AMIO
GLOBAL HUB
FOR ADVANCED MATERIALS AND INTEGRATED OPTOELECTRONICS

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA
CREATE CHANGE

## INAUGURAL

# AMIO SYMPOSIUM

## 2025

## BRISBANE

## QUEENSLAND

## AUSTRALIA

## THE UNIVERSITY OF QUEENSLAND
## ST LUCIA

## 8TH – 10TH
## DECEMEBER

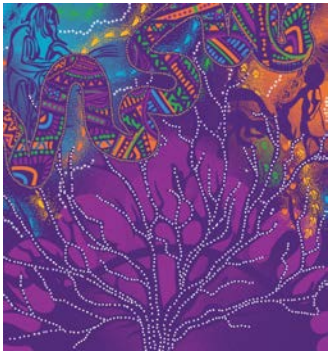
**CONTENT PAGE**

# Acknowledgement of Country

The University of Queensland (UQ) acknowledges the Traditional Owners and their custodianship of the lands on which we meet.

We pay our respects to their Ancestors and their descendants, who continue cultural and spiritual connections to Country.

We recognise their valuable contributions to Australian and global society.



# Welcome from the Local Organising Committee

The organising committee wishes you a very warm welcome to The University of Queensland (UQ) for the inaugural Advanced Materials and Integrated Optoelectronics (AMIO) Symposium.

The AMIO serves as a global hub dedicated to the development of cost-effective advanced semiconductors utilising carbon and perovskite semiconductors. Its mission is to advance next-generation light conversion devices, sensors, and ultra-high brightness devices within both research and manufacturing settings. We envision AMIO as a collaborative platform that nurtures the growth of carbon and perovskite-based semiconductor community, with the goal of promoting future optoelectronic and quantum technologies.

The event will feature research engagement and discussions on the current state of the science in organic and perovskite-based semiconductor optoelectronics and related areas. We hope that you will enjoy your time at the AMIO symposium, and with your help, wish for continued cooperation and growth within organic semiconductor community.

# Local Organising Committee

AMIO GLOBAL HUB
FOR ADVANCED MATERIALS AND INTEGRATED OPTOELECTRONICS

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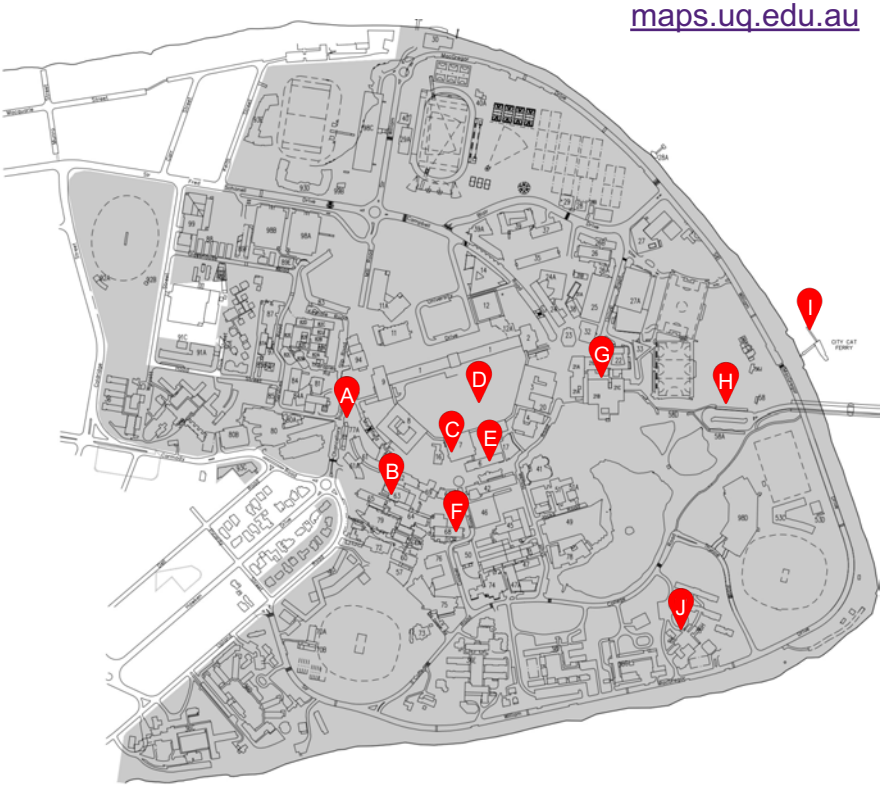
**Members of the Local Organising Committee, along with additional UQ staff and students, will be wearing purple name badges. Please don't hesitate to approach them if you require assistance.**

# Getting Around UQ

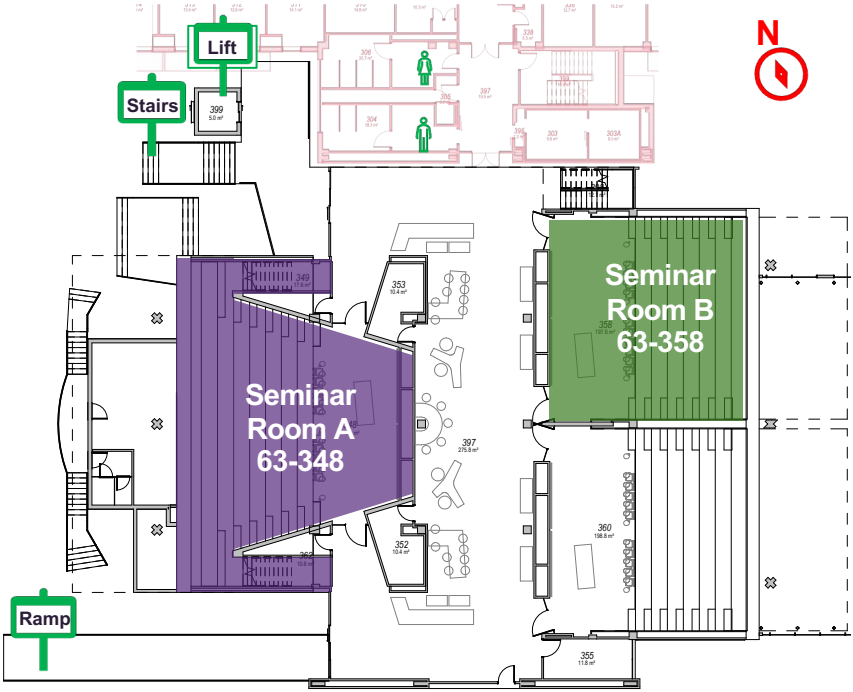
**For More**
maps.uq.edu.au




A. Chancellors Place Bus Stop
B. Physiology Lecture Theatres (63) **Symposium Location**
C. Physics Building (07)
D. Great Court
E. Physics Annexe (06)
F. Chemistry Building (68)
G. Food Precinct
H. UQ Lakes Bus Stop
I. Ferry (City Cat) Terminal
J. Women's College **Poster Presentations & BBQ Dinner on 8th**

## Physiology Lecture Theatres (63) Level 3

# Symposium Location




- **Access Level 3 from outside via a lift, stairs or ramp.**
- **There are bathrooms in the adjacent building (John Hines Building 62 – red on this map)**
- **Registration, sponsors displays, morning tea and afternoon tea will be in the space between the two Rooms (397).**
- **Lunch will be held on level 3 of the Chemistry Building (68), approximately a 2-minute walk.**
- **Level 2 of building 63 has food retailers (Sushi, Mexican, etc.)**

# Internet Access (WIFI)

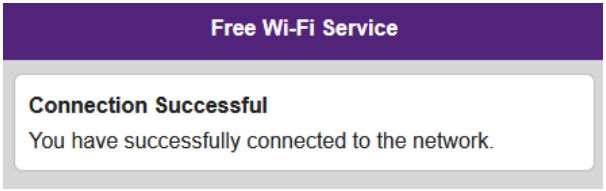
1. Open your device's wireless settings.

2. Select UQ Guest from the list of available wireless networks.


3. Once connected, your browser will open a Free Wi-Fi Service captive portal screen.

4. Click Accept to agree to Terms and Conditions.

5. You will be advised that you are now connected to UQ's Guest Wi-Fi network.




**For Eduroam:** Use the same **Eduroam** login details as you normally use at your own institution.
For example, staff or students at QUT should use username@qut.edu.au.

# DAY 1 – ROOM A

AMO GLOBAL HUB FOR ADVANCED MATERIALS AND INTEGRATED OPTOELECTRONICS

| Seminar 1A (Room 63-348) | | |
|---|---|---|
| 08:15 | **Registration** (in the Foyer) | |
| 08:40-09:00 | **Opening (**Shih-Chun Lo**)**<br>Prof. Melissa Brown (Executive Dean, FoS, UQ) & Dr. Peter Derbyshire (ATSE) | |
| **09:10-09:50** | **Keynote**<br>Chair: Shih-Chun Lo | |
| 09:10-09:50 | Chihaya Adachi | Advanced organic optoelectronic devices by controlling precise charge transfer phenomena |
| 09:50-10:20 | **Morning Tea** | |
| **10:20-12:25** | **Session 1A: Luminescent Frontiers** *(Light-Emitting materials)*<br>Chair: Koushik Venkatesan | |
| 10:20-10:45 | Yun Chi | Iridium(III) carbene phosphors for blue organic light emitting diodes |
| 10:45-11:10 | Ken Onda | Structural dynamics accompanied by intersystem crossing in TADF molecules |
| 11:10-11:35 | Hironori Kaji | Quantitative prediction of rate constants for OLEDs and development of inverted singlet-triplet materials |
| 11:35-12:00 | Vinich Promarak | Excited state intramolecular proton transfer (ESIPT) molecules: solid-state fluorophores for devices |
| 12:00-12:25 | Cameron Cole | Solution-processed to printed: the development of inkjet printed TADF polymer OLEDs |
| 12:25-13:40 | **Lunch** (at Chemistry Podium) | |
| **13:40-15:40** | **Session 2A: Smart Illumination** *(Light-Emitting Devices)*<br>Chair: Fabrice Mathevet | |
| 13:40-14:00 | Yong-Jin Pu | The origin of the inverted singlet and triplet excited states of azaphenalene molecules |
| 14:00-14:20 | Koushik Venkatesan | Gold carbenes for OLED applications |
| 14:20-14:40 | Evan Moore | Synergistic hetero-TTA: fact or fiction? |
| 14:40-15:00 | Jeong-Hwan Lee | Transient electroluminescent behaviors in OLEDs |
| 15:00-15:20 | Can Gao | Excited state management and device applications of high mobility emissive organic semiconductors |
| 15:20-15:40 | Weidong Xu | Perovskite light-emitting diodes and beyond |
| 15:40-16:00 | **Afternoon Tea** | |
| **16:00-18:00** | **Session 3A: Chirality & Computation** *(Designing with Symmetry and Simulation)*<br>Chair: Hironori Kaji | |
| 16:00-16:20 | Girish Lakhwani | Dual-responsive optical switches using chiral materials |
| 16:20-16:40 | Kai Lin Woon | Bridging theory, computation and experiment to power the next generation of OLED materials and devices |
| 16:40-17:00 | Anirban Mondal | Dark light, smart design: cracking the code of NIR-TADF with ml-guided inverse design |
| 17:00-17:20 | Xiuwen Zhou | Quantitative calculations of the photoluminescence quantum yield of organometallic emitters |
| 17:20-17:40 | Elise Kenny | Understanding structure–activity relationships in metal-functionalized organic photocatalysts |
| 17:40-18:00 | Yu-Chiang Chao | Optoelectronic devices based on chiral halide perovskites and organic semiconductors |
| **18:15-21:30** | **Posters & BBQ at The Women's College** | |

# DAY 1 – ROOM B

| Seminar 1B (Room 63-358) | | |
|---|---|---|
| 08:15 | **Registration** (in the Foyer) | |
| 08:40-09:00 | **Opening** (in Room 63-348)<br>Prof. Melissa Brown (Executive Dean, FoS, UQ) & Dr. Peter Derbyshire (ATSE) | |
| **09:10-09:50** | **Keynote**<br>Chair: Mats Andersson | |
| 09:10-09:50 | Koen Vandewal | New device architectures for organic infrared sensors |
| 09:50-10:20 | **Morning Tea** | |
| **10:20-12:25** | **Session 1B: Harvesting the Sun** *(Organic Photovoltaics)*<br>Chair: Safa Shoaee | |
| 10:20-10:45 | Wai-Yeung Wong | Photofunctional organometallic materials for solar cell applications |
| 10:45-11:10 | Alexander Gillett | Spin-triplet excited states in organic semiconductors |
| 11:10-11:35 | Hideo Ohkita | Charge generation dynamics at heterojunction with cascade energy structures |
| 11:35-12:00 | Yanming Sun | High-performance all-polymer solar cells |
| 12:00-12:25 | Hongzheng Chen | Material design and device engineering for high-performance semi-transparent organic solar cells |
| 12:25-13:40 | **Lunch** (at Chemistry Podium) | |
| **13:40-15:40** | **Session 2B: Harvesting the Sun** *(Organic Photovoltaics)*<br>Chair: Alexander Gillett | |
| 13:40-14:00 | Shinuk Cho | HTL- & ETL-free metal-semiconductor-metal structure organic solar cells |
| 14:00-14:20 | Maciej Klein | Solid-state photon upconversion mediated by charge transfer states in a bulk-heterojunction sensitizer |
| 14:20-14:40 | Ke Gao | Organic solar cells: from low band-gap porphyrin materials to mechanism study |
| 14:40-15:00 | Paul Hume | Towards high-throughput property prediction in molecular semiconductors |
| 15:00-15:20 | Anirudh Sharma | Decoding charge generation in pristine NFAS: from interfacial physics to module-scale OPVs |
| 15:20-15:40 | Paul Shaw | High-performance Y6 homojunction organic solar cells |
| 15:40-16:00 | **Afternoon Tea** | |
| **16:00-18:00** | **Session 3B: Perovskite Horizons** *(Next-Gen Solar Materials)*<br>Chair: Dechan Amigo | |
| 16:00-16:20 | Munkhbayar Batmunkh | Engineering metal halide perovskite films for photovoltaic devices |
| 16:20-16:40 | Aung Ko Ko Kyaw | Advanced interface engineering: unlocking the full potential of perovskite solar cells |
| 16:40-17:00 | Hui Jin | Synergistic effects of alkyl chain length and halide anions in fluorinated additives for perovskite PV |
| 17:00-17:20 | Rui Zhang | Microstructural studies of solution-processed organic optoelectronic materials |
| 17:20-17:40 | Chih-Hsin Chen | Metal-free phthalocyanine additives for enhanced stability and efficiency in perovskite solar cells |
| 17:40-18:00 | Fabrice Mathevet | Multifunctional hybrid 2D perovskites for optoelectronic applications |
| **18:15-21:30** | **Posters & BBQ at The Women's College** | |

# DAY 2 – ROOM A

| Seminar 2A (Room 63-348) | | |
|---|---|---|
| **08:30-09:10** | **Keynote**<br>Chair: Bright Walker | |
| 08:30-09:10 | Dawei Di | Bright and stable perovskite light-emitting devices |
| **09:10-10:25** | **Spotlight**<br>Chair: Bright Walker | |
| 09:10-09:35 | Atul Shukla | What's reducing the photovoltaic efficiency of narrow-bandgap organic solar cells? |
| 09:35-10:00 | Shizuo Tokito | Advanced flexible printed sensors and their applications |
| 10:00-10:25 | Yunqi Liu | 2D materials-based field-effect transistors for high-performance sensors |
| 10:25-10:45 | **Morning Tea** | |
| **10:45-12:25** | **Session 4A: Materials on the Edge** *(Emerging Organic Materials)*<br>Chair: Prashant Sonar | |
| 10:45-11:10 | Ryota Kabe | Controlling persistent charge carriers in organic materials |
| 11:10-11:35 | Bright Walker | Stable organic radical ions for charge transport and charge storage |
| 11:35-12:00 | Hung-Ju Yen | Bottom-up synthesis of luminescent nanographenes |
| 12:00-12:25 | Petri Murto | Luminescent spin-optical interfaces from bright and dark radicals |
| 12:25-13:30 | **Lunch** (at Chemistry Podium) | |
| **13:30-15:30** | **Session 5A: The Flexible Frontier** (Stretchable & Wearable Electronics)<br>Chair: Jung Hwa Seo | |
| 13:30-13:50 | Yunlong Guo | Stretchable polymeric semiconductor and optoelectronics |
| 13:50-14:10 | Prashant Sonar | Innovation in molecular & thin film engineering for stretchable electronics |
| 14:10-14:30 | Yanchun Han | Optimizing morphology for charge transport and mechanical properties of stretchable polymer films |
| 14:30-14:50 | Qian Liu | Stable free radicals enable flexible SWCNTs/organic hybrid films with high thermoelectric performance |
| 14:50-15:10 | Wen-Yong Lai | The development of printable materials for flexible electronics |
| 15:10-15:30 | Guohua Xie | Transfer printing of organic light-emitting diodes |
| 15:30-15:50 | **Afternoon Tea** | |
| **15:50-17:30** | **Session 6A: Bridging Science & Industry** (Industry Talks)<br>Chair: Shizuo Tokito | |
| 15:50-16:10 | Monica Katiyar | Inkjet printing: new manufacturing paradigm for organic light emitting diodes |
| 16:10-16:30 | Dong-Wook Park | Transparent and flexible neural electrodes for simultaneous in vivo imaging and electrophysiology |
| 16:30-16:50 | Mun Seok Jeong | Defect investigations of 2D nanomaterials with tip- enhanced Raman scattering and AI spectroscopy |
| 16:50-17:10 | G. Rajeswaran | Close space sublimation of organic materials for AMOLED displays |
| 17:10-17:30 | Masaaki Oka | Chemicals for electronic devices of Sanyo Chemical |
| **17:45-21:30** | **(Optional) Banquet at Customs House** | |

# DAY 2 – ROOM B

| Seminar 2B (Room 63-358) | | |
|---|---|---|
| **08:30-09:10** | **Keynote**<br>Chair: Ebinazar Namdas | |
| 08:30-09:10 | Caroline Murawski | Flexible, waterproof organic photodetectors and LEDs for optogenetics and fluorescence imaging |
| 09:10-10:25 | **Spotlight**<br>Chair: Ebinazar Namdas | |
| 09:10-09:35 | Mats Andersson | Amorphous donor polymers for stable organic photovoltaics using low donor content |
| 09:35-10:00 | Safa Shoaee | Tracing the lifecycle of charges in organic solar cells |
| 10:00-10:25 | Mei Gao | Opportunities and challenges of roll-to-roll-printed flexible solar cells |
| 10:25-10:45 | **Morning Tea** | |
| **10:45-12:25** | **Session 4B: New Light Frontiers** *(Advanced Light Harvesting Systems)*<br>Chair: Soniya Yambem | |
| 10:45-11:10 | Toshinori Matsushima | Halide perovskite solar cells towards high operational durability: strategies and advances |
| 11:10-11:35 | Matthew Griffith | Nanoengineered electroactive polymers: soft materials to solve hard challenges in energy and health |
| 11:35-12:00 | Attila Mozer | Radiation tolerant molecular semiconductors |
| 12:00-12:25 | Han Young Woo | Organic photocatalysts and photoelectrochemical cells for green hydrogen production |
| 12:25-13:30 | **Lunch** (at Chemistry Podium) | |
| **13:30-15:30** | **Session 5B: Tools of Tomorrow** *(Emerging applications & Techniques)*<br>Chair: Julian Steele | |
| 13:30-13:50 | Qin Li | Colloidal synthesis of carbon quantum dots and their heterostructures |
| 13:50-14:10 | Soniya Yambem | Solution processable organic transistors for sensing/biosensing |
| 14:10-14:30 | Li-Yin Chen | Toward scalable and deployable organic gas sensors: from device innovation to real-world applications |
| 14:30-14:50 | Xiaotao Zhang | Preparation and photoelectric properties of organic co-crystal materials |
| 14:50-15:10 | Peng Chen | 2D/3D heterostructures for efficient tin halide perovskite photovoltaics |
| 15:10-15:30 | Paul Low | Ene-y mean-ing? Yny-y…OH! |
| 15:30-15:50 | **Afternoon Tea** | |
| **15:50-17:30** | **Session 6B: Hybrid Materials** *(Inorganic–Organic Integration)*<br>Chair: Peng Chen | |
| 15:50-16:10 | Jung Hwa Seo | Ion-mediated interfacial control in polyelectrolytes: bridging materials chemistry and device physics |
| 16:10-16:30 | Samaresh Das | Merging organic and inorganic materials for fast and broadband photodetection |
| 16:30-16:50 | Pichaya Pattanasattayavong | Coordination electronics: the potential of hybrid organic-inorganic materials for semiconductor devices |
| 16:50-17:10 | Watcharaphol Paritmongkol | Tailoring crystallization in hybrid metal organochalcogenide semiconductors |
| 17:10-17:30 | Shun-Wei Liu | Next-generation imaging: from organic upconversion to UV and perovskite photodetectors |
| **17:45-21:30** | **(Optional) Banquet at Customs House** | |

# Poster Presentations

| Location: The Women's College | | |
|---|---|---|
| 1 | Qiyin Chen | Organic-sensitized red circularly polarized quantum dot light-emitting diodes with high luminescence efficiency and large asymmetry factor |
| 2 | Cameron Cole | Every photon counts: developing ultra-sensitive and fast photodetectors |
| 3 | Innes Gale | Utilizing metal-metal-to-ligand charge transfer (MMLCT) in Pt(II) aggregates for enhanced brightness and efficiency |
| 4 | Minh Tam Hoang | Advancing green solvent processing for efficient and stable perovskite solar cells |
| 5 | Keigo Ishii | Reduction of ASE threshold by suppressing concentration quenching of organic semiconductor laser materials |
| 6 | Chattarika Khamhanglit | Bendable pedot:tosylated based organic electrochemical transistor (OECT) with biocompatible chitosan substrate |
| 7 | Rajesh Kothandaraman | High-performance n-type OFETS enabled by pyridine-substituted diketopyrrolopyrrole organic semiconductor and elastomer stretchable blends |
| 8 | Vijay Rahane | Development of efficient organic laser materials towards the realisation of organic laser diodes |
| 9 | Sahil Shah | Ion-induced field screening as a dominant factor in perovskite solar cell operational stability |
| 10 | Atul Shukla | Excitons at the limit: strategies for high-current-density organic light devices |
| 11 | Julian Steele | Atomistic origins of anharmonic lattice dynamics and thermal expansion in perovskite photovoltaics |
| 12 | Yoshiki Sugai | Hindered photo-induced phase segregation via temperature-dependent phase transition of organic-inorganic hybrid perovskite |
| 13 | Altankhuyag Sugarmaa | Controlling efficiency roll-off in hyperfluorescent OLEDs via terminal emitter HOMO alignment |
| 14 | Connor Tweedie | Ion migration in mixed-halide perovskites |
| 15 | Mia Whittaker | Structure–property modulation in oligophenylenes for organic lasers |
| 16 | Hui Qi Wong | Atomically precise halogenated nanographenes via bottom-up chemical synthesis |
| 17 | Yuting Xu | Spin light-emitting diodes enabled by distorted perovskitoids heterointerface |

# Notes

# SEMINAR ROOM A

## 63-348

DAY 1

**8TH DECEMBER**

# Advanced organic optoelectronic devices by controlling precise charge transfer phenomena

Chihaya Adachi*

Center for Organic Photonics and Electronics Research (OPERA), Kyushu Univ.

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**Abstract:**

In the last 10 years, there have been a wide variety of studies on thermally activated delayed fluorescence (TADF)-OLEDs focusing on the unlimited possibilities of molecular design.[1] Further, hyperfluorescence (HF)-OLEDs have been developed since they can realize the compatibility of high efficiency with narrow spectral width, which is ideal for practical display applications. The advanced HF-OLEDs realized high light-emitting performance by engineering host, TADF, and terminal emitter (TE) molecules. Firstly, we mention the comprehensive design principle for the materials and device architectures used in HP-OLEDs by focusing on fast T-S upconversion, negative gap, efficient FRET, GSP, and carrier trapping aimed at high-performance EL.[2-5] In addition, we underscore the crucial role of CT in organic optoelectronic devices, shedding light on its importance in future organic devices such as organic thermoelectrics.[6]

**References:**

1. Uoyama, H., et al., *Highly efficient organic light-emitting diodes from delayed fluorescence*. Nature, 2012. **492**(7428): p. 234-238.
2. Chan, C.-Y., et al., *Stable pure-blue hyperfluorescence organic light-emitting diodes with high-efficiency and narrow emission. Nature Photonics*, 2021. **15**(3): p. 203-207.
3. Lee, Y.-T., et al., *Investigating HOMO Energy Levels of Terminal Emitters for Realizing High-Brightness and Stable TADF-Assisted Fluorescence Organic Light-Emitting Diodes*. Advanced Electronic Materials, 2021. **7**(4): p. 2001090.
4. Tanaka, M., et al., *Precise Exciton Management of Quaternary Emission Layers for Highly Stable Organic Light-Emitting Diodes Based on Thermally Activated Delayed Fluorescence*. ACS Applied Materials & Interfaces, 2020. **12**(45): p. 50668-50674.
5. Hu, L., Y.-C. He, and W. Zhu, *Solving conformal defects in 3D conformal field theory using fuzzy sphere regularization. Nature Communications*, 2024. **15**(1): p. 3659.
6. Kondo, S., et al., *Organic thermoelectric device utilizing charge transfer interface as the charge generation by harvesting thermal energy*. Nature Communications, 2024. **15**(1): p. 8115.

Research topics: Organic optoelectronic materials and devices

Prof. Chihaya Adachi obtained his Ph.D. in 1991 from Kyushu University. He held positions as a research chemist and physicist in the Chemical Products R&D Center at Ricoh Co., a research associate at Shinshu University, a research staff at Princeton University, and an associate professor and professor at Chitose Institute of Science and Technology. In 2005, he returned to Kyushu University as a professor and his current posts also include director of Kyushu University's Center for Organic Photonics and Electronics Research (OPERA). He published over 750 research papers. He was selected as a highly cited researcher (Clarivate) (2018-2024).

# Iridium(III) carbene phosphors for blue organic light emitting diodes

Yun Chi*

Department of materials Science and Engineering, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong SAR

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**Abstract:**

Iridium(III) complexes bearing carbene cyclometalates should be one of the most suitable blue OLED emitters for potential industrial applications, according to their photophysical properties, i.e., high emission quantum yield, short radiative lifetimes and improved stabilities. Work on the Ir(III) carbene complexes was first reported in 2003 by Thompson et.al. and continued by BASF and UDC Inc. Unfortunately, development of blue Ir(III) OLED phosphors was overpowered by the thermally activated delay fluorescent (TADF) emitters due to the lack of adequate molecular designs and synthetic methodologies. However, Ir(III) carbene complexes still possess all essential intrinsic characteristics demanded for efficient and durable blue phosphors and deserved continuous investigation. Their remarkable features are now partially confirmed by our investigation, to which tuning emission from purple to true-blue region can be accomplished via addition of electron deficient substituent(s) on the functionalized carbene entities, while the overall stability of devices can be improved by introduction of dual N-aryl appendages on carbene coordination entities. These modifications have afforded a series of new Ir(III) carbene complexes, as well as the successful fabrication of both the blue phosphorescent OLED (PhOLEDs) and hyper-luminescent OLED devices (hyper-OLEDs).

In this presentation, pathways that gave efficient blue Ir(III) carbene complexes will be discussed. Examples on Ir(III) carbene emitters featuring fast radiative rate constant ($k_r$), high $EQE_{1000}$ (i.e., EQE recorded at 1000 cd·m$^{-2}$) and high $J_{90}$ (current density at 90% of max. EQE) will be given. Moreover, unique designs that gave dominant through-space charge transfer (TSCT) rather than the commonly postulated metal-to-ligand charge transfer (MLCT) transition processes were achieved, which allowed direct comparison between phosphorescent and TADF properties within this family of Ir(III) based carbene complexes, paving the way to ultimate blue OLED phosphors.

**References:**

1. Ni, G., et al., *Transition-metal phosphors with emission peak maximum on and beyond the visible spectral boundaries.* Inorganic Chemistry Frontiers, 2023, **10**, 1395-1401.
2. Hung, C.-M., et al., *High-performance near-infrared OLEDs maximized at 925 nm and 1022 nm through interfacial energy transfer.* Nature Communications, 2024, **15**, 4664.
3. Yan, J., et al., *Structural Engineering of Iridium(III) Phosphors with Imidazo[4,5-b]pyrazin-2-ylidene Cyclometalates for Efficient Blue Electroluminescence*. Small Methods 2024, **8**, 2301555.
4. Wu, Y., et al., *Iridium(III) Blue Phosphors with Heteroleptic Carbene Cyclometalates: Isomerization, Emission Tuning, and OLED Fabrications*. Angewandte Chemie International Edition, 2025, **64**, e202421664.
5. Yan, J. et al., *Iridium(III) Carbene Complexes Featuring either Metal-to-Ligand Charge Transfer (MLCT) or Through-Space Charge Transfer (TSCT) Blue Luminescence*. Angewandte Chemie International Edition, 2025, **64**, e202424694.

