. Y., Nguyen, D., Lai, P. L., Sung, H. W. In situ self-assembling micellar depots that can actively trap and passively release NO with long-lasting activity to reverse osteoporosis. *Advanced Materials* 2018, 30, e1705605.

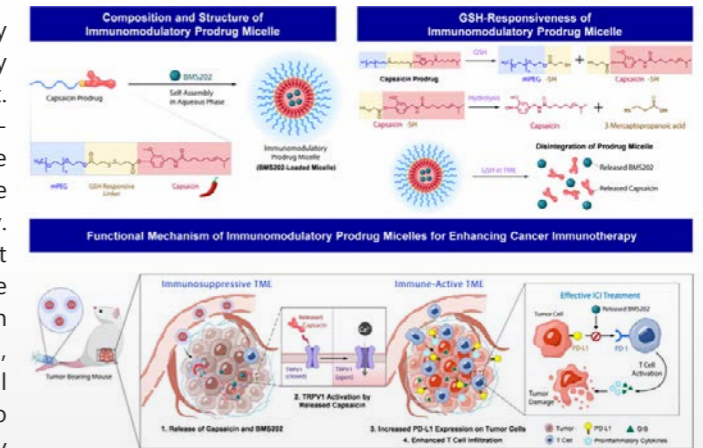
## Research Focus

### 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.

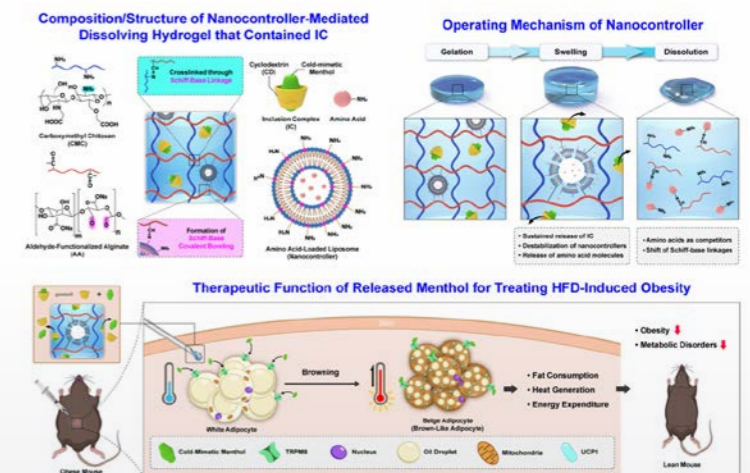


### Nanocontroller-Mediated Dissolving Hydrogel that Can Sustainably Release Cold-Mimetic Menthol to Induce Adipocyte Browning for Treating Obesity and Its Related Metabolic Disorders

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.



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# Tung-Han Hsieh

Research Specialist

## Education

Ph.D. Physics, National Taiwan University, Taiwan (2002)

## Positions and Career

- Research Specialist, Research Center for Applied Sciences, Academia Sinica (2020 – present)
- Associate Research Specialist, Research Center for Applied Sciences, Academia Sinica (2016 – 2020)
- Assistant Research Specialist, Research Center for Applied Sciences, Academia Sinica (2006 – 2015)
- Assistant Professor, Physics Division, Commission of General Education, National United University (2005 – 2006)
- Postdoctoral fellow, Physics Department, National Taiwan University (2002 – 2005)

## Honors and Awards

- 2023 19th National Innovation Award in the Academic Research Category
- 2005 The Excellent Ph. D. Thesis Award of the Physical Society of the Republic of China.

## Research Interests

- Machine learning.
- Biomedical image processing and signal analysis.
- Computational physics.
- Development and maintenance of high-performance computing facilities.
- Lattice QCD computation.

## Selected Publications

1. Dao-Ming Chang, Heng-Hua Hsu, Ping-Liang Ko, Wei-Jen Chang, Tung-Han Hsieh, Hsiao-Mei Wu, and Yi-Chung Tung, "Rapid time-lapse 3D oxygen tension measurements within hydrogels using widefield frequency-domain fluorescence lifetime imaging microscopy (FD-FLIM) and image segmentation", *Analyst* 149, 1727 (2024).
2. 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).
3. 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.
4. Justin Chu, Wen-Tse Yang, Wei-Ru Lu, Yao-Ting Chang, Tung-Han Hsieh, and Fu-Liang Yang, "90% Accuracy for Photoplethysmography-Based Non-Invasive Blood Glucose Prediction by Deep Learning with Cohort Arrangement and Quarterly Measured HbA1c", *Sensors* 2021, 21(23), 7815.
5. 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.
6. Hsiao-Mei Wu, Tse-Ang Lee, Ping-Liang Ko, Wei-Hao Liao, Tung-Han Hsieh, and Yi-Chung Tung, "Widefield frequency domain fluorescence lifetime imaging microscopy (FD-FLIM) for accurate measurement of oxygen gradients within microfluidic devices", *Analyst*, 2019, 144, 3494.
7. 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).
8. Wing Kiu Yeung, Huai-Yi Chen, Juan-Jie Sun, Tung-Han Hsieh, Mansoureh Z. Mousavi, Hsi-Hsien Chen, Kuang-Li Lee, Heng Lin, Pei-Kuen Wei, and Ji-Yen Cheng, "Multiplex detection of urinary miRNA biomarkers by transmission surface plasmon resonance", *Analyst*, 2018, 143, 4715.

## 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)

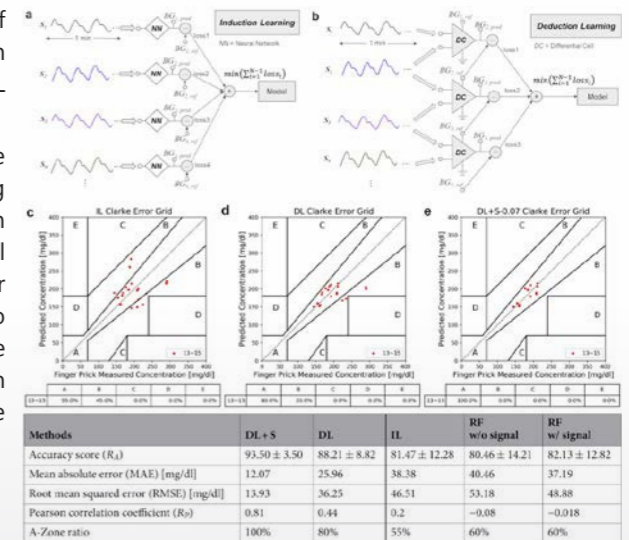
Diabetes mellitus (DM) is a chronic condition of abnormally elevated blood glucose level (BGL), which leads to various complications. Currently, reliable BGL measurement utilize invasive methods.

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.

$$DL \leftarrow \sum_{i=2}^N f(S_i, S_{i-1}, BG_{i-1})$$

$$BG_k \leftarrow DL(S_k, S_N, BG_N)$$

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.



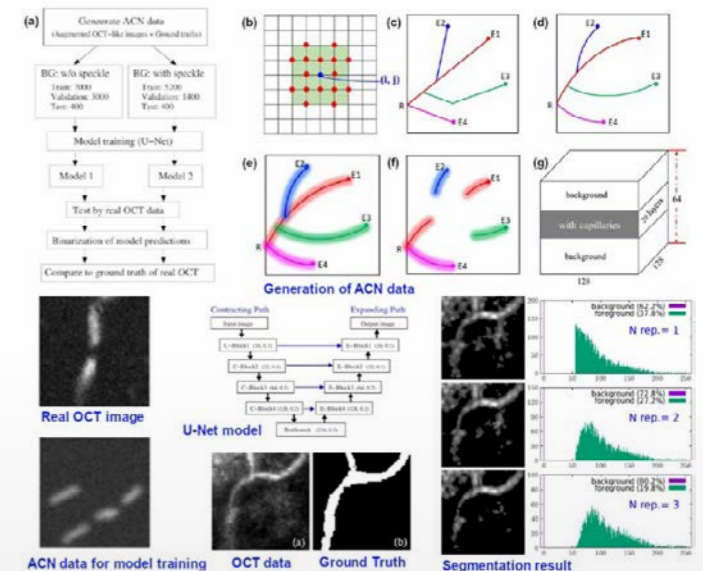
### OCT skin image analysis for capillary network reconstruction

Bitewulign K. Mekonnen, Tung-Han Hsieh, Dian-Fu Tsai, Shien-Kuei Liaw, Fu-Liang Yang, Sheng-Lung Huang

Research Center for Applied Sciences, Academia Sinica  
(*Diagnostics* 2021, 11, 685)

Automated capillary segmentation plays an important role in computer vision and clinical application. Full-Field Optical Coherence Tomography (FF-OCT) provides a convenient tool for noninvasive in vivo visualization for dermatology, oncology, retinal, micro-angiography in intercellular resolution.

In this work, we developed a machine learning model for capillary segmentation from FF-OCT images of human skin. Due to lack of sufficient annotated data for model training, an algorithm was developed to generate a large set of augmented capillary network (ACN) data. Then the U-Net model was trained by the ACN data to perform the task of capillary segmentation from the real FF-OCT image volume. Finally, the more accurate segmentation from the predicted image volume was achieved by counting the number N of repeated appearance of signal for each pixel over the layers in the image volume. Setting N=1 as the binarization threshold, we attained accuracy 0.798, and F1 score 0.814.



# Shu-Yi Hsieh

Assistant Research Specialist

Education | Ph.D. Department of Chemistry, National Tsing Hua University (2008)

## Positions and Career

- Assistant Research Specialist, Research Center for Applied Sciences, Academia Sinica (2020-)
- Postdoctoral Research, Research Center for Applied Sciences, Academia Sinica (2011-2020)
- Postdoctoral Research, Institute of Biotechnology and Pharmaceutical Research, National Health Research Institutes, (2080-2011)

## Research Interests

- Organic Synthesis
- Nanomaterial Synthesis
- Small Molecule Drug Development and Drug Delivery
- Biosensor Development and Applications

## Selected Publications

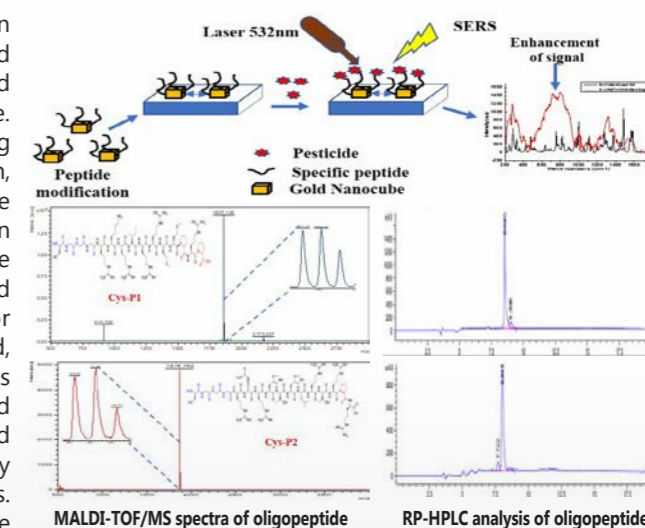
1. S. H. Wang, S. C. Y. J. Tung, C. W. Kuo, Y. H. Tai, S. Y. Hsieh, K. L. Lee, S. R. Hsiao, J. F. Sheen, J. C. Hsu and P. K. Wei. "Multichannel Nanoplasmonic Platform for Imidacloprid and Fipronil Residues Rapid Screen Detection Biosensors and Bioelectronics or its open access mirror" *Biosens. Bioelectron.* **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.
6. W. H. Lin, S. Y. Hsieh, S. C. Yen, C. T. Chen, T. K. Yeh, T. Hsu, C. T. Lu, C. P. Chen, C. W. Chen, L. H. Chou, Y. L. Huang, A. H. Cheng, Y. I. Chang, Y. J. Tseng, K. R. Yen, Y. S. Chao, J. T. Hsu, W. T. Jiaang. "Discovery and evaluation of 3-phenyl-1H-5-pyrazolylamine-based derivatives as potent, selective and efficacious inhibitors of FMS-like tyrosine kinase-3 (FLT3)." *Bioorganic & medicinal chemistry*, **2011**, *19*(14), 4173-82.
7. S. Y. Hsieh, M. D. Jan, L. N. Patkar, C. T. Chen, C. C. Lin. "Synthesis of a carboxyl linker containing Pk trisaccharide." *Carbohydrate research*, **2005**, *340*(1), 49-57.
8. K. C. Lu, S. Y. Hsieh, L. N. Patkar, C. T. Chen, C. C. Lin. "Simple and Efficient per-O-Acetylation of carbohydrates by lithium perchlorate catalyst." *Tetrahedron*, **2004**, *60*(40), 8967-8973.

## Research Focus

### Multiple Pesticides Detection by Integrating Synthetic Peptides and Gold Nanoparticles

Tran Thi Anh Hong,<sup>1</sup> Sheng-Hann Wang,<sup>1</sup> Ting-Wei Chang,<sup>1</sup> Pei-Kuen Wei,<sup>1</sup> Shu-Yi Hsieh<sup>1\*</sup>

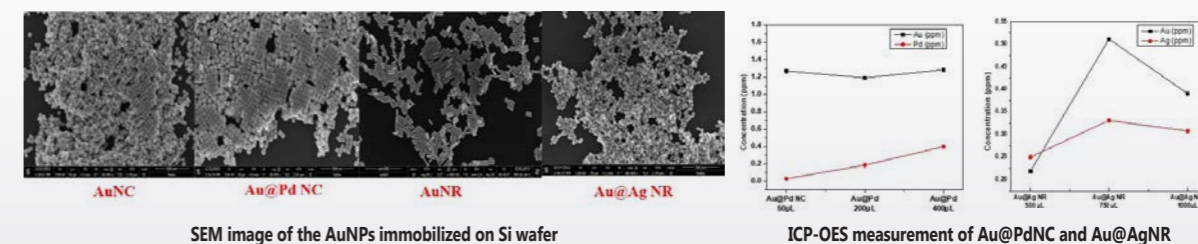
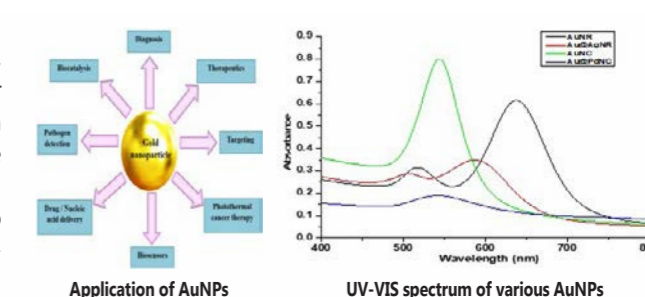
In this study, we attempt to develop a detection system by integrating self-synthesized peptides and gold nanoparticles (AuNPs) that is time-saving and enhances specificity as well as a simple technique. Principally, the surface-enhanced Raman scattering (SERS) technique is applied for pesticide detection, herein, AuNPs can be used as SERS substrate due to its roughened surfaces induces Raman signal enhancement. In addition, oligopeptide sequences CGGGRKRIRMMMPRPS (Cys-P1) and CGGGRNRHTLRTPR (Cys-P2) were found for specific binding with thiacloprid and imidacloprid, respectively, whereas the CGGG fragment helps to bind with AuNPs forming peptides-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,<sup>1</sup> Shu-Yi Hsieh<sup>1\*</sup>

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.



