Green Technology
綠色科技專題中心

Research Fellow / Executive Officer of TCGT

朱治偉 Chih-Wei Chu

- Thin film electronics and optoelectronics
- Next generation batteries

Research Fellow

包淳偉 Chun-Wei Pao

- Multiscale Simulation of Materials

Research Fellow

郭宗枋 Tzung-Fang Guo

- 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 lightemitting diodes

Research Fellow

張允崇 Yun-Chorng Chang

- Nanofabrication and Nanophotonics
- Semiconductor and Biosensing

Associate Research Fellow

程育人 Yuh-Jen Cheng

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

Associate Research Fellow

呂宥蓉 Yu-Jung Lu

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

Assistant Research Fellow

方牧懷 Mu-Huai Fang

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

Quantum Photonics
量子光電專題中心

Distinguished Research Fellow / Executive Officer of TCQP

張文豪 Wen-Hao Chang

- 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

Research Fellow / Deputy Director

施閔雄 Min-Hsiung Shih

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

Research Fellow

闕肇正 Chao-Cheng Kaun

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

Research Fellow

林時彥 Shih-Yen Lin

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

Associate Research Fellow

張書維 Shu-Wei Chang

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

Associate Research Fellow

陳　祺 Chi Chen

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

Assistant Research Specialist

陳俞辰 Yu-Chen Chen

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

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RCAS Website

中央研究院
ACADEMIA SINICA

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

RCAS (Research Center for Applied Sciences) has established three thematic centers in **Intelligent Biotechnology**, **Green Energy**, and **Quantum Photonics** to drive cutting-edge research and meet industry needs.

Each thematic center leads forward-looking projects that deliver breakthrough technologies and promote a sustainable, innovation-driven future.

Intelligence Bioengineering
智慧生物工程專題中心

Research Fellow / Executive Officer of TCIB

童奕鍾 Yi-Chung Tung

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

Research Fellow

薛景中 Jing-Jong Shyue

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

Research Fellow / Director

魏培坤 Pei-Kuen Wei

- Nanophotonics & Nanoplasmonics
- Biosensors & Bioelectronics
- Massive Nanofabrication
- Integrated Optics

Research Fellow

郭志禹 Chih-Yu Kuo

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

Research Fellow / Deputy Director

鄭郅言 Ji-Yen Cheng

- Nucleic acid and protein biosensors
- Microfluidic device development and applications
- Cell-based microalaysis, electrotaxis

Research Fellow

陳璧彰 Bi-Chang Chen

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

Distinguished Research Fellow

楊富量 Fu-Liang Yang

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

Assistant Research Fellow

林鉅容 Yu-Jung Lin

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

Research Fellow

陳培菱 Peilin Chen

- Advanced imaging: intravital, superresolution, single molecule
- Biomedical and bioelectronic devices
- Multifunctional nanomaterials

Research Specialist

謝東翰 Tung-Han Hsieh

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

Research Fellow

林榮信 Jung-Hsin Lin

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

Assistant Research Specialist

謝書宜 Shu-Yi Hsieh

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

Research Fellow

李超煌 Chau-Hwang Lee

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

RCAS functions as a diverse hub incorporating multiple specialized research centers. It has 3 thematic centers:

- Intelligence BioEngineering
- Green Technology
- Quantum Photonics

Faculty Directory

Intelligence Bioengineering
智慧生物工程專題中心

» 3D cell culture for cancer therapy and tissue development of organoind

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

Science Advances **2025,** 11 (11), ado1164

This study shows that a timed rise in tissue oxygen between weeks 4–6 enhances neurogenesis in human cerebral organoids, involving neuroglobin. Multiomic analysis reveals oxygen's regulatory role in early brain development, with implications for neurodegenerative disease therapy.

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 **2023,** 7 (1), 016117

A 3D co-culture model revealed that nintedanib enhances cisplatin's effects in reducing lung cancer cell growth and invasion. The drug also downregulates four fibroblast genes linked to adhesion and ECM remodeling.

» Nanometer resolution Light microscopy

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

Nature Communications **2024,** 15, 10911

We developed a potassium acrylate-based ExM platform with Bessel lightsheet microscopy, enabling 3D imaging of whole Drosophila brains at 40× enhanced resolution with nanoscale detail and robust sample handling.

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

Communications Biology **2022,** 5, 879

By integrating optogenetic stimulation into lattice lightsheet microscopy, we achieved long-term, subcellular 3D control of cell migration with minimal phototoxicity, enabling repeated activation and guided movement for up to 6 hours.