Professor Chi, Yun received his BS degree in chemistry from National Tsing Hua University in 1978 and doctoral degree from University of Illinois at Urbana-Champaign in 1986. After spending one year as postdoc at M.I.T., he joined Department of Chemistry, National Tsing Hua University as Associate Professor in 1987 and promoted to Professor in 1991. He had been on the editorial board of Journal of Cluster Science (1992 – 1998) and the advisory board of Organometallics (1996 – 1998). He was elected as fellow of the Asia Pacific Academy of Materials (APAM) in 2013. He was also awarded the Academic Award, National Chair Professorship, Academic Medal from the Chinese Chemical Society of Taipei and Permanent National Chair Professorship in 2006, 2011, 2014, and 2016, respectively. He moved to City University of Hong Kong in February 2018 and until now.

# Structural dynamics accompanied by intersystem crossing in TADF molecules

Ken Onda*

Department of Chemistry, Kyushu University, Motooka, Nishi-Ku, Fukuoka 819-0395, Japan

E-mail: konda@chem.kyushu-univ.jp

**Abstract:**

Recently, thermally activated delayed fluorescence (TADF) molecules have attracted more attention owing to various applications, such as organic lasers, organic solar cells, photocatalysts, as well as OLED. In TADF molecules, intersystem crossing process (ISC) plays a key role; however, the details of ISC mechanism are still controversial. We have been exploring the role of structural dynamics accompanied by ISC using the combination methods of time-resolved infrared (TR-IR) spectroscopy, which is sensitive to molecular structure, and quantum chemical calculations.[1-4] To date, we have elucidated the relation between the reverse ISC rate and the structural change between the singlet and triplet states,[1] the acceleration of delayed fluorescence by the internal rotation,[2] the suppression of structural change in aggregation induced TADF,[3] and the relation between the spin-orbit coupling and molecular structure.[4] We also explore ISC by combination with another molecular-structure-sensitive method: time-resolved electron diffraction,[5,6] and succeeded in direct observation of rotational motion between the donors and the accepter during ISC.[7]

**References:**

1. Saigo, M., et al., *Suppression of Structural Change upon S1–T1 Conversion Assists the Thermally Activated Delayed Fluorescence Process in Carbazole-Benzonitrile Derivatives*. The Journal of Physical Chemistry Letters, 2019. **10**(10): p. 2475-2480.
2. Shimoda, Y., et al., *Intramolecular-rotation driven triplet-to-singlet upconversion and fluctuation induced fluorescence activation in linearly connected donor–acceptor molecules*. The Journal of Chemical Physics, 2020. **153**(20).
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Ken Onda is a Professor of Chemistry at Kyushu University in Japan. He completed his Ph.D. thesis with Professor Kaoru Yamanouchi at the University of Tokyo in 1994. In 1995 he became a research associate at Tokyo Institute of Technology. In 2002 he joined the research group of Professor Hrvoje Petek at University of Pittsburgh. In 2004 he became a researcher of Koshihara Non-Equilibrium Dynamics Project of JST. In 2008 he was appointed an associate professor of Environmental Chemistry and Engineering at Tokyo Institute of Technology. He was appointed the current position in 2017. His current research interests include ultrafast dynamics in complex and practical chemical systems.

# Quantitative prediction of rate constants for OLEDs and development of inverted singlet-triplet materials

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**Abstract:**

We are currently conducting research on OLEDs based on the following five aspects: 1) high-throughput development of TADF materials and realization of highly efficient OLEDs,[1-3] 2) development of inverted singlet-triplet energy gap (iST) materials,[4-5] 3) quantitative prediction and fundamental understanding of emission processes in OLEDs based on precise quantum chemical calculations,[6] 4) quantitative prediction and fundamental understanding of charge transports in OLEDs based on multiscale simulations,[7-9] and 5) NMR analysis of OLEDs.[10] Here, we outline the overall and then discuss recent developments in 2) and 3). We have recently succeeded in proposing a method to theoretically predict rate constants and quantum yields of all electronic transitions related to emission quantitatively. It also allows quantitative predictions of time evolutions of excitons. Our prediction method is applicable to a wide variety of systems. We recently applied this method to organophotocatalysts for Alzheimer's disease.[11,12] We will also present our recent studies on iST emitters.

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Hironori Kaji received his Ph.D. in inorganic chemistry from Kyoto University in 1994. In 1994, he joined Institute for Chemical Research, Kyoto University, as Assistant Professor, where in 2003 he was promoted to Associate Professor and in 2009 to Full Professor. He was a visiting scientist at University of Massachusetts (Amherst) from 1998 to 1999. He was a research fellow of the PRESTO program in JST from 2002 to 2006. His present research interests center on molecular design for the fabrication of excellent OLEDs, quantum chemical calculations and multiscale simulations for comprehensive understanding of the emission and charge transport mechanisms in OLEDs, and development of advanced solid-state NMR methodologies.

# Excited state intramolecular proton transfer (ESIPT) molecules: potential solid-state fluorophores for electroluminescent devices and luminescent solar concentrators

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**Abstract:**

Fluorescent organic molecules with excited-state intramolecular proton transfer (ESIPT) features have received considerable attention in recent years because of their unique photophysical properties related to large Stokes-shifted fluorescence emission or non-self-absorbing fluorescent emission. ESIPT fluorophores as light-emitting materials for organic light-emitting diodes (OLEDs) and as luminophores for luminescent solar concentrators (LSCs) would make a perfect counterpart since the difference between positions of absorption and emission peaks, unlike most organic fluorophores, can help to avoid unwanted self-reabsorption of the emitted light, leading to improved electroluminescence and efficiency. This talk will present an advance in the development of new ESIPT fluorophores. For example, a series of ESIPT–aggregate-induced emission (AIE) solid-state fluorophores as self-absorption-free emitters will be presented. These ESIPT–AIE fluorophores exhibit high thermal and electrochemical stability with decent hole mobilities and are successfully utilized as emitters in OLEDs, which achieved moderate-to-good EL performances. Other types of ESIPT fluorophores, including ESIPT–hybridized local and charge-transfer (HLCT) and ESIPT–triplet-triplet annihilation (TTA) materials, as single molecules white light-emitting materials will be also mentioned. For LSC applications, a series of modified phenanthroimidazole-phenol/(benzo[d]thiazol-2-yl)phenol ESIPT dyes will be reported.

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7. Unpublished results.

Prof. Vinich Promarak received his D.Phil. in Organic Chemistry in 2002 from the University of Oxford, UK. His research interests involve "high-tech" organic materials that can be used in optoelectronic devices. To date, he has co-authored more than 290 peer-reviewed papers with a current H-index of 49. He was presented many awards including Outstanding National Researcher Award 2016, CST High Impact Chemist Award 2017, Thailand's Outstanding Scientist Award 2021, and Distinguished Professor Research Grant 2022.

# Solution-processed to printed: the development of inkjet printed TADF polymer OLEDs

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## Abstract:

Thermally activated delayed fluorescent (TADF) emitters have emerged as one of the most promising classes of materials for high-efficiency organic light-emitting diodes (OLEDs). To move toward scalable and cost-effective OLED manufacturing, solution processing and printing techniques are being explored as alternatives to vacuum deposition. While these methods are well established for OLEDs, their application to TADF systems is more recent, with the first report of printed TADF materials in OLEDs occurring ~ 10 years ago.[1] A recent review of solution-processed TADF OLEDs shows that fully solution-processed devices remain rare, accounting for only ≈4% of reported examples, and that most printing efforts focus on the emissive layer, predominantly using inkjet printing.[2] These printed TADF OLEDs typically emit in the green region (≈500–<600 nm), as shown in **Figure 1**. Building on these insights, we have recently demonstrated self-hosted TADF polymers engineered for inkjet printing, integrating emissive, hole-transporting, and electron-transporting functionalities within a single polymer backbone.[3–5] This strategy simplifies device architecture, removes the need for external hosts, and enables precise patterning with minimal material waste. Collectively, these advances establish inkjet-printed TADF polymers as a promising route toward scalable, flexible, and cost-effective OLED technologies, while identifying opportunities for future research.

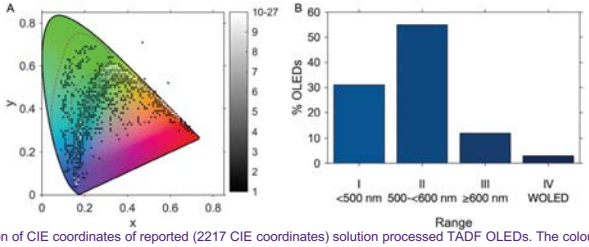


**Figure 1 |** A) Distribution of CIE coordinates of reported (2217 CIE coordinates) solution processed TADF OLEDs. The colour bar represents the number of reported solution processed TADF OLEDs at a particular (x, y). Data points containing 10 to 27 OLEDs account only for 2.6% of the recorded coordinates, and hence given the same maximum colour (white). A list of the sources of (x, y) coordinates is provided in the supporting document. The points within the red dashed outline are predominantly OLEDs that use multiple resonance TADF emitters. B) The percentage distribution of solution processed TADF OLEDs for the four different categories of OLEDs. Categories I–III represent OLEDs whose peak wavelengths fall in <500 nm (I), 500 to <600 nm (II), and ≥600 nm (III). Category IV is WOLED.[2]

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Dr Cameron Cole is a researcher in School of Mathematics and Physics at The University of Queensland (UQ). He received his BSc Hons. and Ph.D. degree from QUT 2017 and 2023, respectively. His honours research was on organic photovoltaics and his Ph.D. research was on inkjet-printed polymer thermally activated delayed fluorescent (TADF) organic light emitting diodes (OLEDs). For his PhD work, Cameron received the Executive Dean's Commendation for Outstanding Doctoral Thesis in 2023. His current research interests include material science and organic electronics, more specifically OLEDs, organic electrochemical transistors (OECTs), and organic and perovskite photodetectors (OPDs).

# The origin of the inverted singlet and triplet excited states of azaphenalene molecules

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**Abstract:**

Negative $\Delta E_{ST}$ has been observed in the molecules with azaphenalene moieties. [1–3] In these molecules, their HOMO and LUMO do not overlap each other, so that the exchange interaction between electrons on the HOMO and LUMO is close to zero in the excited state, while multi-electron excitation (mainly two-electron excitation) stabilizes only the singlet state. Consequently, the energetic inversion between the excited singlet and the excited triplet can be occurred. Usually, electronic configuration of the singlet and triplet excited states are same, and thus $\Delta E_{ST}$ is positive. But if the electronic configuration of the singlet and triplet excited states are different, $\Delta E_{ST}$ is not necessarily positive. Therefore, in order to achieve negative $\Delta E_{ST}$, a molecular design that simultaneously satisfies HOMO/LUMO separation and multi-electron excitation is required.

The number of nitrogen atoms in the azaphenalene skeleton has been changed and different electron-withdrawing and electron-donating groups have been substituted to reduce the symmetry of the molecular orbitals to improve the PLQY and adjust the HOMO/LUMO levels, mainly to improve the OLED properties. However, molecules exhibiting negative $\Delta E_{ST}$ are still limited to the azaphenalene skeletons, and the molecular design guidelines for exhibiting the negative $\Delta E_{ST}$ are not fully understood. We have investigated, by quantum chemical calculations, what kind of molecular design is necessary for effective HOMO/LUMO separation (**Figure 1**) and how the azaphenalene skeleton exhibiting negative $\Delta E_{ST}$ can be extended.[4, 5]

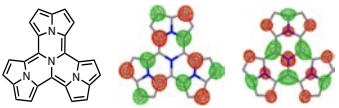


**Figure 1 |** Less overlapping HOMO and LUMO based on the non-azaphenalene structure.

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# Gold carbenes for OLED applications

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**Abstract:**

Gold complexes have recently attracted significant attention owing to their high luminescence efficiencies rivalling platinum and iridium complexes.[1] Due to the significant improvements in their luminescence properties, gold complexes are becoming suitable for organic light emitting diodes (OLEDs) applications.[1] Although, highly efficient green and red emitters based on gold complexes have been achieved, blue/ deep blue emitting complexes remains an enormous challenge.[2] This lack of blue/ deep blue emitting can be attributed to the complexes comprising of mostly pyridine based cyclometalating ligands that results in the emission properties mostly in the longer wavelength region of the electromagnetic spectrum.[2] Gold complexes with a N-heterocyclic carbene ligand that combines strong sigma donor properties, a low lying HOMO or a higher lying LUMO can yield complexes that have emission in the blue/deep blue region. N-heterocyclic carbene (NHC) ligands possess properties ideally suited for this purpose. The plethora of available NHC's with different electronic properties would allow for further fine tuning of the luminescent properties. In line with the above hypothesis, our group has recently developed a series of NHC gold(I) and gold(III) complexes that display emission properties in the deep blue and blue region.[3,4] The stability of the gold(III) complexes and the efficiencies were further tuned through implementing monodentate and bidentate anionic ancillary ligands. The observed excited-state properties have been further supported by DFT and TD-DDFT calculations. OLED devices based on both gold(I) and gold(III) complex have been fabricated and evaluated.

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Koushik Venkatesan is currently an Associate Professor at the School of Natural Sciences, Macquarie University, Australia. He obtained his PhD from the University of Zurich (UZH) with Prof. Heinz Berke. After his postdoctoral work with Prof. Timothy Swager at Massachusetts Institute of Technology, he joined UZH as a group leader and later as an associate professor at Macquarie University. His independent career spanning over a decade has focussed on the design and implementation of new conceptual approaches based on organic, inorganic and organometallic materials focused towards applications such as organic light emitting diode devices, molecular electronics and sensors.

# Synergistic hetero-TTA: fact or fiction?

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**Abstract:**

Photochemical upconversion (UC) via Triplet-Triplet Annihilation (TTA) is a fascinating process, which enables formation of a single high-energy photon from two non-coherent low energy photons, and has attracted a myriad of applications ranging from biological sensing and imaging to improved efficiency of photocatalytic reactions and photovoltaic devices.[1,2]

TTA-UC systems often rely on efficient triplet-triplet energy transfer (TTET) between a long-lived phosphorescent metal complex as a photosensitiser (S) coupled with highly fluorescent organic molecules as acceptors (A) and can yield UC efficiencies >30% under intense illumination. Methods to improve limited efficiency at lower intensity illumination have included pre-organisation of organic chromophores using supramolecular or Coulombic approaches and the use of energy transfer mediators to improve the performance of annihilators, allowing lower concentrations to be used to limit parasitic loss by sensitizer reabsorption.[3]

In recent years, improvements in UC efficiency obtained by using two (or more) chemically different annihilators has been reported, both in solution and the solid state, facilitated by hetero-TTA which it has been argued can also be synergistic.[4,5] A consideration of the decay kinetics involved can reveal whether the high energy organic triplet states participate in UC pathways, or more simply act as an energy shuttle to the lower energy annihilator. Herein, we report our analysis for these systems using steady state emission and time-resolved transient absorption techniques and provide a detailed kinetic model to explain our observations.

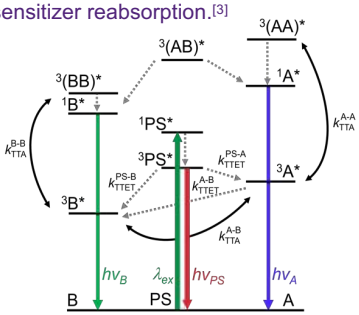


**Figure 1 |** A simplified Jablonski diagram showing the different excited states and processes involved in homo- and hetero-TTA. S = sensitizer, A = annihilator (or mediator), B = annihilator.

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I completed my PhD at the University of Queensland in 2004 and undertook postdoctoral research at UC Berkeley with Prof Kenneth Raymond. I returned to Australia in 2008 as an ARC Postdoctoral Fellow in the Ultrafast and Microspectroscopy Labs (UML) at the University of Melbourne. I was awarded a Marie-Curie International Fellowship in 2011 at the Università di Bologna (Italy) in the Photochemical Nanosciences Laboratory, before returning to UQ in 2012 as an ARC Future Fellow. In 2021, I was promoted to Associate Professor at UQ where I lead an active research group and manage the UQ Photochemistry and Ultrafast Laser Spectroscopy (UQ-PULSE) facility in the School of Chemistry and Molecular Biosciences.

## Transient electroluminescent behaviours in OLEDs

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**Abstract:**

Controlling polarons in organic light-emitting diodes (OLEDs) is crucial for improving both the efficiency and stability of the devices, as OLEDs are current-driven [1]. During operation, not all injected charges are converted into excitons, especially when driven at high current, leading to unwanted quenching processes caused by unpaired polarons. These processes include polaron-exciton annihilation and the generation of local electric fields within the device. Consequently, reducing the number of polarons presents a significant challenge, and various strategies have been proposed through molecular engineering and device structural design to minimize their presence. Here, we investigate the transient electroluminescence (Tr-EL) characteristics of OLEDs as a means to assess polarons quantitatively. We observe distinct Tr-EL signals depending on the device structure, with polarons being characterized by an overshoot feature in the Tr-EL curves. Additionally, this technique is applied to blue-emitting phosphorescent-sensitized fluorescent (PSF) OLEDs to enhance device efficiency and improve efficiency roll-off properties [2]. Further details of these findings are presented in this study.

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| Present | Associate Professor, Inha University, Korea |
| 2017 | Postdoctoral researcher, imec, Belgium |
| 2014 | B.S. ~ Ph.D. in Materials Science and Engineering, Seoul National University, South Korea |

# Excited state management and device applications of high mobility emissive organic semiconductors

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**Abstract:**

Organic light-emitting transistors (OLETs) integrate the switching and amplification functions of organic field-effect transistors (OFETs) with the light-emitting properties of organic light-emitting diodes (OLEDs), offering great potential in next-generation displays, optical communication, and sensing. Achieving high-performance OLETs requires precise control of excited-state dynamics, such as exciton migration, recombination, and annihilation, though fundamental mechanisms remain unclear. Addressing these challenges, we have designed and synthesized a series of high mobility emissive organic semiconductors with enhanced exciton utilization and transport. We systematically investigated their excited-state behaviors and energy loss pathways in OLETs, yielding key insights into photoelectric conversion processes. Through device structure and fabrication optimization, we achieved white-light OLETs with an external quantum efficiency (EQE) of 13.9%. Additionally, by exploiting the intrinsic microcavity effect of OLETs, we developed narrow-spectrum, wide-gamut devices with a minimum full width at half maximum (FWHM) of 13 nm, demonstrating substantial advances toward their practical applications in high-performance organic optoelectronics.

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Can Gao is currently an associate professor at the Institute of Chemistry, Chinese Academy of Sciences. She received her PhD degree from the University of Melbourne, Australia in 2019. Her research interests are focused on the development of organic light-emitting transistor materials and investigation of their photoelectric properties. She has published over 30 peer reviewed papers on Nat. Mater., Adv. Mater., Angew. Chem. Int. Ed., et al. She serves as the managing editor of Wearable Electronics.

# Perovskite light-emitting diodes and beyond

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**Abstract:**

Perovskite light-emitting materials have garnered widespread attention due to their high colour purity, excellent photoluminescence quantum efficiency, and low-cost solution processability. In recent years, the external quantum efficiency (EQE) of perovskite-based light-emitting diodes (LEDs) has approached that of state-of-the-art organic LEDs. Beyond their outstanding luminescent properties, perovskites also exhibit unique features such as strong spin–orbit coupling, Rashba band splitting and slow Auger recombination rates, making them highly promising for spintronic applications and lasers. Here, we will first analyse the key factors limiting the performance and stability of perovskite LEDs from multiple perspectives and propose corresponding strategies for improvement. We will then present our recent progress in realizing efficient perovskite spin-LEDs and high-power LEDs. Finally, we will discuss potential opportunities and challenges toward the realization of electrically driven perovskite laser diodes.

**References:**

1. Liu, X.-K., et al., *Metal halide perovskites for light-emitting diodes*. Nature Materials, 2021. **20**(1): p. 10-21.
2. Li, Z., et al., *Highly bright perovskite light-emitting diodes enabled by retarded Auger recombination*. Nature Communications, 2025. **16**(1): p. 927.
3. Luo, X., et al., *Ultrabright Blue Lead-Halide Perovskite Light-Emitting Diodes Based on Phosphonic Acid Functionalized Hole Injection Layer*. ACS Nano, 2025. **19**(17): p. 16850-16858.

Dr Weidong Xu is currently a professor at the Institute of Flexible Electronics, Northwestern Polytechnical University. He was selected in 2021 for China's National Young Overseas Talent Program and serves as deputy director of the Ministry of Industry and Information Technology Key Laboratory of Flexible Electronics. Dr. Xu received his Ph.D. from Nanjing University of Posts and Telecommunications under the supervision of Academician Huang Wei. In 2017 he was awarded a Wenner-Gren Fellowship in Sweden and carried out post-doctoral research in the Biogel Division of the Department of Physics, Chemistry and Biology (IFM) at Linköping University, where he was promoted to Principle Research Engineer in 2021. His research focuses on the development of organic and organic-inorganic hybrid optoelectronic materials, device fabrication, and mechanism studies. To date he has published more than 60 papers in journals such as Nature Photonics, Nature Materials, Nature Electronics, and Nature Communications (h-index 30, with over 5,400 citations). His work has been highlighted and highly praised in Science (Science 2019, 364, 918) and Nature Electronics (Nat. Electron. 2020, 3, 135). Dr. Xu is a long-standing reviewer for the Nature family of journals and serves on the editorial board of FlexMat.

## Dual-responsive optical switches using chiral materials

Girish Lakhwani*

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**Abstract:**

Chiroptical switches are made of chiral materials that can be reversibly switched between two (or more) states with distinctively different chiroptical signals. These materials hold great promise in applications such as chiral sensing, nonlinear optics, molecular-level optoelectronic devices and catalysis.[1] Here, I will describe the design and functionality of new molecular and framework materials for highly sensitive, stable, and reversible redox-modulated optical switches.

In the first instance, I will demonstrate fatigue-resistant and reversible redox-modulated optical switching in binaphthyl-based chiral materials. We employ a range of spectroelectrochemical (SEC) techniques to characterise the reduced states of binaphthyl materials *in situ*, which remains one of the few examples in the literature that successfully demonstrates this approach. [2]

Dual-responsive chiroptical switches, which respond to two different stimuli, can enable the implementation of logic operations. To this end, I will present the design and functionality of ferrocene amino acid chiral conjugates. Not only do these materials exhibit redox-modulated optical switching through oxidation of the ferrocene core, but temperature can also be used to modulate the optical response by exploiting the intramolecular hydrogen bonding between amino acid groups. I will outline how these materials can serve as the basis for logic gates.

Finally, I will provide an example of how the above designer molecules can be utilised as ligands in chiral metal-organic framework (MOF) materials for applications in photoswitches, nonlinear optics, and photonics—fields beyond the traditional uses of MOFs, such as energy storage and separations.

**References:**

1. Hall, L.A., D.M. D'Alessandro, and G. Lakhwani, *Chiral metal–organic frameworks for photonics*. Chemical Society Reviews, 2023. **52**(10): p. 3567-3590.
2. Hall, L.A., et al., *Chiroptical Switching in an Enantiomeric Pair of Binaphthylenes Based on Redox-Active 1,8-Naphthalimide Substituents*. The Journal of Physical Chemistry Letters, 2025. **16**(6): p. 1529-1534.
3. Clutterbuck, K.M., et al., *Photoswitching chiroptical response in camphorate-based chiral metal–organic frameworks*. Dalton Transactions, 2025. **54**(28): p. 11089-11094.

Dr. Girish Lakhwani is a professor in the School of Chemistry at the University of Sydney. He obtained his integrated Master of Science (Chemistry) degree in 2005 from the Indian Institute of Technology (IIT), Kanpur. He completed his PhD in 2009 at Eindhoven University of Technology in the Netherlands. After two postdoctoral positions at the University of Texas at Austin and the University of Cambridge, he joined the School of Chemistry at the University of Sydney in 2014.

Girish's research focuses on the optical and electronic properties of advanced functional materials for use in chiral optics, polaritonics, and photonic computing. He holds an Australian Research Council Future Fellowship, serves on the Editorial Advisory Board of the Journal of Physical Chemistry A/B/C and is a member of the Australian Research Council's College of Experts.

# Bridging theory, computation and experiment to power the next generation of OLED materials and devices

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**Abstract:**

Organic light-emitting diodes (OLEDs) combine high efficiency, tunable color, mechanical flexibility, and fast response, yet achieving optimal brightness, lifetime, and color purity remains challenging. Here, we present an integrated pipeline that unites first-principles computation, molecular simulation and targeted experimentation to accelerate the next generation of OLED materials and device optimization. Time-dependent density functional theory and molecular dynamics furnish structure–property maps and predict excited-state behavior, guiding the synthesis of candidate emitters. Along with ultrafast time-resolved and photoelectron spectroscopy uncover the underlying photophysical dynamics and material interface physics. Five case studies illustrate this synergy: (1) organic semiconductor interfacial physics (2) multiple resonance thermally activated delayed fluorescence; (3) room temperature phosphorescence in purely organic materials; (4) atomistic kinetic Monte Carlo insights into charge-transfer pathways and mobility; and (5) ab initio molecular dynamics in capturing the physics of vibrationally induced conformational disorder in a system. This multidisciplinary approach reconciles conflicting literature reports, defines mechanistic design principles, and establishes a robust framework for applications in OLEDs.

Dr. Woon Kai Lin earned his PhD in photonic liquid crystals from the University of Hull. He conducted postdoctoral research on electroluminescent liquid-crystalline displays and natural photonic crystals at Oxford. Returning to Malaysia, he joined OSRAM to develop OLED materials and solution-processed lighting, collaborating with Merck, Sumitomo, and Philips. Now at the University of Malaya, he leads organic electronics research spanning computational modeling, photophysics, and device fabrication of OLEDs, TADF emitters, utilizing synchrotron and time-resolved spectroscopy.

## Dark light, smart design: cracking the code of NIR-TADF with ml-guided inverse design

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**Abstract:**

Designing efficient thermally activated delayed fluorescence (TADF) emitters in the near-infrared (NIR) region remains a formidable challenge due to the energy-gap law and non-radiative losses. In this work, we present a machine learning–guided inverse design strategy that integrates structural insights from non-fullerene acceptors and known TADF materials. Using interpretable models and fragment-based molecular generation, we discover novel hybrid emitters with verified NIR emission (up to 1359 nm) and favourable photophysical properties. Our approach expands the TADF chemical space, offering a scalable path toward next-generation organic materials for optoelectronic and bioimaging applications.

**References:**

1. Nikhitha R. and Anirban Mondal, *Machine Learning–Accelerated Design of Near-Infrared TADF Emitters Beyond Conventional Scaffolds*, [Under review]
2. Eng, J. and T.J. Penfold, *Understanding and Designing Thermally Activated Delayed Fluorescence Emitters: Beyond the Energy Gap Approximation*. The Chemical Record, 2020. **20**(8): p. 831-856.

Dr. Anirban Mondal is an assistant professor of the Department of Chemistry at the Indian Institute of Technology Gandhinagar. He earned his bachelor's degree in chemistry from Visva-Bharati University in 2010, followed by an Integrated Ph.D. in Materials Science from the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), where he completed his doctoral research under the supervision of Prof. Sundaram Balasubramanian in 2016. Dr. Mondal pursued postdoctoral research in several internationally recognized institutions: the Max Planck Institute for Polymer Research (2016–2018) with Prof. Kurt Kremer and Prof. Denis Andrienko; Princeton University (2019–2020) with Prof. Athanassios Panagiotopoulos; and the University of Luxembourg (2021) with Prof. Alexander Tkatchenko. His research interests lie in multiscale modeling of materials and soft matter systems, with a particular emphasis on combining quantum mechanics, machine learning, and molecular simulations for materials discovery.

# Quantitative calculations of the photoluminescence quantum yield of organometallic emitters

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**Abstract:**

Organic light-emitting diodes (OLEDs) are widely viewed as the basis for next generation displays and lighting. However, to apply this technology widely and for it to reach its full potential, improvements in the emission efficiency and device lifetime are vital. So far, the development of blue, and especially deep blue, emitters in OLEDs has progressed rather slowly. Therefore, being able to predict the emission efficiency prior to the synthesis and measurement of properties is of crucial importance for the discovery of new highly efficient blue emitters.

Our work[1–2] has shown that it is possible to predict the emission efficiency through the calculation of the radiative rate and non-radiative rate using state-of-the-art computational strategies. Specifically, we find that the main non-radiative process of a series of iridium(III) complexes is the elongation or even breaking of a metal-ligand bond, and the non-radiative rate can be predicted from the energy barrier to this non-emissive state.

In this talk, I will present our advances[2] in quantitative calculations of the photoluminescent quantum yield of iridium(III) complexes using approaches based on transition state theory and their application[3] in the development of new highly efficient deep blue emitters for OLEDs.

**References:**

1. Zhou, X. and B.J. Powell, *Nonradiative Decay and Stability of N-Heterocyclic Carbene Iridium(III) Complexes*. Inorganic Chemistry, 2018. **57**(15): p. 8881-8889.
2. Zhou, X. and B.J. Powell, *Quantitative calculations of the non-radiative rate of phosphorescent Ir(iii) complexes*. Physical Chemistry Chemical Physics, 2020. **22**(46): p. 27348-27356.
3. Yan, J., et al., *Electroluminescence and hyperphosphorescence from stable blue Ir(III) carbene complexes with suppressed efficiency roll-off*. Nature Communications, 2023. **14**(1): p. 6419.