# Green Technology

| Faculty Members |

# Chih Wei Chu

Research Fellow

## Education

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

## Positions and Career

- Adjunct Professor, Institute of Applied Mechanics, National Taiwan University, (2024 –)
- Deputy Director, Research Center for Applied Sciences (RCAS), Academia Sinica (2016 – 2022)
- Acting Executive Officer of the thematic center for Mechanics and Engineering Science, Academia Sinica (2023 –)
- Adjunct Professor, Department of Photonics, National Yang-Ming Chiao Tung University (2019 –)
- Adjunct Professor, Department of Materials Science and Engineering, National Tsing Hua University, (2017 – 2020)
- Research Fellow, RCAS, Academia Sinica (2014 –)
- Adjunct Professor, College of Engineering, Chang Gung University (2014 –)
- Associate Research Fellow, RCAS, Academia Sinica (2010 – 2014)
- Assistant Research Fellow, RCAS, Academia Sinica (2006 – 2010)

## Honors and Awards

- 2022 World's Top 2% Scientists
- 2022 SPIE Senior Member
- 2019 Young Scientist of Asia Pacific Academy of Materials
- 2019 Associate Academician of Asia Pacific Academy of Materials
- 2014 Career Development Award, Academia Sinica

## Research Interests

Thin film electronics and optoelectronics  
Next generation batteries

## Selected 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 MoO<sub>3</sub>-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  $\alpha$ -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).
6. Anisha Mohapatra, Anupriya Singh, Syed Ali Abbas, Yu-Jung Lu, Karunakara Moorthy Boopathi, Chintam Hanmandlu, Nahid Kaiser, Chih-Hao Lee, Chih-Wei Chu\*, "Bilayer polymer solar cells prepared with transfer printing of active layers from controlled swelling/deswelling of PDMS" *Nano Energy*, 63, 103826 (2019).
7. Mriganka Singh, Annie Ng, Zhiwei, Ren, Hanlin, Hu, Hong-Cheu Lin\*, Chih Wei Chu\*, Gang Li\*, "Facile synthesis of composite tin oxide nanostructures for highperformance planar perovskite solar cells" *Nano Energy*, 60, 275 (2019).
8. Yen-An Lu, Ting-Hsiang Chang, Shang-Hsuan Wu, Chi-Ching Liu, Kuan-Wen Lai, Yun-Chorng Chang, Yia-Chung Chiang, Hsin-Chun Lu, Chih Wei Chu, Kuo-Chuan Ho, Coral-like perovskite nanostructures for enhanced light-harvesting and accelerated charge extraction in perovskite solar cells", *Nano Energy*, 58, 138 (2019).

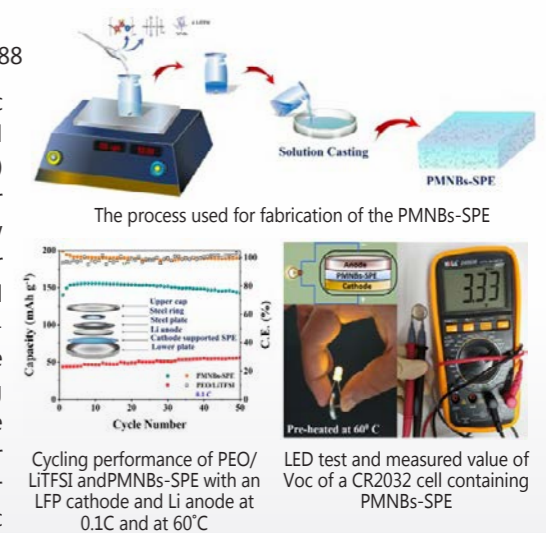
## Research Focus

### Intimate Interaction of TFSI- Anions with MoO<sub>3</sub> Ionic Conductivity of Cathode-supported Solid Polymer Electrolyte

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

Academic Sinica, Research Center for Applied Sciences  
*Chemical Engineering Journal*, 2023, DOI: 10.1016/j.cej.2022.139088

A solid-state electrolyte should display high ionic conductivity, low interfacial impedance, good mechanical properties, and stability. Although poly(ethylene oxide) (PEO) has been investigated extensively as a potential polymer host in solid polymer electrolytes (SPEs), it suffers from low ionic conductivity, flammability, Li dendrite growth, and poor mechanical strength. To address these issues, we developed a composite cathode-supported SPE featuring oxygen-deficient MoO<sub>3</sub>-x nanobelts (MNBs) as passive nanofillers. The synthesis of MNB is easy, economical, and scalable, enabling large-scale production of SPE. Relative to the PEO-only SPE, the composite SPE with 5 % MNBs (PMNBs-SPE) exhibited greater ionic conductivity, enhanced mechanical strength, superior cycling performance, and lower flammability. The greater ionic conductivity resulted from the dissociation of LiTFSI in the presence of oxygen vacancies acting as Lewis acid sites and the shorter diffusion pathways induced by the MNBs.

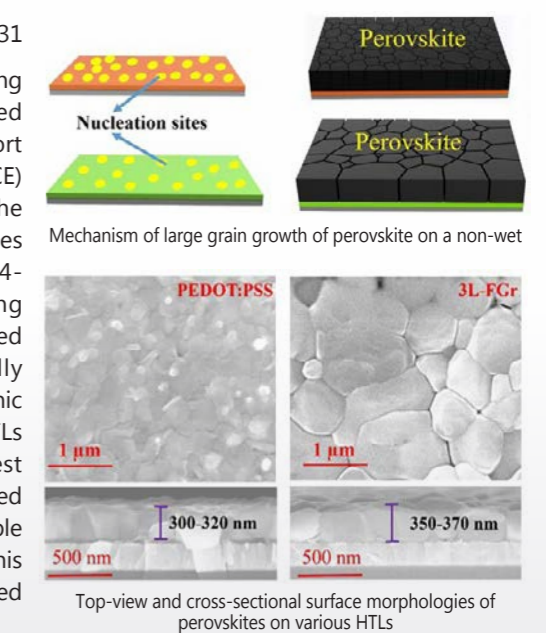


### Few-layer fluorine-functionalized graphene hole-selective contacts for efficient inverted perovskite solar cells

Chintam Hanmandlu, Mamina Sahoo, Chi-Ching Liu, Hsin-An Chen, Chun-Wei Pao, Yun-Chorng Chang, Chih Wei Chu, Chao-Sung Lai

Academic Sinica, Research Center for Applied Sciences  
*Chemical Engineering Journal*, 2022, DOI: 10.1016/j.cej.2021.132831

Charge-selective contacts can play a critical role in enhancing the efficiency of perovskite solar cells (PSCs). We employed fluorine-functionalized graphene (FGr) layers as hole transport layers (HTLs) to improve the power conversion efficiency (PCE) and stability of inverted PSCs. The non-wetting surface of the FGr enhanced the crystallinity of organic-inorganic perovskites films with large aspect ratios, relative to that of poly(3,4-ethylenedioxythiophene): polystyrenesulfonate. Combining the high work function of the HTL interface with the enhanced crystallinity and limited grain boundary area dramatically decreased the charge recombination losses in organic-inorganic trihalide perovskite films. Thus, when incorporating FGr HTLs in inverted PSCs, the best PCE reached 19.34%—the highest efficiency reported to date for any PSC featuring a functionalized graphene HTL. Furthermore, we used this HTL to prepare flexible PSCs and obtained a highest efficiency of 17.50%. Therefore, this highly applicable and facile interface strategy using functionalized graphene HTLs provides stable PSCs displaying high PCEs.



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# Chun-Wei Pao

Research Fellow

Education | Ph.D. Mechanical and Aerospace Engineering,  
Princeton University (2007)

## Selected Publications

- Po-Yu Yang, Yu-Hsuan Chiang, Chun-Wei Pao\*, Chien-Cheng Chang\* (2023), "Hybrid Machine Learning-Enabled Potential Energy Model for Atomistic Simulation of Lithium Intercalation into Graphite from Plating to Overlithiation", *Journal of Chemical Theory and Computation* (in press).
- 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.
- Q.F. He\*, P.H. Tang, H.A. Chen, S. Lan, J.G. Wang, J.H. Luan, M. Du, Y. Liu, C.T. Liu, C.W. Pao\*, Y. Yang\* (2021), "Understanding chemical short-range ordering/demixing coupled with lattice distortion in solid solution high entropy alloys", *Acta Materialia* **216**, 117140.
- 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.
- Po-Yu Yang, Chun-Wei Pao (2021), "Molecular Simulations of the Microstructure Evolution of Solid Electrolyte Interphase during Cyclic Charging/Discharging", *ACS Applied Materials & Interfaces*, **13**, 5017.
- Chih-Hung Chen, Chun-Wei Pao (2021), "Phase-field study of dendritic morphology in lithium metal batteries", *Journal of Power Sources* **484**, 229203
- 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\* (2016), "Multiscale Molecular Simulation of Solution Processing of SMDPPEH:PCBM Small Molecule Organic Solar Cells", *ACS Applied Materials & Interfaces* **8**, 20691-20700
- 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.
- Te-Huan Liu, Grzegorz Gajewski, Chun-Wei Pao\*, Chien-Cheng Chang\* (2011), "Structure, energy, and structural transformations of graphene grain boundaries from atomistic simulations", *CARBON* **49**, 2306-17.

## Positions and Career

- Adjunct Professor, Department of Photonics, National Yang Ming Chiao Tung University (2020 - )
- Joint Professor, Department of Materials Science and Engineering, National Dong Hwa University, (2018 - )
- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2018- )
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2014 – 2018)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2009 – 2014)
- Postdoctoral Research Associate, Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM, USA (2007 – 2009)

## Honors and Awards

- 2023 Y. Z. Hsu Scientific Paper Award
- 2022 Investigator Award, Academia Sinica
- 2018 IUPAC Distinguish Award for Novel Materials and their Synthesis
- 2015 Career Development Award, Academia Sinica
- 2014 Youth Award
- 2014 Young Theorist Award, National Center for Theoretical Sciences
- 2013 Project for Excellent Junior Research Investigators, National Science Council of Taiwan

## Research Interests

Multiscale Simulation of Materials

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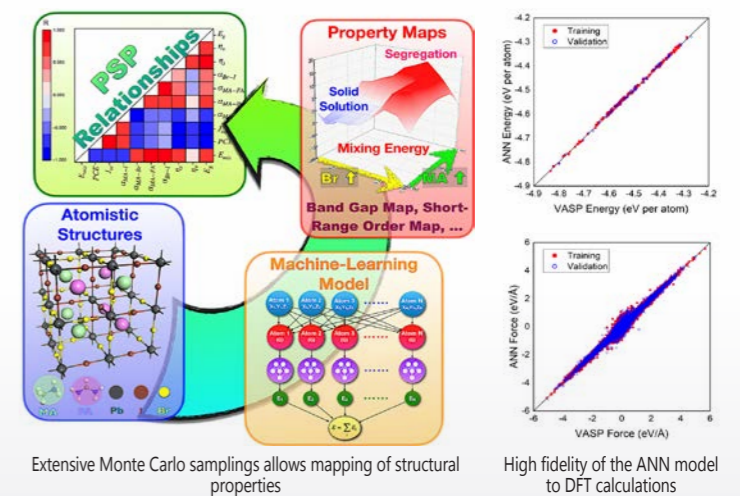
## Research Focus

### 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)

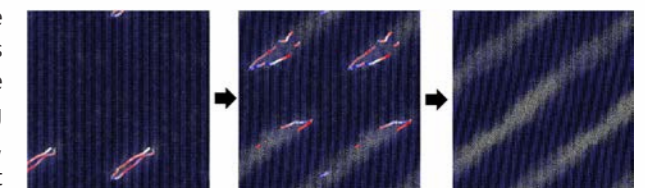
In this work, we trained an artificial neural network (ANN) potential energy model of the  $\text{MA}_y\text{FA}_{1-y}\text{Pb}(\text{Br}_x\text{I}_{1-x})_3$  complex perovskite material and investigated the microstructure over the composition space using extensive Monte Carlo simulations. We sampled around  $8.1 \times 10^5$  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.



### A Highly Distorted Ultra-Elastic Chemically Complex Elinvar Alloy

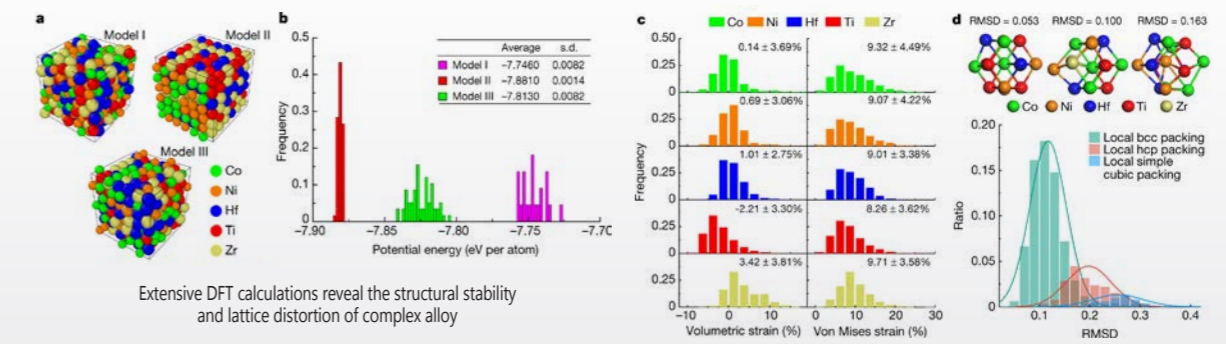
Quanfeng He, J.G. Wang, Hsin-An Chen, Z.Y. Ding, Z.Q. Zhou, L.H. Xiong, Junhua Luan, J.M. Pelletier, J.C. Qiao, Q. Wang, L.L. Fan, Yang Ren, Qiaoshi Zeng, Chain Liu, C.W. Pao\*, David Srolovitz\*, Yong Yang\*

*Nature* **602**, 251 (2022) In this work, we collaborated with our experimental collaborators in Hong Kong and decoded the atomistic structure of  $\text{Ni}_{25}\text{Co}_{25}(\text{HfTiZr})_{50}$  chemically complex alloy using extensive DFT calculations. From DFT calculations, we revealed the judicious chemical ordering at atomic scale helps retain the stability of crystalline



Plastic deformation from MLMD simulations (ongoing)

material while undergoing a 11% of atomic size mismatch, which was also confirmed by STEM-EDS experiments. We performed extensive DFT calculations to examine the lattice distortion of the crystal, indicating that each constituent elements is subjected to ~9% of distortion, which is 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. At this moment we have trained a machine learning energy model for large-scale molecular simulation to further examine its exceptional plastic deformation properties.





