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應用物理及材料工程研究院
INSTITUTO DE FÍSICA APLICADA E ENGENHARIA DE MATERIAIS
INSTITUTE OF APPLIED PHYSICS AND MATERIALS ENGINEERING

IAPME Newsletter

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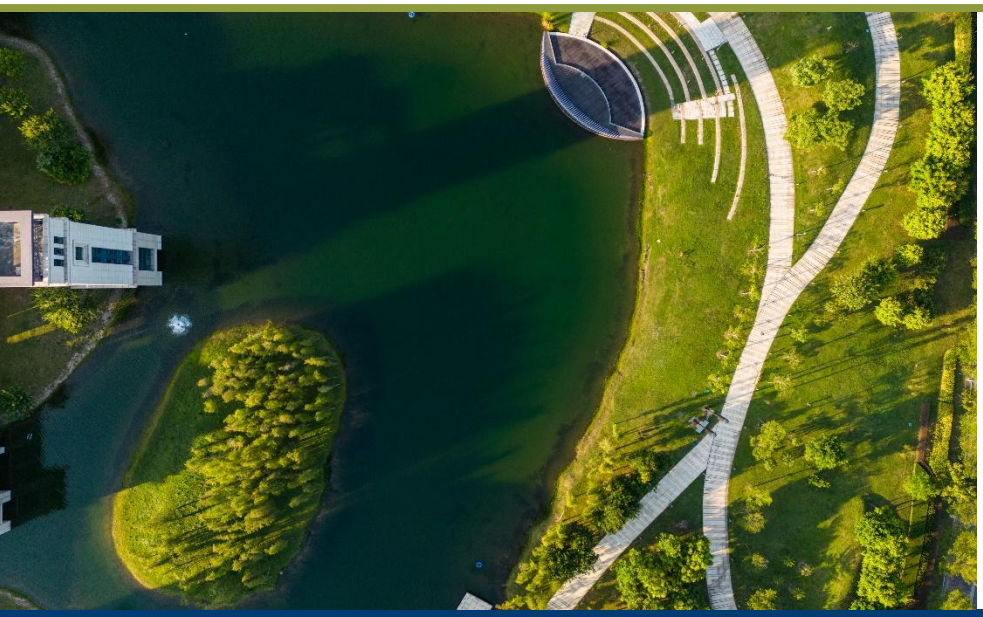

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✧ Content

❖ Publications (IF≥8, and/or Nature Index; *corresponding author)

1. **Qingcheng Wang**, **Quansheng Cheng**, Bingzhe Wang, Tesen Zhang, Yupeng Liu, Ruifeng Zheng, Shi Chen, Guichuan Xing, **Songnan Qu***. From Exciton Dynamics to Cell Fate: A Carbon Dot Based NIR Photocatalytic Platform for Pyroptosis via Self-Trapped Excitons. *Advanced Functional Materials*, e10756 (2025). DOI:10.1002/adfm.202510756. [2025 IF=19.0]

RESEARCH ARTICLE

ADVANCED FUNCTIONAL MATERIALS
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From Exciton Dynamics to Cell Fate: A Carbon Dot Based NIR Photocatalytic Platform for Pyroptosis via Self-Trapped Excitons

*Qingcheng Wang, Quansheng Cheng, Bingzhe Wang, Tesen Zhang, Yupeng Liu, Ruifeng Zheng, Shi Chen, Guichuan Xing, and Songnan Qu**

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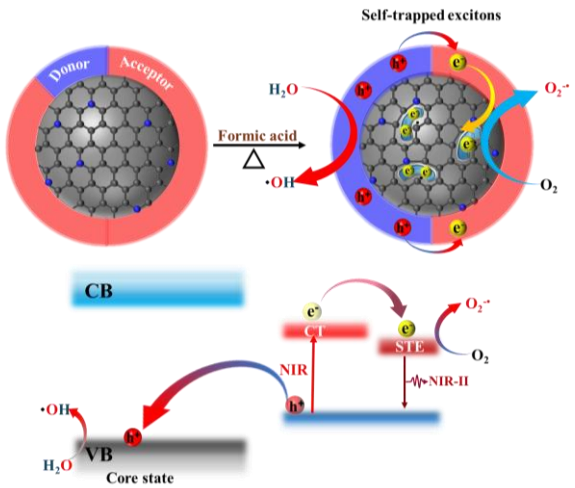
❖ Research Stories

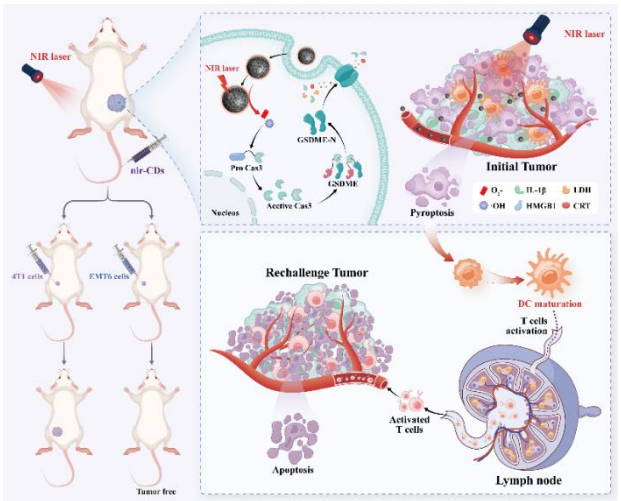
UM research team successfully develops NIR Photocatalytic Platform for Pyroptosis via Self-Trapped Excitons

- The research team resolves rapid charge recombination in carbon-based systems by leveraging self-trapped excitons (STE), bypassing conventional radiative pathways. This strategy enhances electron utilization efficiency for photocatalysis, offering a generalizable approach to modulate electron-phonon coupling in nanomaterials.
- As the first carbon dot system enabling simultaneous •OH and O_2^{-}• generation under NIR irradiation, our platform achieves tumor-specific enrichment and rapid metabolic clearance. Its metal-free composition and deep-tissue penetration address biocompatibility limitations of existing photocatalytic materials.