Dr Zhou leads the Virtual Materials Group at the Queensland University of Technology (QUT). Her group specialises in theoretical study and design of functional materials via developing and applying quantum-mechanics based computational methods. Zhou received her PhD from the University of Geneva (Switzerland) on developing multi-scale modelling methods. She is a Senior Lecturer in physics at QUT since 2024. Before QUT, she visited and worked at University of Queensland supported by four research fellowships, i.e, a Swiss National Science Foundation (SNSF) Early Postdoc Fellowship (2015), an Australia-APEC Women in Research Fellowship (2016), a UQ Development Fellowship (2017-2019), and an ARC DECRA (2019-2025).

# Understanding structure–activity relationships in metal-functionalized organic photocatalysts

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**Abstract:**

Hydrogen peroxide ($H_2O_2$) can be sustainably produced with photocatalysts under visible light. Organic and hybrid systems like carbon nitride embedded single-atom catalysts (SACs), metallated graphdiyne, and metal–organic frameworks (MOFs) combine earth-abundant elements with tunable coordination environments, offering promising platforms for solar-to-chemical energy conversion. Yet, the mechanisms driving their performance remain incompletely understood, particularly the roles of spin-state effects, orbital hybridization, and metal coordination geometry.

Recent studies have revealed strong structure–activity relationships in these systems. For example, paired single-atom catalysts (SACs) in nitrogen-doped graphene exhibit coordination-sensitive activity for oxygen reduction.[1] Nickel–graphdiyne composites modified with carbon dots show enhanced light absorption, $O_2$ adsorption, and interfacial charge transfer, enabling high $H_2O_2$ production rates without sacrificial agents.[2] Meanwhile, p-block metal SACs, have been found to outperform transition-metal analogues due to favorable p–p hybridization and spin density effects.[3]

We aim to use computational techniques, such as density functional theory (DFT), to model and interpret these catalytic systems, with a focus on understanding how local electronic structure and spin effects govern activity. The goal is to develop predictive insight in support of rational photocatalyst design.

**References:**

1. Hunter, M.A., et al., *Evaluating the Catalytic Efficiency of Paired, Single-Atom Catalysts for the Oxygen Reduction Reaction*. ACS Catalysis, 2019. **9**(9): p. 7660-7667.
2. Si, H., et al., *Carbon dots modified metallated graphdiyne with enhanced electron transfer and O2 adsorption capacity for efficient H2O2 photoproduction*. Chemical Engineering Journal, 2025. **516**: p. 163963.
3. Lu, H., et al., *Single-Atom Catalysts with p-Block Metals Surpass Transition-Metal Counterparts in the Photocatalytic H2O2 Production*. Angewandte Chemie International Edition, 2025. **64**(1): p. e202413769.

Elise Kenny is a computational chemist with a background in condensed matter theory. Her previous work focused on the magnetic properties of metal–organic frameworks and other quantum materials. She is currently focused on modelling photocatalysts for sustainable hydrogen peroxide production.

# Optoelectronic devices based on chiral halide perovskites and organic semiconductors

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**Abstract:**

Halide perovskites are among the most promising materials for use in photovoltaic and light-emitting devices. To explore its spin transportation-related properties, chiral 2D halide perovskites are essential, which can be obtained by introducing chiral organic halides such as R- and S-methylbenzylammonium halide and R- and S-1-(2-naphthyl)ethylammonium halide. Similarly, introducing chiral dopants can produce organic semiconductors with chirality. We will present these semiconducting materials that exhibit chiroptical properties. Circularly polarised light-emitting diodes based on these materials will also be presented.[1-3]

**References:**

1. Yang, L.-S., et al., *Circularly Polarized Photoluminescence of Chiral 2D Halide Perovskites at Room Temperature*. ACS Applied Materials & Interfaces, 2022. **14**(48): p. 54090-54100.
2. Yang, L.-S., et al., *Solution-processed spin organic light-emitting diodes based on antisolvent-treated 2D chiral perovskites with strong spin-dependent carrier transport*. Materials Horizons, 2025. **12**(6): p. 1863-1877.
3. Tsai, M.-H., et al., *Chiroptical Activities of Low-Dimensional Lead-Free Chiral Halide Perovskites with White-Light Emission*. Small Science, 2025. **5**(6): p. 2500034.

Professor

Department of Physics

National Taiwan Normal University

# Notes

# SEMINAR ROOM B

# 63-358

## DAY 1

## 8TH DECEMBER

## New device architectures for organic infrared sensors

Koen Vandewal*

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**Abstract:**

Organic photodetectors (OPDs) with a performance comparable to that of conventional inorganic ones have been demonstrated for the visible regime. However, infrared (IR) photodetection has proven to be challenging and, to date, the true potential of organic semiconductors in the near-infrared spectral range (800–2500 nm) and beyond remains largely unexplored.[1] In this talk, I will introduce new device concepts for organic IR detectors, based on resonant optical cavities,[1] doped photo-active layers[2] and near-infrared-to-visible upconversion. Design rules and optimization strategies will be discussed, yielding broadband, as well as wavelength selective devices with a tunability of the detection wavelength over several hundreds of nanometers. In a second part of the talk, we explore the performance limitations of organic IR detectors: A relation between open-circuit voltage, dark current, and noise current is demonstrated for OPDs with detection wavelengths beyond 1100 nm.[3] Based on these findings we estimate an upper limit of achievable specific detectivity values for organic photodiodes as a function of their longest detection wavelength and discuss the potential of organic semiconductors in thermal detectors.

**References:**

1. Vanderspikken, J., W. Maes, and K. Vandewal, *Wavelength-Selective Organic Photodetectors*. Advanced Functional Materials, 2021. **31**(36): p. 2104060.
2. Liu, Q., et al., *Electron-donating amine-interlayer induced n-type doping of polymer:nonfullerene blends for efficient narrowband near-infrared photo-detection*. Nature Communications, 2022. **13**(1): p. 5194.
3. Gielen, S., et al., *Intrinsic Detectivity Limits of Organic Near-Infrared Photodetectors*. Advanced Materials, 2020. **32**(47): p. 2003818.

Prof. Dr. Koen Vandewal obtained his PhD in Physics at Hasselt University in 2009 working on the device physics of organic photovoltaics. After that, he has been working for two years as a Postdoctoral Fellow at Linkoping University in Sweden and another two years at Stanford University in the US. In 2014, he was appointed as endowed professor at the Technische Universitaet (TU) Dresden in Germany. In January 2018, he moved from TU Dresden to Hasselt University leading a research group with the aim to solve fundamental questions in the field of organic, hybrid and molecular electronics with relevance to applications in opto-electronic devices such as organic light emitting diodes, solar cells, energy conversion devices and sensors.

# Photofunctional organometallic materials for solar cell applications

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**Abstract:**

Photovoltaic technology is a clean and pollution-free method for converting sunlight into electrical energy. Currently, commercial photovoltaic technology still primarily uses silicon and inorganic semiconductor materials to fabricate photovoltaic modules, which have a long lifespan. However, the high costs and the difficulty in producing flexible, lightweight, semi-transparent, and roll-to-roll photovoltaic modules limit their applications. In view of this, new photovoltaic technologies have been developed rapidly. These new technologies not only have lower costs but also possess many other advantages, such as being lightweight, flexible, and easy to process. Among these photovoltaic technologies, organic solar cells have developed particularly quickly. Different from organic semiconductors, organometallic-based semiconductor materials impart additional special properties. Different from organic conjugated materials, organometallic materials offer several distinct advantages, with the inclusion of transition metal elements imparting specific properties to the materials. These advantages include: (i) metal atoms facilitating electron transfer, thereby enhancing electronic properties, (ii) metal centers promoting intersystem crossing from the lowest singlet to triplet excited states, which results in long diffusion lengths and extended exciton lifetimes, and (iii) metal-metal and/or metal-ligand interactions influencing intermolecular interactions and enabling the modulation of material morphology. In this talk, we will present the recent advances of organic solar cells using organometallic functional materials.

**References:**

1. Luo, D., et al., *Upper Layer-Modulated Pseudo Planar Heterojunction with Metal Complex Acceptor for Efficient and Stable Organic Photovoltaics*. Advanced Materials. 2024. https://doi.org/10.1002/adma.202410880
2. Luo, D., et al., *Small Singlet–Triplet Gap Terpolymer Donor with a Simple Pt Complex Enables Organic Solar Cells with Low Energy Loss and Over 19.2% Efficiency*. Advanced Science, 2025. **12**(12): p. 2410154.
3. Xia, H., et al., *Leveraging Compatible Iridium(III) Complexes to Boost Performance of Green Solvent-Processed Non-Fullerene Organic Solar Cells*. Advanced Functional Materials, 2024. **34**(52): p. 2411058.
4. Sun, Y., et al., *Steric modulation of tetradentate platinum(II) bis-carbene complex enables over 18.4 % efficiency of layer-by-layer all-polymer solar cells*. Nano Energy, 2024. **130**: p. 110174.
5. Zhang, M., et al., *Metallated terpolymer donors with strongly absorbing iridium complex enables polymer solar cells with 16.71% efficiency*. Chemical Engineering Journal, 2022. **430**: p. 132832.
6. Wong, W.-Y., et al., *Metallated conjugated polymers as a new avenue towards high-efficiency polymer solar cells*. Nature Materials, 2007. **6**(7): p. 521-527.

Prof. Wai-Yeung Wong (Raymond) obtained his B.Sc. (Hons.) and Ph.D. degrees from The University of Hong Kong. After postdoctoral works at Texas A&M University (Advisor: Prof. F. A. Cotton) and the University of Cambridge (Advisors: Profs. The Lord Lewis and P. R. Raithby), he joined Hong Kong Baptist University from 1998 to 2016 and he now works at the Hong Kong Polytechnic University as the Dean of Faculty of Science and Chair Professor of Chemical Technology. He was awarded the RSC Chemistry of the Transition Metals Award, FACS Distinguished Young Chemist Award, State Natural Science Award from China, Croucher Senior Research Fellowship and RGC Senior Research Fellow Award, among others. His research focuses on organometallic and materials chemistry, especially aiming at developing multifunctional molecules and polymers for organic optoelectronics, energy science and metal-based nanomaterials. He has served as the Associate Editor for the Journal of Materials Chemistry C from 2013 to 2022. He is currently the Chairman of Hong Kong Chemical Society and is a Fellow of the Royal Society of Chemistry. In 2023, he was elected as the Foreign Member of the European Academy of Sciences.

## Spin-triplet excited states in organic semiconductors

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**Abstract:**

Electronic excited states with spin-triplet character play a key role in the operation of optoelectronic devices fabricated from organic semiconductors, including organic photovoltaics (OPVs) and organic light emitting diodes (OLEDs). In general, spin-triplet excitations are optically dark and lie deeper in energy than their bright spin-singlet counterparts and can thus be considered low energy trap states that are detrimental to device performance. In my talk, I will discuss some of our recent work employing ultrafast optical spectroscopy to understand the formation mechanisms and photophysics of triplet excitons in organic semiconductor devices.[1-2] This will include the impact of triplet excitons on OPV performance and potential strategies to mitigate this, as well as understanding how vibrational coupling drives the intersystem crossing processes in multiple resonance thermally-activated delayed fluorescence (MR-TADF) emitters.

**References:**

1. Gillett, A. J. et al. *The role of charge recombination to triplet excitons in organic solar cells*. Nature. 2021. **597**: p. 666–671.
2. Gillett, A. J. et al. *Dielectric control of reverse intersystem crossing in thermally activated delayed fluorescence emitters*. Nature Materials. 2022. **21**: p. 1150–1157

Alex Gillett is currently an Assistant Professor at Linköping University in Sweden. Before this, he completed his PhD under the supervision of Professor Sir Richard Friend at the University of Cambridge in 2019, which was followed by a postdoctoral stay in the same group. He began his independent career with the award of a Leverhulme Early Career Fellowship at Cambridge in 2022. In 2024, he was awarded research grants by the Wallenberg Academy Fellows program and Swedish Research Council and moved to his current position at Linköping University in the same year. Alex's research focuses on the development and application of ultrafast optical spectroscopy techniques to study the fundamental photophysics of organic semiconductor materials. He has a particular interest in high spin excitations and their role in optoelectronic device function, as well how vibrational couplings modulate the photophysics of organic molecules.

# Charge generation dynamics at heterojunction with cascade energy structures

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**Abstract:**

In this lecture, I will talk about the charge generation dynamics in most typical amorphous and crystalline polymer solar cells studied by transient absorption spectroscopy: One is based on a blend of amorphous regiorandom poly(3-hexylthiophene) (RRa-P3HT) and a fullerene derivative (PCBM) the other is based on a blend of crystalline regioregular P3HT (RR-P3HT) and PCBM.[1-2] In crystalline polymer/PCBM blends, the photoactive layer typically consists of three phases: crystalline polymer phase, polymer/PCBM mixed disorder phase, and PCBM aggregated phase, forming a cascade energy structure.[3] In order to discuss how such a cascade energy structure impacts on the charge generation dynamics in crystalline polymer solar cells, we measured transient absorption spectra of RR-P3HT/PCBM blend films upon the direct excitation of interfacial CT state formed at P3HT/PCBM interface. As a result, we found efficient hole transfer from a disordered phase to a more stable ordered phase. This would help hole polarons in the disordered phase to escape from geminate recombination, resulting in efficient charge dissociation at the interface with cascade energy structure.

**References:**

1. Guo, J., et al., *Charge Generation and Recombination Dynamics in Poly(3-hexylthiophene)/Fullerene Blend Films with Different Regioregularities and Morphologies*. Journal of the American Chemical Society, 2010. **132**(17): p. 6154-6164.
2. Guo, J., et al., *Bimodal Polarons and Hole Transport in Poly(3-hexylthiophene):Fullerene Blend Films*. Journal of the American Chemical Society, 2010. **132**(28): p. 9631-9637.
3. Fukuhara, T., et al., *Molecular Understanding of How the Interfacial Structure Impacts the Open-Circuit Voltage of Highly Crystalline Polymer Solar Cells*. ACS Applied Materials & Interfaces, 2021. **13**(29): p. 34357-34366.

Hideo Ohkita is a professor in the Department of Polymer Chemistry at Kyoto University. He received his PhD degree from Kyoto University in 1997. He was appointed as an assistant professor in 1997, promoted to associate professor in 2006, and became a professor in the Department of Polymer Chemistry at Kyoto University in 2016. From 2005 to 2006, he worked as an academic visitor under Professor Durrant at Imperial College London. Additionally, from 2009 to 2015, he concurrently served as a researcher in the JST PRESTO program. His primary research fields are the study of photophysics and photochemistry in polymer systems. His current research focuses on spectroscopic and device physics approaches related to polymer solar cells.

## High-performance all-polymer solar cells

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**Abstract:**

In recent years, with the rapid development of non-fullerene small molecule acceptors, the efficiency of organic solar cells has been continuously improved. However, small molecule acceptors have disadvantages, such as easy crystallization, poor photothermal stability and stretchability. In contrast, polymer acceptors can compensate for these shortcomings of small molecule acceptors. The all-polymer solar cells prepared have excellent stability and mechanical flexibility, showing great potential in wearable and flexible stretchable devices. The all-polymer system, with its high solution viscosity and good leveling performance, is very suitable for the preparation of large-area printed devices. Therefore, all-polymer solar cells have more advantages in commercial applications. Although the all-polymer system has many advantages, the research on all-polymer solar cells is relatively limited and the performance is relatively low. This report will systematically introduce the recent research progress of our research group in the field of all-polymer solar cells, including the design of high-performance polymer receptor materials, morphology control of all-polymer systems, device stability research, and green large-area processing.[1-2]

**References:**

1. Song, J., et al., *Optimizing Double-Fibril Network Morphology via Solid Additive Strategy Enables Binary All-Polymer Solar Cells with 19.50% Efficiency. Advanced Materials,* 2024. **36**: p. 2406922.
2. Ma, H., et al., *Binary all-polymer solar cells with 19.30% efficiency enabled by bromodibenzothiophene-based solid additive.* Energy & Environmental Science, 2025. **18**: p. 397-405.

Yanming Sun received his B.S. degree from Shandong University and Ph.D. degree from the Institute of Chemistry, Chinese Academy of Sciences with Prof. Yunqi Liu. From 2007 to 2009, he worked at the University of Manchester as a research assistant. Then, he joined Prof. Alan J. Heeger's group in the University of California at Santa Barbara as a postdoctoral researcher (2009–2013). In 2013, joined Beihang University as a professor. His research interests focus on organic functional materials and optoelectronic devices. He is awarded the 2018 National Science Fund for Distinguished Young Scholars. He is selected as the Highly Cited Researcher by Clarivate Analysis in the years of 2019 to 2024.

# Material design and device engineering for high-performance semi-transparent organic solar cells

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**Abstract:**

Semi-transparent OSCs (STOSCs), capable of generating electricity and transmitting light simultaneously, are a highly promising new energy technology with potential applications in building-integrated photovoltaics for windows and roofs, as well as in agricultural greenhouses and transportation vehicles. However, the balance between the power conversion efficiency (PCE) and average visible light transmittance (AVT) of STOSCs remains a challenge. In this presentation, I will introduce the high performance STOSCs developed in my lab from multiple aspects, including the molecular design of narrow band gap electron acceptor, the device and optical engineering, etc. We successfully increased the light utilization efficiency (LUE) of STOSC, as well as improved PCE and APT related to the energy conversion ability and visible light transmittance ability, respectively. Notably, a high LUE over 5.0% is reached, which represents the best among single junction STOSCs.

**References:**

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2. Li, Y., et al., *High-Performance Semi-Transparent Organic Photovoltaic Devices via Improving Absorbing Selectivity. Advanced Energy Materials*, 2021. **11**(11): p. 2003408.
3. Guan, S., et al., *Self-Assembled Interlayer Enables High-Performance Organic Photovoltaics with Power Conversion Efficiency Exceeding 20%*. Advanced Materials, 2024. **36**(25): p. 2400342.
4. Zhang, N., et al., *Benzothiadiazole-Fused Cyanoindone: A Superior Building Block for Designing Ultra-Narrow Bandgap Electron Acceptor with Long-Range Ordered Stacking*. Angewandte Chemie International Edition, 2025. **64**(7): p. e202420090.

Hongzheng Chen is the Qiushi Distinguished Professor at Zhejiang University. She completed her undergraduate study from Zhejiang University (ZJU) in 1988. She joined ZJU after obtaining her Ph.D. degree in Polymer Chemistry at the same university in 1994, and became a Full Professor in 1999. She once visited Hong Kong University of Science and Technology, University of Antwerpen and Interuniversity MicroElectronic Center of Belgium, and Stanford University. Her research interests focus on the development of organic and organic/inorganic hybrid materials for optoelectronic applications, including solar cells and photodetectors. She issued over 60 patents and published over 500 SCI-indexed papers with more than 35,000 citations, and was honoured as “Highly Cited Researcher” for the last 4 years. Now she serves as Executive Editor for ACS Appl. Polym. Mater..

# HTL- & ETL-free metal-semiconductor-metal structure organic solar cells

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**Abstract:**

In high-performance organic solar cells (OSCs), the electron transport layer (ETL) and hole transport layer (HTL) are essential for facilitating efficient extraction and transport of electrons and holes from the photoactive layer to the respective electrodes. However, challenges associated with the use of ETL and HTL remain critical issues in OSC research. Here, we propose a novel fabrication strategy that eliminates the need for ETL and HTL, achieving structural simplification while maintaining high performance via simple interfacial modifications between the active layer and electrodes. To realize a Metal-Semiconductor-Metal (MSM) architecture without ETL and HTL, we explored three different approaches: Type-I employed a self-assembled monolayer (SAM) at the anode interface and a salt-based interlayer at the cathode; Type-II utilized distinct salt-based modifications at both the anode and cathode interfaces; Type-III involved co-depositing hole-transport-capable molecules with the active layer to spontaneously form a hole extraction interface, while modifying the cathode with amine salts for efficient electron collection. All three strategies successfully yielded high-performance OSCs with MSM structures, achieving power conversion efficiencies exceeding 18%, comparable to conventional devices with both ETL and HTL. Our findings demonstrate a significant simplification in OSC fabrication and represent a promising advancement toward the scalable commercialization of organic photovoltaics.

Shinuk Cho is a professor in the Department of Semiconductor Physics and Engineering at the University of Ulsan. He received his Ph.D. in 2006 from Pusan National University under the supervision of Prof. Kwanghee Lee. He then worked as a postdoctoral researcher at the Center for Polymers and Organic Solids at the University of California, Santa Barbara (UCSB), under the guidance of Prof. Alan J. Heeger, recipient of the 2000 Nobel Prize in Chemistry. He joined the Department of Physics at the University of Ulsan as an assistant professor in 2010, was promoted to associate professor in 2012, and became a full professor in 2016. His current research interests include organic semiconducting materials and organic electronic devices such as organic solar cells and organic field-effect transistors.

# solid-state photon upconversion mediated by charge transfer states in a bulk-heterojunction sensitizer

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**Abstract:**

Photon interconversion in semiconductors is of fundamental importance for digital imaging and quantum sensing [1]. Nonlinear processes such as triplet-triplet annihilation (TTA) offer photon upconversion (UC) under incoherent and low-intensity illumination conditions, making it particularly well-suited for solid-state optoelectronic devices. However, conventional upconversion systems rely on intersystem crossing facilitated by the heavy-atom effect, which severely limits their efficiency [2]. In this talk, I will demonstrate a promising approach to harvesting low-energy photons for sensitized triplet generation utilizing charge transfer (CT) states formed in a low-bandgap donor-acceptor bulk-heterojunction (BHJ) system [3]. A molecular stack comprising a squaraine derivative (DIB-SQ) and fullerene (PCBM), paired with a fully optimized annihilator layer of DBP doped rubrene, yields an upconversion quantum yield ($\Phi_{UC}$) of 1.36%, with an excitation intensity threshold for the onset of the linear regime of $I_{th} = 60.5\, mW/cm^2$. Fine-tuning the photoexcited states by varying the amount of fullerene enables the effective buildup of annihilator triplet states to levels sufficient for TTA-induced UC. This strategy leverages the prevalent back electron transfer in BHJ systems, typically considered as a terminal loss channel in photovoltaics, and repurposes it into a triplet sensitizer to drive beneficial TTA-based upconversion. The proposed strategy opens up a new avenue for solid-state upconversion systems based on low-bandgap semiconductors.

**References:**

1. Wang, J., et al., *Integrated photonic quantum technologies*. Nature Photonics, 2020. **14**(5): p. 273-284.
2. Singh-Rachford, T.N. and F.N. Castellano, *Photon upconversion based on sensitized triplet–triplet annihilation*. Coordination Chemistry Reviews, 2010. **254**(21): p. 2560-2573.
3. Klein, M., et al. *Charge Transfer States in Donor Acceptor Bulk Heterojunctions as Triplet Triplet Annihilation Sensitizer for Solid-State Photon Upconversion*. 2025. arXiv:2509.25679 DOI: 10.48550/arXiv.2509.25679.

Dr Maciej Klein received his PhD in Physics from Gdansk University of Technology in Poland, where he investigated magnetic field effects in organic solids. He then moved to Nanyang Technological University in Singapore, focusing on halide perovskite optoelectronics and dielectric metamaterials. In early 2023, Maciej joined QUT to pursue research in photon upconversion and single photon sensing.

# Organic solar cells: from low band-gap porphyrin materials to mechanism study

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**Abstract:**

The talk will start with design and synthesis of a series of low band-gap porphyrin-based donor materials in OPV. Then it will be focused on the verification of multi-length scale morphology, which clarifies the direction of device optimization. Then the deep physical mechanism for energy loss will be presented. Finally, it will be focused on the applications of porphyrin based donor materials in different kinds of organic solar cells, such as, tandem cell, ternary cell, flexible cell, semitransparent cell, some of which have achieved some record performance. Furthermore, it validates that such class of porphyrin based materials are the best low band-gap donor materials to date.

**References:**

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2. Miao, Y., et al., *Isomerization engineering of solid additives enables highly efficient organic solar cells via manipulating molecular stacking and aggregation of active layer.* Advanced Materials, 2024. **36**: p. 2406623.
3. Kan, Y., et al., *Amino-Functionalized Graphdiyne Derivative as a Cathode Interface Layer with High Thickness Tolerance for Highly Efficient Organic Solar Cells.* Advanced Materials, 2024. **36**: p. 2312635.
4. Zhang, X., et al., *End-Extended Conjugation Strategy to Reduce the Efficiency-Stability-Mechanical Robustness Gap in Binary All-Polymer Solar Cells*. Angewandte Chemie International Edition, 2025. **64**(3): p. e202415583.
5. Sun, Y., et al., *Rational Control of Sequential Morphology Evolution and Vertical Distribution towards 17.18% Efficiency All-Small-Molecule Organic Solar Cells*. Joule, 2022. **6**: p. 2835.
6. Ma., R., et al., *Achieving high efficiency and well-kept ductility in ternary all-polymer organic photovoltaic blends thanks to two well miscible donors*. Matter, 2022. **5**: p. 725.

Ke Gao is a professor at School of Chemistry and Chemical Engineering, Shandong University, Qingdao. He got his phD degree from the State Key Laboratory of Luminescent Materials and Devices, South China University of Technology in 2016 under the guidance of Prof. Yong Cao, Prof. Thomas P. Russell and Prof. Xiaobin Peng. He was a post-doc at UW (Seattle) in collaboration with Prof. Alex Jen from 2017 to 2020. Then he joined Shandong University in 2020. His research interest is focused on design and synthesis of organic functional materials for OPV and hybrid solar cells, fabrication, slot-die printing of OPV devices, and the physics in organic electronic.

# Towards high-throughput property prediction in molecular semiconductors

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**Abstract:**

Innovation in organic photovoltaics (OPVs) is primarily driven by trial-and-error discovery of new materials, which is laborious and expensive. However, the past decade has seen the rise of a new generation of materials: fused-ring electron acceptors (FREAs). These materials have propelled OPV efficiency to >19 % due to their exceptional intrinsic properties and have also altered fundamental light-to-electricity conversion processes. These materials, combined with recent advances in in artificial intelligence, provide an opportunity to understand and control organic semiconductor photophysics in a more predictive way than has previously been possible.

This talk will survey our recent contributions to understanding and predicting the properties of novel of modern OPV materials, including:

- exciton diffusion rate predictions in high-performance organic semiconductors such as fused-ring electron acceptors.[1-2]
- a proof-of-concept machine learning model for high-speed computational semiconductor discovery, drawing on quantum chemical data for ~4000 organic semiconductors.[3]
- the development of new methods to calculate excited state interactions and application to dark states in super-radiant molecular monolayers.[4]

**References:**

1. Weal, G. et al., *Towards high-throughput exciton diffusion rate prediction in molecular organic semiconductors.* Journal of Materials Chemistry C, 2024. **12**: p. 8747-8758.
2. Hume, P. A., Jiao, W., and Hodgkiss, J. M. *Long-Range Exciton Diffusion in a Non-Fullerene Acceptor: Approaching the Incoherent Limit.* Journal of Materials Chemistry C, 2021. **9**: p. 1419-1428.
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4. Hasan, M. M., et al., *Excitonic Dark States in Molecular Monolayer Crystals.* Nano Letters, 2025. **25**: p. 383–390.

Paul's research combines theoretical chemistry, materials synthesis, and ultrafast spectroscopy to understand light-responsive organic materials, with a focus on environmental applications, such as organic solar cells. Paul completed his at the University of Auckland in total synthesis. He then moved to the United Kingdom where he took up a position as a Research Fellow at the University of Nottingham Centre for Sustainable Chemistry, working on organic solar cell materials. In 2016, he returned to the University of Auckland, where he was involved in both teaching and research. Paul joined Victoria University of Wellington in late 2018 where he is an Independent Research Fellow.

# Decoding charge generation in pristine non-fullerene acceptors: from interfacial physics to module-scale organic photovoltaics

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**Abstract:**

The global shift toward sustainable energy demands not only new material paradigms but also device architectures suitable for real-world deployment. Organic photovoltaics (OPVs) offer a promising pathway, combining molecular tunability, low-cost processing, and the potential for semi-transparent integration in applications ranging from smart windows to wearable electronics.

In this talk, I will present our experimental and theoretical investigations on non-fullerene acceptors (NFAs), with a focus on Y6 derivatives. Contrary to the view that pristine NFAs act as standalone photoactive materials, we demonstrate that they function as bilayer systems, with efficient charge generation localized at the interface with the hole transport layer (HTL). Device performance is found to be strongly dictated by the HTL: semiconducting layers such as CuSCN stabilize long-lived interfacial charges, while metal-like PEDOT:PSS promotes ultrafast recombination into triplet states via high trap densities.[1] Even trace donor polymers can lower the hole-injection barrier and enhance bulk charge generation.

Finally, I will discuss how such interfacial strategies enable semi-transparent OPV modules, bridging lab-scale studies with scalable, application-ready technologies.[2]

**References:**

1. Sharma, A., et al., *Elucidating the role of heterojunction in pristine non-fullerene acceptor organic solar cells*. Energy & Environmental Science, 2025. **18**(15): p. 7610-7623.
2. Sharma, A., et al., *Semitransparent Organic Photovoltaics Utilizing Intrinsic Charge Generation in Non-Fullerene Acceptors*. Advanced Materials, 2024. **36**(9): p. 2305367.