# Tzung-Fang Guo

Research Fellow

Education | PhD, Department of Materials and Engineering, University of California, Los Angeles (2002)

## Positions and Career

- Research Fellow, Research Center for Applied Science, Academia Sinica, Taiwan (2024-date)
- Professor, Department of Photonics, National Cheng Kung University, Taiwan (2009-date)
- Department Chairman, Department of Photonics, National Cheng Kung University, Taiwan (2012-2018)
- Associate Professor, Institute of Electro-Optical Science & Engineering, National Cheng Kung University, Taiwan (2006-2009)
- Assistant Professor, Institute of Electro-Optical Science & Engineering, National Cheng Kung University, Taiwan (2003-2006)
- Research Scientist, Nitto Denko Technical Corporation, San Diego, USA (2003)

## Honors and Awards

- 2010 NCKU K. T. LI Research award
- 2012, 2015, 2018, and 2021 NCKU Distinguished Professor Award
- 2018 Academic Outstanding Research Award in Chemistry, Ministry of Science and Technology, Taiwan
- 2020 Fellow of SPIE (International Society for Optics and Photonics)
- 2024 Fellow of OPTICA (formerly OSA)

## Research Interests

- Interfacial studies of organic/polymer light-emitting diodes and photovoltaic cells
- Pentacene-based n-type organic field-effect transistors
- Magnetic field effect of conjugated molecule devices
- Perovskite-based photovoltaic cells and light-emitting diodes

## Selected Publications

1. T. -L. Shen, A. Loganathan, T. -H. Do, C. -M. Wu, Y. -T. Chen, Z. -J. Chen, N. -C. Chiu, C. -H. Shih, H. -C. Wang, J. -H. Chou, Y. -Y. Hsu, C. -C. Liu, Y. -C. Chang, Y. -S. Fu, W. -C. Lai, P. -T. Chen, T. -C. Wen, T. -F. Guo\*, "Characterize and retard the impact of the bias-induced mobile ions in CH<sub>3</sub>NH<sub>3</sub>PbBr<sub>3</sub> perovskite light-emitting diodes" *Adv. Optical Mater.* **10**, 2101439 (2022).
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\*, "NiO<sub>x</sub> electrode interlayer and CH<sub>3</sub>NH<sub>2</sub>/CH<sub>3</sub>NH<sub>3</sub>PbBr<sub>3</sub> interface treatment to markedly advance hybrid perovskite-based light-emitting diodes" *Adv. Mater.* **28**, 8687 (2016).
4. W. -C. Lai\*, K. -W. Lin, Y. -T. Wang, T. -Y. Chiang, P. Chen, and T. -F. Guo\*, "Oxidized Ni/Au transparent electrode in efficient CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> perovskite/fullerene planar heterojunction hybrid solar cells" *Adv. Mater.* **28**, 3290 (2016).
5. 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 CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> perovskite/PCBM planar-heterojunction hybrid solar cells" *Adv. Mater.* **26**, 4107 (2014). (Highly cited papers in ESI)
6. K. -C. Wang, J. -Y. Jeng, P. -S. Shen, Y. -C. Chang, E. W. -G. Diao, C. -H. Tsai, T. Y. Chao, H. -C. Hsu, P. -Y. Lin, P. Chen\*, T. -F. Guo\*, and T. -C. Wen "p-type mesoscopic nickel oxide/organometallic perovskite heterojunction solar cells" *Sci. Rep.* **4**, 4756 (2014). (Highly cited papers in ESI)
7. J. -Y. Jeng, Y. -F. Chiang, M. -H. Lee, S. -R. Peng, T. -F. Guo\*, P. Chen\*, and T. -C. Wen "CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> perovskite/fullerene planar-heterojunction hybrid solar cells" *Adv. Mater.* **25**, 3727 (2013). (SPIE Newsroom highlighted) (Highly cited papers in ESI)
8. T. -D. Tsai, J. -W. Chang, T. -C. Wen, and T. -F. Guo\* "Manipulating the hysteresis in poly(vinyl alcohol)-dielectric organic field-effect transistors toward memory elements" *Adv. Funct. Mater.* **23**, 4206 (2013).
9. J. -W. Chang, C. -G. Wang, C. -Y. Huang, T. -D. Tsai, T. -F. Guo\*, and T.

-C. Wen "Chicken albumen dielectrics in organic field-effect transistors" *Adv. Mater.* **23**, 4077 (2011). (SPIE Newsroom highlighted)

10. J. -Y. Jeng, M. -W. Lin, Y. -J. Hsu, T. -C. Wen, and T. -F. Guo\* "The roles of poly(ethylene oxide) electrode buffers in efficient polymer photovoltaics" *Adv. Energy Mater.* **1**, 1192 (2011).

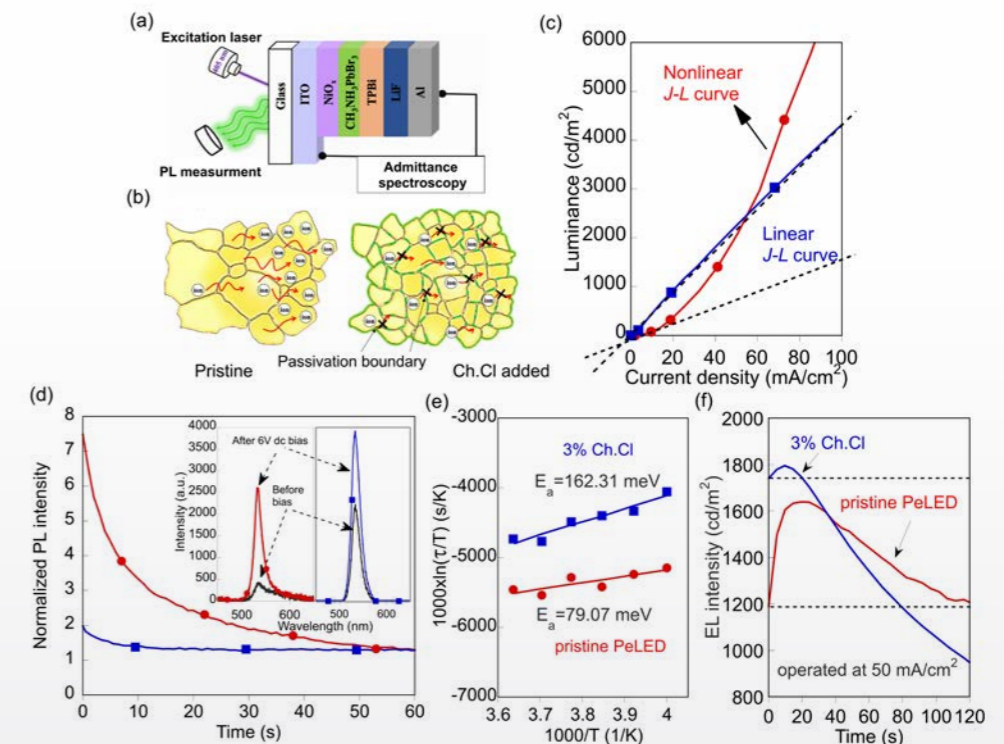
## Research Focus

### Characterize and retard the impact of the bias-induced mobile ions in CH<sub>3</sub>NH<sub>3</sub>PbBr<sub>3</sub> perovskite light-emitting diodes

Teng Lam Shen, Aswaghosh Loganathan, Thi Hoai Do, Chang-Min Wu, Yu-Ting Chen, Zheng-Jun Chen, Nan-Chieh Chiu, Chun-Hua Shih, Hsin-Chih Wang, Jia-Hsian Chou, Yao-Yuan Hsu, Chi-Ching Liu, Yun-Chong Chang, Yaw-Shyan Fu, Wei-Chi Lai, Peter Chen, Ten-Chin Wen, and Tzung-Fang Guo

Department of Photonics and Advanced Optoelectronic Technology Center, National Cheng Kung University  
*Adv. Optical Mater.* **10**, 2101439 (2022)

Herein, we investigate the impact of ion migration in CH<sub>3</sub>NH<sub>3</sub>PbBr<sub>3</sub> thin film on the performance of PeLEDs. The physical insight of bias-induced migration of mobile ions in the perovskite active layer effectuating the observed non-linearity in the increased magnitude of electroluminescence (EL) and luminous efficiency (LE) as a function of current density for PeLEDs is directly evidenced using the capacitance spectroscopy. The addition of Choline chloride (Ch.Cl) passivates the charged defects in organic-inorganic halide perovskite and interferes with the migration of ions crossing the grains in PeLEDs. As a result, the Ch.Cl-additive devices exhibit stable EL and LE magnitude under electric bias. Suppressing the influence of migrating ions on operating PeLEDs is a key issue that needs to be addressed to advance the efficiencies and operational stabilities of perovskite devices.



(a) The general scheme of PeLED in this study. (b) The schematic draw presents the possible mechanism for the migration of mobile ions. (c) Brightness versus current density of (red curve) the pristine and (blue curve) 3% Ch.Cl added. (d) The time-dependent PL decay profiling for (red curve) the pristine and (blue curve) 3% Ch.Cl added and left inset shows the PL spectra of the pristine, right inset shows the PL spectra of 3% Ch.Cl added before and after application of 6 V dc bias. (e) The 1000xln(τ/T) versus 1000/T curves estimate E<sub>a</sub> for the migration of ions. (f) The results of the stress test operated at a constant current density, 50 mA/cm<sup>2</sup>.

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# Yun-Chorng Chang

Associate Research Fellow

Education | Ph.D. Electrical Engineering, North Carolina State University (2001)

## Positions and Career

- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2014- Now)
- Adjunct Associate Professor, Dept. of Photonics, National Yang-Ming Chiao Tung Univ, (2018 -Now)
- Adjunct Associate Professor, Dept. of Physics, National Taiwan Univ. (2016 -Now)
- Adjunct Professor, Dept. of Photonics, National Cheng Kung Univ., (2014 - Now)
- Professor, Dept. of Photonics, National Cheng Kung Univ. (2013 – 2014)
- Associate Professor, Dept. of Photonics, National Cheng Kung Univ. (2008 – 2013)
- Assistant Professor, Inst. of Electro-Optical Science and Engineering, National Cheng Kung Univ. (2003 – 2008)
- Postdoctoral Research, Department of Electrical and Computer Engineering, North Carolina State University (2002 – 2003)

## Honors and Awards

- 2022 IEEE Senior Member
- 2014 SPIE Senior Member
- 2012 2012 Innovative Research Award for Young Scholars, 3rd place, Taiwan Comprehensive University System

## Research Interests

Nanofabrication and Nanophotonics  
Semiconductor and Biosensing

## Selected 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.
6. Y. C. Chang\*, H. C. Chung, S. C. Lu, T. F. Guo, "Large-scale sub-100nm Au nanodisk array fabricated using Nanospherical-Lens Lithography: a low-cost localized surface plasmon resonance sensor", *Nanotechnology*, 2013/03, 24(09), 095302.
7. I. T. Chen, P. H. Chang, Y. C. Chang\*, T. F. Guo\*, "Lighting Up Ultraviolet Fluorescence From Chicken Albumen Through Plasmon Resonance Energy Transfer of Gold Nanoparticles", *Scientific Reports*, 2013/03, 3, 1505.
8. Y. C. Chang\*, S. C. Lu, H. C. Chung, S. M. Wang, T. D. Tsai, T. F. Guo, "High-Throughput Nanofabrication of Infra-red and Chiral Metamaterials using Nanospherical-Lens Lithography", *Scientific Reports*, 2013/11, 3, 3339.
9. Y. H. Liao, Y. J. Chang, Y. Yoshiike, Y. C. Chang\*, Y. R. Chen\*, "Negatively charged gold nanoparticles inhibit Alzheimer's amyloid-beta fibrillization, induce fibril dissociation, and mitigate neurotoxicity", *Small*, 2012/12, 8(23), 3631–3639.

10. Y. C. Chang\*, S. M. Wang, H. C. Chung, C. B. Tseng, S. H. Chang, "Observation of Absorption-Dominated Bonding Dark Plasmon Mode from Metal-Insulator-Metal Nanodisk Arrays fabricated by Nanospherical-Lens Lithography", *ACS Nano*, 2012/04, 6(4), 3390–3396.

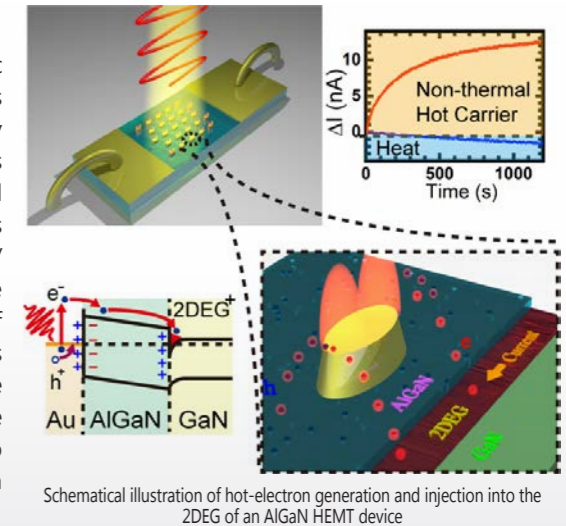
## Research Focus

### 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/adv.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.

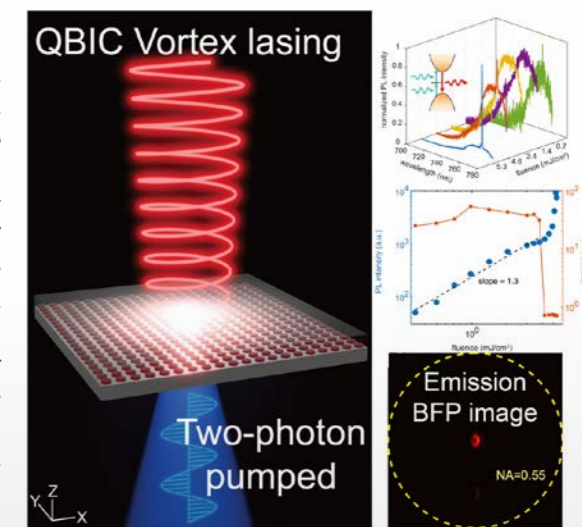


### Nonlinear Two-photon Pumped Vortex Lasing Based on Quasi-Bound States in the Continuum from Perovskite Metasurface

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/cm<sup>2</sup>, 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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# Yuh-Jen Cheng

Associate Research Fellow

Education | Ph.D. Applied Physics, Stanford University (1997)

## Selected Publications

- 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)<sub>2</sub>-Cr<sub>2</sub>O<sub>3</sub>/Ni Hydrogen Evolution Electrocatalyst through Synergistic Reaction Kinetics", *ChemSusChem* 2023, e202300820.
- 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).
- 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 MoS<sub>2</sub> Crystal Growth: Implications for van der Waals epitaxy", *ACS Appl. Nano Mater.* 4, 4930–4938 (2021).
- 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 MoS<sub>2</sub> Photodetector", *Nanomaterials* 2020, 10, 1828.
- Chi-Huang Chuang, Yung-Yu Lai, Cheng-Hung Hou, and Yuh-Jen Cheng\*, "Annealed Polycrystalline TiO<sub>2</sub> Interlayer of the n-Si/TiO<sub>2</sub>/Ni Photoanode for Efficient Photoelectrochemical Water Splitting," *ACS Appl. Energy Mater.* 3, 4, 3902-3908 (2020).
- Yen-Hsien Yeh, Chi-Huang Chuang, Tzu-Yi Yu, Mei-Chun Liu, and Yuh-Jen Cheng\*, "Junction energetics engineering using Ni/NiOx core-shell nanoparticle coating for efficient photoelectrochemical water splitting," *Int J Hydrogen Energy* 44, 16594-16602 (2019).
- Kun-Ching Shen, Chen-Ta Ku, Chieh Hsieh, Hao-Chung Kuo, Yuh-Jen Cheng, and Din Ping Tsai\*, "Deep-Ultraviolet Hyperbolic Metacavity Laser," *Adv. Mater.* 30, 1706918 (2018).
- Kun-Ching Shen, Chieh Hsieh, Yuh-Jen Cheng, and Din Ping Tsai\*, "Giant enhancement of emission efficiency and light directivity by using hyperbolic metacavity on deep-ultraviolet AlGaIn emitter," *Nano Energy* 45, 353–358 (2018).
- Yen-Hsien Yeh, Tzu-Yi Yu, Mei-Chun Liu, and Yuh-Jen Cheng\*, "Enhanced water splitting performance of GaN photoanode using self-assembled nickel/nickeloxide nanoparticle catalyst," *Int J Hydrogen Energy* 42, 27066-27072 (2017).
- Chien-Ting Kuo, Lung-Hsing Hsu, Yung-Yu Lai, Shan-Yun Cheng, Hao-Chung Kuo, Chien-Chung Lin, and Yuh-Jen Cheng\*, "Site-controlled crystalline InN growth from the V-pits of a GaN substrate," *Appl. Surf. Sci.* 405, 449–454 (2017).

## Positions and Career

- Associate Research Fellow, Academia Sinica, 2012-present.
- Assistant Research Fellow, Academia Sinica, 2008-2012.
- Associate Research Technical Staff, Academia Sinica, 2006-2007.
- Staff Optical Engineer/project lead, Bookham Technologies, 2000-2005.
- Senior Engineer, Seagate Technology, 1997-2000.

## Research Interests

- Photoelectrochemical water splitting and electrocatalysis.
- 2D material epitaxy and quantum photonic devices.
- Sustainable green energy and carbon capture.