(From left) Mr. Qingcheng Wang (王青城), Mr. Quansheng Cheng (程全勝), Prof. Songnan Qu (曲松楠)

- The STE-mediated "radical storm" triggers caspase-3/GSDME pyroptosis, leading to near-complete tumor regression in vivo. By linking exciton dynamics to immunogenic cell death, we establish a new paradigm for phototherapy, supported by 100% recurrence prevention via antitumor immunity activation.





Qingcheng Wang, **Quansheng Cheng**, Bingzhe Wang, Tesen Zhang, Yupeng Liu, Ruifeng Zheng, Shi Chen, Guichuan Xing, **Songnan Qu***. From Exciton Dynamics to Cell Fate: A Carbon Dot Based NIR Photocatalytic Platform for Pyroptosis via Self-Trapped Excitons. *Advanced Functional Materials*, e10756 (2025). DOI:10.1002/adfm.202510756. [2025 IF=19.0]

Prof Songnan Qu is the corresponding authors of this study. The first author are Qingcheng Wang and Quansheng Cheng, PhD students in the IAPME. This project was funded by Science and Technology Development Fund of Macau SAR (0139/2022/A3, 0002/2024/TFP, 0007/2021/AKP, 0005/2024/AKP), and University of Macau – Dr. Stanley Ho Medical Development Foundation "Set Sail for New Horizons, Create the Future" Grant 2025 （SHMDF-OIRFS/2025/001）and the National Natural Science Foundation of China (62205384).

❖ Seminars

Prof. Zexiang Shen (申澤襄), School of Physical and Mathematical Sciences, Nanyang Technological University in Singapore, visited IAPME on 26-27 June, 2025. During his visit, he delivered an insightful presentation titled "Engineering few-layer 2D Materials and Perovskites and their Applications". The seminar was hosted by Prof. Handong Sun.

Prof. Shen is Full Professor of Physics in Nanyang Technological University (NTU). He serves as Associate Dean for interdisciplinary research, Graduate College. He is the Co-Director of Centre for Disruptive Photonics Technologies. He also holds a joint appointment at School of Materials Science and Engineering. Prof. Shen's current research work involves spectroscopic and theoretical study of graphene, 2D materials and hybrid perovskites using ultra-low wavenumber Raman spectroscopy, photoluminescence and time resolved spectroscopy in combination with high pressure and low temperature. He is a winner of NTU Nanyang Award for Research and Innovation, Gold Medal for Research Excellence by Institute of Physics Singapore, Honorary Professor of Moscow State University, etc.

In his talk, Prof. Shen first introduced the optical and electronic structures of two-dimensional (2D) materials and perovskites. The properties can also be tuned by stacking configuration, which allows us to build electro and optical devices with the same material and the same thickness. Raman/Photoluminescence (PL) spectroscopy and imaging have been extensively used in the study of nano-materials and nano-devices. They provide critical information for the characterization of the materials such as electronic structure, optical property, phonon structure, defects, doping and stacking sequence. Electrical experiments and ab initio calculations reveal that difference in the electronic structures mainly arises from competition between spin-orbit coupling and interlayer coupling in different structural configurations.

During the visit to IAPME, Prof. Shen has exchanged ideas with members of Prof. Handong Sun's group.

❖ Seminars

On July 4, 2025, the Institute of Applied Physics and Materials Engineering (IAPME) welcomed Prof. Mingzhen Liu (劉明偵) from the University of Electronic Science and Technology of China (UESTC) for a cutting-edge seminar titled "Regulating Carrier Transport toward Highly Efficient Perovskite-based Tandem Solar Cells" Hosted by Prof. Guichuan Xing, the event drew the attention and attendance of over 30 faculty members, researchers, and students.

Prof. Liu, an internationally recognized expert in perovskite photovoltaics and Royal Society of Chemistry Fellow, unveiled breakthrough strategies for achieving >34% certified efficiency in perovskite/silicon tandem devices. She detailed molecular-level innovations in charge transport layer design and conformal perovskite crystallization on textured silicon substrates—critical for industrial scalability. Her talk emphasized overcoming interfacial charge transfer limitations, a major bottleneck in commercializing tandem technology.

Following the presentation, attendees engaged in a dynamic Q&A session, with heated exchanges on carrier dynamics optimization, triple-junction cell architectures, and flexible tandem applications. Doctoral candidates and IAPME's device engineering group particularly explored synergies with ongoing projects in perovskite light-emitting devices and vacuum-evaporated micro-displays.

This seminar strengthened academic ties with UESTC while spotlighting IAPME's leadership in advanced energy materials. Prof. Liu's insights will inform collaborative R&D pathways for high-efficiency photovoltaics, aligning with Macau's green technology initiatives.