Dr. Anirudh Sharma is a Research Scientist at King Abdullah University of Science and Technology (KAUST), where he leads the solar team within the OmegaLab. He holds a PhD in Physics from Flinders University, South Australia, and has held research positions at the University of South Australia and the University of Bordeaux. A recipient of the CSIRO Future Manufacturing Flagship Fellowship, he has also been a visiting researcher at the Max Planck Institute for Polymer Research. His research focuses on energy harvesting technologies—particularly organic photovoltaics—with an emphasis on material energetics, functional interfaces, and device stability.

## High-performance Y6 homojunction organic solar cells

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**Abstract:**

Non-fullerene small molecule acceptor (NFA) materials have enabled bulk heterojunction (BHJ) organic photovoltaic (OPV) devices to exceed 20% power conversion efficiency (PCE). However, BHJ film morphology can be challenging to reproduce and scale up for commercial manufacturing. Single material active layer (i.e., homojunction) architectures could significantly simplify the large-scale fabrication process, but solution-processed homojunction OPV devices have so far achieved only modest PCEs < 1.5%. Recent studies of the optoelectronic properties of the NFA Y6 have described its capability to achieve spontaneous free charge generation, making it a strong candidate for improving homojunction device performance.

I will present the results from a systematic investigation into how device architecture and the choice of charge transport layers affect Y6 homojunction OPV performance. We find the choice of the charge transport layers to be critical to ensuring efficient charge extraction from the Y6 layer, with maximum PCEs exceeding 2.5% – the highest reported efficiency for any solution-processed small molecule homojunction OPV device to date.[1] The improved efficiency was attributed to the inclusion of a TFB layer and its electron blocking and hole extraction properties. The PCE was further improved up to 5.4% through control of the Y6 active layer nanostructure via the use of additives. These findings establish homojunction active layers as a promising route to efficient and scalable OSCs and highlight the prospect for further performance gains through the tuning of active layer nanostructure and the device architecture.

**References:**

1. McAnally, S., et al., *High-Efficiency Y6 Homojunction Organic Solar Cells Enabled by a Secondary Hole Transport Layer*. Small, 2025. **21**(8): p. 2409485.

A/Prof. Paul Shaw Paul Shaw received his PhD in Physics from the University of St Andrews in 2009 on the topic of exciton diffusion in conjugated polymers. Following his PhD, he moved to The University of Queensland to work on fluorescence-based sensors for chemical vapours. He is a director of the Centre of Organic Photonics & Electronics, where he leads multi-disciplinary research programs on organic optoelectronics for applications including solar cells, fluorescence-based chemical sensors and organic light-emitting diodes.

## Engineering metal halide perovskite films for photovoltaic devices

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**Abstract:**

Metal halide perovskites have shown great promise for a broad range of applications due to their fascinating optical, chemical, physical and optoelectronic properties. A classic example of perovskites' applications is photovoltaic (PV), which converts sunlight directly into electricity. Despite the great promise and advancements, the commercialization of perovskite solar cell technology is limited due to the issues associated with the stability of perovskite in ambient conditions and heat. Engineering strategies such as additive engineering, defect engineering and surface passivation are promising approaches for not only improving the stability of perovskite solar cells, they are also widely used for enhancing the PV performances. In this talk, I will present our recent work focused on engineering metal halide perovskite using $O_2$-inducing effect and surface passivation methods and their application in solar cells.

**References:**

1. Suragtkhuu, S., et al., *Oxygen-inducing effects in metal halide perovskite thin films for solar cells*. EES Solar, 2025. **1**(5): p. 857-867.
2. Myagmarsereejid, P., et al., *Large-area phosphorene for stable carbon-based perovskite solar cells*. npj 2D Materials and Applications, 2024. **8**(1): p. 38.

Munkhbayar Batmunkh is currently a Senior Lecturer in the School of Environment and Science at Griffith University. Until recently (early-2025), he was an ARC DECRA fellow. Dr. Batmunkh will be starting his ARC Future Fellow from early-2026. He completed his Ph.D. in chemical engineering at the University of Adelaide (Australia) in 2017. He received his M.E. and B.Sc. degrees in 2012 and 2010 from Gyeongsang National University (South Korea) and National University of Mongolia (Mongolia), respectively. He currently leads an active independent research group at Griffith University working on the development of functional nanomaterials, solar cells, detectors and photovoltaic-integrated new technologies.

# Advanced interface engineering: unlocking the full potential of perovskite solar cells

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**Abstract:**

Perovskite solar cells (PSCs) have achieved remarkable progress, with the power conversion efficiency (PCE) surpassing 26%, rivalling monocrystalline silicon solar cells. Despite this success, their long-term stability remains a critical challenge. This instability arises not only from the perovskite itself but also from the interfaces between adjacent layers. Stress-induced lattice strain — arising from octahedral titling, grain boundaries, and lattice mismatch at the interface— was mitigated by modifying the hole transporting layer (HTL) with 5-Aminopyridine-2-carboxylic Acid (APC).[1] APC promotes homogenous crystallization through uniform molecular adsorption energy, effectively suppressing lattice distortion and strain. Additionally, we employed ionic liquids to strengthen the intercomponent interactions via coordinative and ionic bonds, while simultaneously protecting the underlying self-assembly monolayers (SAMs) from solvent dissolution.[2] Furthermore, a "Seed-Rooting Anchoring" strategy, inspired by the natural process of seeds rooting to prevent soil erosion, was developed to stabilize the stoichiometry of perovskite.[3] We also employed in situ polymerized layer to reinforce structural integrity by strongly anchoring organic cations through multiple hydrogen bonds, adhesively bridging between the perovskite film and HTL.[4] These advanced interfacial engineering techniques not only enhances the efficiency, but also significantly prolong the operation stability of the perovskite solar cells.

**References:**

1. Xu, X., et al., *Uniform Molecular Adsorption Energy-Driven Homogeneous Crystallization and Dual-Interface Modification for High Efficiency and Thermal Stability in Inverted Perovskite Solar Cells.* Advanced Functional Materials, 2024. **34**(44): p. 2470258.
2. Xu, X., et al., *Unraveling the interfacial homogeneity and bulk crystallization for efficient and stable perovskite solar cells via ionic liquids*. Energy & Environmental Science, 2025. **18**(7): p. 3407-3417.
3. Li, S., et al., *In situ Polymerization Induced Seed-Root Anchoring Structure for Enhancing Stability and Efficiency in Perovskite Solar Modules*. Angewandte Chemie International Edition, 2025. **64**(10): p. e202421174.
4. Xu, X., et al., *Adhesively Bridging Co-Self-Assembled Monolayer and Perovskite Via In Situ Polymerization for Enhanced Stability of Inverted Perovskite Solar Cells*. Advanced Materials, 2025. **37**(34): p. 2505745.

Dr. Aung Ko Ko Kyaw is an Associate Professor in Electrical and Electronic Engineering at Southern University of Science and Technology (SUSTech). He earned his B.Eng. (2007) and Ph.D. (2012) from Nanyang Technological University, Singapore, followed by postdoctoral work at UC Santa Barbara (Alan Heeger's lab), the Max Planck Institute for Polymer Research, and A*STAR, Singapore. With about 150 SCI papers (9800+ citations, H-index 48) in journals like Energy Environ. Sci., Nat. Commun., and Adv. Mater., he also holds 20 patents and has delivered 35 invited talks. His research focuses on organic/perovskite optoelectronics for energy, sensing, and wearable devices. Recognized as a World's Top 2% Scientist (Stanford) and recipient of the Green Talents Award (Germany) and IAAM Medal, he drives innovation in sustainable technologies.

# Fluorinated additives for perovskite solar cells

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**Abstract:**

Defect-passivating molecular additives are critical to achieving high efficiency in scalable perovskite photovoltaics. We present the results from a systematic study into the impact of (2,3,4,5,6-pentafluorophenyl)-alkylamine additives on the performance of methylammonium lead triiodide ($MAPbI_3$) solar cells. We varied both the length of the alkyl spacer between methyl (FMAI), ethyl (FEAI) or n-propyl (FPAI) — and the choice of halide counter-anion ($X = I^-$, $Br^-$, $Cl^-$) of 2,3,4,5,6-pentafluorophenylethylammonium halides (FEA-X).

Varying the alkyl chain length reveals a clear correlation between additive structure and the perovskite film morphology: the shorter-chain FMAI is present in the film bulk, while longer-chain FEAI and FPAI diffuse to the surface. The FMAI improved performance most effectively due to its passivation of the surface defects on the grains, while the FPAI decreased the performance due to its detrimental effects on $MAPbI_3$ crystals. Despite its surface localization, FEAI also improves device performance by passivating defects at the grain boundaries.

In comparing the effects of the choice of anion in FEA-X, chloride-based FEACl produced the largest crystal grains, lowest trap density, highest photoluminescence (PL) intensity and longest average PL lifetime, indicative of superior defect passivation. When solar cells containing additive-processed $MAPbI_3$ films were fabricated using a nitrogen knife-assisted blade-coating technique, the resulting devices had a high open-circuit voltage ($V_{oc}$) of 1.17 V and a PCE of 21.4% with improved thermal stability.

Overall, these results show that ethyl-linked additives with chloride counter-anions can act as synergistic levers for enhancing the performance and lifetime of blade-coated perovskite films, offering a rational pathway toward closing the efficiency gap between scalable and lab-scale fabrication methods.

**References:**

1. Wang, X., et al., *Engineering fluorinated-cation containing inverted perovskite solar cells with an efficiency of >21% and improved stability towards humidity*. Nature Communications, 2021. **12**(1): p. 52.
2. Li, H., et al., *Influence of the Alkyl Chain Length of (Pentafluorophenylalkyl) Ammonium Salts on Inverted Perovskite Solar Cell Performance*. ACS Applied Materials & Interfaces, 2022. **14**(35): p. 39939-39950.
3. Li, H., et al., *Efficient Inverted Perovskite Solar Cells Using Dual Fluorinated Additive Modification*. Advanced Materials Interfaces, 2023. **10**(13): p. 2201939.
4. Feng, Y., et al., *Enhanced Efficiency and Stability in Blade-Coated Perovskite Solar Cells through Using 2,3,4,5,6-Pentafluorophenylethylammonium Halide Additives*. ACS Applied Materials & Interfaces, 2025. **17**(5): p. 7670-7678.

Dr. Jin is a mid-career researcher with expertise in organic photonics and electronics, with a focus on organic photovoltaics. She began her postdoctoral career at VTT Technical Research Centre of Finland (2008–2010), before joining the Centre for Organic Photonics and Electronics at The University of Queensland in 2010. There, she has led the development of large-area organic solar cells. Her current research focuses on organic and perovskite optoelectronic materials and devices, including transparent conductive electrodes for flexible and wearable applications.

# Microstructural studies of solution-processed organic optoelectronic materials

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**Abstract:**

Solution-processed organic semiconductors, including organic solar cells and photodetectors, have witnessed remarkable progress in recent years due to their compatibility with large-area, flexible fabrication. Beyond the development of novel materials and device engineering, optimizing device performance through precise control of thin-film morphology remains a critical challenge. The complexity of bulk-heterojunction (BHJ) architectures and the rapid dynamics during film formation hinder effective morphology control during processing. In this talk, we integrate molecular dynamics simulations with *in situ* and *ex situ* nanoscale structural characterizations to systematically investigate the morphological evolution during film deposition. Our results reveal that the molecular conformation of donor and acceptor materials in solution, along with specific interactions between the acceptor and the solvent, govern the sensitivity of the final morphology to solvent choice. By leveraging this understanding, we successfully realized solvent-insensitive organic solar cells. Furthermore, we extended this morphological control strategy to circularly polarized organic photodetectors, demonstrating promising potential for near-infrared CPL detection applications.

**References:**

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2. Wan, L., et al., *Sensitive near-infrared circularly polarized light detection via non-fullerene acceptor blends*. Nature Photonics, 2023. **17**(8): p. 649-655.
3. Chen, H., et al., *A guest-assisted molecular-organization approach for >17% efficiency organic solar cells using environmentally friendly solvents*. Nature Energy, 2021. **6**(11): p. 1045-1053.

Dr. Rui Zhang is a Distinguished Professor at the Institute of Functional Nano & Soft Materials (FUNSOM), Soochow University. He received his Ph.D. from the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences (advisor: Prof. Yanchun Han), followed by postdoctoral research at Linköping University in Sweden (co-supervisor: Prof. Feng Gao) and Lawrence Berkeley National Laboratory in the U.S. (co-supervisor: Dr. Chenhui Zhu). His research focuses on condensed matter physics and photophysics of organic semiconductors, with a particular emphasis on synchrotron X-ray/neutron-based characterization methodologies and their application in structural investigations. To date, he has published over 20 papers as first or corresponding author (including co-authorships) in prestigious journals such as Nature Energy (2 papers), Nature Photonics, and Advanced Materials, with more than 3300 citations.

# Metal-free phthalocyanine additives at high concentration for enhanced stability and efficiency in perovskite solar cells

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**Abstract:**

Metal phthalocyanines have demonstrated considerable potential as functional additives in perovskite solar cells (PSCs); however, their application is often constrained by issues such as solubility limitations, narrow absorption spectra, and efficiency loss at high concentrations. In contrast, metal-free phthalocyanines remain relatively underexplored despite offering structural versatility and promising optoelectronic properties. Herein, we report CG-0, a fully substituted, metal-free phthalocyanine derivative, rationally designed with peripheral electron-withdrawing groups, non-peripheral electron-donating groups, and solubilizing ethoxy chains. This tailored molecular design improves near-infrared absorption, solubility, and photoelectrochemical stability. When employed as an additive in PSCs, CG-0 deliver ed a power conversion efficiency of 20.41% and a fill factor of 83.2%, with negligible variation in performance across different concentration ranges. These results highlight CG-0 as a promising molecular strategy to address the current limitation of phthalocyanine-based materials in high-efficiency perovskite photovoltaics.

**References:**

1. Feng, Y., et al., *Homogenized Self-Assembled Molecules for Inverted Perovskite Solar Cells*. Angewandte Chemie International Edition, 2025. **64**(30): p. e202505876.
2. Sekar, K., et al., *Significance of Formamidinium Incorporation in Perovskite Composition and Its Impact on Solar Cell Efficiency: A Mini-Review*. Advanced Energy and Sustainability Research, 2024. **5**(8): p. 2400003.
3. Zhu, C., et al., *Optimizing the light-humidity stability of formamidinium halide perovskites through intermediate phase and strain stress adjustment*. Materials Today Energy, 2025. **47**: p. 101757.

Dr. Chih-Hsin Chen received his Ph.D. degree in chemistry from National Taiwan Normal University in 2006. He worked as a post-doctoral researcher at Academia Sinica, Taiwan between 2006 and 2007 then moved to the Department of Chemical and Biomolecular Engineering, National University of Singapore as a research fellow from 2008 to 2012. He is currently a professor and chair at Department of Chemistry, Tamkang University, Taiwan. He also serves as the chair of ACS Taiwan Chapter. His research interests include liquid crystal-based sensors and organic materials for optoelectronic applications. His research won FutureTech Award in 2020, Gold Medal Award of Invention Competition in 2018 and 2023, and Silver Medal Award of Invention Competition in 2022 at the Taiwan Innotech Expo.

# Multifunctional hybrid 2D perovskites for optoelectronic applications

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**Abstract:**

Two-dimensional (2D) organic-inorganic perovskites are an emerging class of materials with great potential for optoelectronics, as a wide variety of functional chromophores can be regularly incorporated, resulting in advanced electronic or optoelectronic devices such as light-emitting diodes (LEDs), solid-state lasers, field-effect transistors (FETs), solar cells, and photodetectors.[1] 2D hybrid perovskites differ from their three-dimensional (3D) counterparts due to the presence of large organic cations, which lead to a layered structure composed of 2D inorganic metal-halide octahedral sheets separated by organic layers. Generally, these organic cations (also referred to as “ligands”) are simple alkyl- or phenyl alkyl-ammonium salts and, apart from their effect on the inorganic sheets separation, they do not impart any specific functionality or optoelectronic properties to the system. Over the past decade, however, 2D perovskites incorporating more complex organic cations have been widely investigated for novel optoelectronic applications.[2]

In this context, we recently developed new hybrid 2D perovskite systems based on various functional organic ligands, such as large electron-rich aromatic molecules to promote ambipolar charge transport properties, strong acceptor units to enhance charge separation and photodetection, and luminescent dyes for the fabrication of light-emitting diodes.[3,4,5] These materials have been successfully integrated into optoelectronic devices and the beneficial contributions of the new organic cations have been thoroughly investigated and clearly demonstrated.

**References:**

1. Saparov, B. and D.B. Mitzi, *Organic–Inorganic Perovskites: Structural Versatility for Functional Materials Design*. Chemical Reviews, 2016. **116**(7): p. 4558-4596.
2. Li, X., J.M. Hoffman, and M.G. Kanatzidis, *The 2D Halide Perovskite Rulebook: How the Spacer Influences Everything from the Structure to Optoelectronic Device Efficiency*. Chemical Reviews, 2021. **121**(4): p. 2230-2291.
3. Liu, X., et al., *Investigation of Charge Transport Properties in a 2D Dion–Jacobson Halide Perovskite Based on Terphenyl Dications*. ACS Materials Letters, 2023. **5**(8): p. 2148-2155.
4. Feng, Z., et al., *Artificial p–n-like Junction Based on Pure 2D Organic–Inorganic Halide Perovskite Structure Having Naphthalene Diimide Acceptor Moieties*. Advanced Optical Materials, 2023. **11**(10): p. 2202734.
5. Matsushima, T., et al., *Efficient Electroluminescence from Organic Fluorophore-Containing Perovskite Films*. Advanced Materials, 2024. **36**(49): p. 2408775.

Dr. Fabrice Mathevet obtained his PhD in Chemistry and Materials Science in 2002 from the University of Strasbourg, France. His doctoral research was carried out at the Institute of Physics and Chemistry of Materials of Strasbourg (IPCMS). He subsequently held postdoctoral positions at the University Pierre and Marie Curie (Paris) and at the French Atomic Energy Commission (CEA) in Grenoble. In 2007, he was appointed as a CNRS* Researcher at Sorbonne University, within the Paris Institute of Molecular Chemistry (IPCM), where he is now CNRS Research Director in the Polymer Chemistry team. His multidisciplinary research focuses on chemical engineering approaches to design and develop novel organic, hybrid and macromolecular semiconducting materials for photonic and electronic applications. Since 2020, he has also been on secondment at the Center for Organic Photonics and Electronics Research (OPERA) at Kyushu University (Japan), as part of a strategic partnership between CNRS and the OPERA Center. Since 2023, he has served as co-director of the CNRS International Research Project ‘LUXERIT’, a collaborative initiative between CNRS and OPERA. Dr. F. Mathevet has published more than 86 papers in refereed scientific journals and is a co-inventor on 5 patents. His current h-index is 31 with i-10 index of 60, and his work has received over 2884citations (WoS).

# Notes

# SEMINAR ROOM A

# 63-348

DAY 2

**9TH DECEMBER**

## Perovskite LEDs and lasers

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**Abstract:**

As a novel light source technology, perovskite light-emitting diodes (PeLEDs) have achieved external quantum efficiencies comparable to OLEDs, and with superior colour space coverage. In this talk, we discuss some key considerations behind the high efficiencies and the potential mechanisms that may approach or exceed the efficiency limits. We focus on the critical challenges in this field, including device instability, brightness and downscaling. We have demonstrated, for the first time, that ultralong operational lifetimes satisfying the practical demands can be achieved in perovskite LEDs. We show that it is possible to control the p- and n-type behaviours in emissive perovskite semiconductors, enabling ultra-high brightness of 1.16 million nits in perovskite LEDs, setting a brightness record for solution-processed LEDs. Our efforts of downscaling micro- and nano-perovskite LEDs to below the size limit of conventional LEDs are presented, showcasing the potential of micro/nano-PeLEDs for next-generation display technologies. Finally, we present our results on the first electrically-driven perovskite laser and its potential as a new semiconductor laser technology.

Dawei Di is a professor and Deputy Director of the International Research Center for Advanced Photonics, Zhejiang University. He received B.Eng. and Ph.D. degrees (in Photovoltaic Engineering) from the University of New South Wales (2004-2012), and a second Ph.D. (in Physics) from Cavendish Laboratory, University of Cambridge (2012-2017). He continued his work as a postdoctoral researcher at Cavendish Laboratory, Cambridge (2017-2018) before joining Zhejiang University in 2018. Dawei Di's research interests include the physics and application of novel optoelectronics, with a current focus on perovskite and organic devices. His group demonstrated the first electrically-driven perovskite lasers, micro/nano-perovskite LEDs, controllable p- and n-type doping in perovskite semiconductors, long-term stable perovskite LEDs, room-temperature continuous-wave perovskite polariton lasers, and revealed the unified physics of ultralow-voltage LED operation. Their findings were published in leading academic journals including Nature (3), Science, Nature Photonics (3), Nature Nanotechnology, Nature Electronics, Nature Communications (3) and Science Advances (2). Dawei Di was an honouree of MIT Technology Review Innovators Under 35 (global, 2019).

# What's reducing the photovoltaic efficiency of narrow-bandgap organic solar cells?

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**Abstract:**

Understanding the loss mechanism in organic solar cells (OSCs) with narrow optical bandgap is critical for the development of conventional and next-generation photovoltaic technologies, especially for tandem and semi-transparent solar cells. Here, we quantitatively discern the losses incurred at different steps of photocurrent generation in two low-bandgap OSCs ($E$g~1.23 eV) based on the binary blends of structurally analogous non-fullerene acceptors (NFAs), namely BTPV-4F-eC9 and BTPV-4Cl-eC9.[1] Bias-dependent free charge generation and photoluminescence studies identify geminate charge transfer (CT) state recombination as the predominant loss mechanism limiting photocurrent in both systems. Transient absorption spectroscopy reveals in agreement a critical competition between decay and separation dynamics of the CT state, with plausible explanations from poor NFA aggregation in the photoactive blends. Owing to this loss pathway, both low-bandgap OSCs exhibit a higher bimolecular recombination coefficient and a higher Langevin reduction factor relative to the state-of-the-art PM6:Y6-based OSCs. Nonetheless, the low-bandgap blends exhibit comparable overall voltage losses of ≈0.56 V, and efficient exciton dissociation despite a lower driving force. This analysis underscores the notion that suppression of geminate loss pathways can vitally balance recombination losses with improved charge generation, and markedly move the overall internal quantum efficiency towards the detailed balance limit.

**References:**

1. Shukla, A., et al., *Discerning Performance Bottlenecks of State-of-the-Art Narrow Bandgap Organic Solar Cells*. Advanced Energy Materials, 2025. **15**(32): p. 2502398.

Dr Atul Shukla earned his B.Tech from the Indian Institute of Technology Roorkee in 2016 and completed his Ph.D. in organic light–emitting devices at The University of Queensland in 2021, where he investigated exciton–charge interactions under high excitation densities. He then conducted postdoctoral research in Germany at the University of Potsdam, focusing on organic solar cells. His research spans high-brightness OLEDs, electrically pumped organic lasers, solar cells, and quantum-functional devices, advancing exciton-management strategies to enable next-generation optoelectronic technologies.

## Advanced flexible printed sensors and their applications

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**Abstract:**

To realize a truly sustainable future, next-generation sensors must adopt eco-friendly manufacturing methods that support a circular economy—an essential concept of *sustainable electronics*. In this presentation, we introduce a series of flexible sensors that operate via resistance changes in carbon-based conductive layers. All devices are fabricated on flexible substrates using simple and scalable techniques such as stencil and screen printing, and the performance can be enhanced through precise control of the sensing layer's microarchitecture.

Conductive composite inks were formulated by blending polydimethylsiloxane (PDMS), carbon black (CB), and a deep eutectic solvent (DES). After printing, the sensing layers were annealed at 120 and 140 °C. DES-induced phase segregation generated tunable pores (~100 µm) in the sensing layer. The resulting pressure sensors exhibited large, linear resistance changes and rapid responses by applied pressure. The same composite ink system was also applied to stretchable strain and bending sensors, which showed excellent sensitivity and durability.

In a complementary approach, thermally expandable microspheres (TEMs) were incorporated into a poly(styrene-butadiene-styrene)/CB ink. Annealing at 125 °C produced microdomes (20–50 µm in diameter) in the printed composite layer. By stacking a low-conductivity bottom layer and a high-conductivity top layer, we achieved tunable sensitivity, dynamic range, and linearity—all within a fully screen-printed bilayer structure.

For humidity sensing, cellulose nanofibers (CNFs) were employed as a host for CB. Their strong affinity ensured uniform, sparse dispersion, forming a hydrophilic porous network that rapidly adsorbs and desorbs moisture. Printed CB/CNF sensors exhibited large resistance changes with variations of humidity, along with fast response times, and excellent stability.

As demonstrations, the developed flexible printed sensors enabled real-time monitoring of vital signals and finger motion in wearable applications. In addition, a sensor-integrated robotic gripper successfully grasped delicate objects without damage and detected their softness. These results highlight the potential of the printed sensors for applications in wearable devices, human–machine interfaces, and intelligent robotics.

Dr. Shizuo Tokito received his Ph.D. in Materials Science from the Graduate School of Engineering Sciences, Kyushu University. He began his academic career as an Assistant Professor at Kyushu University in 1987 and later worked as a postdoctoral researcher with Prof. Alan J. Heeger, Nobel Laureate in Chemistry, at UC Santa Barbara (USA). In 1990, he joined Toyota Central R&D Labs Inc. as a Senior Research Engineer. In 2001, he moved to the Japan Broadcasting Corporation (NHK) and became a Research Director. Since 2010, Dr. Tokito has been a Distinguished Research Professor at Yamagata University, first at the Research Center for Organic Electronics (ROEL), where he also served as Director.

With more than 40 years of experience, he has conducted extensive research on conducting polymers, organic light-emitting diodes (OLEDs), organic thin-film transistors (OTFTs), and various sensors based on organic small molecules and polymers, as well as printing technolgy. Over the past decade, his work has focused on printed electronics, with a strong emphasis on environmental benefits.

Currently, he serves as a Distinguished Research Professor at the Innovation Center for Organic Electronics (INOEL), where he leads several research initiatives, engages in practical collaborations with industry, and promotes international partnerships for future innovations.

# 2D materials-based field-effect transistors for high-performance sensors

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**Abstract:**

The evolutionary success in information technology has been sustained by the rapid growth of sensor technology. Among various sensing techniques, field-effect transistors (FETs) with channels made of two-dimensional (2D) materials attract increasing attention for advantages such as label-free detection, fast response, easy operation, and capability of integration. With atomic thickness, 2D materials restrict the carrier flow within the material surface and expose it directly to the external environment, leading to efficient signal acquisition and conversion. In this presentation, the preparation and characterization of a few 2D materials will be introduced, 2D FET sensors are fabricated, their sensor behaviour for detection of pesticide, chiral molecules, hydroxyl free radical and COVID-19 virous are investigated.

Yunqi Liu was graduated from Nanjing University in 1975, received a doctorate from Tokyo Institute of Technology, Japan in 1991. Presently, he is a Professor at the Institute of Chemistry, Chinese Academy of Sciences (CAS), an Academician of CAS, and a Fellow of The World Academy of Sciences (TWAS). His current research interests include design and synthesis of molecular materials, including π-conjugated small molecules, polymers, and graphene, fabrication of related devices, including field-effect transistors and molecular electronics, and investigation of their electronic properties.

He has published more than 700 papers in SCI journals, and cited by other researchers for more than 60,000 times with an h-index greater than 120. In addition, he has obtained 80 of granted patents, published three books and 17 book chapters. He received the National Natural Science Award (2nd grade) in 2007, 2016 and 2019, and Beijing Science and Technology Award in 2017 (1st grade). He serves on the Editorial Board Member or Advisory Board Members for Nanoscale, ACS Mater. Lett., Chin. J. Struct. Chem., SmartMat., Wearable Electronics, FlexMat, etc.

## Controlling persistent charge carriers in organic materials

*Ryota Kabe**

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**Abstract:**

Photostimulated luminescence (PSL) is a phenomenon in which previously stored charges are released as light upon optical stimulation. It has found applications in fields such as radiation dosimetry and optical data storage. However, most existing PSL materials are inorganic and require rigid processing and high-energy light sources, limiting their use in emerging applications like flexible electronics or wearable sensors. In this work, we present a new strategy to achieve PSL using organic materials. By tuning the energy landscape of the system, we demonstrate long-term charge storage under ambient conditions and selective optical readout using low-energy near-infrared light. Spontaneous charge recombination can be suppressed, allowing information to be stored for several months. Furthermore, stored charges can be erased by mild heating, enabling a reversible write–read–erase memory cycle.

**References:**

1. Kabe, R. and C. Adachi, *Organic long persistent luminescence*. Nature, 2017. **550**(7676): p. 384-387.
2. Sakurai, M., et al., *Organic photostimulated luminescence associated with persistent spin-correlated radical pairs*. Communications Materials, 2021. **2**(1): p. 74.

Dr. Ryota Kabe is an Assistant Professor at the Okinawa Institute of Science and Technology Graduate University (OIST), where he leads the Organic Optoelectronics Unit. He earned his B.Sc. from Kansai University (2005), M.Sc. from Osaka University (2007), and Ph.D. from Kyushu University (2010). Following his doctoral studies, Dr. Kabe pursued postdoctoral research at Bowling Green State University (2010–2011), the Max Planck Institute for Polymer Research (2011–2012), and Kyushu University (2012–2014). He subsequently served as an Assistant Professor at Kyushu University (2014–2019), working in collaboration with Prof. Chihaya Adachi. In 2019, he joined OIST, where he continues to advance research in organic optoelectronics. His work focuses on the design and synthesis of novel organic materials, the manipulation of organic exciton dynamics, and their application in next-generation optoelectronic devices.