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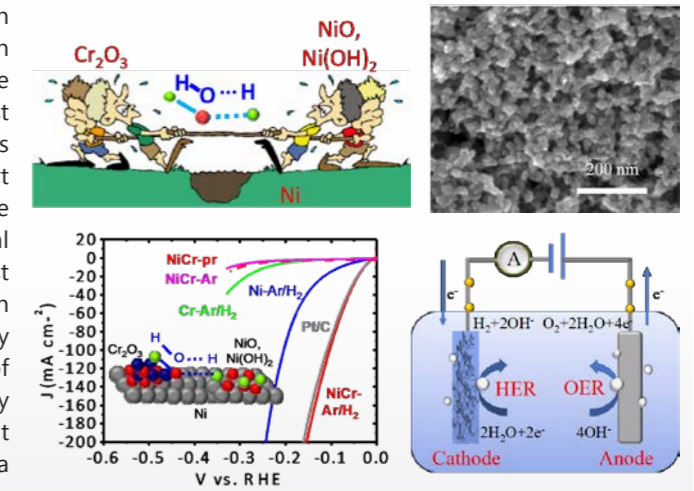
## Research Focus

### Highly Active NiO-Ni(OH)<sub>2</sub>-Cr<sub>2</sub>O<sub>3</sub>/Ni Hydrogen Evolution Electrocatalyst through Synergistic Reaction Kinetics

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

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

Catalyst with high activity for hydrogen evolution reaction (HER) plays a key role in converting renewable electricity to storable hydrogen fuel. Pt has been the benchmark catalyst for HER. However, its high cost and scarcity hinders its use in large-scale applications. Great effort has been devoted to search for noble metal free catalysts to make electrolysis viable for practical applications. Here, we report a composite catalyst consisting of non-precious metal composition NiOx-Cr<sub>2</sub>O<sub>3</sub>/Ni, that exhibits high activity comparable with Pt/C. The catalyst consisting of NiO, Ni(OH)<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub>, and Ni metal exhibits a very low overpotential of -27, -103, and -153 mV at current density of -10, -100, and -200 mA cm<sup>-2</sup> in a 1.0 M NaOH electrolyte. The activity is much higher than that of NiOx/Ni or Cr<sub>2</sub>O<sub>3</sub> alone. The synergistic effect of NiOx/Ni and Cr<sub>2</sub>O<sub>3</sub> on catalyzing HER is attributed to the different affinity to OH<sup>-</sup> and H\* of Cr<sub>2</sub>O<sub>3</sub> and NiOx, respectively, which helps breaking OH-H bond, and creates preferred sites on Ni with low H\* adsorption energy to promote the H\* to gaseous H<sub>2</sub> evolution.

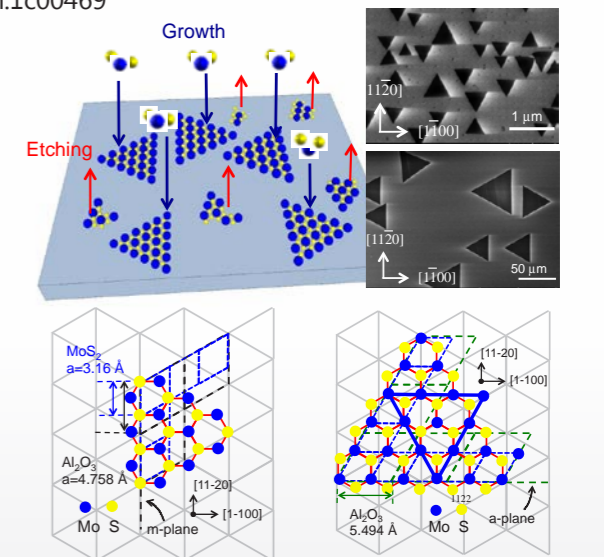


### Substrate Lattice Guided MoS<sub>2</sub> Crystal Growth

Yung-Yu Lai, Chi-Huang Chuang, Cheng-Hung Hou, and Yuh-Jen Cheng

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

Two-dimensional (2D) monolayer molybdenum disulfide (MoS<sub>2</sub>) semiconductor is an emerging material with interesting device applications. 2D crystals grown on a substrate often show random orientations due to the weak van der Waals (vdW) interaction with the underlying substrate, leading to multiple defective grain boundaries when random orientated crystals coalesce. By introducing oxygen in the growth, a carefully adjusted oxygen flow can selectively etch away or prohibit the growth of unstable and defective MoS<sub>2</sub>, while allowing energetically stable crystal structure to grow. Under proper growth condition, single crystals are found to grow in two preferential orientations with triangle crystal edges aligned to two sapphire crystal directions, corresponding to a superlattice of (3x3) MoS<sub>2</sub> on (2x2) sapphire and (5x5) MoS<sub>2</sub> on (3x3) sapphire. The commensurate of MoS<sub>2</sub> crystal with sapphire lattice in superlattice lowers the surface energy of MoS<sub>2</sub> on sapphire lattice, thereby becoming the preferred stable growth orientation. This study demonstrates the use of etching-growth competition in substrate lattice guided 2D material growth, which paves the way for the future development of large area vdW single crystal epitaxy.





# Yu-Jung Lu

Associate Research Fellow

Education | Ph.D. in Physics, National Tsing Hua University (2013)

## Selected Publications

- 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\*, Enhancing Photogating Gain in Scalable MoS<sub>2</sub> 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)
- Mriganka Singh#, I-Hung Ho#, Anupriya Singh, Ching-Wen Chan, Jing-Wei Yang, Tzung-Fang Guo, Hyeyoung Ahn, Vincent Tung, Chih Wei Chu, and Yu-Jung Lu\*. Unveiling Ultrafast Carrier Extraction in Highly Efficient 2D/3D Bilayer Perovskite Solar Cells. *ACS Photonics* 9, 3584–3591(2022)
- Zong-Yi Chiao, Yu-Chia Chen, Jia-Wern Chen, Yu-Cheng Chu, Jing-Wei Yang, Tzu-Yu Peng, Wei-Ren Syong, Ho Wai Howard Lee, Shi-Wei Chu, and Yu-Jung Lu\*, Full-Color Generation Enabled by Refractory Plasmonic Crystals. *Nanophotonics* 11, 2891–2899 (2022)
- Meng-Ju Yu, Chih-Li Chang, Hao-Yu Lan, Zong-Yi Chiao, Yu-Chia Chen, Ho Wai Howard Lee, Yia-Chung Chang, Shu-Wei Chang, Takuo Tanaka, Vincent Tung, Ho-Hsiu Chou\*, and Yu-Jung Lu\*, Plasmon-Enhanced Solar-Driven Hydrogen Evolution Using Titanium Nitride Metasurface Broadband Absorbers. *ACS Photonics* 8, 3125–3132 (2021).
- 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 MoS<sub>2</sub> Phototransistor with Ultrahigh Photoresponsivity. *Nano Letters* 21, 3083–3091 (2021).
- Yu-Jung Lu\*, Teng Lam Shen, Kang-Ning Peng, Pi-Ju Cheng, Shu-Wei Chang, Ming-Yen Lu, Chih Wei Chu, Tzung-Fang Guo, and Harry Atwater\*, Upconversion Plasmonic Lasing from an Organolead Trihalide Perovskite Nanocrystal with Low Threshold. *ACS Photonics* 8, 335–342 (2021).
- Yu-Hung Hsieh, Bo-Wei Hsu, Kang-Ning Peng, Kuan-Wei Lee, Chih Wei Chu, Shu-Wei Chang, Hao-Wu Lin\*, Ta-Jen Yen\*, and Yu-Jung Lu\*, Perovskite Quantum Dot Lasing in a Gap-Plasmon Nanocavity with Ultralow Threshold, *ACS Nano* 14, 11670–11676 (2020).

## Positions and Career

- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2022 –)
- Joint Appointment Professor, Department of Physics, National Taiwan University (2018 –)
- Assistant Research Fellow, RCAS, Academia Sinica (2017 – 2022)
- Visiting Scholar, Applied Physics and Materials Science, Caltech, USA (2017 –)
- Postdoctoral Scholar, Applied Physics and Materials Science, Caltech, USA (2015 – 2017)
- Postdoctoral Scholar, Department of Physics, National Tsing Hua University (2013– 2015)

## Honors and Awards

- 2023 SPIE Senior Members, USA
- 2021 SPIE Women in Optics Planner, USA
- 2020 Youth Photonics Award, Taiwan Photonics Society, Taiwan
- 2018 Career Development Award, Academia Sinica, Taiwan
- 2018 56th Ten Outstanding Young Persons, Taiwan
- 2014 Postdoctoral Research Abroad Fellowship, Taiwan
- 2013 Taiwan Outstanding Women in Science - Chui-Chu Mon Fellowship, Taiwan
- 2013 Chien-Shiung Wu Fellowship, Taiwan Physical Society, Taiwan
- 2010 The President's Scholarship of NTHU, Taiwan
- 2010 The Honorary Member of the Phi Tau Phi Scholastic Honor Society, Taiwan
- Associate Editor of Optics Continuum (Optica; 2021- 2023)
- Associate Editor of Advanced Photonics (SPIE; 2021-present)
- Associate Editor of Journal of Lightwave Technology (IEEE; 2022- present)
- Associate Editor of APL Quantum (AIP; 2023- present)

## Research Interests

- Plasmonics, nanophotonics, and metamaterials
- 2D photonics and green photonics
- Nitride-based plasmonic/superconducting materials
- Atom-scale light-matter interaction
- Ultrafast charge-carrier dynamics

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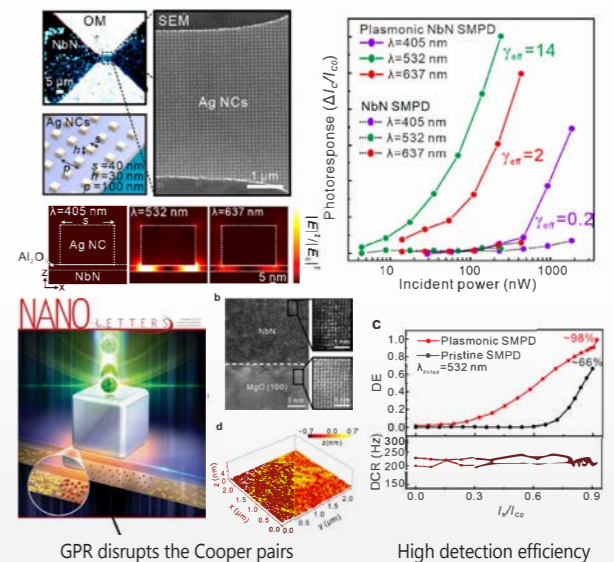
## Research Focus

### 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)

□ NbN: A plasmonic material with superconductivity



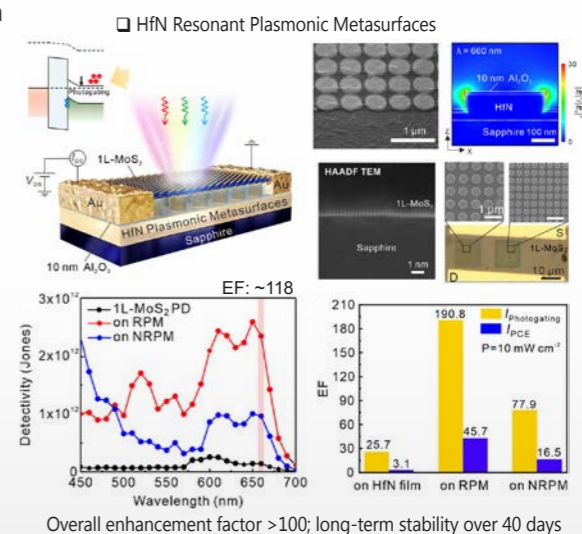
With a growing demand for detecting light at the single-photon level in various fields, researchers are focused on optimizing the performance of superconducting single-photon detectors (SSPDs) by using multiple approaches. However, input light coupling for visible light has remained a challenge in the 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. In addition, the plasmonic SMPDs exhibit a hot-belt effect that generates a nonlinear photoresponse in the visible range operated at 9 K (~0.64 Tc), resulting in a 233-fold increase in phonon-electron interaction factor ( $\gamma$ ) compared to pristine SMPDs at resonance under CW illumination. These findings open new opportunities for ultrasensitive single-photon detection in areas like quantum information processing, quantum optics, imaging, and sensing at visible wavelengths.

GPR disrupts the Cooper pairs High detection efficiency

### Enhancing Photogating Gain in Scalable MoS<sub>2</sub> 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 MoS<sub>2</sub> photodetectors with a nitride-based resonant plasmonic metasurface to achieve a high detectivity of  $2.58 \times 10^{12}$  Jones with a record-low dark current of 8 pA and long-term stability over 40 days. Upon comparison with control devices, we observe an overall enhancement factor of >100; this can be attributed to the local strong EM field enhanced photogating effect by the resonant plasmonic metasurface. 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.

Overall enhancement factor >100; long-term stability over 40 days

# Mu-Huai Fang

Assistant Research Fellow

Education | Ph.D. Department of Chemistry, National Taiwan University (2018)

## Selected Publications

1. Bilo, J. A. V.; Chang, C.-K.; Chuang, Y.-C.; **Fang, M.-H.**\* Co-Precipitation Strategy for Halide Solid-State Electrolyte and Atmospheric-Dependent In-Situ Analysis. *ACS Appl. Mater. Interfaces* **2024**, DOI: 10.1021/acsami.4c03694.
2. 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.
3. Tsai, Y.-T.; Chen, P.-X.; Kamiński, M.; Majewska, N.; Mahlik, S.\*; **Fang, M.-H.**\* Sharp-to-Broad Band Energy Transfer in Lithium Aluminate and Gallate Phosphors for SWIR LED. *ACS Appl. Opt. Mater.* **2024**, DOI: 10.1021/acsaom.3c00464.
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 a Short-Wave Infrared Photodetector. *Adv. Opt. Mater.* **2024**, *12*, 2302062.
5. Hsu, J.-Y.; Chung, R.-J.; Kuo, Y.-L.; Lin, C. C.; Majewska, N.; Kreft, D.; Mahlik, S.\*; **Fang, M.-H.**\* Concentration-Induced Hetero-Valent Partial-Inverse Occupation of Infrared Phosphor. *Adv. Opt. Mater.* **2023**, *11*, 2300121.
6. Majewska, N.; Tsai, Y.-T.; Zeng, X.-Y.; **Fang, M.-H.**\*; Mahlik, S.\* Advancing Near-Infrared Light Sources: Enhancing Chromium Emission through Cation Substitution in Ultra-Broadband Near-Infrared Phosphors. *Chem. Mater.* **2023**, *35*, 10228–10237.
7. Tsai, Y.-T.; Majewska, N.; Kamiński, M.; Lin, B.-H.; Mahlik, S.\*; **Fang, M.-H.**\* Hidden Hexavalent Chromium Ions with Subtle Structural Evolution in Near-Infrared Phosphors. *ACS Appl. Mater. Interfaces* **2023**, *15*, 49379–49389.
8. Zhang, Y.-Y.; Liu, K.-T.; **Fang, M.-H.**\*; Leung, M.-k.\* Quantum Dot–vitrimers Composites: An Approach for Reprocessable, Self-healable, and Sustainable Luminescent Materials. *ChemSusChem* **2023**, *16*, 202300227e.
9. Hsu, J.-Y.; Chung, R.-J.; Majewska, N.; Kreft, D.; Sheu, H.-S.; Lee, J.-F.; Mahlik, S.; **Fang, M.-H.**\* Probing Local Structural Change by Sharp Luminescent Infrared Nano-Phosphor for Application in Light-Emitting Diodes. *Chem. Mater.* **2022**, *34*, 11093–11100.