» AI-Assisted biomedical signal analysis

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

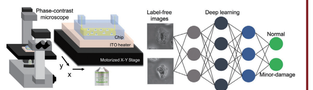
Bioengineering **2023,** 10 (10), 1207

To improve non-invasive fasting blood glucose (NIBG) prediction from PPG, we replaced explicit HbA1c input with an "implicit HbA1c" estimated from pretested PPG and glucose values. Trained on 1494 samples, the model maintained 87% accuracy over 90 days and improved performance by 16% compared to the explicit HbA1c method. The remaining 13% of predictions remained close to the Clarke's Error Grid zone A boundary. This approach enhances model practicality without extra HbA1c measurements. A Wilcoxon paired test confirmed significant error reduction (p = 2.75e−7), supporting its clinical potential.

AI-Assisted cell viability quantification

Microchemical Journal **2025,** 212, 113159

We developed an AI-assisted system using label-free phase-contrast images and deep learning to classify cell viability without damaging cells. Among tested CNNs, VGG-16 achieved 89% accuracy in distinguishing non- and minor-damaged cells. Raman spectroscopy validated metabolic activity. This approach offers an efficient, non-invasive alternative for drug screening and biomedical research.

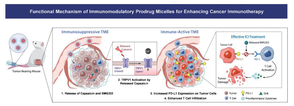


» Drug delivery and Nanobiosensing

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

ACS Nano **2024,** 18 (7), 5632–5646

We developed GSH-responsive prodrug micelles co-delivering capsaicin and BMS202 to modulate the tumor microenvironment. Capsaicin activates TRPV1, boosting PD-L1 expression and T cell recruitment, while BMS202 blocks immune checkpoints. This synergistic strategy enhances cancer immunotherapy by reshaping the tumor immune landscape.



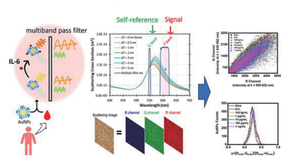
Adsorption of Drug Guest Molecules in Metal-Organic Frameworks Studied by Quartz Crystal Microbalance with Dissipation (QCM-D)

This study used quartz crystal microbalance with dissipation (QCM-D) to investigate the adsorption/desorption of acetaminophen, caffeine, and aspirin in aqueous solutions using UiO-66-coated quartz chips. The adsorption was repeatable and followed the order: aspirin > caffeine > acetaminophen, influenced by charge, polarity, and π–π interactions. pH effects revealed that acetaminophen adsorption decreased at low pH due to disrupted hydrogen bonding, while caffeine adsorption slightly increased from enhanced electrostatic interactions. Aspirin showed a non-monotonic trend, with reduced uptake at pH 3 due to molecular neutralization. Kinetic analysis showed that a non-linear pseudo-first-order model best described the system, with good agreement between model and experimental data. Interactions between the MOF and drug molecules significantly influenced kinetic behavior.

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

ACS Sensors **2025,** 10 (2), 1178–1186

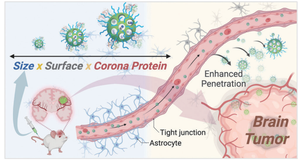
We developed a self-referenced digital chromatic LSPR platform using gold nanoparticles to detect IL-6 in diluted plasma with high sensitivity. By analyzing image contrast across multiple nanoparticles, the method achieved an LOD of <19.2 fg/mL and 96% recovery within 45 minutes using only 0.5 mL sample. This system offers a rapid, label-free approach for clinical IL-6 monitoring.



Receptor Ligand-Free Mesoporous Silica Nanoparticles: A Streamlined Strategy for Targeted Drug Delivery across the Blood–Brain Barrier

ACS Nano **2024,** 18, 20, 12716–12736

Ligand-free PEGylated MSNs ($RMSN_{25}$-PEG-TA) effectively cross the BBB, achieving 6-fold DOX accumulation in brain tumors and extending survival by 28%. Apolipoprotein E and albumin in the protein corona may mediate transport, highlighting $RMSN_{25}$-PEG-TA's promise for safe and effective brain tumor therapy.



Green Technology
綠色科技專題中心

» Safe, efficient, and scalable solid-state battery technologies

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

Small **2024,** 20, 23011382

We developed a composite solid polymer electrolyte (CSPE) incorporating aluminum-doped A-LLTO nanoparticles, forming a percolation network that boosts Li^+ transport and achieves 1.1 × 10^{-3} S cm^{-1} ionic conductivity at room temperature. The optimized CSPE (CAL-10%) is self-healing and enables a $LiFePO_4$‖CAL-10%‖Licell to deliver ≈165 mAh g^{-1} over 120 cycles with 98.85% coulombic efficiency. This design demonstrates strong potential for safe, high-performance solid-state Li-metal batteries.