## Stable organic radical ions for charge transport and charge storage

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**Abstract:**

Charge carrier generation, motion, and recombination underpin the operation of most organic semiconducting devices such as organic light emitting diodes, solar cells, and transistors. These charge carriers usually take the form of organic radical cations (RCs) and radical anions (RAs) for holes and electrons, respectively. In semiconducting devices, RCs and RAs often exist as transient states and are prone to degradation and side reactions. Our research group has endeavoured to identify and isolate conjugated organic molecules that form stable RC and RA states. Further, we have investigated their use for charge storage applications in the form of redox flow batteries (RFBs), which offer an excellent solution to the need for energy storage infrastructure. Specifically, we explore the use of organic semiconducting moieties, including the 3,4-ethylenedioxythiophene (EDOT) moiety, phenoxathiin, and benzothioxanthene dicarboximide as radical ion storing active molecules in RFBs. By judiciously designing molecules with solubility in polar electrolyte solutions, stable radical ion states, and blocked degradation mechanisms, we demonstrate RFBs with outstanding voltage and energy density.

**References:**

1. Hwang, H.K., et al., *Improved voltage and solubility in hybrid non-aqueous redox flow batteries using a molecular 3,4-ethylenedioxythiophene (EDOT) derivative with a stable radical cation state*. Journal of Materials Chemistry C, 2025. **13**(7): p. 3215-3225.
2. Khan, Y., et al., *Synthesis of a Stable Radical Cation of Bis-Tert-Butyl Ethylenedioxythiophene and its Application as a Dopant in Organic Semiconductors*. Small, 2025. **21**(31): p. 2503035.

Bright Walker is an Associate Professor of Chemistry at Kyung Hee University in South Korea, where he researches conjugated organic molecules and hybrid semiconducting materials. The goal of his research team is to develop innovative new materials for applications in batteries, solar cells, transistors, light-emitting transistors and unique types of semiconducting devices. Bright holds a B.Sc. in Chemistry from the University of California at Berkeley (2003) as well as a Ph.D. in Chemistry from the University of California at Santa Barbara (2012). He worked as a Research Scientist and Research Professor at Ulsan National University of Science and Technology, (UNIST), South Korea (2012-2018). Prior to working with semiconducting devices, Bright worked for several years in the setting of a start-up company, synthesizing and characterizing commodity polymers.

## Bottom-up synthesis of luminescent nanographenes

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**Abstract:**

It is known from the literatures that unsubstituted hexa-peri-hexabenzocoronene (HBC) or nanographene is poorly soluble in common solvents due to strong intermolecular interactions. Substitution by alkyl chains or other functional groups can greatly increase the solubility. The goal of our work is to develop new HBC derivatives with fjord edge. In this work, we introduced triarylamine with branched, bulky alkyl substituents and tert-butyl groups into twisted HBC. The photophysics, electrochemistry of molecules and the correlation between the size of the HBC have been investigated and compared. Additionally, the dihedral angles formed between substituents were also manifested by UV-visible absorption spectroscopy, photoluminescence spectroscopy, cyclic voltammetry, X-ray diffraction analysis and theoretical calculations.

**References:**

1. Baskoro, F., et al., *Lithium-Ion Dynamic and Storage of Atomically Precise Halogenated Nanographene Assemblies via Bottom-Up Chemical Synthesis*. ACS Applied Materials & Interfaces, 2024. **16**(22): p. 29016-29028.
2. Wong, H.Q., et al., *Electroactive Carbazole-Based Polycyclic Aromatic Hydrocarbons: Synthesis, Photophysical Properties, and Computational Studies*. ACS Omega, 2024. **9**(27): p. 29379-29390.
3. Yen, H.-J., et al., *Structurally Defined 3D Nanographene Assemblies via Bottom-Up Chemical Synthesis for Highly Efficient Lithium Storage*. Advanced Materials, 2016. **28**(46): p. 10250-10256.

Dr. Hung-Ju Yen is currently an Associate Research Fellow in Institute of Chemistry at Academia Sinica. He earned his B.S. (2006) and M.S. (2007) from National Chi Nan University and then completed his Ph.D. degree from National Taiwan University (NTU) in 2011. He joined Los Alamos National Laboratory as the J. Robert Oppenheimer Fellow (2013-2017) after the postdoctoral training at NTU (2011, 2012-2013). Dr. Yen joined Academia Sinica as an assistant research fellow in 2017 and was promoted to associate research fellow in 2025. Dr. Yen's main research interest lies in the bottom-up chemical synthesis of nanographenes and electroactive high-performance polymers for optoelectronic and energy applications (lithium-ion battery, supercapacitor, redox flow battery, solar cells, fuel cells, electrochromic, electrofluorochromic, light-emitting and memory devices).

## Luminescent spin-optical interfaces from bright and dark radicals

Petri Murto,[1,2,3*] Sebastian Gorgon,[3,4] Daniel G. Congrave,[2,3,5] Lujo Matasovic,[3] Andrew D. Bond,[2] William K. Myers,[4] Hugo Bronstein,[2,3] Richard H. Friend[3]

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**Abstract:**

Organic radicals can introduce a new function to quantum technology by enabling optical read and write of the spin state of the system, its memory. It is possible to design various organic open-shell molecules with non-zero net spin ($S > 0$) but obtaining efficient emission from these materials is challenging. Radicals contain an unpaired electron in their neutral ground state ($S = 1/2$ doublet) which gives rise to unique spin and optical properties that can allow emission of light from the doublet excited state with 100% efficiency. We have utilized this property and demonstrated that chemical coupling of radicals into doublet-doublet ($S = 1$ triplet) and doublet-triplet ($S = 3/2$ quartet) ground and excited state manifolds allows synthetic control of the spin coherence of the quantum systems, while maintaining the optical output of the radical.[1-2] This contribution covers some of the key design principles for luminescent quantum systems. For example, spin-optical interfaces do not necessarily have to rely on emissive, bright radicals. Molecules delivering thermally activated delayed fluorescence (TADF) provide a well-known approach to triplet harvesting and emission of light from the singlet excited state. We show that appending TEMPO as a non-emissive, dark radical into TADF chromophores provides optical access to doublet-triplet coupled quartet excited states. We observe up to 72% of emission emerging via these high spin states. Notably, this process does not require cooling down to near 0 K temperatures, but instead can operate at room temperature, making use of readily available materials for practical spin-optical interfaces.

**References:**

1. Chowdhury, R., et al., *Bright triplet and bright charge-separated singlet excitons in organic diradicals enable optical read-out and writing of spin states*. Nature Chemistry, 2025. **17**(9): p. 1410-1417.
2. Gorgon, S., et al., *Radical TADF: Quartet-Derived Luminescence with Dark TEMPO*. Advanced Materials, 2025. **37**(30): p. 2501164.

Dr Petri Murto is an Academy Research Fellow at Aalto University. He received his double PhD in Materials Science and Chemistry from Chalmers University of Technology and Flinders University in 2019. After his PhD, he joined University of Cambridge to develop organic semiconductors that comprise spin-half radicals, with the support of prestigious research grants such as the MSCA Individual Fellowship (2019–2024). In 2024, he received the Academy Research Fellowship from the Research Council of Finland and launched his own research group at Aalto. His research focuses on development of luminescent radical semiconductors and finding new ways to utilize their optical, electronic and magnetic properties in optoelectronic applications.

## Stretchable polymeric semiconductor and optoelectronics

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**Abstract:**

Transistor is the key device of the existing microelectronics industry, promoting significant progress in the human modern society. In recent years, organic optoelectronic devices with organic semiconductors have received significant attention from scientists due to their tunable molecular functions, low-temperature preparation, and good compatibility with organisms. Especially, intrinsically stretchable polymeric materials and devices are attracted many eyes. It can have stable performance and detection functions under large deformation conditions, which gives people great space for application imagination. Recently, we fabricated stretchable organic-inorganic perovskite photodetectors, which showed high sensitivity to high energy photons, such as UV light or X-ray. Further, we tuned the morphology of perovskite in SEBS and achieved ultra-low power synapse devices.

Yunlong Guo received his Ph.D. degree in Physical Chemistry from ICCAS in 2010. In April 2016, he became a project associate professor at the Department of Chemistry, the University of Tokyo. Since October 2016, he has been a professor at ICCAS. His research interest includes organic–inorganic hybrid perovskite electronics and stretchable electronics. He has published more than 200 papers in SCI journals, and cited by other researchers for more than 15,000 times with an h-index of 73. He serves on Associated Editor of Wearable Electronics and the Editorial Board Member for Adv. Electron. Mater.; CCL etc.

# Innovation in molecular & thin film engineering for stretchable electronics

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**Abstract:**

Skin-like soft electronic devices and stretchable conducting films are a prime necessity for future stretchable and wearable electronics. We deposited highly conducting poly(3,4 ethylenedioxythiophene):Tosylate (PEDOT:Tos) films on extremely stretchable styrene-ethylene-butylene-styrene (SEBS) as well as biocompatible seafood waste derived Chitosan substrates via vapor phase polymerisation (VPP) for charge transport study including there use in organic electrochemical transistor (OECT) devices.[1-2] Such devices hold great potential for highly sensitive wearable biosensors & medical device technology. Our newly developed pyridine flanked diketopyrrolopyrrole (DPPPy) end capped with thienyl naphthalimide n-type small molecule DPPPy-C-Si-TN together with SEBS blend show a high electron mobility of 0.322 $cm^2\ V^{-1}\ s^{-1}$.[3] We also synthesized a series of high mobility inherently stretchable polymers based on furan/thiophene/selenophene/pyridine flanked diketopyrrolopyrrole (DPP), comprising, without, with a non-conjugated spacer in their backbone and cyano substituted thienyl-vinylene-thienyl polymers for high performance stretchable OFETs (with highest hole mobility of 1.8 $cm^2\ V^{-1}\ s^{-1}$ and electron mobility 2.0 $cm^2\ V^{-1}\ s^{-1}$) and these devices were further demonstrated for advanced stretchable logic circuits, photodetectors & artificial neuromorphic visualizer e-Skin applications.[3- 4]

**References:**

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2. Khamhanglit, C., et al., *PEDOT:Tosylate on Biocompatible Chitosan Film by Vapor Phase Polymerization: Promising Technology toward Biocompatible and Wearable Organic Electrochemical Transistor*. Small Structures, 2025. p. 2400642.
3. Kranthiraja, K., et al., *Low Band Gap Furan-Flanked Diketopyrrolopyrrole-Naphthobisthiadiazole Based Conjugated Polymer/Stretchable Blend for Organic Field Effect Transistors*. Advanced Electronic Materials, 2025. **11**(6): p. 2400614.
4. Kothandaraman, R., et al., *High-Performance n-Type OFETs Enabled by Pyridine-Substituted Diketopyrrolopyrrole Organic Semiconductor and Elastomer Stretchable Blends*. Advanced Materials Technologies, 2025. **10**(11): p. 2401518.

Prof. Prashant Sonar is ARC Future Fellow and Professor in School of Chemistry & Physics at Queensland University of Technology, (QUT), Australia. Prior joining to QUT, he was PhD student at Max Planck Institute, Germany (2000-2004), Postdoctroal Scientist at ETH, Zurich, Switzerland (2004-2006) & Research Scientist at A*STAR, Singapore (2006-2014). He is a Fellow of Royal Chemical Society (FRSC) and Foreign Fellow of Maharashtra Academy of Sciences (FFMAS). Prof. Sonar delivered more than 100 talks at various international conferences/institutes. He has published more than 250 peer-reviewed research papers (H-index-64 with 15700 citations, GS) and filed 3 US patents. His two patents successfully licensed to the US based company. He has been recognised in Stanford's top 2% of researchers since past 4 years. He is a recipient of the Award for Excellence-Impact and Translation (2020) & Vice-Chancellors Performance Award from QUT Australia (2016).

# Optimizing morphology to trade off charge transport and mechanical properties of stretchable conjugated polymer films

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**Abstract:**

The conjugated semiconducting polymers are important materials for flexible and stretchable electronic devices such as field-effect transistors (OFET), organic light-emitting diodes (OLEDs), and organic solar cells (OPVs) because of their tunable electrical and mechanical properties, light weight, and low-cost solution processing.[1] Significant research progress has been achieved in stretchable polymer electronics by synthesizing novel conjugated polymer materials and designing new device geometries. However, the inherent competition between high charge mobility and good mechanical compliance has long existed for conjugated polymer films. The solid-state electrical and mechanical properties of conjugated polymers depend sensitively on their morphologies across all length scales. This multiscale morphology in the solid state is largely affected by molecular weight and its polydispersity, solution-state aggregates and their assembly pathways from solution to thin films.[2] In this talk, we will provide an understanding of how to balance the electrical properties and mechanical properties from the point of view of multiple length scale microstructures of conjugated polymers. We first focus on how to design the percolation morphology with the aggregates, tie chains, and amorphous phase via controlling solution preaggregation and film-formation dynamics. Furthermore, the rational transfer of film morphology from small-area coating to large-area printing is discussed in terms of film uniformity and crystallization control. Finally, we summarize the challenges and opportunities in microstructure control of stretchable conjugated polymer films.[3]

**References:**

1. Ding, Z., et al., *Optimizing Morphology to Trade Off Charge Transport and Mechanical Properties of Stretchable Conjugated Polymer Films*. Macromolecules, 2021. **54**(9): p. 3907-3926.
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Yanchun Han received her B.S. degree from University of Science and Technology of China in 1990 and her Ph.D. degree from Changchun Institute of Applied Chemistry (CIAC), Chinese Academy of Sciences (CAS), in 1995. After working as a visiting scholar at the University of Naples, the University of Kaiserslautern (Alexander von Humboldt Research Fellow), and the University of Michigan, she joined the State Key Lab of Polymer Physics and Chemistry, CIAC, as a full professor in 2000. She now serves as a senior editor of POLYMER. Her current research interests include polymer thin films and inherent structure−property−processing relations of conjugated polymers.

## Stable free radicals enable flexible SWCNTs/organic hybrid films with high thermoelectric performance

Qian Liu*

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**Abstract:**

Overcoming the dispersion of single-walled carbon nanotubes (SWCNTs) to make high thermoelectric SWCNTs hybrid films for flexible thermoelectric devices (F-TEDs) is a challenging topic.[1-2] In this talk, I will present our recent work on how radicals attached onto conjugated backbone enable well-dispersed SWCNTs for a high thermoelectric performance in F-TEDs. Specifically, a small molecule (named as OTN), possessing donor-acceptor type backbone and pending TEMPO radical units attached with flexible alkyl chain, was designed and characterized. When hybridizing with SWCNTs, the donor-acceptor backbone of OTN favours the π interactions with SWCNTs and the radical-radical interactions further hinder the aggregation of hybrid SWCNTs. This synergy effects of backbone and pending TEMPO radicals enable resultant OTN-SWCNTs hybrid film to exhibit an exceptional power factor of 30.1 μW cm$^{-1}$ K$^{-2}$ that represents the record value among CNT-related thermoelectric films.[3-4] More promisingly, the OTN-SWCNTs hybrid film shows an excellent flexibility, indicated by a negligible resistance difference ($\Delta R/R_0$) of less than 0.02 after bending for 1000 times at a low radius of 2.5 mm. The assembled nine-leg F-TED with optimal OTN-SWCNTs films obtained a Power (P) of 0.90 μW, and an open-circuit voltage ($V_{OC}$) of 13.94 mV, delivering an outstanding normalized power density ($\omega_n$) of 0.653 μW cm$^{-2}$ K$^{-2}$, which is also the state-of-the-art performance among CNT-based F-TEDs. Our work highlights the potential of smart molecular design upon small molecules regarding backbone and side chains for efficient SWCNTs dispersion to push SWCNTs hybrid films forward for practical application in F-TEDs.

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Dr. Qian Liu is an ARC DECRA Fellow specializing in emerging organic semiconductors for functional electronic devices. His research focuses on tailoring molecular structures to engineer desired functionalities for diverse applications, including transistors, thermoelectrics, photovoltaics, and (bio)sensors. By leveraging advanced characterization techniques, his work elucidates the interplay of molecular structure-electronic property-electrical performance, delivering insights to accelerate the development of organic semiconductors that will bridge the gap between fundamental research and real-world multi-scenario applications.

# The development of printable materials for flexible electronics

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**Abstract:**

Flexible electronics have attracted particular interest from the diverse fields including materials, chemistry, electronics, engineering and so on. With significant advances, various flexible electronic products, such as flexible displays, wearable devices, and smart electronic skins, are bringing profound impact on human life. After years of development, organic light-emitting diodes based on organic small molecules is becoming more and more mature and now become real in the market, which are widely used in cell phones and TV sets. While the flexible electronic technology based on optoelectronic functional polymers still remains largely to be explored. The development of novel materials and new technologies makes this field rather attractive. Our work focuses on the design and development of high-performance printable organic polymer optoelectronic materials, organic interfacial materials, flexible electrodes, the regulation and optimization of their functionality, with the aim to develop high-performance large-area printed flexible electronics.

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3. Wang, S., et al., *Intrinsic Structural and Coordination Chemistry Insights of Li Salts in Rechargeable Lithium Batteries.* Advanced Materials, 2025. **37**(11): p. 2420428.
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16. Liu, Y.-Y., et al., *Self-templated synthesis of uniform hollow spheres based on highly conjugated three-dimensional covalent organic frameworks.* Nature Communications, 2020. **11**(1): p. 5561.

Dr. Wen-Yong Lai is a full professor at State Key Laboratory of Flexible Electronics (LoFE), Institute of Advanced Materials (IAM), Nanjing University of Posts and Telecommunications. He received his PhD from Fudan University in 2007. His research mainly focuses on the design, synthesis, and application of organic & polymer optoelectronic materials for organic/flexible electronics. He is also interested in the exploration of novel materials and processes for printed electronics.

# Transfer printing of organic light-emitting diodes

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**Abstract:**

Solution-process is of great interest in organic light-emitting diodes (OLEDs) due to the intrinsically simple and low-cost nature for mass-production. However, it is very challenging to fabricate the multi-layer device structure via all-solution-process approach to realize efficient electroluminescence, mainly limited to the interfacial mixing effect in the non-orthogonal system. We developed the transfer-printing method to deposit the organic layer on target substrates by mediating the surface energy and thus work of adhesion between two different layers. For instance, a luminescent polymer could be feasibly grown on a small-molecular hole transporting layer without any interfacial mixing. This approach is also found to be effective to make flexible polymer-based OLEDs more robust. Finally, transfer printing plays a vital role in reducing leakage current, out-performing spin coating for OLEDs.

**References:**

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2. Tang, Y., et al., *Flexible all-organic photodetectors via universal water-assisted transfer printing*. The Innovation, 2023. **4**(4).
3. Ni, M., et al., *Intrinsically stretchable fully π-conjugated polymers with inter-aggregate capillary interaction for deep-blue flexible inkjet-printed light-emitting diodes*. Nature Communications, 2025. **16**(1): p. 330.
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Dr. Guohua Xie obtained his Ph.D. degree from Jilin University (China) in 2011, working on OLED microdisplays. From August 2011, Dr. Xie carried out his postdoctoral research at TU Dresden (Germany), sponsored by Alexander von Humboldt Foundation. Later, Dr. Xie worked for the University of St Andrews (UK) since 2013. From 2015, he joined the College of Chemistry and Molecular Sciences of Wuhan University (China). Since 2023, Dr. Xie served as a full professor in the Institute of Flexible Electronics (IFE, Future Technologies) of Xiamen University, working on the interdisciplinary research of the emerging optoelectronic materials and devices. Dr. Xie has co-authored over 270 peer-reviewed publications with an H-index of 57 and contributed to 1 book as the editor-in-chief. In 2020, Dr. Xie has been admitted as a Fellow of Royal Society of Chemistry. Currently, he serves as a member of Youth Editorial Board respectively for Flexmat, SmartMat, InfoMat, InfoScience, and The Innovation. Meanwhile, Dr. Xie also takes the role of Academic Editor for the journal The Innovation Materials.

# Inkjet printing: new manufacturing paradigm for organic light emitting diodes

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**Abstract:**

Inkjet printing offers a promising, cost-effective alternative to traditional vacuum-based methods for manufacturing Organic Light Emitting Diodes (OLED). This digital, maskless technique enables high-resolution, additive deposition of functional layers, making it suitable for flexible, large-area, and customizable OLED displays. Researchers at IIT Kanpur have demonstrated multilayer OLED fabrication using inkjet printing for the anode, emissive layer, and dielectric patterning, eliminating the need for photolithography and indium tin oxide. Key challenges addressed include ink formulation, droplet control, interlayer compatibility, and achieving uniform film morphology. Using a Pixdro LP50 platform, the team successfully printed high-resolution patterns, flexible devices, and hybrid electrode structures, validating inkjet printing's scalability and design versatility. Applications range from wearable displays to smart signage. Ongoing optimization in material development and process integration is vital to fully realize inkjet printing 's potential. Overall, this work establishes inkjet printing as a transformative technology for next-generation, low-cost, and environmentally sustainable OLED manufacturing.

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Dr. Monica Katiyar is Fellow of INAE and Professor in the Department of Materials Science and Engineering at IIT Kanpur, where she has been a faculty member since 1997 and served as the Head of the department from 2018-21. She holds a B.Tech. in Metallurgical Engineering from IIT Kanpur, an M.Eng. from McMaster University, Canada, and a Ph.D. in Materials Science and Engineering from the University of Illinois at Urbana-Champaign. Her research specializes in organic electronics, including OLEDs, organic solar cells, and flexible printed batteries. Dr. Katiyar has coordinated several major research initiatives at IIT Kanpur, including the Solar Energy Research Enclave and the FlexE Centre. She has published over 100 research papers and holds multiple patents related to optoelectronic devices and materials processing. Her work has earned her numerous accolades, such as the National Metallurgist of the Year Award (2018), the INAE Young Engineer Award (2001), and the SBI Chair Professorship (2011–2014).

# Transparent and flexible neural electrodes for simultaneous *in vivo* imaging and electrophysiology

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**Abstract:**

Transparent neural electrodes are advancing the frontier of neural interfacing by not only enhancing signal detection and stimulation capabilities but also by minimizing image artifacts across various medical imaging modalities. This talk presents the development and application of a novel, cost-effective, and highly transparent neural electrode array based on an inorganic-organic composite structure (BioCLEAR: Bi-layer inorganic-organic Clear Electrode ARray). BioCLEAR features a random network of silver nanowires (AgNW) embedded in a poly(3,4-ethylenedioxythiophene):poly-(styrenesulfonate) (PEDOT:PSS) matrix. We demonstrate the system's capability for electrophysiology and in vivo calcium imaging by integrating BioCLEAR with an implantable GRadient INdex (GRIN) lens. This integration allows for simultaneous recording of electrical signals and optical imaging, significantly reducing image artifacts. Comprehensive evaluations, including electrochemical impedance spectroscopy, cyclic voltammetry, accelerated soak tests, cell viability assessments, and neural recordings, validate the efficacy of BioCLEAR. Our results reveal that the BioCLEAR system, in conjunction with the GRIN lens, facilitates high-resolution electrophysiological and calcium imaging in rodent models with minimal interference, highlighting its potential for advancing neural signal analysis and imaging techniques.

**References:**

1. Park, D.-W., et al., *Electrical Neural Stimulation and Simultaneous in Vivo Monitoring with Transparent Graphene Electrode Arrays Implanted in GCaMP6f Mice*. ACS Nano, 2018. **12**(1): p. 148-157.
2. Park, D.-W., et al., *Fabrication and utility of a transparent graphene neural electrode array for electrophysiology, in vivo imaging, and optogenetics*. Nature Protocols, 2016. **11**(11): p. 2201-2222.

Dr. Dong-Wook Park is an Associate Professor at the School of Electrical and Computer Engineering, University of Seoul, South Korea. He received his Ph.D. in Electrical and Computer Engineering from the University of Wisconsin-Madison, USA, in 2016. Following his Ph.D., he was a Postdoctoral Research Fellow at Stanford University, where he studied implantable neural electrodes and biosensors. Prior to his Ph.D., he gained industry experience as an AMOLED circuit design engineer at Samsung SDI and Samsung Display from 2007 to 2011. Dr. Park's research interests focus on emerging biomedical devices and systems using novel materials and nanotechnology. It includes the development of transparent neural electrodes, biocompatible field-effect transistors, and flexible neuromorphic devices. He is also CEO of Trans Bio Lab Co., Ltd.

# Defect investigations of 2D nanomaterials with tip- enhanced Raman scattering and AI spectroscopy

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**Abstract:**

In recent years, there has been a growing interest in two-dimensional(2D) nanomaterials such as graphene and transition metal dichalcogenides to overcome the limitations of conventional materials and find new applications. The high surface area and layered structure favourable for ion transport of 2D nanomaterials can be utilized as electrode materials in electrochemical energy storage, and inorganic flexible optoelectronic devices with atomic-scale thickness can be realized. In order to expand the applicability of these 2D nanomaterials, it is necessary to improve their quality; for this purpose, research on defects is essential. In this talk, I will introduce our research on defects in 2D nanomaterials through tip-enhanced Raman scattering and AI spectroscopy. I will also Introduce the SMClab. Inc. which is leading the way of standard measurement and characterization of nanomaterials.

**References:**

1. Kim, D.H., et al., *Anomalous Phonon Softening with Inherent Strain in Wrinkled Monolayer WSe2*. Advanced Materials, 2025. **37**(35): p. 2419414.
2. Suh, H.C., et al., *Probing nanoscale structural perturbation in a WS2 monolayer via explainable artificial intelligence*. Applied Physics Reviews, 2025. **12**(2).
3. Yoo, J., et al., *Unraveling the role of Raman modes in evaluating the degree of reduction in graphene oxide via explainable artificial intelligence*. Nano Today, 2024. **57**: p. 102366.
4. Yoo, J., et al., *Explainable Artificial Intelligence Approach to Identify the Origin of Phonon-Assisted Emission in WSe2 Monolayer*. Advanced Intelligent Systems, 2023. **5**(7): p. 2200463.

Prof. Jeong is the tenured full professor in the Department of Physics, Hanyang University. He is also the director of the Center for Semiconductor Physics and Devices at Hanyang University. He has published/co-published over 280 international journal articles and co-invented 20 patents related to novel spectroscopic methods and optoelectronic devices. His research focuses on the optical characterization of organic/inorganic materials using various spectroscopic techniques and artificial intelligence. He is also leading the SMClab. Inc. as a CEO.

## Close space sublimation of organic materials for AMOLED displays

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**Abstract:**

The Organic Light Emitting Diode (OLED) device was invented by Ching Tang and Steve Van Slyke at Kodak Research Laboratories in 1987 and the first full-colour AMOLED display was developed and demonstrated by Rajeswaran et al in 1999. The first commercial AMOLED displays were delivered to the market in 2002 by SK Display, a Kodak-Sanyo joint venture. The AMOLED display industry has now grown to >$50 billion in market size. The recent commercial success of flexible AMOLED displays signals the promise of further growth in the AMOLED display industry. This talk will review the several drawbacks in the current OLED production technologies, namely, substrate size limitation in OLED patterning, poor materials utilization and low productivity and discuss opportunities for next generation production technologies. The prospects of overcoming these limitations with a new method of organic materials delivery called close space sublimation will be explored and early results obtained by the author and his co-workers will be reviewed. A state-of-the-art AMOLED display development facility has been set up at the Indian Institute of Technology Madras to explore next generation manufacturing technologies based on the close space sublimation of organic materials.

**References:**

1. Tang C, Van Slyke S, Rajeswaran G. The development of OLED—retrospection and outlook. Presented at: Display Week 2022; 11 May 2022; San Jose, CA: Society for Information Display.

Dr. G. Rajeswaran (“Raj”) received the B.E, M.Tech and Ph.D. degrees, all in Electrical Engineering, in 1976, 1978 and 1983 from the University of Madras, Indian Institute of Technology Bombay and the State University of New York, respectively. Over the past 40 years, Raj has been actively engaged in technology development and the commercialization of LED, OLED and PV technologies. A substantial portion of his research and management career has focused on OLED manufacturing technologies, commercialization and product delivery. In 2013, Raj was elected as Fellow of the Society for Information Display for pioneering contributions to the development, manufacturing and commercialization of AMOLED displays.
From 2020, Raj has been serving as a Professor of Practice in the Electrical Engineering department at IIT Madras in Chennai/India.

## Chemicals for electronic devices of Sanyo Chemical

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**Abstract:**

Founded in 1949 in Kyoto, Japan, Sanyo Chemical is a global performance chemicals company. Originally producing soap and texture agents, we have expanded our portfolio to over 3,000 products, serving industries such as automotive, electronics, cosmetics, and medical equipment worldwide. In this presentation, we will introduce our UV-curable resins and ionic liquids for electronic devices, as well as recent developments.

1. UV-Curable Resin

UV-curable resins are resins that cure upon exposure to ultraviolet (UV) light. They offer excellent mechanical and electrical properties, chemical resistance, and heat resistance, and are used across a wide range of fields and industries, including paints, inks, electronic materials, coatings, and semiconductors. Sanyo Chemical offers a lineup of UV resins suitable for imprint applications and inkjet coating. Most recently, we have developed high-refractive-index UV resins for AR/VR applications, as well as stretchable UV resins with both flexibility and shape recovery.