## Positions and Career

- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2021–now)
- Postdoctoral Research, Department of Chemistry, National Taiwan University (2019–2021)

## Honors and Awards

- 2023 Career Development Award, Academia Sinica
- 2019 Scholarship for Postdoctoral Fellow, National Science and Technology Council
- 2018 Outstanding Award, Chinese Chemical Society
- 2018 Yan's Award of Thesis, National Taiwan University
- 2018 Dean's Prize, College of Science, National Taiwan University
- 2017 Excellent Conference Report Award, Rare-Earth Luminescent Materials Symposium

## Research Interests

- Solid-state Materials
- Battery Materials
- Quantum Dots
- Optoelectronic Materials
- Phosphors

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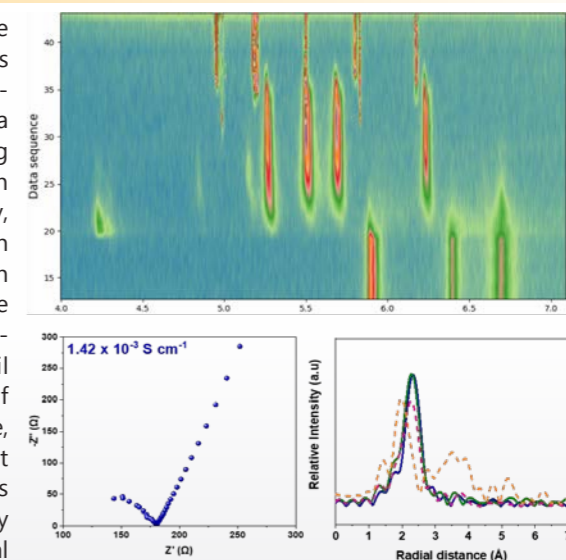
## Research Focus

### Energy-storage High-ionic-conductivity Solid-state Electrolyte via Modified Solution-based Synthesis and the In-situ Structural Analysis

Josanelle Angela V. Bilo and Mu-Huai Fang\*

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 that warrant both structural control and commercial scalability. In this study, we utilize our method to synthesize  $\text{Li}_3\text{InCl}_6$ , exhibiting both structural and electrochemical performance stability, with high ionic conductivity of  $1.42 \times 10^{-3} \text{ S cm}^{-1}$ , comparable to traditionally prepared counterparts. Through the in-situ synchrotron X-ray diffraction technique, we unveil the stability mechanisms and rapid chemical reactions of  $\text{Li}_3\text{InCl}_6$  under dry  $\text{Ar}$ , dry  $\text{O}_2$ , and high-humidity atmosphere, which were not previously reported. Furthermore, the fast reversibility capability of moisture-exposed  $\text{Li}_3\text{InCl}_6$  was tracked under vacuum, revealing the optimal recovery conditions at low temperatures. This work addressed critical challenges in structural engineering and sustainable mass production and provided insights into chemical reactions under real-world conditions.

*ACS Appl. Mater. Interfaces* 2024. DOI: 10.1021/acsami.4c03694.

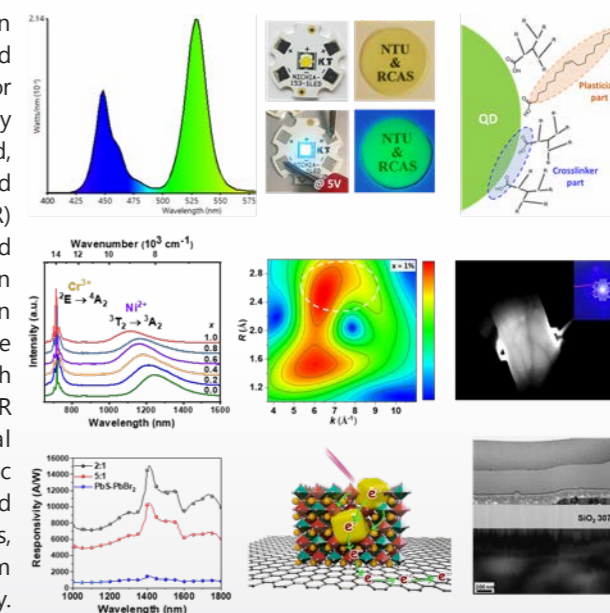


### Energy-saving Luminescent and Optoelectrical Materials with Applications in Light-emitting Diodes and Photodetectors

Yi-Ting Tsai, Yong-Yun Zhang, Meng-Yu Lin, Man-kit Leung\*, Shih-Yen Lin\*, and Mu-Huai Fang\*

Light-emitting diodes (LEDs) play a central role in energy-saving targets around the world. We developed a robust quantum-dot@vitrimers thin film composite for backlighting LED that can be physically and chemically recycled. The recycled compound can also be reused, making it a sustainable material. We also developed near-infrared (NIR) and short-wave infrared (SWIR) phosphors, applying them to energy-saving broadband infrared LEDs. This phosphor-converted LED can potentially replace the energy-consuming halogen lamp and be installed in smartphones, smart wearable devices, etc. On the other hand, to work together with LED light sources, we develop the energy-saving SWIR photodetector as well. We synthesized the colloidal quantum dots (QDs) hybridized with the metal-organic framework and halide double perovskite materials and applied them to the graphene field-effect transistors, which we can detect the SWIR light in 900–1700 nm with high responsivity, detectivity, and chemical stability.

*ACS Appl. Opt. Mater.* 2024. / *Adv. Opt. Mater.* 2023, *11*, 2300121. / *ACS Appl. Mater. Interfaces* 2023, *15*, 49379. / *Adv. Opt. Mater.* 2023, *12*, 2302062. / *Chem. Mater.* 2023, *35*, 10228. / *ChemSusChem* 2023, *16*, 202300227e. / *Chem. Mater.* 2022, *34*, 11093.



# Quantum Photonics

| Faculty Members |





# Wen-Hao Chang

Executive Officer of the TCQP and  
Distinguished Research Fellow

Education | Ph.D. in Physics, National Central University  
(2001)

## Positions and Career

- Distinguished Research Fellow, Research Center for Applied Sciences, Academia Sinica (2020.11 -)
- Acting Executive Officer, Thematic Center for Quantum Photonics, Academia Sinica (2020.11 -)
- Distinguished Professor, Department of Electrophysics, National Yang Ming Chiao Tung University (NYCU) (2018.05 -)
- Professor, Department of Electrophysics, NYCU (2012 -)
- Associate Professor, Department of Electrophysics, NYCU (2009 - 2012)
- Assistant Professor, Department of Electrophysics, NYCU (2005 - 2009)
- Postdoctoral Researcher, Department of Physics, National Central University (2001 - 2005)

## Honors and Awards

- 2021 Fellow, The Physical Society of Taiwan
- 2020 Achievement in Asia Award (Robert T. Poe Prize), International Organization of Chinese Physicists and Astronomers (OCPA)
- 2018 Distinguished Research Award, National Science and Technology Council (NSTC), Taiwan
- 2018 Sun Yet-Sen Academic Award, Sun Yet-Sen Academic and Cultural Foundation
- 2018 Distinguished Professorship, NYCU
- 2010 Wu Ta-Yu Memorial Award, NSTC, Taiwan

## Research Interests

Semiconductor quantum light sources, microcavity, cavity quantum electrodynamics  
Quantum optics of nanophotonics  
Spin dynamics in semiconductors  
2D layered materials: synthesis, material properties and device applications

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## Selected Publications

1. 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 MoSe<sub>2</sub>/MoS<sub>2</sub> Twisted Heterobilayers, *Nano Letters* **23**, 1306–1312 (2023).
2. Cheng-Chu Chung, Han Yeh, Po-Hsien Wu, Cheng-Chieh Lin, Chia-Shuo Li, Tien-Tien Yeh, Yi Chou, Chuan-Yu Wei, Cheng-Yen Wen, Yi-Chia Chou, Chih-Wei Luo, Chih-I Wu, Ming-Yang Li, Lain-Jong Li, Wen-Hao Chang\*, Chun-Wei Chen\*, Atomic-Layer Controlled Interfacial Band Engineering at Two-Dimensional Layered PtSe<sub>2</sub>/Si Heterojunctions for Efficient Photoelectrochemical Hydrogen Production, *ACS Nano* **15**, 4627–4635 (2021)
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 PdSe<sub>2</sub> 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)
6. Wei-Ting Hsu, Li-Syuan Lu, Po-Hsun Wu, Ming-Hao Lee, Peng-Jen Chen, Pei-Ying Wu, Yi-Chia Chou, Horng-Tay Jeng, Lain-Jong Li, Ming-Wen Chu & Wen-Hao Chang\*, Negative circular polarization emissions from WSe<sub>2</sub>/MoSe<sub>2</sub> commensurate heterobilayers, *Nature Comm.* **9**, 1356 (2018)
7. Wei-Ting Hsu, Li-Syuan Lu, Dean Wang, Jing-Kai Huang, Ming-Yang Li, Tay-Rong Chang, Yi-Chia Chou, Zhen-Yu Juang, Horng-Tay Jeng, Lain-Jong Li & Wen-Hao Chang\*, Evidence of indirect gap in monolayer WSe<sub>2</sub>, *Nature Comm.* **8**, 929 (2017)

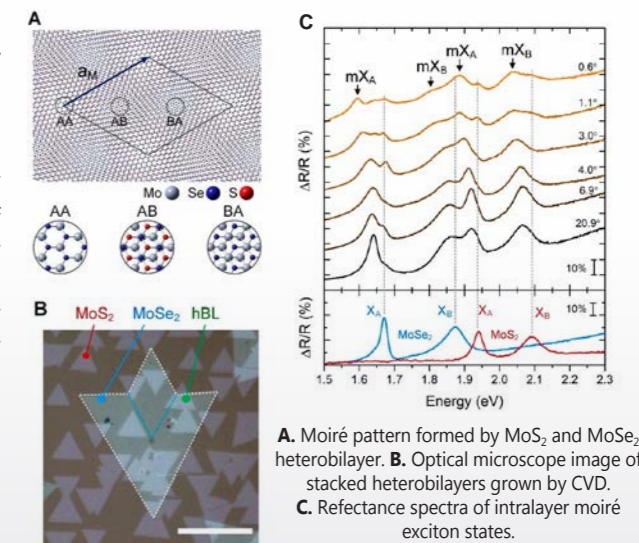
## Research Focus

### Remarkably Deep Moiré Potential for Intralayer Excitons in MoSe<sub>2</sub>/MoS<sub>2</sub> 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

Academic 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 MoSe<sub>2</sub>/MoS<sub>2</sub> 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.

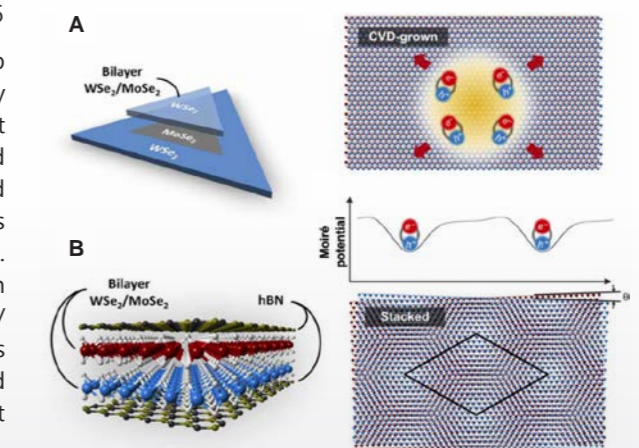


### Moiré Potential Impedes Interlayer Exciton Diffusion in Van der Waals Heterostructures

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, Wen-Hao Chang

Academic Sinica, Research Center for Applied Sciences  
Department of Electrophysics, National Yang Ming Chiao Tung University  
*Science Advances* 2020, DOI: 10.1126/sciadv.aba8866

In a moiré crystal with a large supercell and deep potential, interlayer excitons may be completely localized. As the moiré period reduces at a larger twist angle, excitons can tunnel between supercells and diffuse over a longer lifetime. The diffusion should be the longest in commensurate heterostructures where the moiré superlattice is completely absent. Here, we experimentally demonstrate the rich phenomena of interlayer exciton diffusion in WSe<sub>2</sub>/MoSe<sub>2</sub> heterostructures by comparing several samples prepared with chemical vapor deposition (CVD) and mechanical stacking with accurately controlled twist angles.



**A.** Commensurate WSe<sub>2</sub>/MoSe<sub>2</sub> heterobilayer without moiré potential formed by direct CVD growth. **B.** Mechanically stacked twisted WSe<sub>2</sub>/MoSe<sub>2</sub> heterobilayer with moiré potential formed by direct CVD growth.

# Min-Hsiung Shih

Deputy Director and Research Fellow

## Education

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

## Selected Publications

1. 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 WSe<sub>2</sub> monolayer/AlGaInP quantum well light-emitting device", *Nanoscale*, 15(3), 1347 (2023).
2. 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).
3. C-Y Chang, C-L Yu, C-A Lin, H-T Lin, A B Lee, Z-Z Chen, L-S Lu, W-H Chang, H-C Kuo, M-H Shih\*, "Hybrid Composites of Quantum Dots, Monolayer WSe<sub>2</sub>, and Ag Nanodisks for White Light-Emitting Diodes", *ACS Applied Nano Materials*, 3(7) 6855 (2020).
4. C-Y Chang, H-T Lin, M-S Lai, C-L Yu, C-R Wu, H-C Chou, S-Y Lin, C. Chen and M-H Shih\*, "Large-Area and Strain-Reduced Two-Dimensional Molybdenum Disulfide Monolayer Emitters on a Three-Dimensional Substrates", *ACS Applied Materials & Interfaces*, 11, 26243 (2019)
5. H-T Lin, C-Y Chang, P-J Cheng, M-Y Li, C-C Cheng, S-W Chang, L. L. J. Li, C-W Chu, P-K Wei, M-H Shih\*, "Circular Dichroism Control of Tungsten Diselenide (WSe<sub>2</sub>) Atomic Layers with Plasmonic Metamolecules", *ACS Applied Materials & Interfaces*, 10, 15996 (2018)
6. M.-H. Shih\*, K.-S. Hsu, K. Lee, K.-T. Lai, C.-T. Lin, and P.-T. Lee, "Compact Tunable Laser With InGaAsP Photonic Crystal Nanorods for C-Band Communication," *IEEE Journal of Selected Topics in Quantum Electronics*, 21, 1, (2015)
7. Kevin C. J. Lee, Y.-H. Chen, H.-Y. Lin, C.-C. Cheng, P.-Y. Chen, T.-Y. Wu, M.-H. Shih\*, K.-H. Wei, L.-J. Li & C.-W. Chang, "Plasmonic Gold Nanorods Coverage Influence on Enhancement of the Photoluminescence of Two-Dimensional MoS<sub>2</sub> Monolayer", *Scientific Reports*, 5, 16374 (2015)
8. M.-H. Shih\*, L.-J. Li, Y.-C. Yang, H.-Y. Chou, C.-T. Lin, C.-Y. Su, "Efficient Heat Dissipation of Photonic Crystal Microcavity by Monolayer Graphene", *ACS Nano*, 7(12), 10818 (2013)
9. C-W Cheng, M. N. Abbas, C-W Chiu, K-T Lai, M.-H. Shih\*, and Y.-C. Chang, "Wide-angle polarization independent infrared broadband absorbers based on metallic multi-sized disk arrays," *Optics Express* 20(9), 10376 (2012)
10. M.-H. Shih\*, K. Hsu, W. Kuang, Y. Yang, Y. Wang, S. Tsai, Y. Liu, Z. Chang, and M. Wu, "Compact optical curvature sensor with a flexible microdisk laser on a polymer substrate", *Optics Letters* 34, 2733 (2009)