Supersaturation-Driven Co-Precipitation for Halide Solid-State Electrolytes with In-situ Analyses

ACS Appl. Mater. Interfaces **2024,** 16, 21, 27394–27399

We developed a supersaturation-driven co-precipitation method to synthesize halide-based solid-state electrolytes, achieving Li_3InCl_6 with 1.42 × 10^{-3} S cm^{-1} conductivity and phase-pure Na_3InCl_6 with record-high performance. In-situ synchrotron XRD revealed unique stability mechanisms under various atmospheres. This scalable approach advances structural control and sustainable production of SSEs for solid-state batteries.

» Highly efficient solar cells and water splitting

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

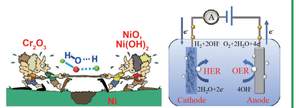
Chemical Engineering Journal **2025,** 504, 158070

We introduce 2D $NbSe_2$ and NbS_2 nanoparticles to passivate surface defects in MA-based perovskites. Their divalent anions reduce trap states and enhance stability via strong coordination and hydrogen-bond-like interactions. PSCs with $NbSe_2$ passivation reached 23.03% efficiency, 1.14 V Voc, and >84% fill factor, showing improved stability and commercial potential.

Noble-metal-free Electrocatalyst for Water Splitting

ChemSusChem **2023,** 16, e202300820

We developed noble-metal-free NiOx-Cr_2O_3/Ni and NiFe electrocatalysts showing Pt-like HER and efficient OER activity, enabled by synergistic effects and ultrasonic-assisted fabrication.

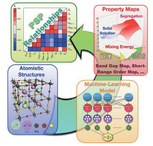


» Machine-learning assisted material design

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

Journal of Physical Chemistry Letters **2021,** 12 (14), 3591-3599

We used an ANN energy model and Monte Carlo sampling to map microstructures of $MA_xFA_{1-x}Pb(Br_yI_{1-y})_3$ perovskites. Correlation analysis showed reduced lattice distortion favors efficient single-phase formation.



Quantum Photonics
量子光電專題中心

» Quantum photonics

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

ACS Photonics **2025,** 12, 3, 1351–1358

We observed the exciton–polariton valley Hall effect by strongly coupling monolayer TMDs with plasmonic metasurfaces. Spin-momentum-locked surface plasmons enabled directional separation of valley-resolved polaritons, both in momentum and real space. This spatial routing of valley pseudospins via circularly polarized light offers a promising platform for valleytronic applications.

Sustained robust exciton emission in suspended monolayer WSe_2 within the low carrier density regime for quantum emitter applications

APL Mater. **2024,** 12 (3), 031125

Suspending monolayer WSe_2 significantly enhances PL intensity and PLQY by mitigating carrier trapping under low-power excitation. Compared to supported samples, suspended WSe_2 exhibits stronger excitonic emission in the low carrier density regime where SRH recombination dominates, demonstrating its promise for low-power quantum emitter applications.

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

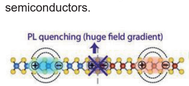
Nano Lett. **2023,** 23 (24), 11387–11394

We integrated NbN superconducting photon detectors with gap-plasmon resonators to enhance visible-light detection efficiency to 98% while maintaining polarization insensitivity. The gap plasmon mode boosts light–matter interaction, enabling efficient Cooper pair disruption. This advancement supports ultrasensitive single-photon detection for quantum optics, imaging, and sensing applications.

» 2D materials analysis and applications

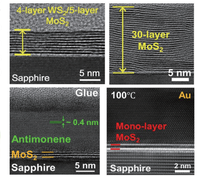
Revealing the Local Band Structures of WS_2/MoS_2 Heterojunction $W_xMo_{1-x}S_2$ Alloy by Near-Field Optical Imaging

Using near-field PL and broadband transmission imaging, we resolved nanoscale band structure and strain features in $WS_2$$MoS_2$ heterojunctions and $W_xMo_{1-x}S_2$ alloys. Our SNOM setup achieved 68 nm resolution, revealing 1D interface quenching widths of 105 nm and interlayer coupling in bilayers. These methods enable high-resolution mapping of local band structures in laterally inhomogeneous 2D semiconductors.



2D Material Homo- and Hetero- Structures

One unique property of 2D materials is the van der Waals attachment instead of chemical bonding between 2D material layers, which has provided possible stackings of either 2D material homo- and hetero- structures. With the assist of van der Waals epitaxy on 2D material surfaces, conventional crystals can also be grown despite the very different crystal structures.



2D Material Electrical and Optical Devices

The observation of their unique characteristics down to few atomic layer thicknesses has demonstrated their potential application in electronic devices with line widths < 1.0 nm. The separation of carrier transport and light absorption layers in the device architecture has provided a ready access for high-performance photodetectors fabricated by using 2D material hetero-structures.