2. Ionic Liquid

Ionic liquids are salts consisting exclusively of cations and anions, with melting points below 100°C. They exhibit extremely low vapor pressure, are non-flammable, offer high ionic conductivity, demonstrate excellent thermal stability, and possess a wide electrochemical window. These unique properties make them suitable for a broad range of applications, including electrochemical devices, solvents, pharmaceutical development, and cosmetics. Sanyo Chemical has more than 40 years of experience manufacturing and supplying ionic liquids for use as electrolytes. The company is also actively expanding into additional application areas.

Masaaki Oka earned his master's degree from the Graduate School of Engineering, Osaka University. In 2004, he joined Sanyo Chemical Industries, Ltd. as a researcher, where he engaged in the development of a wide range of materials, including superabsorbent polymers, copier-toner materials, and photoacid generators. Since 2023, he has managed the development team, leading research and development of materials for electronic devices, including electrolytes for capacitors and UV-curable resins.

# SEMINAR ROOM B

# 63-358

## DAY 2

## 9TH DECEMBER

# Flexible, waterproof organic photodetectors and LEDs for optogenetics and fluorescence imaging

Caroline Murawski[1,2]*, Rabiul Islam[1,2], Siddhartha Saggar[1,2], Giuseppe Ciccone[1], Ajisha C.[1,2], Jens P. Weber[1,2]

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**Abstract:**

Organic electronics show considerable prospect for application as wearable and implantable biomedical sensors due to their mechanical flexibility and potential for microscale patterning. In this presentation, we will first describe our recent investigations on ultra-thin, transparent metal electrodes consisting of polymer seed layers and 7 nm Ag films. These extremely bendable electrodes are implemented on multilayer flexible substrates consisting of parylene-C and ALD-deposited nanolaminates[1] for subsequent implementation of organic photodetectors (OPDs). The OPDs withstand more than 10,000 bending cycles at a radius of 750 µm. Furthermore, they are waterproof for 300 hrs, are machine-washable, and can measure photoplethysmography signals in ambient light conditions.

Second, we will demonstrate bi-colour organic light-emitting diodes (OLEDs) that can activate and inhibit neuronal activity by optogenetic addressing of motor neurons in *Drosophila melanogaster*.[2] Devices are fabricated by stacking a red and a blue OLED on top of each other. We provide high-resolution stimulation through patterned pixels and performed optical simulations to calculate spatial light distribution. The devices achieve light output powers up to 1 mW/mm$^2$, microsecond response times and low device heat-up.

Third, we will present how organic light-emitting diodes (OLEDs) and OPDs may be combined for fluorescence imaging of cellular signals. For this, narrowband emission and absorption is required, which we pursue by material and device design, in combination with additional absorption filters.

Organic semiconductors not only pave the way for wearable technologies but also hold potential to shape the field of optogenetics and fluorescence imaging, offering new avenues for understanding and interacting with biological systems at cellular scale.

**References:**

1. Keum, C., et al., *A substrateless, flexible, and water-resistant organic light-emitting d*iode. Nature Communications, 2020. **11**(1): p. 6250.
2. Ciccone, G., et al., *Multiplexed Optogenetics with Striped Organic LEDs*. Advanced Optical Materials, 2024. **12**(2): p. 2301340.

Caroline Murawski is professor for biomedical sensor technology at the institute of solid-state electronics at TUD Dresden University of Technology, Germany, since 2024. She received a PhD in Physics in 2015 working on excitonic processes in organic light-emitting diodes, then joined the University of St Andrews, UK, for a postdoctoral position, and started a junior research group at Kurt Schwabe Institute for Sensor Technologies in 2018. Caroline now works on new biomedical sensor technology based on organic semiconducting materials.

# Amorphous donor polymers for stable organic photovoltaics using low donor content

Mats R Andersson*

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**Abstract:**

This work focuses on the design and synthesis of new materials, as well as the thermal stability of polymer solar cells. Thermally stable materials are important, as solar cells are often exposed to elevated temperatures during fabrication and operation. Our work includes device stability measurements and morphology stability studies using dynamic mechanical thermal analysis (DMA). The DMA technique is a highly sensitive method for determining the thermal transitions of the used materials. Several completely amorphous indacenodithiophene based polymers were synthesised and used in solar cells combined with the Y6 acceptor material. Low donor:acceptor (D:A) ratios are generally believed to yield lower efficiency than the more conventional 1:1.2 ratio. However, several of the solar cells exhibit a peak performance over 11% PCE at a lower D:A ratio. Unexpectedly, as the polymer proportion increases, a reduced photovoltaic performance is observed. Similarly, nanoparticles made of the materials and used for photocatalytic hydrogen evolution show an analogous trend with a peak performance at a D:A ratio of 1:6.7. Importantly, our experiments also show that the stability at 85 $^{o}$C of the solar cells is significantly improved for a low donor:acceptor ratio (1:10), outperforming commercial high performance polymer systems in efficiency after 30 days degradation.

Mats Andersson performed a joint PhD-work at the Departments of Organic Chemistry and Polymer Technology, Chalmers University of Technology, Gothenburg, Sweden, and received his PhD in Organic Chemistry in 1995. He was appointed Professor in Polymer Chemistry in 2004, and he held a chair in Polymer Chemistry from 2007 to 2015. In 2012, he was elected to the Royal Swedish Academy of Engineering Sciences. In 2013, he was awarded a South Australian Chair in Energy, and in 2014, Mats moved to Adelaide, Australia, to join the University of South Australia as a Research Professor. In 2017, he moved to Flinders University, Adelaide, as a Matthew Flinders Professor, and he is currently the director of the Flinders Institute for Nanoscale Science and Technology.

## Tracing the lifecycle of charges in organic solar cells: How triplet excitons shape recombination and efficiency limits

*Safa Shoaee**

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**Abstract:**

The power conversion efficiency of organic solar cells has recently surpassed 20%, yet a unified framework that captures the underlying photophysical mechanisms remains elusive. These devices operate through a complex excited-state choreography arising at the donor-acceptor interface where excitons, charge transfer (CT) and charge-separated states continuously interconvert according to the materials' energetic landscape.

In this talk, we share our kinetic model that, for the first time, explicitly incorporates the formation and re-splitting of local triplet excitons. Fully parameterised by the interfacial energy offset, this unified framework reproduces key photovoltaic observables – such as the charge generation efficiency, photoluminescence, electroluminescence and Langevin reduction factor. Our results show that the triplet state dynamics govern device performance across a wide range of energy offsets. In systems with short triplet lifetime, triplet decay emerges as the dominant recombination pathway, reconciling long-standing experimental findings, including those in benchmark systems like PM6:Y6. In systems with long triplet lifetimes, triplets can be recycled to mitigate this loss channel. The model further offers a mechanistic explanation for the empirically observed link between energy offset and reduced-Langevin recombination and accurately predicts the device efficiency across different material systems.

Notably, it identifies a singlet-CT offset of ~150 meV as optimal for efficient charge separation while suppressing loss pathways. By connecting excited-state kinetics with macroscopic device metrics, our work provides a unified mechanistic picture of the photophysics in organic semiconductors.

Safa Shoaee's research centres on organic semiconductors, with a particular emphasis on developing environmentally sustainable solar cells and energy devices.
She holds a dual appointment as a professor at the University of Potsdam and leading the Heterostructure Semiconductor Physics group at the Paul-Drude-Institut in Berlin.
Shoaee earned her PhD from Imperial College London in 2010. Following postdoctoral positions at both ICL and the University of Queensland, she was awarded the Sofja Kovalevskaja Prize to establish a research group at the University of Potsdam. Her expertise and leadership were further recognised in 2018, when she was appointed associate professor.

## Opportunities and challenges of roll-to-roll-printed flexible solar cells

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**Abstract:**

Flexible solar cells, especially those manufactured through roll-to-roll (R2R) printing technology, have garnered significant attention in the realm of photovoltaics. Their lightweight, flexibility, and cost-efficient solution processing render them ideal for a diverse array of applications, from building-integrated photovoltaics (BIPV) to wearable electronics and portable devices. These attributes make them particularly advantageous in domains where weight is a critical constraint, such as aerospace technologies and unmanned aerial systems.

Perovskite solar cells (PSCs) are a promising next-generation photovoltaic power generation technology and are rapidly transitioning from laboratory small-scale research to industrial reality, attributed to their high power conversion efficiency and ease of fabrication.

Over the past decade, CSIRO has developed advanced solar cell printing capabilities and deep expertise to produce lightweight, rollable, and cost-effective thin-film solar cells in a single-factory setup. As pioneers in this space, we have set a new benchmark in efficiency for fully R2R-printed solar mini-modules. By embracing vacuum-free, solution-based processes, we eliminate the need for the energy-intensive, multi-factory infrastructure required for conventional silicon PV.

This talk presents the journey from early-stage research to a pre-commercial, large-scale demonstration, highlighting the key milestones, breakthroughs, challenges, and vision that continue to shape the future of solar energy.

### References:

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2. Angmo, D., et al., *Toward Rollable Printed Perovskite Solar Cells for Deployment in Low-Earth Orbit Space Applications*. ACS Applied Energy Materials, 2024. **7**(5): p. 1777-1791.

Dr. Mei Gao is a Principal Research Scientist and Team Leader of the Printable Photovoltaics (PV) team at the Commonwealth Scientific and Industrial Research Organisation (CSIRO). She earned her PhD from the University of Wollongong, Australia. Her research expertise spans small molecule and polymer synthesis, surface modification, conducting polymers, and the development of high-sensitivity biosensors based on nanomaterials and, more recently, optoelectronic materials.

Since 2011, Dr. Gao's research has primarily focused on developing organic photovoltaics and perovskite solar cells on flexible substrates, aiming to achieve facile, solution-processable, reproducible, and fully printable high-performance single-junction and module devices through high-throughput roll-to-roll printing processes, with applications ranging from terrestrial power generation to space satellites.

# Halide perovskite solar cells towards high operational durability: Strategies and advances

*Toshinori Matsushima**

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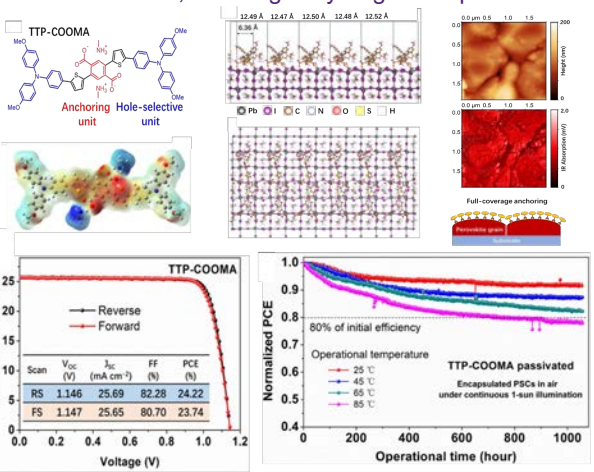
**Abstract:**

Exploiting the defect passivation molecules has been an effective strategy to improve the efficiency and long-term stability of perovskite solar cells (PSCs). However, realizing stable, dense defect passivation molecules on halide perovskite surfaces in n-i-p PSCs is still challenging. In this work, novel defect passivation molecules for n-i-p device are developed. Our defect passivation molecules feature a terephthalic methylammonium core structure that possesses double-site anchoring ability and a matching diameter (6.36 Å) with the lattice constant of formamidinium lead iodide ($FAPbI_3$) perovskite (6.33 Å), which facilitates an ordered and full-coverage defect passivation molecules atop $FAPbI_3$ perovskite. Moreover, theoretical calculations and experimental results indicate that compared to the frequently used acid or ester anchoring groups, this ionic anchoring group with a dipolar charge distribution has much larger adsorption energy on both organic halide terminated and lead halide terminated surfaces, resulting in synergistic improvement of hole extraction and defect passivation ability. Benefiting from these merits, the efficiency of PSCs is increased from 21.68% to 24.22%. The long-term operational stability under white LED illumination (100 mW $cm^{-2}$) and at a high temperature of 85 °C is also much improved.




Dr. Toshinori Matsushima is an Associate Professor at Kyushu University, Japan. He specializes in organic and hybrid optoelectronic devices, including perovskite light-emitting diodes and solar cells. His research focuses on charge transport, interface engineering, and device physics to improve efficiency and stability. He earned his Ph.D. in Engineering from Kyushu University and has published extensively in high-impact journals. Dr. Matsushima collaborates with both academic and industrial partners to advance next-generation energy and display technologies.

# Nanoengineered electroactive polymers: soft materials to solve hard challenges in energy and health

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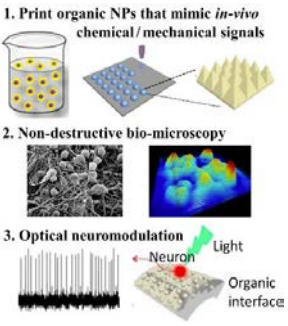
**Abstract:**

Communicating with the human body using electronic devices is a grand challenge in materials science. In this talk I will discuss some highlights from our team's efforts to combine new electroactive polymer materials with nanoscale science and create printable devices that were first proven as a technology for printed solar cells, and have now been used to overcome the gap between the electronic and biological worlds.

We will first provide an overview of the design rules we uncovered for controlling electronic functionality in conducting polymers by tuning their chemical and physical structure. We will then explore how we developed processes to formulate these electroactive polymers into solution processible aqueous inks using colloidal chemistry, how this process influences the electronic properties of the materials and devices, and how we developed these materials into printed solar cells that were taken all the way from an idea through to industry by creating printable solar cells at the scale of hundreds of square meters, and installing these on roofs and in parks for local business.

Next, the talk will outline how these materials were employed as a platform to explore new frontiers in bioelectronics. Implantable neurostimulation devices play a key role in treating injuries and diseases, however, they have typically been fabricated with stiff electronic materials such as metals and silicon and thus progression out of the laboratory remains limited by low biocompatibility, a requirement for external power, and poor spatial resolution.[1] By combining soft carbon-based polymer inks with new bio-printing technologies[2] and establishing routes to incorporate neuroprotective drugs into these bio-inks,[3] our team established paradigm-shifting materials that combine electronic, chemical, and mechanical stimuli to communicate with biological cells in their natural language. Finally, we employ whole-cell patch clamp electrophysiology recordings to demonstrate an exciting result; wireless neuromodulation of nerve cells via capacitive coupling which can be optimized by judicious selection of the device architecture.[4]




Our results have highlighted that nanoengineering electroactive polymers can provide a multi-purpose electronic device platform, capable of opening up new industrial opportunities or enabling exciting new frontier research in energy and health applications.

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## Radiation tolerant molecular semiconductors

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**Abstract:**

Molecular semiconductors are lightweight, flexible and compatible with rapid high volume manufacturing methods at low cost. The performance metrics of molecular semiconductors normalised to their weight can be one to two orders of magnitude higher than that of their inorganic counterparts. Therefore, molecular semiconductors are potentially superior in unmanned aerial systems, LEO satellite applications and space. For terrestrial applications, large area (>$m^2$) detectors manufactured by solution printing would aid security screening at airports and shipyards. Molecular semiconductors consist of low atomic number (Z) elements (C, O, N, S), leading to inherently the same absorption response to ionising radiation as the human body, requiring fewer or smaller correction factors to correlate measured signals with actual radiation dose.

The questions arise: How long molecular semiconductors are able to retain their electronic function under high energy ionising radiation? And, does it matter to their stability how the elements of C, O, N, S are arranged?

We answered these questions by exposing over 40 organic semiconductors to gamma radiation produced from the decay of Co-60 isotopes at the GATRI Facility at ANSTO. Co-60 gamma radiation has been the industry benchmark to test radiation hardness of other materials, but systematic studies of molecular semiconductors have only been very few. We have developed a testing protocol by encapsulating a thin layer of the molecular semiconductor inside an argon-filled glass cavity mimicking the oxygen / water-free environment in space. By monitoring the UV-visible absorption bands of the molecular semiconductor films following increasing doses of Co-60 radiation, we were able to compare the radiation tolerance in a (relatively) high-throughput experiment. We have found over two orders of magnitude variation in the ionizing radiation tolerance, with some materials exhibiting “infinite” stability surpassing the industry standard for low-orbit applications > 20 kGy. Using a data science approach combining molecular descriptors and a stability target, we are developing the first predictive model of radiation tolerance of molecular semiconductors, which, one day, may enable the inverse design of high performance, low cost and stable molecular semiconductors for their application in low orbit Earth, space and terrestrial applications.

Attila is Professor at the University of Wollongong with a research background in laser spectroscopy and charge transport measurements of organic semiconductors / energy conversion devices. His recent interest is in developing an Australian capability combining robotic / data science / high performance computing approaches to accelerate the development of new molecular semiconductor devices for their application is ionising radiation detection in defence, border protection and health.

## Organic photocatalysts and photoelectrochemical cells for green hydrogen production

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**Abstract:**

Hydrogen ($H_2$) has emerged as a clean and efficient energy carrier due to its high energy density, ease of transport, and zero carbon emissions during energy generation. Among various production methods, photocatalytic systems offer a simple and cost-effective route for green hydrogen generation, although their relatively low efficiency remains a key limitation. Therefore, the development and optimization of advanced photocatalytic materials are essential to improve $H_2$ production efficiency and reduce the overall cost of green hydrogen.

At the same time, growing efforts to reduce the carbon footprint from energy consumption have accelerated the demand for renewable energy sources such as solar power. This has driven significant interest in photoelectrochemical (PEC) cells, which enable the direct conversion of solar energy into chemical fuels. In particular, organic semiconductors have attracted attention as photoelectrode materials due to their tunable optoelectronic properties and potential for high photocurrent generation. However, practical implementation remains challenging due to issues such as inefficient charge transfer and film delamination in aqueous environments.

In this contribution, we present a new class of photoactive materials designed to address these critical challenges. We will discuss their optical properties and hydrogen evolution performance in both photocatalytic and PEC systems. Furthermore, we will highlight recent findings that elucidate the correlations among molecular structure, physical properties, and device performance, providing insights into the underlying mechanisms that govern efficient photocatalytic and PEC hydrogen production.

Han Young Woo received his Ph.D. in Chemistry from the Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea, in 1999. After postdoctoral training at the University of California, Santa Barbara (UCSB) in the USA, he joined Pusan National University as an assistant professor. In 2015, he moved to Korea University, where he is currently a professor in the Department of Chemistry. His research focuses on the design and synthesis of conjugated polymers and conjugated polymer electrolytes to develop organic and polymer semiconductor materials with controlled optical and electrical properties. These materials are applied to various optoelectronic devices, including solar cells, transistors, photodetectors, and photocatalysts.

## Colloidal synthesis of carbon quantum dots and their heterostructures

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**Abstract:**

Quantum materials are materials that are governed by quantum excitations and quasi-particles such as electrons, magnons, excitons, among others. Heterostructures of quantum materials are highly interesting from both fundamental and application perspectives, because they provide manipulation routes to alter the energy states of the material. Colloidal synthesis using Ligand mediated surface engineering is a powerful approach to synthesize 0-, 1-, 2-D quantum materials. Its versatility and readiness for upscaling has earned it the 2023 Nobel Prize. In this talk, we present a colloidal synthesis method to grow high-quality carbon quantum dots (CQDs) on ZnSe nanoplatelets (NPLs), i.e., metal chalcogenide quantum wells.[1,2] The resultant organic-inorganic hybrid nanoparticles, CQD-NPLs, are able to perform methanol dehydrogenation with the occurrence of α-C-H splitting and C-C coupling. The novel CQD-based organic-inorganic heterostructure quantum material is poised to enable the discovery of a host of new nano-hybrid photocatalysts with full tunability of the band structure, charge transfer, and divergent surface chemistry for guiding photoredox pathways and accelerating reaction rates.

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2. Chen, D., et al., *Colloidal Synthesis of Carbon Dot-ZnSe Nanoplatelet Van der Waals Heterostructures for Boosting Photocatalytic Generation of Methanol-Storable Hydrogen*. Small, 2024. **20**(40): p. 2402613.

Dr. Qin Li is a Professor of Environmental Engineering at Griffith University. She obtained her PhD in Chemical Engineering from the University of Queensland (2002) and BEng (1994) and MEng degrees (1997) from Zhejiang University. Dr. Li conducts research on functional materials, catalysis and applied nanotechnology to provide solutions for renewable energy, environmental monitoring, water purification, and waste reformation. With two edited books, 6 book chapters, over 160 journal papers and 4 international patents with an h-index of 56 (Google Scholar), Qin is ranked in the top 2% of researchers across all discplines in the world by Standardford Analysis. Qin is a former Marie Curie Fellow at the Max Planck Institute for Polymer Research, winner of Curtin Innovation Award 2009, and the finalist of Women in Technology Research Award in 2015 and 2020. Qin is the Co-Founding Chair of the Green and Sustainable Chemistry & Engineering National Interest Group at RACI, and advocates for Innovating Sustainably.

## Solution processable organic transistors for sensing/biosensing

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**Abstract:**

Sensors and biosensors contribute significantly to improving the speed, accuracy, and accessibility of diagnostic and analytical processes across a wide range of fields, making them indispensable in modern science and technology. Our group focuses on developing organic thin film transistors (OTFTs) for applications in sensors, biosensors and bioelectronics. OTFTs can amplify signals and can be functionalised to detect different analytes using selective membranes and intelligent device designs, making them highly suitable for sensing applications. We specifically focus on solution processable OTFTs, exploiting organic semiconductors that can be processed at low temperatures using solution processing methods and can be directly deposited into complex patterns using techniques such as inkjet printing. In this talk, I will cover our work on solid-state OTFT sensors that operate at low voltages (< 1V). Low operational voltages are critical to prevent electrolysis of water when working with aqueous based analytes. The solid-state nature of our OTFTs enables multiplexed sensing. We demonstrated this by designing a multiplexed ion sensing chip capable of detecting multiple ions in artificial blood plasma. We are actively working on developing different types of solution processable solid state OTFTs and designs for applications in including biosensors, bioelectronics, and integrated OTFT circuits.

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6. Arthur, J.N. and S.D. Yambem, *Detection of H2O2 with Hygroscopic Insulator Organic Thin Film Transistor*. Advanced Materials Technologies, 2022. **7**(4): p. 2101149.
7. Arthur, J.N. and S.D. Yambem, *Simple Solution Processed Solid-State Organic Transistor Chip for Multi-Ion Sensing*. Advanced Materials Technologies, 2024. **9**(8): p. 2301786.

Dr. Soniya D. Yambem is a physicist and an Associate Professor in the Faculty of Science at Queensland University of Technology (QUT), Australia. With a robust research background in organic electronic devices, her work over the past few years has centred on developing printable thermally activated delayed fluorescence organic light-emitting diodes and low-voltage operating organic transistors. Dr. Yambem completed her Ph.D. at the University of Houston, Texas, USA, in 2011, where she focused her thesis on organic photovoltaics. After earning her doctorate, she moved to Australia to further her research as a post-doctoral fellow at the Centre for Organic Photonics and Electronics (COPE) at the University of Queensland, Brisbane. In 2015, she joined QUT as a Vice Chancellor's Research Fellow. Since then, Dr. Yambem has been instrumental in advancing the university's research capacity in organic electronics, making significant contributions to the field, and mentoring the next generation of scientists.

# Toward scalable and deployable organic gas sensors: from device innovation to real-world applications

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**Abstract:**

This talk highlights recent progress in the development of organic semiconductor-based gas sensors that achieve high sensitivity while significantly reducing hardware complexity, thereby enabling broader and more accessible applications. In response to increasingly stringent air quality regulations and the growing demand for real-time gas monitoring, our research emphasizes the design of cost-effective sensors characterized by low power consumption, high selectivity, and stable operation under ambient conditions.

A key breakthrough presented in this talk is the use of 2,4-diphenyl-6-bis(12-phenylindolo[2,3-a]carbazole-11-yl)-1,3,5-triazine (DIC-TRZ), a bipolar host material widely adopted in OLEDs, as the active sensing layer for room-temperature ammonia detection. By implementing a vertical nanojunction device architecture and incorporating a p-type doping strategy with F4-TCNQ, we achieved a nearly 20-fold enhancement in operational current, while maintaining a high sensitivity of 0.0391 %/ppb and reaching a detection limit as low as 16.0 ppb. The sensor exhibits excellent selectivity for ammonia over interfering gases and demonstrates robust performance across a range of humidity conditions. These improvements enable real-time signal acquisition using a low-cost commercial multimeter, eliminating the need for bulky and expensive measurement equipment.

This advancement lays the foundation for scalable deployment of ammonia sensors in environmental surveillance, agricultural odor management, and non-invasive medical diagnostics. In addition, ongoing collaborations with governmental agencies in Taiwan aim to further validate and integrate the system into real-world applications.

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2. Chen, B.-X., et al., *Enhancement in operational current of PTB7 based ammonia gas sensor utilizing F4-TCNQ as P-type dopant*. Sensors and Actuators B: Chemical, 2022. **361**: p. 131723.

Li-Yin Chen is a Professor in the Department of Photonics at National Yang Ming Chiao Tung University (NYCU), Taiwan. She received her Ph.D. in Photonics and Optoelectronics from National Taiwan University in 2008. Her research focuses on organic semiconductor based optoelectronic devices, with particular emphasis on gas sensors, as well as high-stability color converters for visible light communication and immersive display systems. She has led interdisciplinary projects integrating materials science, device engineering, and circuit-level design to develop low-power, high-sensitivity sensor technologies. Prof. Chen is the recipient of multiple awards for excellence in research and teaching, and she is a Senior Fellow of Advance HE for her contributions to higher education.

# Preparation and photoelectric properties of organic co-crystal materials

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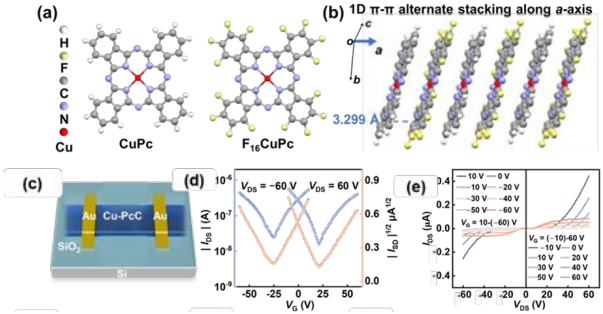
**Abstract:**

Organic cocrystals, known as organic alloy, use two or more material molecular assembly methods to achieve new material properties, they are connected through weak noncovalent bonds among different constituent compounds, which can be altered much easier than that of strong covalent in inorganic crystalline materials, offering an opportunity to tune their bulky physicochemical properties when respond to various external stimuli, and they have great advantages for constructing new optoelectronic devices, such as bipolar field effect transistors. We designed and prepared a series of organic cocrystal materials by simple methods. Aiming at the weakness of their electrical properties, we introduced materials with large conjugation area and used zinc phthalocyanine and copper perfluorophthalocyanine as donors and acceptors, respectively, to obtain pn-balanced bipolar devices, and further constructed light transistor.

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3. Liu, M., et al., *Recent advances in organic stimuli-responsive tunable circularly polarized luminescence materials*. Journal of Materials Chemistry C, 2025. **13**(25): p. 12584-12611.

Xiaotao Zhang, Chair Professor of Tianjin University, Doctoral Supervisor, Deputy Director of the Institute of Molecular Aggregation Science, National high-level leading talents. He has published more than 100 SCI papers in Adv. Mater., Angew. Chem. Int. Ed. and J. Am. Chem. Soc, etc. Several of his papers have been selected as cover articles, hot papers, and ESI highly cited papers, with the highest citation of more than 2,600 times, and the H-factor of 54.

## 2D/3D heterostructures for efficient tin halide perovskite photovoltaics

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**Abstract:**

Tin halide perovskites (THPs) have emerged as promising lead-free candidates for eco-friendly perovskite solar cells, but their photovoltaic performance still lags behind that of lead-based counterparts due to poor thin-film quality. Constructing two-dimensional/three-dimensional (2D/3D) heterostructures can effectively regulate crystallization and suppress defect formation for developing high-quality polycrystalline THP thin films.[1,2] Here, we introduced colloidal chemistry engineering strategies to synchronize the nucleation kinetics of 2D and 3D crystalline phases for the growth of homogeneous 2D/3D THP heterostructures.[3] Consequently, the optimised devices deliver an excellent power conversion efficiency of 17.13% (certified 16.65%) and exhibit stable operation under continuous one-sun illumination for over 1,500 h in nitrogen without encapsulation. This study offers new insights into colloidal chemistry and crystallisation regulation of mixed-dimensional heterostructures, paving the way for high-performance lead-free perovskite photovoltaics.

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Dr. Peng Chen is a Lecturer at the School of Chemical Engineering and Australia Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland (UQ). He received his PhD from UQ in 2020, before moving to AIBN for two consecutive fellowships: Australian Centre for Advanced Photovoltaics (ACAP) Research Fellowship (2020-2022) and ARC DECRA Fellowship (2023-2025). His research focuses on the crystallization regulation and interfacial engineering of polycrystalline perovskite thin films for various optoelectronic applications. In the past decade at UQ, he has contributed to 64 peer-reviewed publications in leading journals, such as Science, Nat. Nanotechnol., Nat. Commun., Adv. Mater., Angew. Chem. In. Ed., etc. His publications have attracted over 7200 citations with a H-index of 35 (Google Scholar). He has attracted over AUD $3.6 million in competitive research funds from ARC and Commonwealth Government.