## Positions and Career

- Deputy Director, Research Center for Applied Sciences (RCAS), Academia Sinica (2023 – )
- Acting Executive Officer of the thematic center for Green Technology, RCAS, Academia Sinica (2020 – 2022)
- Research Fellow, RCAS, Academia Sinica, Taiwan (2016 – )
- Associate Research Fellow, RCAS, Academia Sinica, Taiwan (2011 – 2016)
- Assistant Research Fellow, RCAS, Academia Sinica, Taiwan (2007 – 2011)
- Adjunct Professor, Department of Photonics, National Yang Ming Chiao Tung University, Taiwan (2017 – )
- Adjunct Professor, Department of Photonics, National Sun Yat-sen University, Taiwan (2017 – )
- Postdoctoral Associate, University of Southern California (USC), USA (2006 – 2007)

## Honors and Awards

- 2021 International Electron Devices & Materials Symposium (IEDMS), Excellent paper award.
- 2021 Optics & Photonics Taiwan International Conference (OPTIC), Paper award.
- The Optical Society (OSA) Senior member (2016 – )
- 2010 Lam Research PhD Thesis Award, National Chiao Tung University (Advisor)
- 2011 Taiwan Photonics Society PhD Thesis Award (Advisor)
- 2016 Lam Research PhD Thesis Award, National Chiao Tung University (Advisor)

## Research Interests

- Nanophotonics
- Two-dimensional materials and devices
- Plasmonic devices
- Photonic crystal devices
- High-Q cavities for quantum communication

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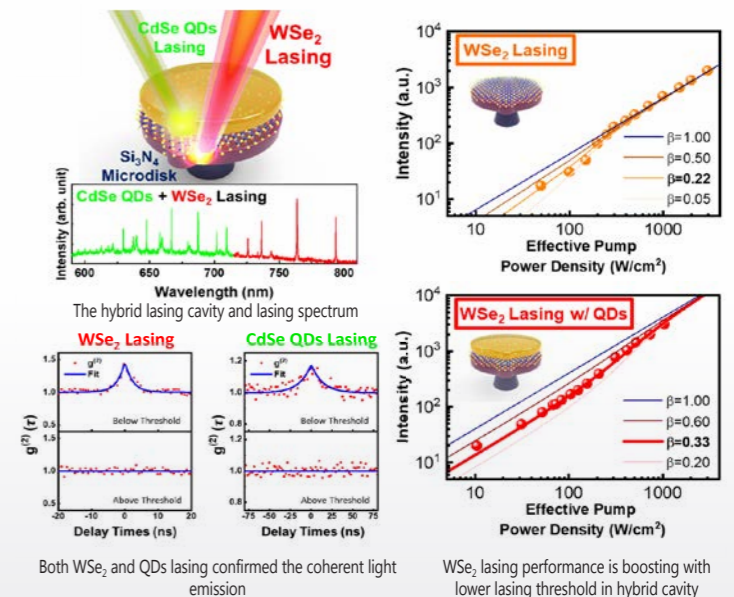
## Research Focus

### Boost lasing performances of 2-D semiconductor in A hybrid tungsten diselenide monolayer / cadmium selenide quantum dots microcavity laser

Hsiang-Ting Lin, Chiao-Yun Chang, Cheng-Li Yu, Andrew Boyi Lee, Shih-Yu Gu, Li-Syuan Lu, Yu-Wei Zhang, Shih-Yen Lin, Wen-Hao Chang, Shu-Wei Chang, and Min-Hsiung Shih\*

Academic Sinica, Research Center for Applied Sciences  
Advanced Optical Materials, 2022, DOI: 10.1002/adom.202200799

We investigated dual-color continuous-wave microcavity lasers by integrating a tungsten diselenide (WSe<sub>2</sub>) monolayer and cadmium selenide (CdSe) quantum dots (QDs) into a single microdisk cavity. The hybrid WSe<sub>2</sub>/QDs microcavity device not only provides the lasing action in two distinct wavelength regions, but also boost the lasing performances of WSe<sub>2</sub> monolayer because of the energy conversion between two gain materials. The results indicate the lasing threshold of the 2-D WSe<sub>2</sub> monolayer cavity with the CdSe QDs reduces more than 2.5 times, compared to the WSe<sub>2</sub> cavity without the QDs. Our findings both expand the wavelength range of TMDC-based compact lasers at room temperature and support their implementation in such applications as photonic integrated circuits, broad-band LEDs, and quantum display systems.



Both WSe<sub>2</sub> and QDs lasing confirmed the coherent light emission

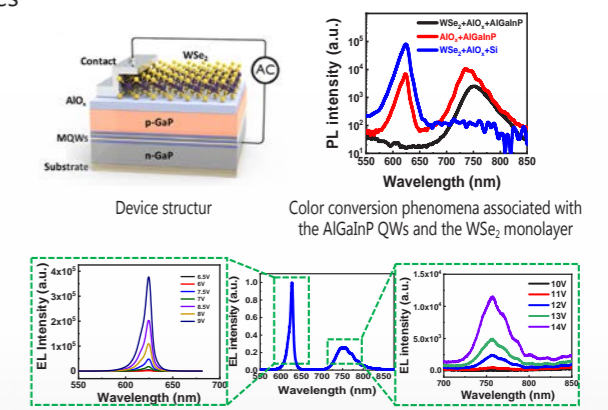
WSe<sub>2</sub> lasing performance is boosting with lower lasing threshold in hybrid cavity

### AC-driven multicolor electroluminescence from a hybrid WSe<sub>2</sub> monolayer/AlGaInP quantum well light-emitting device

Ya-Hui Chang, Yen-Shou Lin, Konthoujam James Singh, Hsiang-Ting Lin, Chiao-Yun Chang, Zheng-Zhe Chen, Yu-Wei Zhang, Shih-Yen Lin, Hao-Chung Kuo and Min-Hsiung Shih\*

Academic Sinica, Research Center for Applied Sciences  
Nanoscale, 2023, <https://doi.org/10.1039/D2NR03725D>

A multicolor AC-driven light-emitting device is developed by integrating a WSe<sub>2</sub> monolayer and AlGaInP–GaInP multiple quantum well (MQW) structures. The CVD-grown WSe<sub>2</sub> monolayer was placed on the top of an AlGaInP-based light-emitting diode (LED) wafer to create a two-dimensional/three-dimensional heterostructure. More than 20% energy conversion from the AlGaInP MQWs to the WSe<sub>2</sub> monolayer was observed to boost the WSe<sub>2</sub> monolayer emissions. Electroluminescence intensity–voltage characteristic curves indicated that thermionic emission was the mechanism underlying carrier injection across the potential barrier at the Ag–WSe<sub>2</sub> monolayer interface at low voltage, whereas Fowler–Nordheim emission was the mechanism at voltages higher than approximately 8.0 V. These multi-color hybrid light-emitting devices both expand the wavelength range of 2-D TMDC-based light emitters and support their implementation in applications such as chip-scale optoelectronic integrated systems, broad-band LEDs, and quantum display systems.



EL spectra of the device at various voltages and fixed frequency (AlGaInP-based MQW (left) and WSe<sub>2</sub> emissions (right))

# Chao-Cheng Kaun

Research Fellow

Education | Ph.D. in Physics, McGill University (2004)

## Selected Publications

- 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).
- C.-H. Chuang, P.-H. Kang, Y.-Y. Lai, C.-H. Hou, W.-C. Tseng, Y.-J. Huang, M.-H. Fang, J.-J. Shyue, C.-C. Kaun, and Y.-J. Cheng\*, "Highly Active NiO-Ni(OH)<sub>2</sub>-Cr<sub>2</sub>O<sub>3</sub>/Ni Hydrogen Evolution Electrocatalyst through Synergistic Reaction Kinetics", *ChemSusChem* 16, e202300820 (2023).
- W.-C. Tseng, C.-W. Chang, C.-C. Kaun\*, and Y.-H. Su\*, "Catalytic hydrogen evolution reaction on surfaces of metal-nanoparticle-coated zinc-based oxides by first-principles calculations", *Int. J. Hydrogen Energy* 47, 40768 (2022).
- M. R. Aziza, C.-W. Chang, C.-C. Kaun\*, and Y.-H. Su\*, "Hydrogen Evolution Driven by Photoexcited Entangled Skyrmion on Perovskite Ca<sub>2</sub>Nan-3NbnO<sub>3n+1</sub> Nanosheet", *J. Phys. Chem. Lett.* 12, 6244 (2021).
- M. R. Aziza, C.-W. Chang, A. Mohapatra, C.-W. Chu, C.-C. Kaun\*, and Y.-H. Su\*, "Dion-Jacobson Phase Perovskite Ca<sub>2</sub>Nan-3NbnO<sub>3n+1</sub>- (n = 4, 5, 6) Nanosheets as High- $\eta$  Photovoltaic Electrode Materials in a Solar Water-Splitting Cell", *ACS Appl. Nano Mater.* 3, 6367 (2020).
- I.-H. Hong\*, C.-J. Gao, K.-B. Lin, and C.-C. Kaun\*, "Self-organized C<sub>70</sub>/C<sub>60</sub> heterojunction nanowire arrays on Si(110) for Si-based molecular negative differential resistance nanodevices", *Applied Surface Science* 531, 147338 (2020).
- K.-B. Lin, Y.-H. Su\*, and C.-C. Kaun\*, "Interfacial effects on leakage currents in Cu/ $\beta$ -cristobalite/Cu junctions", *Scientific Reports* 10, 5303 (2020).
- H.-W. Tsao, C.-C. Kaun\*, and Y.-H. Su\*, "Decorating a WSe<sub>2</sub> monolayer with Au nanoparticles: A study combined first-principles calculation with material genome approach", *Surf. Coat. Technol.* 388, 125563 (2020).
- K. P. Dou, C.-H. Chang, and C.-C. Kaun\*, "Gate-Tunable Fano Resonances in Parallel-Polyacene-Bridged Carbon Nanotubes", *J. Phys. Chem. C* 123, 4605 (2019).
- L.-W. Huang, Y.-H. Su\*, and C.-C. Kaun\*, "Conductance Switching in Single-Peptide Molecules through Interferer Binding", *ACS Omega* 3, 9191 (2018).

## Positions and Career

- Research Fellow, Research Center for Applied Sciences, Academia Sinica (2017- )
- Adjunct Professor, Department of Physics, National Tsing Hua University (2018 - 2021)
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2013 - 2017)
- Adjunct Associate Professor, Department of Physics, National Tsing Hua University (2014 - 2018)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2006 - 2013)
- Adjunct Assistant Professor, Department of Physics, National Tsing Hua University (2006 - 2014)
- Postdoctoral Fellow, Department of Chemistry, Northwestern University (2004 - 2006)

## Honors and Awards

- 2022 Future Tech Award, National Science and Technology Council
- 2021 Future Tech Award, Ministry of Science and Technology

## Research Interests

- Computational nanoelectronics and spintronics
- Quantum transport in mesoscopic systems
- Emerging materials for sustainable energy

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- C.-C. Kaun and Y.-C. Chen\*, "Thermoelectric Charge and Spin Current Generation in Magnetic Single-Molecule Junctions: First-Principles Calculations", *J. Phys. Chem. C* 122, 12185 (2018).
- C.-H. Chang\*, K.-P. Dou, G.-Y. Guo, and C.-C. Kaun\*, "Quantum-well-induced engineering of magnetocrystalline anisotropy in ferromagnetic films", *NPG Asia Mater.* 9, e424 (2017).

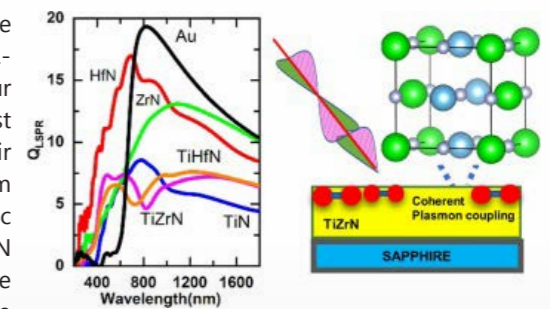
## Research Focus

### Tailoring the Plasmonic Properties of Complex Transition Metal Nitrides: A Theoretical and Experimental Approach

M. U. Javed, J.-W. Yang, S. Kumari, M. Mustaqeem, T.-Y. Peng, L. C. Yang, Y.-J. Lu, and Chao-Cheng Kaun

Academic Sinica, Research Center for Applied Sciences  
Applied Surface Science, 2023, DOI:10.1016/j.apsusc.2023.158486

We computationally and experimentally investigate the plasmonic properties of transition metal nitrides (TMNs), Ti<sub>1-x</sub>Zr<sub>x</sub>N and Ti<sub>1-x</sub>Hf<sub>x</sub>N, where x = 0, 0.25, 0.50, 0.75, and 1. Our calculated dielectric permittivities and quality factors suggest that the overall performance of TMNs is well-tuned by their compositions, supported by our measured data obtained from the 50-nm thick TMN films. Particularly, at the dielectric-metallic interface, Ti<sub>0.25</sub>Hf<sub>0.75</sub>N (ENZ of 401 nm) and Ti<sub>0.50</sub>Zr<sub>0.50</sub>N (ENZ of 406 nm) show a better dielectric response than the binary TMNs. Ti<sub>0.50</sub>Hf<sub>0.50</sub>N (ENZ of 457 nm) holds promise for applications requiring efficient energy absorption and enhanced wave manipulation in the near-infrared range. Using mixed ternary TMNs to tune plasmonic properties in the visible and near-infrared regions can thus achieve frequency-targeting photonics applications.



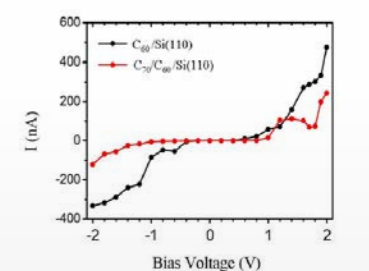
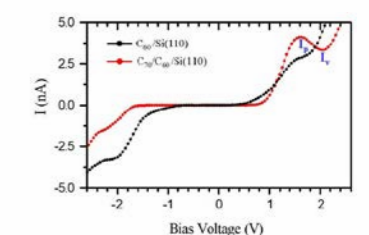
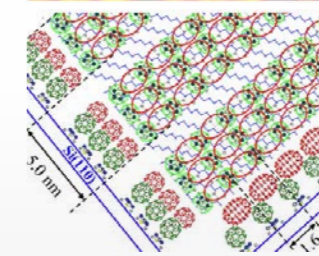
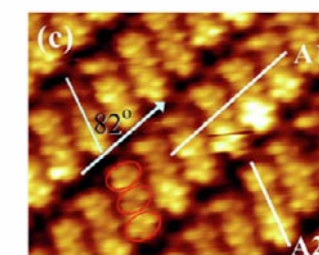
The structure and calculated quality factors of TMNs.

### Self-organized C<sub>70</sub>/C<sub>60</sub> heterojunction nanowire arrays on Si(110) for Si-based molecular negative differential resistance nanodevices

Ie-Hong Hong, Chai-Jung Gao, Kuan-Bo Lin, and Chao-Cheng Kaun

Academic Sinica, Research Center for Applied Sciences  
Applied Surface Science, 2020, DOI:10.1016/j.apsusc.2020.147338

The parallel-aligned C<sub>70</sub>-triplet/C<sub>60</sub>-triplet heterojunction nanowires over a large area on Si(1 1 0) were successfully constructed through self-assembly. Scanning tunneling spectroscopy results show that these C<sub>70</sub>/C<sub>60</sub> heterojunction nanowires on Si(1 1 0) exhibit obvious negative differential resistance (NDR) at room temperature. Using first-principles calculations, we suggest that the observed NDR of C<sub>70</sub>/C<sub>60</sub> heterojunction nanowires on Si(1 1 0) is due to the relatively weak interaction between C<sub>70</sub> molecules and Si(1 1 0) via the spacers of C<sub>60</sub> molecules. This controlled organic heterojunction nanowire array on Si(1 1 0) provides a feasible way for applications in nanoelectronics.



Topographic STM images of a nanowire array and the corresponding structural model.

The measured and calculated I-V curves of the systems.

# Shih-Yen Lin

Research Fellow

Education | Ph.D. in Electrical Engineering, NTU (2001)

## Positions and Career

1. Research Fellow, RCAS, Academia Sinica (2016.5~now)
2. Adjunct Professor, GIEE, National Taiwan University (2016.8~now)
3. Adjunct Professor, DoEE, National Cheng Kung University (2017.2~now)
4. Adjunct Professor, DMSE, National Dong Hwa University (2016.8~now)
5. Associate Research Fellow, RCAS, Academia Sinica (2011.9~2016.5)
6. Assistant Research Fellow, RCAS, Academia Sinica (2006.10~2011.8)
7. Engineer and PI, Industrial Technology Research Institute (2003.2~2006.10)
8. RD deputy manager, LandMark Optoelectronics Corp. (2001.6~2003.1)

## Honors and Awards

1. Research Scholarship award from Wen-Yuan Pan Foundation (2005)
2. Outstanding young engineer (2011, Chinese Institute of Engineers, Taiwan)
3. IEEE senior Member, 2012.8
4. Outstanding Young Scholar Research Project, NSC (2013.8-2016.7)

## Research Interests

2D Materials, Semiconductor nano-structures, Optical and electrical devices

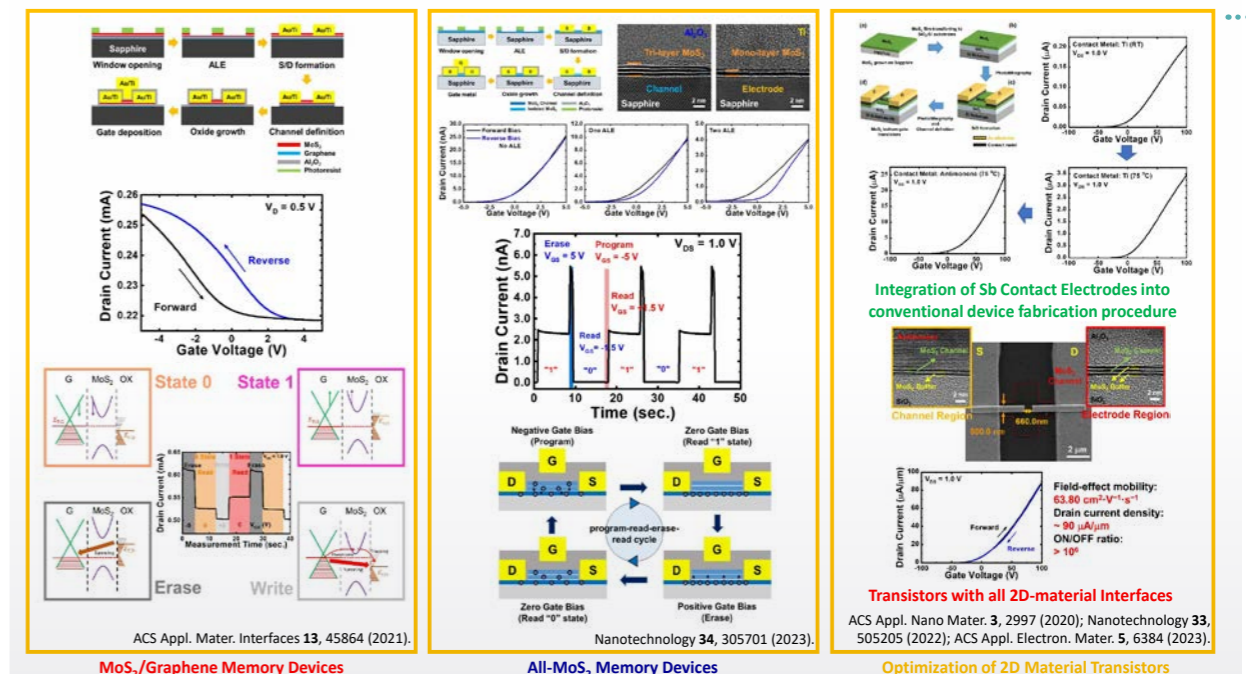
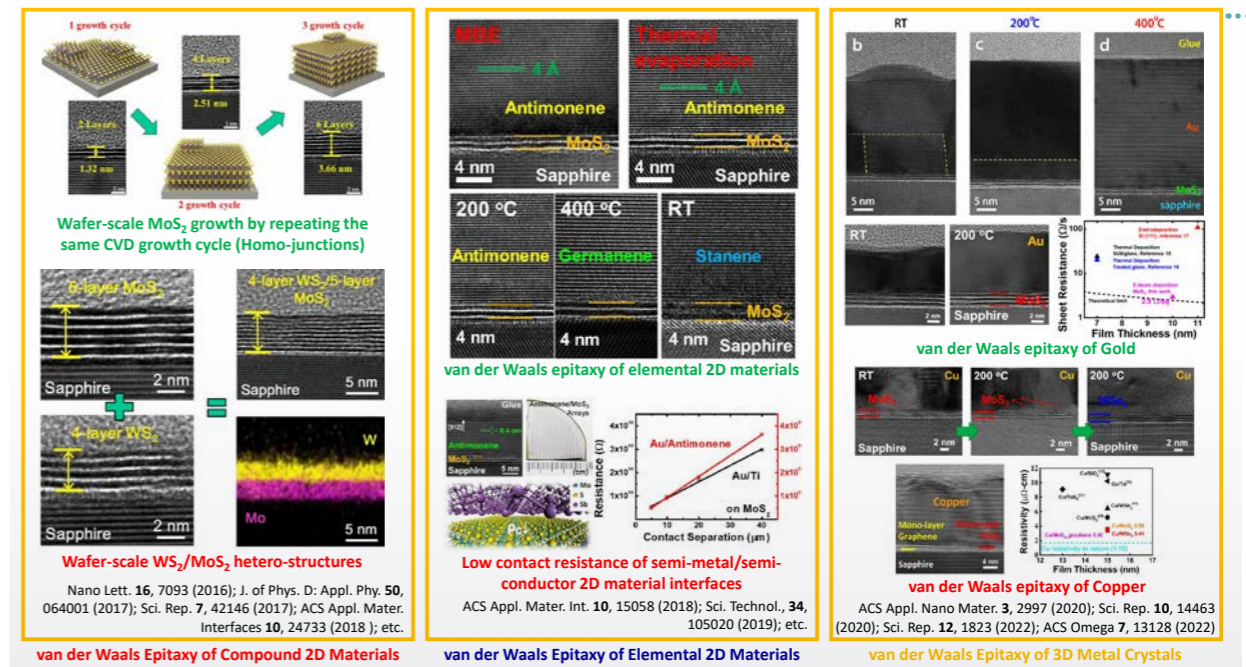
## Selected Publications

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. **Shih-Yen Lin\***, Chi-Che Tseng, Wei-Hsun Lin, Shu-Cheng Mai, Shung-Yi Wu, Shu-Han Chen and Jen-Inn Chyi, "Room-Temperature Operation Type-II GaSb/GaAs Quantum-Dot Infrared Light-Emitting Diode", *Appl. Phys. Lett.*, vol. 96, pp. 123503, March 2010.
3. 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.
4. 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.
5. Meng-Yu Lin, Chung-En Chang, Cheng-Hung Wang, Chen-Fung Su, Chi Chen, Si-Chen Lee, and **Shih-Yen Lin\***, "Toward Epitaxially Grown Two-Dimensional Crystal Hetero-Structures: Single and Double MoS<sub>2</sub>/Graphene Hetero-Structures by Chemical Vapor Depositions", *Appl. Phys. Lett.* vol. 105, no. 7, pp. 073501, August 2014.
6. 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.
7. Kuan-Chao Chen, Tung-Wei Chu, Chong-Rong Wu, Si-Chen Lee and **Shih-Yen Lin\***, "Atomic Layer Etchings of Transition Metal Dichalcogenides with Post Healing Procedures: Equivalent Selective Etching of 2D Crystal Hetero-structures", *2D Materials*, vol. 4, no. 3, pp. 034001, June 2017.
8. Hsuan-An Chen, Hsuan-Yu Chen, Wei-Chan Chen, and **Shih-Yen Lin\***, "Type-II Superlattice Infrared Photodetectors with Graphene Transparent Electrodes", *IEEE Photonics Technology Lett.*, vol. 29, no. 19, pp. 1691 – 1694, October 2017.
9. 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.

10. Po-Cheng Tsai, Chun-Wei Huang, Shouu-Jinn Chang, Shu-Wei Chang\*, and **Shih-Yen Lin\***, "Charge Storage of Isolated Monolayer Molybdenum Disulfide in Epitaxially Grown MoS<sub>2</sub>/Graphene Heterostructures for Memory Device Applications", *ACS Appl. Mater. Interfaces*, vol. 13, no. 38, pp. 45864-45869, September 2021.
11. Che-Jia Chang, Bo-Hao Chen, Tzu-Hsuan Chang, Shouu-Jinn Chang, and **Shih-Yen Lin\***, "Molybdenum Disulfide Transistors Bearing All-2D-Material Interfaces: Device Performance Optimization and Influences of Interfaces and Passivation Layers", *ACS Appl. Electron. Mater.*, vol. 5, issue 11, pp. 6384-6391, Nov. 2023.

## Research Focus



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# Shu-Wei Chang

Associate Research Fellow

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

## Positions and Career

- Adjunct Associate Professor, National Chiao-Tung University (2015 – )
- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica (2015 – )
- Adjunct Assistant Professor, National Chiao-Tung University (2011 – 2015)
- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2010 – 2015)
- Postdoctoral Research, University of Illinois at Urbana-Champaign, (2008 – 2010)

## Honors and Awards

- 2015 OSA Senior Member
- 2015 IEEE, Senior Member
- 2006 John Bardeen Graduate Memorial Award, ECE, Dept. University of Illinois at Urbana-Champaign

## Research Interests

- Non-Hermitian Photonics
- Chiral Photonics
- Semiconductor Photonics
- Device Physics

## Selected Publications

1. C. Y. Peng, H. T. Cheng, Y. H. Hong, W. C. Hsu, F. H. Hsiao, T. C. Lu, S. W. Chang, S. C. Chen\*, C. H. Wu\*, and H. C. Kuo\*, "Performance analyses of photonic-crystal surface-emitting laser: toward high-speed optical communication," *Nanoscale Res. Lett.* 17, 90 (2022). [DOI: 10.1186/s11671-022-03728-x]
2. 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]
3. 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]
4. H. T. Lin, Y. Y. Hsu, P. J. Cheng, W. T. Wang, S. W. Chang, and M. H. Shih\*, "In situ tunable circular dichroism of flexible chiral metasurfaces composed of plasmonic nanorod trimers," *Nanoscale Adv.* 4, 2428 (2022) [DOI: 10.1039/d2na00144f]
5. C. T. Tung, S. W. Chang, and C. H. Wu\*, "Analytical modeling of tunnel junction transistor lasers," *IEEE J. Sel. Top. Quantum Electron.* 28 1501008 (2022). [DOI: 10.1109/JSTQE.2021.3090527]
6. M. J. Yu, C. L. Chang, H. Y. Lan, Z. Y. Chiao, Y. C. Chen, H. W. H. Lee, Y. C. Chang, S. W. Chang, T. Tanaka, V. Tung, H. H. Chou\*, and Y. J. Lu\*, "Plasmon-enhanced solar-driven hydrogen evolution using titanium nitride metasurface broadband absorbers," *ACS Photon* 8, 3125 (2021). [DOI: 10.1021/acsp Photonics.1c00927]
7. P. C. Tsai, C. W. Huang, S. J. Chang, S. W. Chang\*, and S. Y. Lin\*, "Charge storage of isolated monolayer molybdenum disulfide in epitaxially grown MoS2/graphene hetero-structures for memory device applications," *ACS Appl. Mater. & Inter.* 13, 45864 (2021). [DOI: 10.1021/acsaami.1c12064]
8. C. T. Tai, P. Y. Chiu, C. Y. Liu, H. S. Kao, C. T. Harris, T. M. Lu, C. T. Hsieh, S. W. Chang, and J. Y. Li\*, "Strain effects on Rashba spin-orbit coupling of two-dimensional hole gases in GeSn/Ge heterostructures," *Adv. Mater.* 33, 2007862 (2021). [DOI: 10.1002/adma.202007862]
9. L. A. Chu\*, S. W. Chang, W. C. Tang, Y. T. Tseng, P. Chen, B. C. Chen\*, "5D superresolution imaging for a live cell nucleus," *Current Opinion in Genetics & Development* 67, 77 (2021). [DOI: 10.1016/j.gde.2020.11.005]

j.gde.2020.11.005]

10. C. H. Lin, D. W. Huang, T. T. Shih, H. C. Kuo, and S. W. Chang\*, "Increasing responsivity-bandwidth margin of germanium waveguide photodetector with simple corner reflector," *Opt. Express* 29, 10364 (2021). [DOI: 10.1364/OE.414691]

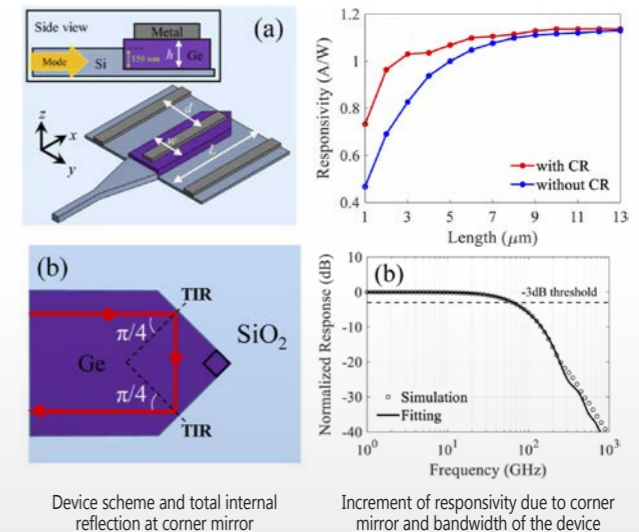
## Research Focus

### Increasing responsivity-bandwidth margin of germanium waveguide photodetector with simple corner reflector

Chih-Hsien Lin, Ding-Wei Huang, Tien-Tsornng Shih, Hao-Chung Kuo, and Shu-Wei Chang

Academic Sinica, Research Center for Applied Sciences  
Opt. Express, 2021, DOI: 10.1364/OE.414691

The external bandwidth of germanium waveguide photodetectors (PDs) decreases with the device length due to the load and parasitic effects even if the internal one is less affected. Shortening PDs raises the external bandwidth but lowers the responsivity, introducing a trade-off between the two figures of merits. We present a scheme of waveguide PDs based on total internal reflections of corner reflectors. The reflector can be easily fabricated with the standard photolithography at the end of PDs to efficiently reflect optical power back to germanium for additional absorption, allowing for further size reduction. The structure may render the optimization of PDs more flexible.

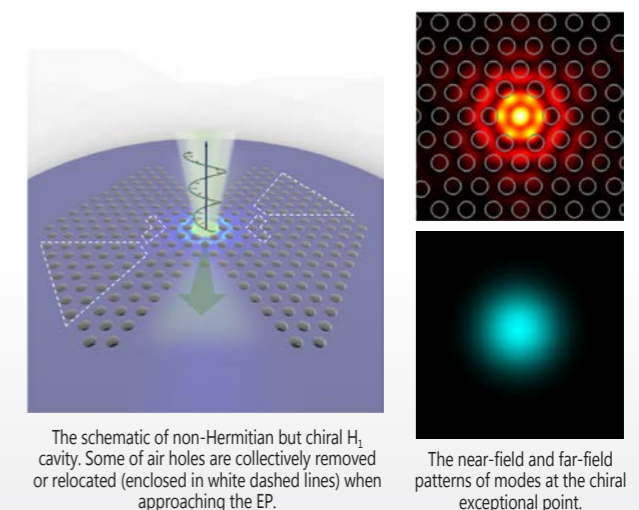


### Spinning Mode with Maximum Chirality in Photonic Crystal Defect Cavity at Exceptional Point

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  
Optica, 2023, DOI: 10.1364/OPTICA. 481825

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.