# Ene-y mean-ing? Yny-y…OH!

Jarred Potter,[1] James Morris,[2] Andrea Vezzoli,[2] Paul J. Low[1]*

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**Abstract:**

Carbon allotropes such as fullerenes, carbon nanotubes and graphene, and carbon rich materials, such as polyacetylene, hold special fascination through the remarkable electrical, optical and physical proprieties they offer.[1] This presentation will discuss results from the study of electron transfer through (quasi-)linear molecular carbon structures chosen to mimic polyacetylene and the contentious 'missing' 1D carbon allotrope carbyne, using various combinations of mixed-valence models,[2] single-molecule STM-break junction measurements,[3] large area device assemblies[4] and computational models. The prospects for using such structures in applications such as thermoelectric devices will also be highlighted.[5]

**References:**

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5. *Moneo, A., et al., Towards molecular electronic devices based on 'all-carbon' wires*. Nanoscale, 2018. **10**(29): p. 14128-14138.
6. Vavrek, F. and M. Hromadová, *Thermopower measurement and control in molecular junctions via diverse experimental approaches*. Current Opinion in Electrochemistry, 2025. **51**: p. 101690.

After PhD studies at the University of Adelaide and a postdoctoral position at the Canadian National Research Council, Paul was appointed to the academic staff in the Department of Chemistry at Durham University, UK (1999 Lecturer, 2006 Reader, 2010 Professor). There he was able to engage with the dynamic molecular electronics and inorganic chemistry community across the UK and Europe, developing the collaborations, concepts and friendships that have been pivotal to his work in both molecular electronics and mixed-valence chemistry. In 2013, Paul was awarded an ARC Future Fellowship, and appointed to a Chair in Chemistry at the University of Western Australia. He was awarded a Fredrich Wilhelm Bessel research award by the Alexander von Humboldt Foundation in 2016, the RACI H.G. Smith Memorial Medal in 2020 and the J.G. Burrows Award in 2024. Since 2022 he has been the Head of the School of Molecular Sciences at UWA.

# Ion-mediated interfacial control in polyelectrolytes: bridging materials chemistry and device physics

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**Abstract:**

Research in organic electronics has been progressing steadily in understanding electron and hole transport, and device performance has improved significantly over the past several decades as novel interfacial materials have been developed. In this presentation, we report the synthesis of an ionic charge-dependent interfacial material composed of a metal:polymer (styrenesulfonate) (PSS) polymer electrolyte, and its study as a structural analogue of the widely used polymer (3,4-ethylenedioxythiophene:polystyrenesulfonate) (PEDOT:PSS) hole transport layer, to elucidate the relationship between the metal cations and the cationic PEDOT components. The metal ions chosen in this study are Li, Mg, V, Mn, Co, Ni, Cu, Zn, Pd, Ag, Cs, and Pb. We analyze the interfacial energy level alignment, electronic band structure, and band bending at the transparent electrode oxide (ITO)/metal:PSS interface using X-ray photoelectron spectroscopy (XPS) and ultraviolet photoelectron spectroscopy (UPS). Alkali (earth) and post-transition metals exhibit deep highest occupied molecular orbitals and low work functions (WFs) due to the Fermi level equilibrium, which indicate inefficient hole transport. Nevertheless, Cu:PSS exhibits a unique electronic structure, demonstrating its potential as a hole transport layer with a high WF and low hole injection barrier. Doping these metal ion-doped polymer materials into organic solar cells, perovskite solar cells, and organic-inorganic hybrid light-emitting devices demonstrates improved hole transport properties, and we propose new materials and novel device structures that enhance the performance of organic semiconductor devices.

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3. Park, Y.J., et al., *Improved Hole Injection in Hybrid Light-Emitting Transistors Incorporating Lithium and Copper(II) Poly(Styrene Sulfonate)*. Advanced Materials Interfaces, 2023. **10**(31): p. 2300261.

Dr. Jung Hwa Seo received her Diploma in Physics (Magna Cum Laude) from Dong-A University in 2001 and earned her Ph.D. in Physics from Yonsei University in 2007 under Prof. Chung Nam Whang. She then conducted postdoctoral research at the University of California, Santa Barbara (2007–2011) with Professors Guillermo C. Bazan, Thuc-Quyen Nguyen, and Nobel Laureate Alan J. Heeger.

Dr. Seo was a faculty member in the Department of Materials Physics at Dong-A University from 2011 to 2022 and is currently a Professor in the Department of Physics at the University of Seoul. Her research focuses on organic solar cells, organic transistors, light-emitting transistors, and photoelectron spectroscopy, with an emphasis on the development and characterization of new organic materials for energy-related applications.

# Merging organic and inorganic materials for fast and broadband photodetection

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**Abstract:**

Organic–inorganic hybrid heterostructures offer a powerful platform for next-generation optoelectronic devices by combining the strong light absorption, flexibility, and tunable spectra of organic semiconductors with the high carrier mobility and electrical stability of inorganic materials. We demonstrate high-performance hybrid photodetectors by integrating P3HT with transition metal dichalcogenides (TMDs). A P3HT/tungsten diselenide ($WSe_2$) lateral heterojunction achieves broadband detection (400–1100 nm), enhanced responsivity of 17.6 A $W^{-1}$, and ultrafast response times of 9.5/5.1 µs, enabled by efficient exciton dissociation, type-II band alignment, and long-range energy transfer from P3HT to $WSe_2$. A field-effect transistor architecture further allows gate-tunable photoresponse. Using molybdenum diselenide ($MoSe_2$) with P3HT, we realize a phototransistor with 40.4 A $W^{-1}$ responsivity, detectivity of $2.03 \times 10^{10}$ Jones (660 nm), and fast response times of 363/370 µs. These results highlight the potential of organic–inorganic hybrid systems to deliver broadband, high-speed, and highly sensitive photodetectors, providing a versatile pathway toward advanced optoelectronic applications.

**References:**

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2. Khanikar, P.D., et al., *MoSe2/P3HT Hybrid Heterostructure Field-Effect-Transistor for Photodetection*. Advanced Materials Technologies, 2025. **10**(6): p. 2401157.

Dr. Samaresh Das is a Professor at the Centre for Applied Research in Electronics (CARE), IIT Delhi, and holds the Uma-Puruskar–Liril Gupta Chair Professorship in Future Computing Technologies. He received his M.Sc. and Ph.D. from IIT Kharagpur, followed by research positions at Tyndall National Institute, Ireland, and Hitachi Cambridge Laboratory, U.K., working on advanced nanoelectronic and quantum devices. Since joining IIT Delhi in 2014, his group has focused on infrared photodetectors, THz electronics, and quantum information technologies. His awards include the Faculty Research Award (IIT Delhi, 2019), ISSS Young Scientist Award (2019), INAE Young Engineer Award (2017), and MeitY Visvesvaraya Young Faculty Research Fellowship.

# Coordination electronics: unlocking the potential of hybrid organic-inorganic materials for semiconductor devices

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**Abstract:**

Coordination polymers (CPs) consist of metal centers bridged by organic ligands into 3D, 2D, or 1D extended structures. These hybrid materials offer a vast library of materials with remarkable tunability from the unlimited combinations of metals and organic molecules. However, their applications in electronic and optoelectronic devices have only begun to appear. One of the biggest challenges for CPs is their limited processability, particularly for solution-processing routes, making thin-film deposition and device fabrication difficult.

Among the CPs, copper(I) thiocyanate (CuSCN) is a unique example – now extensively used across a wide range of devices. Its wide applicability is based on the use of an unconventional group of solvents. Recently, we have revealed that diethyl sulfide (DES), a standard solvent for CuSCN, interacts strongly with Cu(I) centers and can act as a 'co-ligand'.[1] Other co-ligands can be used to realize 2D CuSCN-based CPs with tunable electronic energy levels and optical properties.[2] Importantly, removing these co-ligands by annealing can restore the structure of the parent 3D CuSCN.

We can extend this concept to use volatile co-ligands as 'coordinating solvents' for thin-film deposition. Herein, we show that certain volatile co-ligands can be used to dissolve and deposit high-quality, compact, thin films of another group of CPs: metal thiophenolates (MSPhR, M = Cu or Ag, R = H or OH), which are usually not solution-processable. In particular, we demonstrate a new transparent p-channel material for thin-film transistors based on 1D CuSPhH. The ability to deposit high-quality thin films of CPs can unlock their potential for electronic and optoelectronic applications as well as expand the material library for device engineering.

**References:**

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2. Songkerdthong, J., et al., *Band gap engineering in pyridyl-functionalized two-dimensional (2D) CuSCN coordination polymers*. Molecular Systems Design & Engineering, 2024. **9**(8): p. 814-825.

Dr. Pichaya Pattanasattayavong obtained his PhD in Solid-State Physics from Imperial College London, UK, in 2015. He has since joined VISTEC, first as a Lecturer and promoted to Assistant Professor in 2021. His research focuses on advanced materials for opto/electronic applications. He has won numerous grants and awards, such as Thailand's Young Scientist Award (2020), Outstanding Mid-Career Grant from National Research Council of Thailand (2022), research grant from the US Air Force Office of Scientific Research (2022), Distinguished Lectureship Award from Chemical Society of Japan (2024), and most recently, Thailand's Young Materials Research Award (2024).

# Tailoring crystallization in hybrid metal organochalcogenide semiconductors: from large structures to nanocrystals

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**Abstract:**

Crystallization is fundamental to the development of semiconductors that underpin modern technologies. While traditional methods cater to purely inorganic or organic semiconductors, hybrid organic-inorganic materials often face challenges due to their low thermal stability and poor solvent compatibility. This talk highlights our advancements in tailoring crystallization in metal chalcogenide semiconductors, focusing on large-scale structures and nanocrystals.

In one study, we address the long-standing solubility challenge of metal organochalcogenides (MOCs), a promising class of hybrid semiconductors. By leveraging poly-dentate amine solutions, we achieve solution-based single-crystal growth of 15 MOC species, including eight novel compounds with diverse structures and substituents. Single-crystal X-ray diffraction reveals a structural correlation with substituent positions, and spectroscopic studies elucidate the dissolution mechanism, involving fragmentation into polymeric units driven by nitrogen-lone pair interactions. This work enables a pathway for crystallizing previously insoluble MOCs, expanding their structural and functional applications.

Complementing this, our second study pioneers a rapid, scalable synthesis of MOC nanocrystals. Using a hot-injection method, we produce silver phenylselenide nanocrystals in with a ~70% yield, demonstrating tunable sizes from 50 nm to 10 μm. These nanocrystals exhibit long-term colloidal stability, high thermal resilience, and ease of film fabrication for device integration. Optical and electronic studies reveal bandgap tunability, strong p-type behavior, and a hole mobility of $4.48 \times 10^{-2}$ $cm^2 \cdot V^{-1} \cdot s^{-1}$, rivaling top-performing inorganic hole-transporting materials.

These findings underscore the transformative potential of MOCs, from designing large single crystals to engineering nanoscale materials for advanced electronics.

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3. Paritmongkol, W., et al., *Layered Metal–Organic Chalcogenides: 2D Optoelectronics in 3D Self-Assembled Semiconductors*. ACS Nano, 2025. **19**(13): p. 12467-12477.

Dr. Watcharaphol Paritmongkol is a faculty member of the School of Molecular Science and Engineering at VISTEC, Thailand. He earned his MChem (combined Bachelor's and Master's degree) from the University of Oxford in 2015 and his PhD from MIT in 2021. Following a postdoctoral fellowship at the University of Toronto, he joined VISTEC in 2023, where he leads a research group specializing in hybrid semiconductor synthesis and optoelectronic devices.

Since establishing his independent lab, he has secured multiple prestigious grants and awards, including the Research Grant for New Scholars (National Research Council of Thailand) and the Science & Technology Research Grant (Thailand Toray Science Foundation). He serves as an Early Career Advisory Board Member for Inorganic Chemistry Frontiers (RSC) and as a Committee Member of the Thailand Younger Chemists Network.

# Next-generation imaging: from NIR organic upconversion to UV and perovskite photodetectors

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**Abstract:**

We have advanced organic upconversion imaging by integrating organic infrared photodetectors with OLEDs, enabling real-time infrared-to-visible conversion with strong potential for anti-surveillance and low-light applications, which was highlighted by NATURE.[1] Our early devices exhibited turn-on voltages below 1.7 V, resolutions above 1500 ppi, over 65% visible transparency, and NIR sensitivity under 1 μW/cm².[2,3] To boost efficiency, we introduced a tandem OLED design with a charge generation layer, reaching over 30% upconversion efficiency.[4] Recently, we reported an all-solution-processed imager using Zn-doped $CsPbBr_3$ quantum dots,[5] and demonstrated biosensing of African Swine Fever by coupling our NIR imagers with surface plasmon resonance platforms. To broaden spectral coverage, we developed SWIR-active layers based on non-fullerene acceptors, spanning 0.9-1.5 μm.[6] We also realized high-gain organic UV photomultiplier-type photodetectors with detectivity above $10^{15}$ Jones, offering outstanding UV-A/B sensitivity. In parallel, we developed fully vacuum-deposited perovskite visible photodetectors with ultra-thin, uniform films. These devices exhibit low dark current, wide linear range, and excellent spatial uniformity—key for high-resolution, multispectral imaging arrays. This presentation will highlight our integrated strategies across organic and hybrid platforms, focusing on core device physics, scalable architectures, and fabrication methods driving next-generation imaging and sensing systems.

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Dr. Shun-Wei Liu is Distinguished Professor of Electronic Engineering and Associate Dean of Engineering at Ming Chi University of Technology (MCUT), Taiwan, where he leads global research efforts and academic–industry partnerships. In 2017, he secured a $2.5 million USD investment to establish the Organic Electronics Research Center (OERC)—Taiwan's first university-level center for organic electronics—positioning MCUT at the forefront of hybrid optoelectronic research. Under his direction, OERC has become a multidisciplinary hub integrating chemistry, materials science, and device engineering. Dr. Liu's work focuses on organic and perovskite materials for advanced optoelectronic systems, including SWIR/NIR/UV imagers, transparent photovoltaics, OLED-based medical lighting, and vacuum-deposited perovskite photovoltaics and photodetectors. He has published over 180 SCI-indexed papers with an H-index of 40 (Google Scholar), and his technologies have generated over $600,000 USD in licensing revenue in the past five years. Notably, he co-developed Taiwan's first OLED-based circadian eyewear with Formosa Biomedical Technology Corp.—a $100 USD medical device selling over 2,000 units annually—representing a rare academic-to-product success in display technology. His honors include the Ta-You Wu Memorial Award, the NSTC Award for Technology Transfer, and the Outstanding Young Researcher Award from the Taiwan Photonics Society. In 2023, his work on upconversion optoelectronics was featured by NATURE's research highlight and earned the Future Technology Award at Taiwan Innotech Expo. In 2024, he was appointed Adjunct Professor at KAIST, recognizing his global leadership in advanced materials.

# POSTER PRESENTATIONS

# WOMEN'S COLLEGE

## DAY 1

### 8TH DECEMBER

# Organic-sensitized red circularly polarized quantum dot light-emitting diodes with high luminescence efficiency and large asymmetry factor

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**Abstract:**

The emerging display technology based on circularly polarized luminescence (CPL) demonstrates advantages in reducing reflectivity and improving viewing angles. However, current implementations relying on external optical components suffer from low integration levels and complex processes. Although electrically driven circularly polarized quantum dot light-emitting diodes (CP-QLEDs) that directly generate CPL show great potential, existing systems face challenges of weak chiral signals and poor emission capability in luminescent materials, making it difficult to simultaneously achieve high luminous efficiency and large asymmetric factor (g-factor). This study proposes a novel strategy employing chiral organic luminescent materials to sensitize green-emitting quantum dots. Leveraging the synergistic effects between the high structural tunability of organic molecules and the superior optoelectronic properties of quantum dots, we demonstrate the all solution-processed high-performance green CP-QLEDs. The champion device exhibits both a high g-factor of $1\times10^{-3}$ and exceptional external quantum efficiency over 18%. This work provides a new design paradigm for advancing CPL display technologies.

**References:**

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3. Kim, J., et al., *Recent Advances and Challenges of Colloidal Quantum Dot Light-Emitting Diodes for Display Applicatio*ns. Advanced Materials, 2024. **36**(20): p. 2212220.
4. Chen, Q., et al., *Promise to electrically pumped colloidal quantum dot lasers*. The Innovation, 2023. **4**(5).

Dr. Qiyin Chen obtained his Master of Science degree from the College of Chemistry, Xiangtan University in 2020. He subsequently received his Doctor of Philosophy degree from the College of Chemistry and Molecular Sciences, Wuhan University in 2024. During his doctoral studies, from 2021 to 2024, Dr. Chen conducted research as a visiting PhD student at the Oxford Suzhou Centre for Advanced Research (OSCAR). Currently, Dr. Chen holds a postdoctoral research fellowship within the research group of Professor Wei Huang and Professor Guohua Xie at the Institute of Flexible Electronics (IFE, Future Technologies), Xiamen University. His primary research focus encompasses optoelectronic devices based on organic semiconductors and quantum dots, with a specific specialization in circularly-polarized light-emitting diodes (CPLEDs).

# Every photon counts: developing ultra-sensitive and fast photodetectors

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**Abstract:**

Organic and perovskite based photodetectors are changing the game in optoelectronics, combining high sensitivity, fast response, tuneable bandgaps, and scalable fabrication.[1] In our most recent work we developed a unified approach to achieve both speed and sensitivity in formamidinium lead iodide ($FAPbI_3$) based devices, reaching an ultrawide linear dynamic range of ~ 200 dB and detecting light down to tens of pW $cm^{-2}$ through careful optimisation of hole transport layers.[2] These results address key performance challenges and open the door to new possibilities in light detection. Studies have shown that metal-halide perovskites can be used under zero bias for counting photons under very low-light conditions using simplified designs, which is an exciting next step.[3] Building on our design principles we are exploring strategies for efficient detection at ultra-low photon flux. Moving from fast and sensitive detectors to technologies that make every photon count could unlock new applications for organic and perovskite materials.

*This project is proudly funded through the Queensland Government Quantum and Advanced Technologies Commercialisation Infrastructure Program.*

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1. Tong, S., et al., *Fully-printed, flexible cesium-doped triple cation perovskite photodetector.* Applied Materials Today, 2019. **15**: p. 389-397.
2. Khanikar, P.D., et al., *Unified Approach to Sensitive and Fast Perovskite Photodetectors Featuring an Ultrawide Linear Dynamic Range.* Advanced Optical Materials. p. e01967.
3. Zhou, Y., et al., *Self-powered perovskite photon-counting detectors.* Nature, 2023. **616**(7958): p. 712-718.

Dr Cameron Cole is a researcher in School of Mathematics and Physics at The University of Queensland (UQ). He received his BSc Hons. and Ph.D. degree from QUT 2017 and 2023, respectively. His honours research was on organic photovoltaics and his Ph.D. research was on inkjet-printed polymer thermally activated delayed fluorescent (TADF) organic light emitting diodes (OLEDs). For his PhD work, Cameron received the Executive Dean's Commendation for Outstanding Doctoral Thesis in 2023. His current research interests include material science and organic electronics, more specifically OLEDs, organic electrochemical transistors (OECTs), and organic and perovskite photodetectors (OPDs).

# Utilizing metal-metal-to-ligand charge transfer (MMLCT) in Pt(II) aggregates for enhanced brightness and efficiency

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**Abstract:**

Organic light-emitting diodes (OLEDs) have witnessed the remarkable advancements in the wide use in high-end display technologies. This evolution is significantly contributed by the continuous development of highly efficient fluorescent, phosphorescent, and thermally activated delayed fluorescent (TADF) materials. Despite of these advancements, achieving high brightness while maintaining high efficiency remains challenging, notably due to triplet-triplet annihilation (TTA) and the associated long triplet excited-state lifetime. An innovative solution involves leveraging metal-metal-to-ligand charge transfer (MMLCT) in platinum [Pt(II)] aggregates. These aggregates, characterized by overlapping Pt(II) $dz^2$ orbitals, exhibit near-unity neat-film photoluminescence quantum yield (PLQY) and a markedly short excited-state lifetime. This unique property enables the creation of highly efficient, host-free OLEDs with high external quantum efficiency (EQE) and mitigates efficiency roll-off.

Our investigation delves into the nuances of MMLCT through spectroscopic studies, device characterisation, and techniques such as Extended X-ray Absorption Fine Structure (EXAFS), and X-ray crystallography. A comparative analysis will underscore the distinctions between an MMLCT emitter and its counterpart emitting from MLCT aggregates. This research offers insights crucial for future material development that are not only highly efficient, but also capable of achieving high brightness in OLEDs.

Keywords: metal-metal-to-ligand charge transfer, extended X-ray absorption fine structure, EQE roll-off

Innes Gale completed his PhD at UQ, focusing on novel organometallic emitters for high-brightness OLEDs under the supervision of A. Prof. Shuh-Chun (Lawrence) Lo and A. Prof. Ebinazar Namdas. Innes is currently a researcher at The University of Queensland (UQ), where he works on developing new materials for organic light-emitting devices (OLEDs), organic lasers, and other optoelectronic applications. His research combines molecular synthesis with detailed photophysical and thermal characterisation to design emitters that achieve both high brightness and low efficiency roll-off.

# Advancing green solvent processing for efficient and stable perovskite solar cells

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**Abstract:**

The pursuit of environmentally friendly manufacturing processes is crucial for the commercialization of perovskite solar cells (PSCs).[1,2] This presentation will discuss our recent progress in research green solvent for solution processing of PSCs. First, we introduce a novel additive strategy to overcome the challenges of water-processed PSCs. The addition of lead fluoride ($PbF_2$) to the aqueous precursor solution effectively modulates crystallization kinetics, leading to perovskite films with superior morphology, enhanced crystallinity, and reduced defect density. This approach resulted in devices with a champion power conversion efficiency (PCE) of 18.1%, and significantly enhanced stability.[3] Second, we developed a fabrication protocol using the green solvent γ-valerolactone (GVL under ambient air conditions. The high boiling point and excellent coordination ability of GVL allow for robust film formation even at relative humidity levels. Devices fabricated in ambient air with this GVL-based ink achieved a stabilized PCE of 23.9% and demonstrated improved operational stability, retaining more than 90% of their initial performance after 500 hours of continuous illumination. These works provide two viable and scalable pathways for the sustainable fabrication of high-performance PSCs, significantly reducing their environmental footprint and production costs.

**References:**

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Dr. Minh Tam Hoang is a Postdoctoral Research Fellow at Queensland University of Technology (QUT). In 2025, he was awarded the ARC Early Career Industry Fellowship. Dr. Hoang obtained a PhD from QUT in 2022, where his research focused on the development of sustainable processing methods for perovskite materials. His current work explores the design and fabrication of perovskite materials for photovoltaic and optoelectronic applications, with a particular emphasis on green solvent systems and scalable manufacturing approaches.

# Reduction of ASE threshold by suppressing concentration quenching of organic semiconductor laser materials

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**Abstract:**

To date, various organic semiconductor laser materials have been developed, and 4,4'-bis[(N-carbazole)styryl]biphenyl (BSBCz) is well known for exhibiting excellent properties.[1] However, it has been suggested that BSBCz is possible to occur trans-cis isomerization via triplet excitation states, and the molecule may decompose from the cis isomer.[2] Therefore, there is a pressing need to further lower the threshold in robust organic laser materials with excellent stability. In addition, since the electron mobility of BSBCz is about one order of magnitude lower than that of hole mobility, it is also necessary to develop well-balanced bipolar materials.[3] Benzobisoxazole (BOX) derivatives, which eliminate the stilbene group and allow carrier balance adjustment, were reported as new laser materials and showed high photostability. However, the PLQY decreased due to concentration quenching in the solid films.[4]

In this study, we focus on self-quenching due to dipole-dipole interactions, demonstrating the BZ derivatives with a structure that relaxes the rigidity of the BOX derivatives. As a result, the PLQY was improved, and the ASE threshold was reduced in the solid films by increasing the Stokes shift and suppressing aggregation. Moreover, a lower ASE threshold ($E_{th}$=0.38 $\mu$J cm$^{-2}$) was achieved in BZCz2 than in BSBCz ($E_{th}$=0.70 $\mu$J cm$^{-2}$). In addition, high photostability was achieved due to the non-stilbene structure and high electron transport properties were obtained through the electron affinity derived from benzoxazole groups.

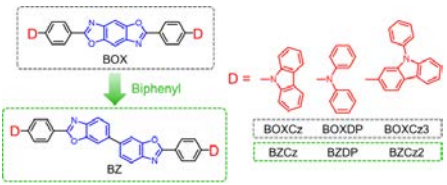


Figure 1 | Chemical structures of BOX and BZ derivatives.

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Research topics
Organic semiconductor laser diodes

Education
2025: Bachelor of Eng. Applied Chemistry from Kyushu University

## Bendable PEDOT:Tosylated based organic electrochemical transistor (OECT) with biocompatible chitosan substrate

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**Abstract:**

The growing global interest in wearable biosensor technology shows its great potential to transform healthcare and personal wellness by allowing real-time testing and continuous monitoring of vital signs during daily activities.[1] Many flexible, biocompatible, and biodegradable materials have been studied for use in these sensors. For example, polyethylene terephthalate (PET), a common type of plastic, is widely used as a base material because it works well with conductive materials like silver and graphene.[2,3] Other materials, such as polydimethylsiloxane mixed with carbon nanotubes (PDMS-CNT), are promising for electronic devices that can be implanted in the body.[4] Among natural materials, chitosan; a biodegradable substance made from chitin found in shellfish, has proven to be an excellent choice. It is non-toxic, has good mechanical strength, and contains chemical groups that make it easy to attach biological molecules and conductive materials.[5] Chitosan has been successfully used in very sensitive biosensors, such as those detecting the procalcitonin protein by coating it on graphene tracks to attach antibodies,[6] and sensing glucose that preserve their sensitivity and enzyme activity for long-term application.[7]

At the same time, organic electrochemical transistors (OECTs) have become popular because they are flexible, small, and highly sensitive, as well as this device is an ideal feature for wearable biosensors.[8] A common material for these transistors is poly(3,4-ethylene dioxythiophene):poly (styrene sulphonate), or PEDOT:PSS, known for its transparency, thermal stability, and ability to be easily made from water-based solutions. Scientists have improved the conductivity of PEDOT:PSS by adding dopants, using acid treatments, or changing its structure.[9] More recently, a related material called PEDOT:Tos, where PSS is replaced by the Tosylate, has gained an attention because it allows better charge movement, higher carrier concentration, and greater stability in air.[10] This improvement is due to the smaller molecule of tosylate , which facilitate the ion moving more easily and help distribute charges more effectively within the material.[11]

A method called vapor phase polymerization (VPP) is often used to make high-quality PEDOT:Tos films.[12] In this method, an oxidant such as iron(III) tosylate mixed with butanol or other additives is first coated onto a surface, and then exposed to the vapor of the monomer EDOT, which forms a highly ordered and conductive PEDOT:Tos film. These films have excellent crystallinity, electrical performance, and are even potentially compatible with human skin cells, making them perfect for wearable electronics.[13]

Herein, our study introduces a flexible and biocompatible OECT wearable device made by coating a chitosan film with a conductive PEDOT:Tos layer using the VPP method. The device also includes a PSSNa solid as a device's electrolyte, as well as the gold electrodes were employed for the source, drain, and gate. Subsequently, our devices with different channel sizes were tested for their electrical performance and flexibility, showing stable operation even after 500 bending cycles. Furthermore, to evaluate the durability of the interface between the chitosan and PEDOT:Tos layers, nanoscratch tests were conducted to confirm how strongly the layers stuck together, and Young's modulus tests were performed to demonstrate their exceptional mechanical compatibility.

Ultimately, this research provides valuable insights into how chitosan and PEDOT:Tos can work together to create flexible, durable, and cell-friendly electronic materials. These results show great promise for developing the next generation of wearable bioelectronic devices and biosensors for health monitoring.

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Chattarika Khamhanglit is a PhD student with expertise in biomedical engineering, and researcher recognized for her recent innovative work in developing sustainable and biocompatible wearable health sensors from seafood waste. Holding a Master of Engineering from Tokyo Medical and Dental University, her research expertise spans biomedical engineering, biosensors, and organic transistors, and includes developing methods for detecting cancer cell markers, using ion-sensitive field-effect transistors.