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# Chi Chen

Associate Research Fellow

Education | Ph.D. Chemistry, University of California-Irvine (2009)

## Positions and Career

2022- Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica.  
2013-22 Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica.  
2009-13 Postdoctoral researcher, Nanophotonics laboratory, RIKEN, Japan

## Honors and Awards

2022 Academia Sinica career development award.  
2014 "96 Achievements at RIKEN in 100 years", RIKEN, Japan.  
2008-09 University of California Regent's dissertation fellowship award.  
2002 Dr. Yan's thesis award in National Taiwan University.  
2002 Chinese chemical society outstanding thesis award.

## Research Interests

- Scanning near-field optical microscopy
- Tip-enhanced optical spectroscopy
- AFM, STM, and SNOM instrumentation
- Low-dimensional materials
- Mesoscopic molecular assemblies

## Selected 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, 7503 (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. Chen\*, Near-field spectroscopic imaging of exciton quenching at the atomically sharp  $MoS_2/WS_2$  lateral heterojunction. *Nanoscale* 14, 6323 (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 (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 (2021)
5. H.-C. Chou, W.-C. Hsu, Y. Yang, K. S. Schanze\*, S.-C. Luo \*, C. Chen\*, "Real-time spectral evolution of interchain coupling and assembling during solvent vapor annealing of dispersed conjugated polymers", *Macromolecular Chemistry and Physics*, 222, 2100125 (2021)
6. W.-P. Chan, J.-H. Chen, W.-L. Chou, W.-Y. Chen, H.-Y. Liu, H.-C. Hu, C.-C. Jeng, J.-R. Li, C. Chen, S.-Y. Chen \*, "Efficient DNA-driven nanocavities for approaching quasi-deterministic strong coupling to a few fluorophores", *ACS Nano*, 15, 13085 (2021)
7. J.-R. Yu, H.-C. Chou, C.-W. Yang, W.-S. Liao, I.-S. Hwang, and C. Chen\*, A horizontal-type scanning near-field optical microscope with torsional mode operation toward high-resolution and non-destructive imaging of soft materials. *Review of Scientific Instruments* 91, 073703 (2020)
8. K.-C. Chen, S.-M. Lai, B.-Y. Wu, C. Chen\*, and S.-Y. Lin\*, Van der Waals epitaxy of large-area and single-crystalline gold films on  $MoS_2$  for low contact-resistance 2D-3D interfaces. *ACS Applied Nano Materials* 3, 2997 (2020)
9. V. M. Balois, N. Hayazawa\*, C. Chen\*, E. Kazuma, Y. Yasuyuki, Y. Kim, T. Tanaka\*, Development of tip-enhanced Raman spectroscopy based on a scanning tunneling microscope in a controlled ambient environment, *Japanese Journal of Applied Physics*, 58, S10801 (2019)

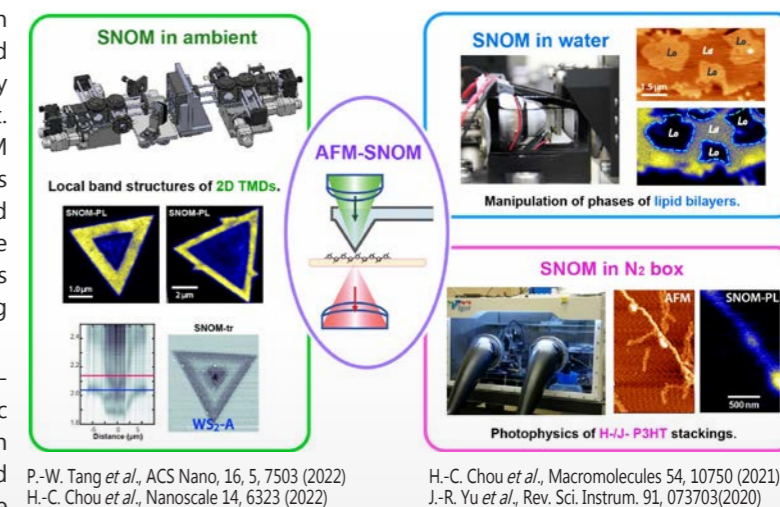
## Research Focus

### 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\*

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.

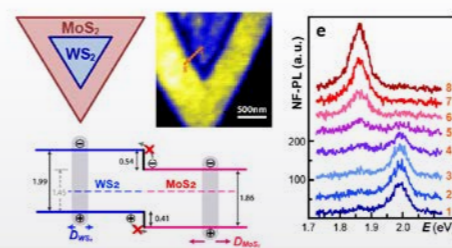


### Revealing the Local Band Structures of $WS_2/MoS_2$ Heterojunction $W_xMo_{1-x}S_2$ Alloy by Near-Field Optical Imaging

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

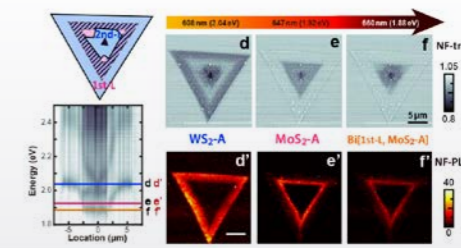
#### Lateral Heterojunction

We employed near-field photoluminescence (NF-PL) imaging to study the atomically sharp 1D interfaces between  $WS_2$  and  $MoS_2$  heterojunction with an optical resolution of 68 nm. Our NF-PL imaging resolved the narrowest quenching width (105 nm) and sharpest strain mapping because of the superior spatial resolution and stability of our home-built SNOM.



#### Vertical Stacking

We further developed a near-field broadband transmission, (NF-tr) imaging method for low-quantum-yield materials. The energy contour maps present the bandgap evolution in the  $W_xMo_{1-x}S_2$  alloy and reveal the interlayer coupling in bilayer  $W_xMo_{1-x}S_2$ . The NF-tr technique provides abbreviation-free and nanoscale-resolution imaging capability of the entire conduction band over highly lateral inhomogeneity.



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# Yu-Chen Chen

Assistant Research Fellow

Education | Ph.D. Department of Materials, University of Oxford (2017)

## Positions and Career

- Assistant Research Fellow, Research Center for Applied Sciences, Academia Sinica (2022-)
- Postdoctoral Researcher, Research Center for Applied Sciences, Academia Sinica (2021-2022)
- Postdoctoral Researcher, 3rd Institute of Physics, University of Stuttgart (2018-2020)

## Honors and Awards

- 2013-2016 DPhil programme scholarship sponsored by De Beers

## Research Interests

- Fabrication and femtosecond laser writing of spin defects in wide band gap materials
- Manipulation of spin states

## Selected Publications

1. 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).
2. 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).
3. C. J. Stephen, B. L. Green, Y. N. D. Lekhai, L. Weng, P. Hill, S. Johnson, 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).
4. M. Widmann\*, M. Niethammer, D. Y. Fedyanin, I. A. Khramtsov, T. Rendler, I. D. Booker, J. Ul Hassan, N. Marioka, **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).
5. **Y. C. Chen**, B. Griffiths, L. Weng, S. S. Nicley, S. N. Ishmael, Y. Lekhai, S. Johnson, C. J. Stephen, B. L. Green, G. W. Morley, M. E. Newton, M. J. Booth, P. S. Salter, and J. M. Smith\*. Laser writing of individual nitrogen-vacancy defects in diamond with near-unity yield. *Optica* 6, 5, 662-667 (2019).
6. R. Nagy, M. Niethammer, M. Widmann, **Y. C. Chen**, P. Udyarhelyi, C. Bonato, J. Ul Hassan, R. Karhu, I. G. Ivanov, N. T. Son, J. R. Maze, T. Ohshima, O. O. Soykal, A. Gali, S. Y. Lee\*, F. Kaiser\*, and J. Wrachtrup. High-fidelity spin and optical control of single silicon-vacancy centres in silicon carbide. *Nature Communications* 10, 1954 (2019).
7. **Y. C. Chen**\*, P. S. Salter, M. Niethammer, M. Widmann, F. Kaiser, R. Nagy, N. Morioka, C. Babin, J. Erlekampf, P. Berwian, M. J. Booth, and J. Wrachtrup. Laser writing of scalable single color centers in silicon carbide. *Nano Letters* 19, 4, 2377-2383 (2019).
8. P. R. Dolan, S. Adekanye, A. A. P. Trichet, S. Johnson, L. C. Flatten, **Y. C. Chen**, L. Weng, D. Hunger, H.-C. Chang, S. Castelletto, and J. M. Smith\*. Robust, tunable, and high purity triggered single photon source at room temperature using a nitrogen-vacancy defect in diamond in an open microcavity. *Optics Express* 26, 6, 7056-7065 (2018).

9. **Y. C. Chen**, P. S. Salter, S. Knauer, L. Weng, A. C. Frangeskou, C. J. Stephen, S. N. Ishmael, P. R. Dolan, S. Johnson, B. L. Green, G. W. Morley, M. E. Newton, J. G. Rarity, M. J. Booth, and J. M. Smith\*. Laser writing of coherent colour centres in diamond. *Nature Photonics* 11, 77-80 (2017).

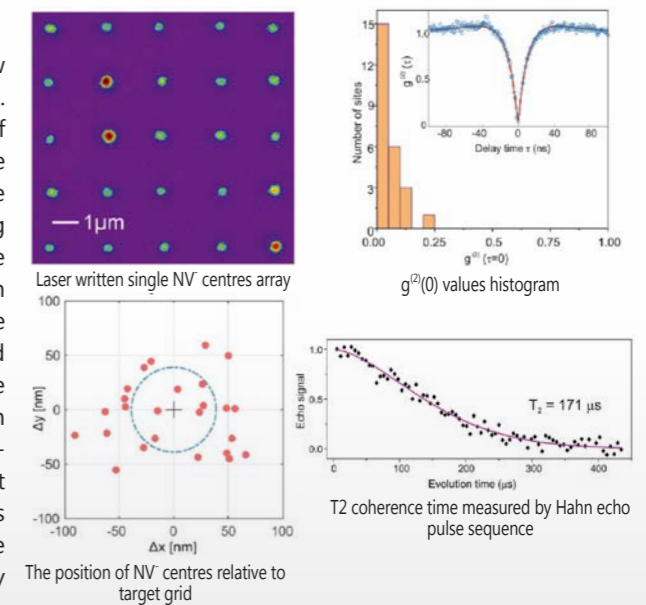
## Research Focus

### 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 T2 coherence time was measured up to 170  $\mu$ s by standard Hahn echo measurements.

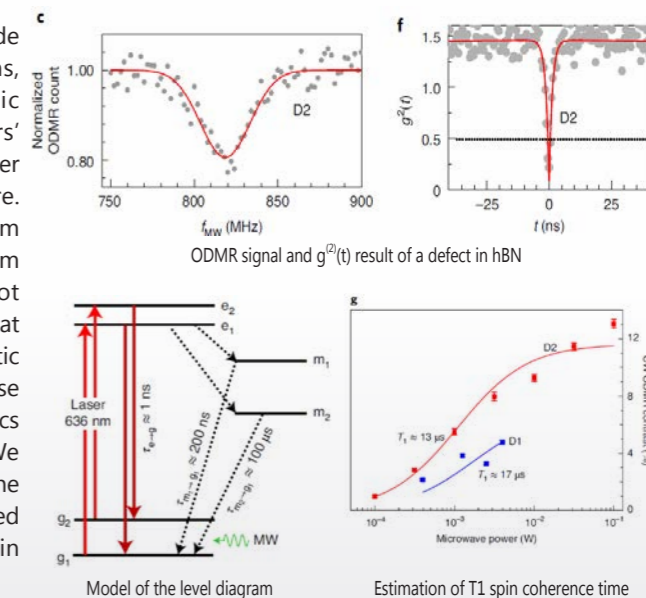


### Spin readout and manipulation of single defect in hBN 2D material

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 T1 spin coherence time of the spin defects were estimated to be around 13~17  $\mu$ s.



2024

**Tzung-Fang Guo** Fellow of OPTICA (formerly OSA)

2023

**Yu-Jung Lu** SPIE Senior Members, USA

**Mu-Huai Fang** Career Development Award, Academia Sinica

**Chun-Wei Pao** Y. Z. Hsu Scientific Paper Award

2022

**Yi-Chung Tung** Scientist with Top 2% Single Year Impact

**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

**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** SPIE Women in Optics Planner, USA

**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

**Chao-Cheng Kaun** Future Tech Award, Ministry of Science and Technology

2020

**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

2019

**Chih Wei Chu** Associate Academician of Asia Pacific Academy of Materials

**Chih Wei Chu** Young Scientist of Asia Pacific Academy of Materials

**Jung Hsin Lin** Academia Sinica Investigator Award

**Peilin Chen** Fellow, the Royal Society of Chemistry

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 6<sup>th</sup>, 4<sup>th</sup> 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**

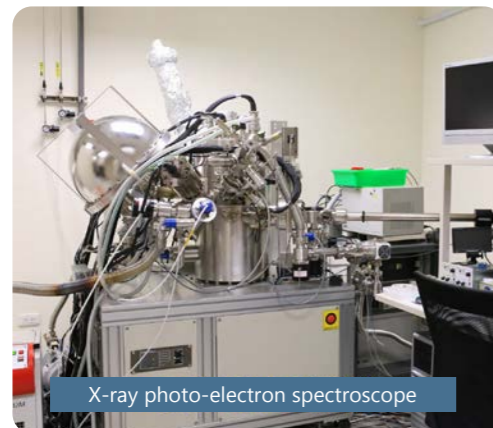
	Instruments	Features	Brand Model	Location
Microscope	Atomic force microscope	Material surface analysis	Bruker DM-CAFM	NCTU TKP506
	Laser scanning Confocal Spectral Microscope	Bio and fluorescent sample detection	Leica TCS-SP5	IRBST 4B20
	Atomic force microscope	Bio materials and nano components detection	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
	Variable angle spectroscopic ellipsometer	Material film thickness and refractive index analysis	VUV-VASE, Gen-II	IRBST 6A02
	Color 3D Laser Scanning Microscope	Surface profile and roughness detection	Keyence VK9710K S/N 2190011	IRBST 4C01
Micro Fabrication	Benchtop maskless lithography system	Structure production of photoresist on components	Heidelberg uPG501	IRBST B2C02
	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

# 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 6<sup>th</sup>, 4<sup>th</sup> 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.

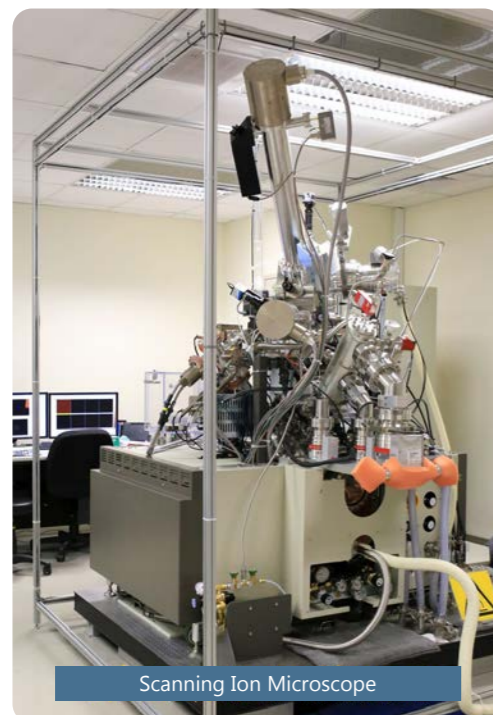
In addition to routine maintenance every year, we would upgrade the facilities and improve the laboratory configuration. Moreover, we have suitable plan and management for every lab and instrument in safety considerations of research.



X-ray photo-electron spectroscopy



Laser scanning Confocal Spectral Microscope



Scanning Ion Microscope



Focus Ion Beam



Specimen Preparation Equipment

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