# High-performance n-type OFETs enabled by pyridine-substituted diketopyrrolopyrrole organic semiconductor and elastomer stretchable blends

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**Abstract:**

The contemporary research on developing n-type organic semiconducting materials (OSMs) has great significance for stretchable organic field-effect transistors (OFETs). Two n-type OSMs (DPPPy-C10-TN and DPPPy-C-Si-TN) based on alkyl/siloxane-substituted pyridine flanked diketopyrrolopyrrole (DPPPy) end capped with thienyl naphthalimide (TN) are reported. Although DPPPy-C10-TN and DPPPy-C-Si-TN show similar optical and electrochemical properties, they show a significant variation in their morphological and crystalline properties in pristine form or within an elastic polymer (polystyrene-*block*-poly(ethylene-*ran*-butylene)-*block*-polystyrene; SEBS) matrix, which further reflects on their electrical properties. Interestingly, bottom-gate top-contact OFETs of as-cast pristine DPPPy-C10-TN show a higher electron mobility ($\mu_e$ = 0.103 cm$^2$ V$^{-1}$ s$^{-1}$) than DPPPy-C-Si-TN ($\mu_e$ = 0.0145 cm$^2$ V$^{-1}$ s$^{-1}$), underscoring the influence of alkyl substitution on charge transport efficiency. By contrast, stretchable DPPPy-C-Si-TN:SEBS blend shows a significantly higher electron mobility ($\mu_e$ = 0.322 cm$^2$ V$^{-1}$ s$^{-1}$) in comparison to the DPPPy-C10-TN:SEBS blend ($\mu_e$ = 0.00196 cm$^2$ V$^{-1}$ s$^{-1}$). To the best of the authors' knowledge, this is the first successful report about a high $\mu_e$ value reported for a DPPPy-based n-type small molecule stretchable OSM blend in OFETs and provides new insights into the design and processing principles of small molecule based OSMs for flexible electronics.

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I am Rajesh, pursuing my PhD at QUT in Materials Chemistry, with a specific focus on organic electronics such as OFETs.

# Development of efficient organic laser materials towards the realisation of organic laser diodes

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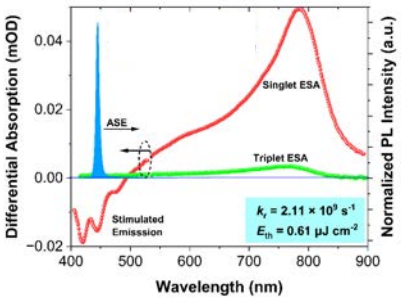
**Abstract:**

We have achieved a significant advancement in the development of stable organic laser materials, marked by an exceptional radiative decay rate and a remarkably low amplified spontaneous emission (ASE) threshold. The laser emitter demonstrates outstanding photophysical characteristics, including a high photoluminescence quantum yield of 94%, an ultrashort excited-state lifetime of 445 picoseconds, and a radiative rate of 2.11 × $10^9$ $s^{-1}$ reportedly the highest among all known organic lasing materials to date. Furthermore, a solution-processed blend film incorporating this emitter exhibits a low ASE threshold of 0.61 μJ $cm^{-2}$ at 447 nm wavelength. Our strategic molecular design successfully separates the regions of stimulated emission and triplet absorption, effectively mitigating optical loss pathways and enhancing device performance.




**Key Words:** Organic laser materials, amplified spontaneous emission, organic laser diode.

Vijay P. Rahane earned his Bachelor of Science (B.Sc.) degree in Chemistry in 2018, followed by a Master of Science (M.Sc.) with a specialization in Organic Chemistry from Savitribai Phule Pune University, Pune, India, in 2020. After completing his postgraduate studies, he joined Dr. Reddy's Laboratories in Bangalore, where he worked in the Medicinal Chemistry Division, gaining valuable industrial experience in industrial research and development. In August 2021, he commenced his doctoral studies under the IIT Delhi – The University of Queensland Joint Ph.D. Program, focusing on the development of advanced organic materials for optoelectronic devices. Within the first year of his Ph.D., he was awarded the prestigious Prime Minister's Research Fellowship (PMRF) in recognition of his outstanding academic performance and the significance of his collaborative research.

# Ion-induced field screening as a dominant factor in perovskite solar cell operational stability

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**Abstract:**

Mobile ions in metal halide perovskites are widely linked to poor device stability, yet their exact share of performance loss relative to trap-assisted recombination remains unclear. We address this gap by quantifying ionic losses using scan-rate-dependent current–voltage measurements (“Fast Hysteresis”, FH), supported by mobile-ion density measurements and drift–diffusion simulations. The study spans multiple perovskite compositions and device architectures, including single-junction cells as well as Si/perovskite and all-perovskite tandem solar cells. Devices were aged under different external stressors, with an emphasis on light-induced degradation.

Our results identify mobile-ion-induced field screening as the dominant driver of intrinsic, early-time degradation, outweighing increases in bulk and interfacial trap-assisted recombination. This finding clarifies the relative roles of ionic motion and recombination pathways during the onset of performance loss and highlights the need to control ion density/mobility and electrostatics at interfaces. FH emerges as a rapid, informative diagnostic to separate ionic from electronic degradation channels across device types. A companion poster will detail the FH methodology and its use for routine stability screening.

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Sahil Shah is a postdoctoral researcher at The University of Queensland, where he explores charge-carriers and ionic dynamics in organic and hybrid optoelectronic devices using transient electrical measurements and device simulations. He completed his PhD (Dr. rer. nat.) at the University of Potsdam on the ion migration in perovskite solar cells, following an MSc in Physics at IIT Roorkee, India.

# Excitons at the limit: strategies for high-current-density organic light devices

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**Abstract:**

Managing exciton populations under high excitation densities is essential for advancing high-brightness organic light-emitting devices (OLEDs) and enabling electrically driven organic lasers.[1-3] Across our collective studies, we map these challenges from the fundamental exciton–charge interactions to practical device-engineering strategies. Time-resolved investigations of polymer and small-molecule OLEDs under high-voltage nanosecond excitation reveal how non-linear charge injection, transient carrier dynamics, and spatio-temporal exciton distributions govern emission efficiency at extreme current densities. These measurements expose the central role of triplet accumulation, which drives losses such as singlet–triplet annihilation (STA), triplet–polaron annihilation (TPA), and electric-field-dependent exciton dissociation. [2-5]

Complementary analyses of thermally activated delayed fluorescence (TADF) emitters and donor–acceptor blends further quantify the relative contributions of singlet–polaron and triplet–polaron annihilation to efficiency roll-off, highlighting charge imbalance and STA as primary limiting factors at high brightness. Studies of exciton–exciton annihilation in TADF systems provide additional insight into delayed fluorescence quenching pathways and their dependence on molecular energetics and recombination kinetics. [6,7]

To suppress triplet-driven losses, we introduce a solid-state cyclooctatetraene-based quencher that effectively eliminates STA under both optical and electrical excitation while preserving optical gain.[5] In parallel, molecular-design-driven triplet–triplet upconversion (TTU) in anthracene derivatives demonstrates that triplets can be repurposed to enhance singlet formation, reducing threshold current densities when TTU is maximized and STA minimized. Polymer-based emitters and macromolecular host–guest systems developed in these works also demonstrate improved photostability, balanced charge transport, and low amplified spontaneous emission thresholds.[4]

Together, these studies establish a cohesive exciton-management framework for achieving high-brightness OLEDs and advancing toward stable electrically pumped organic lasers.[8,9]

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Dr Atul Shukla earned his B.Tech from the Indian Institute of Technology Roorkee in 2016 and completed his Ph.D. in organic light–emitting devices at The University of Queensland in 2021, where he investigated exciton–charge interactions under high excitation densities. He then conducted postdoctoral research in Germany at the University of Potsdam, focusing on organic solar cells. His research spans high-brightness OLEDs, electrically pumped organic lasers, solar cells, and quantum-functional devices, advancing exciton-management strategies to enable next-generation optoelectronic technologies.

# Atomistic origins of anharmonic lattice dynamics and thermal expansion in perovskite photovoltaics

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**Abstract:**

Metal halide perovskites are swiftly becoming a leading class of photovoltaic materials, yet unlike conventional semiconductors, they exhibit highly anharmonic lattice vibrations that produce extreme rates of thermal expansion and significant mismatch with other device layers. These effects are exacerbated under natural day/night cycling, where repeated heating and cooling drive cumulative stress, defect generation, and accelerated degradation.[1] Here, we connect the atomistic origins of anharmonic lattice dynamics in perovskites with their macroscopic thermo-mechanical properties, from phonon–phonon interactions and local disorder, to complex thermal-phase relations.[2] We assess how both the degree of anharmonicity and thermal expansion rates vary across temperature, composition, and phase, and highlight the emergence of anisotropic and even negative thermal expansion in low-symmetry perovskite phases. By linking fundamental physics to device-level challenges, we provide a framework for engineering durable perovskite absorbers and outline promising approaches to regulate thermal strain in pursuit of long-lived, commercially viable solar cell technologies.

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Julian A. Steele received his Ph.D. in physics from The Institute for Superconducting and Electronic Materials (ISEM), University of Wollongong, before undertaking postdoctoral work at KU Leuven (Belgium) and UC Berkeley (USA). From 2023, he began a DECRA Fellowship at the Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, working on a range of condensed matter topics, within which phase transition phenomena in metal halide perovskite semiconductors feature heavily.

# Hindered photo-induced phase segregation via temperature-dependent phase transition of organic-inorganic hybrid perovskite

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**Abstract:**

Organic-inorganic hybrid perovskites have shown great promise for next-generation photovoltaics due to their low fabrication costs, high absorption coefficients, long carrier diffusion lengths, and tunable band gaps.[1] However, their ionic conductive properties and the soft ionic crystal structure allow ion migration to occur during exposure to heat, light, and electric fields, which will lead to defects, phase segregation, induce hysteresis and accelerate device decay.[2] Here, we focused on one of the major defects due to the ion-migration of the halides; *photo-induced phase segregation*. There have been various attempts to hinder this phenomenon by methods, such as compositional engineering, light-induced remixing, and dimensional engineering.[2] Each arrives at a valid result, yet much remains unknown regarding the relationship with temperature-related phase changes. We aim here to reveal the relation between the photo-induced phase segregation and temperature-dependent phase transition in organic-inorganic mixed halide perovskite ($MAPbIBr_2$). The film was prepared by a solvent method, and its phase-transitioning temperature was measured to be 190K and 230K by temperature-dependent GIWAXS measurement. The light intensity required for a phase segregation to occur under a set period of time below and over these phase-transitioning temperatures was compared using temperature-dependent PL microscopy. It reveals that more than twice the light intensity is required at the orthorhombic phase compared to the tetragonal phase. These findings demonstrate the importance of the perovskite phase toward hindering phase segregation and suggests phase control as one of the methodologies for stabilization.

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Yoshiki Sugai is a Ph.D. candidate in the Australian Institute for Bioengineering and Nanotechnology at the University of Queensland, Australia. His research focuses on the structural and optical characterisation of disordered optoelectronic materials and devices.

# Controlling efficiency roll-off in hyperfluorescent OLEDs via terminal emitter HOMO alignment

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**Abstract:**

Hyperfluorescent organic light-emitting diodes (HF-OLEDs) are a promising platform for achieving high-efficiency and narrowband emission suitable for next-generation displays[1]. However, efficiency rolloff at high luminance remains a major challenge[2]. In this study, we systematically investigate the role of terminal emitters' HOMO level alignment on efficiency rolloff in HF-OLEDs using three multiple-resonance thermally activated delayed fluorescent (TADF) emitters: DBPA-Cz, DABNA-Cz blue, and DABNA-Cz green (Figure 1a). All emitters exhibited high photoluminescence quantum yields (>90%) and narrowband emission (<26 nm full-width at half-maximum, FWHM) in the solid-state films. Despite their closely aligned HOMO levels (−5.48, −5.40, and −5.51 eV, respectively) (Figure 1b), the devices exhibited different efficiency rolloff behaviours. The maximum external quantum efficiencies (EQEs) were 26.8%, 20.4%, and 22.4% for DBPA-Cz, DABNA-Cz blue, and DABNA-Cz green, respectively, with rolloff values of 17%, 53%, and 15% at 1000 cd/m². Transient electroluminescence measurements confirmed stronger charge trapping in the devices employing DABNA-Cz blue having a shallower HOMO level (Figure 1c). These results highlight the critical impact of terminal emitters' energy-level alignment on exciton management, providing practical design strategies for achieving stable, high-brightness HF-OLEDs.

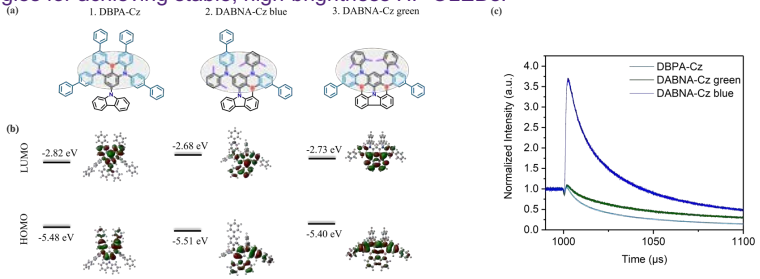


Figure 1 | a) Molecular structures, b) FMOs distributions calculated with B3LYP/6-31g(d,p) level of theory and experimental HOMO/LUMO energy level of DBPA-Cz, DABNA-Cz blue, and DABNA-Cz green, c) transient electroluminescence (EL) measurements of HF-OLEDs employing these materials as terminal emitters.

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**2016-2020** Bachelor's degree at Faculty of Nano and Chemical Engineering, New Mongol Institute of Technology

**2020-2022** Master's degree at Faculty of Physics, National University of Mongolia

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# Ion migration in mixed-halide perovskites

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**Abstract:**

Halide perovskites have shown promise as one of the leading materials in advancing solar cell design, with power conversion efficiencies above 20% achieved more than a decade ago and still growing higher today.[1] A great strength of these materials is their tunability by swapping the chemical composition of both the cations and anions. For the all-inorganic system $CsPbX_3$, the choice of halide (X) greatly affects the electronic and optical properties, and mixing different halides can provide even finer control.[2] The microscopic structure of these alloys is difficult to analyse from experiment alone, but first-principles modelling can be used to determine thermodynamic behaviour,[3] as well as study the significance of defects on stability and charge transport.[4] Here, density functional theory simulations of various mixtures of $CsPb(I_{1-x}Br_x)_3$ are performed to calculate phase diagrams and determine migration barriers for intrinsic defects. These simulations provide insight into the role that structural phase and temperature play on ion diffusion dynamics, leading to better understanding of how to optimise the performance of perovskite solar cells.

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PhD Candidate at The University of Queensland, working under the supervision of Dr Carla Verdi, Dr Julian Steele, and Assoc. Prof. Ebinazar Namdas. Interested in first-principles modelling of defects in various novel semiconductor materials.

# Structure–property modulation in oligophenylenes for organic lasers

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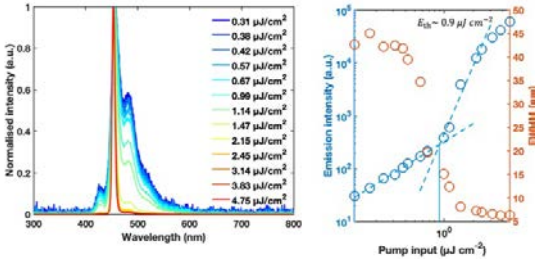
**Abstract:**

Chromophores with short excited-state lifetimes are highly desirable for minimizing exciton–exciton annihilation, suppressing triplet accumulation, and enabling ultrafast modulation in applications such as time-resolved imaging, high-speed data transmission, and light fidelity (Li-Fi). However, achieving rapid excited-state dynamics without compromising emission efficiency remains a significant challenge. Here, we discuss three new solution-processable oligophenylene-based chromophores which exhibit remarkably short excited-state lifetimes (down to 0.45 ns), high molar extinction coefficients (up to 236,000 $M^{-1}$ $cm^{-1}$ at 399 nm), and large radiative decay rates (up to 2.02 × $10^9$ $s^{-1}$). In the context of organic lasing, they also show large emission cross-sections (up to 9.61 × $10^{-16}$ $cm^2$), minimal spectral overlap between triplet absorption and ASE, and low solid-state amplified spontaneous emission (ASE) thresholds (0.9–1.1 μJ $cm^{-2}$) in the deep blue region. Computational studies attribute these excellent properties to extended π-conjugation and high HOMO-LUMO overlap enhancing oscillator strengths.

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1. Sugai, Y., et al., *End Cap Effect on Solution-Processable Deep Blue Lasing Materials with Low-Amplified Spontaneous Emission Thresholds*. ACS Applied Materials & Interfaces, 2024. **16**(35): p. 46506-46515.
2. Choi, E.Y., et al., *Photophysical, amplified spontaneous emission and charge transport properties of oligofluorene derivatives in thin films*. Physical Chemistry Chemical Physics, 2014. **16**(32): p. 16941-16956.
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5. Mamada, M., et al., *Impact of Host–Emitter Interactions on Light Amplification in Laser Dyes*. Aggregate, 2025. **6**(5): p. e70030.

Mia Whittaker received her 1st Class Honours of BSc with dual degrees in Chemistry and Mathematics from The University of Queensland, Australia, in 2024. Currently, she is a PhD student at The University of Queensland, working on the development of advanced organic optoelectronics materials under the supervision of A. Prof. Shih-Chun Lo and A. Prof. Ebinazar Namdas.

# Atomically precise halogenated nanographenes via bottom-up chemical synthesis

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**Abstract:**

Graphene has attracted significant scientific interest as an electrode material for lithium-ion batteries due to its remarkable physical and electrical properties. However, its practical application as a carbon-based anode has been limited by issues such as poor structural control and the tendency of graphene sheets to restack. To enhance its performance, various modification strategies have been explored, including edge functionalization and the introduction of electron-donating or electron-withdrawing groups. Among these, group 7A elements have emerged as particularly promising due to their high electronegativity and strong electron-withdrawing nature, which can further optimize the electronic and structural characteristics of the material.

In this study, we investigated nanographenes with edge-substituted group 7A elements as anode materials for lithium-ion batteries. These halogenated nanographenes were synthesized via a bottom-up organic approach to ensure precise structural control. Our findings demonstrate that incorporating halogen atoms at the edges of nanographenes not only modifies their structural and electronic features but also enhances their stability, reactivity, and lithium-ion storage capacity. Detailed spectroscopic analysis revealed that the charge polarization induced by halogens plays a key role in regulating lithium-ion transport, charge transfer energy, and storage behavior. This work presents a novel molecular design strategy for developing advanced nanographene-based anodes for next-generation lithium-ion batteries.

**References:**

1. Baskoro, F., et al., *Lithium-Ion Dynamic and Storage of Atomically Precise Halogenated Nanographene Assemblies via Bottom-Up Chemical Synthesis*. ACS Applied Materials & Interfaces, 2024. **16**(22): p. 29016-29028.
2. Wong, H.Q., et al., *Electroactive Carbazole-Based Polycyclic Aromatic Hydrocarbons: Synthesis, Photophysical Properties, and Computational Studies*. ACS Omega, 2024. **9**(27): p. 29379-29390.

Dr. Hui Qi Wong earned her Ph.D. in Chemical Engineering from National Taiwan University in 2024, and is currently a postdoctoral research fellow at Academia Sinica, Taiwan. Her research mainly focuses on the synthesis of functional, structurally defined nanographenes for energy storage and optoelectronic applications.

# Spin light-emitting diodes enabled by distorted perovskitoids heterointerface

Yuting Xu*, Weidong Xu

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**Abstract:**

Low-dimensional chiral halide perovskites have recently emerged as promising candidates for spin-polarized optoelectronic devices such as spin light-emitting diodes (spin-LEDs). This largely benefits from the chiral-induced spin selectivity (CISS) imposed by organic cations, allowing spin generation without stringent external condition.[1] However, simultaneously attaining high optical polarization and efficient electroluminescence remains a major challenge. This is largely due to the short spin lifetime and the inherent trade-off between spin selectivity and radiative recombination in low-dimensional chiral perovskites.[2,3] Herein, we address these critical challenges by achieving distinct chirality and spin selectivity in three-dimensional (3D) $FAPbI_3$ emitters. This result is enabled by epitaxial growth of a heterostructure that combines a highly distorted one-dimensional (1D) chiral perovskitoids with 3D perovskites, leading to centro-asymmetric distortion and Rashba band splitting in $FAPbI_3$. It thus results in a record-high dissymmetry factor for circularly polarized electroluminescence reaching 0.376, alongside external quantum efficiencies over 14%. Further investigations suggest that this remarkable performance is also contributed to a spin transfer process from the long-lived spin states in 1D chiral perovskitoids. The spin-generation in 3D perovskites also results in a broad and asymmetric optical response spanning the entire visible region, enabling promising performance for circularly polarized light detection. Our work demonstrates the promise of chiral material design and heterostructure engineering in boosting the performance of chiral perovskite-based spintronic applications such as quantum communications.

**References:**

1. Long, G., et al., *Spin control in reduced-dimensional chiral perovskites*. Nature Photonics, 2018. **12**(9): p. 528-533.
2. Kim, Y.-H., et al., *Chiral-induced spin selectivity enables a room-temperature spin light-emitting diode*. Science, 2021. **371**(6534): p. 1129-1133.
3. Yao, J., et al., *Efficient Green Spin Light-Emitting Diodes Enabled by Ultrafast Energy- and Spin-Funneling in Chiral Perovskites*. Journal of the American Chemical Society, 2024. **146**(20): p. 14157-14165.

Yuting Xu is currently a Ph.D. candidate at Northwestern Polytechnical University under the supervision of Prof. Weidong Xu. Her research focuses on spin-optoelectronic devices based on chiral perovskite materials.

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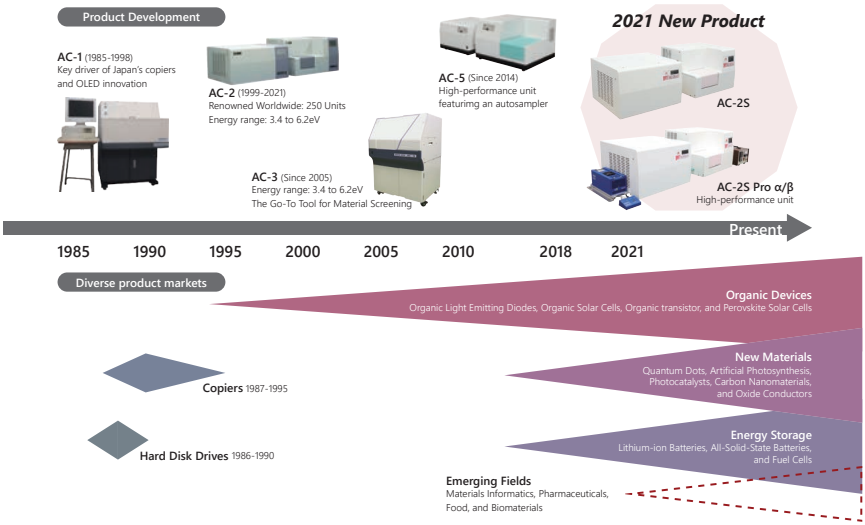

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## ▼ Usage example ▼

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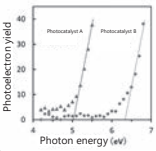
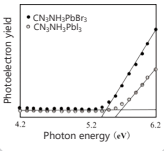


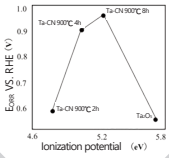

Finding a correlation between ionization potential and catalytic performance.

**Perovskite solar cells**




Reaction mechanism is determined from the difference in threshold values, which is an indicator of energy conversion efficiency improvement.

**Fuel cell electrocatalysts**




Contributed to the elucidation of the relationship between ionization potential and redox potential.

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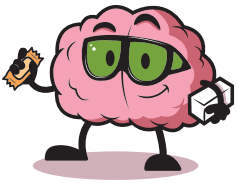

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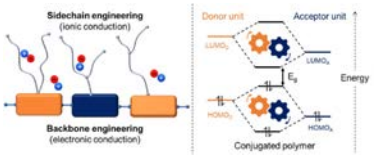
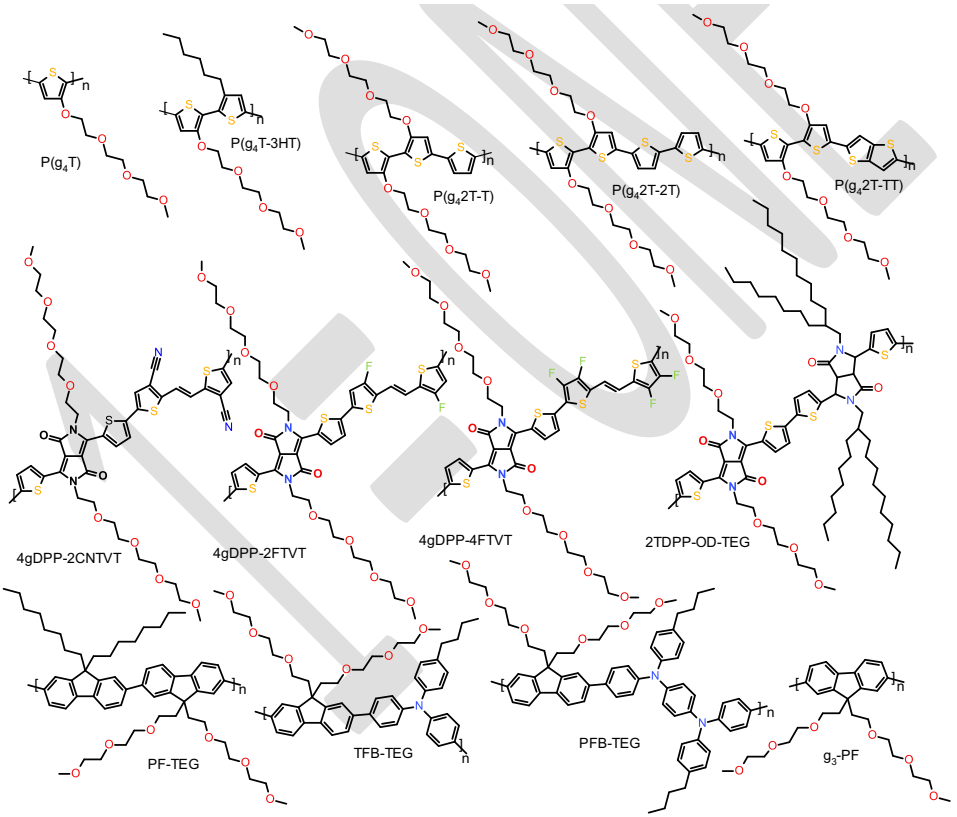
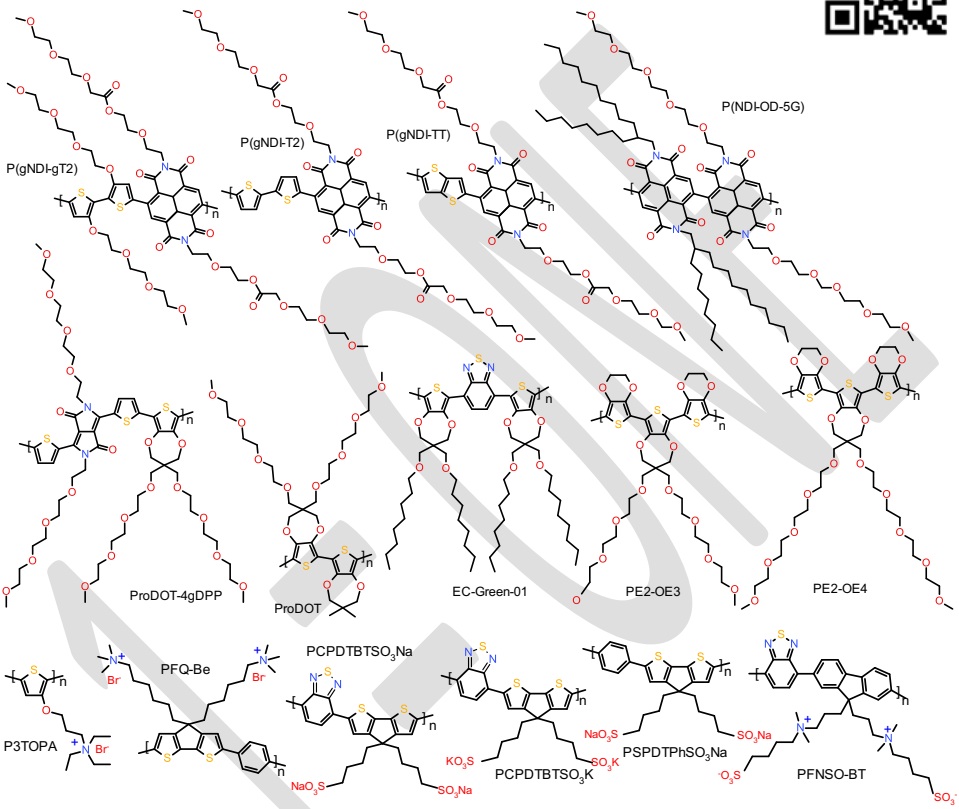





Organic mixed ionic-electronic conductors (OMIEC), exhibiting both ion and electron/hole conductivity, with ionic-electronic coupling (i.e., capacitance) allowing them to effectively transduce ionic signals to electronic ones, and vice versa, are found applications in energy storage, electrochromic displays, bioelectronics, sensors, electrocatalysis, neuromorphic devices, thermoelectric, and actuators. Structured below are examples of polymeric mixed conductors from 1-Material Inc.



## Examples of 1M Mixed ionic-electronic conductors (OMIEC)




Despite many organic mixed ion-electronic conductors (OMIEC) have been explored, challenges remain in characterizing and modeling the dynamic relationship among electronic transport, ionic transport, and material structure during device operation. As exampled above, we have demonstrated flanking conjugated backbones with long glycol side chains may enhance their interaction with hydrated ions and water and therefore facilitate electrochemical switching in aqueous solutions. We can also custom make other ion-electron transporting polymers for your specific needs. Furthermore, all building blocks exampled in the above are available for you to construct structures you may design. For more information, please contact info@1-material.com