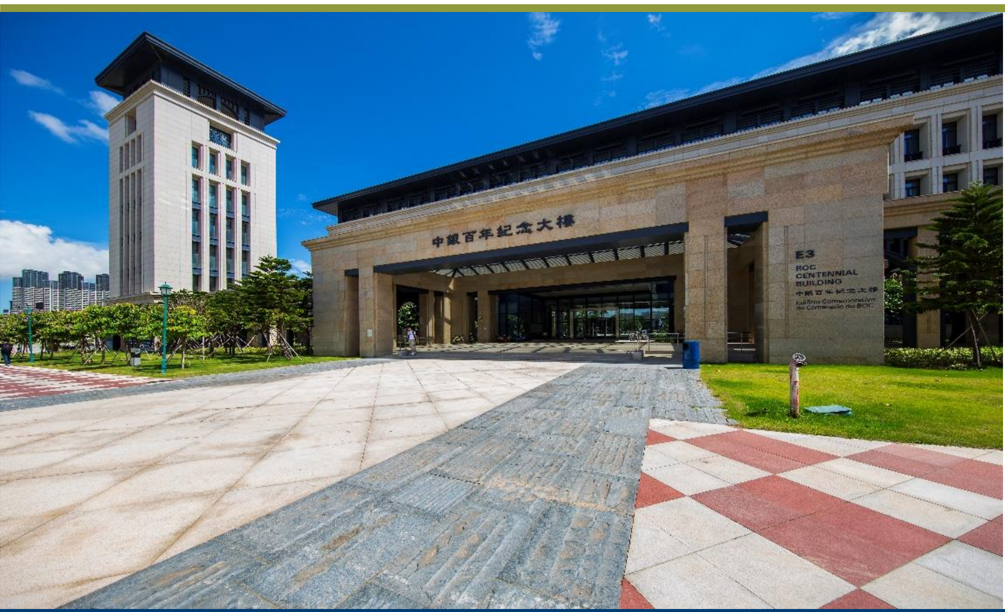
澳門大學
UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

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

https://iapme.um.edu.mo/



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Content

❖ Publications (IF≥10; *corresponding author)

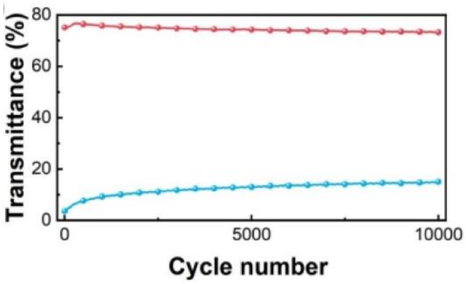
1. **Zhisheng Wu**, Zhendong Lian, Ting Ding, Jielei Li, Jincheng Xu, Jinxiao Wang, Liangxing Zhang, Bo Wang, Shi Chen, Peng Xiao, Hua Xu, **Shuang-Peng Wang*** and **Kar Wei Ng***. Inhibiting the phase transition of WO3 for highly stable aqueous electrochromic battery. *Journal of Energy Chemistry,* 95, 86-95 (2024). DOI:10.1016/j.jechem.2024.03.029. [2023 IF=14.0]

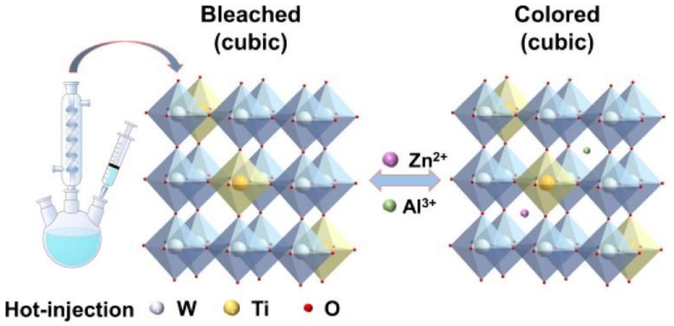
❖ Research Stories

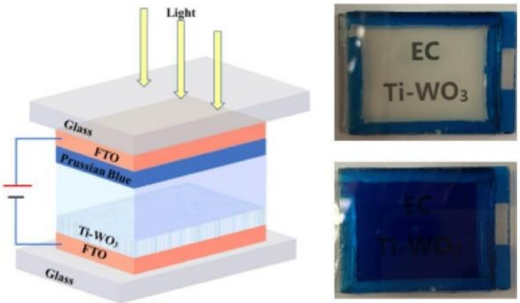
UM research team developed novel electrochromic materials for smart windows

- Tungsten oxide (WO_3) is one of the most promising electrochromic (EC) materials for making smart windows, which can reduce the energy consumption for light and heat regulation in buildings. However, WO_3 is unstable when working in an aqueous environment due to the repeated phase transition during the redox process
- By alloying WO_3 with titanate, the team has successfully synthesized novel Ti-WO_3 nanostructures that can maintain the cubic crystal phase throughout the whole coloring-bleaching process. The stability of the EC material has increased significantly from ~ 200 to > 20000 operation cycles, which is good enough to be used in commercial products.
- The team further developed, for the first time, a fully complementary aqueous electrochromic device, using a Ti-WO_3/Prussian Blue architecture. The full device not only shows > 10000 stable operation cycles, but also exhibits remarkable energy storage capability (39.56 mA h m^{-2}). These exciting results highlight the dual-functionality of the device, which makes it attractive for energy storage applications.

(From left) Prof. Shuangpeng Wang, Dr. Zhisheng Wu and Prof. Kar Wei Ng







Zhisheng Wu, Zhendong Lian, Ting Ding, Jielei Li, Jincheng Xu, Jinxiao Wang, Liangxing Zhang, Bo Wang, Shi Chen, Peng Xiao, Hua Xu, **Shuang-Peng Wang*** and **Kar Wei Ng***. Inhibiting the phase transition of WO3 for highly stable aqueous electrochromic battery. *Journal of Energy Chemistry,* 95, 86-95 (2024). DOI:10.1016/j.jechem.2024.03.029. [2023 IF=14.0]

Prof. Shuangpeng Wang and Prof. Kar Wei Ng are the corresponding authors of this study. The first author is Dr. Zhisheng Wu, who obtained his PhD from IAPME in 2024. This work was supported by the Science and Technology Development Fund, Macao SAR (File no. 0052/2021/AGJ, 0027/2023/AMJ, 0083/2023/ITP2 and 0107/2023/AFJ), the Multi-Year Research Grants (MYRG2022-00063-IAPME, MYRG-GRG2023-00230-IAPME-UMDF) from the University of Macau, the Guangdong Science and Technology Plan (2022A0505020022), and the Major Science and Technology Research and Development Project of Jiangxi Province (20223AAE01003).

❖ Seminars

Prof. Huiyun Liu, Chair Professor of Semiconductor Photonics at University College London, UK, delivered a seminar titled "Quantum-dot laser technology: the key for Si-based lasers for Si photonics" on 08 November 2024.

Prof. Huiyun Liu received his PhD from form Institute of Semiconductor, Chinese Academy of Sciences in 2001. After receiving his PhD, he joined the EPSRC National Centre for III-V Technologies at Sheffield University. In 2007, he was awarded Royal Society University Research Fellow, and started his academic career by taking Senior Lecturer position in the Department of Electronic and Electrical Engineering at University College London with commissioning the first new Molecular Beam Epitaxy reactor in London, and creating a new group. In 2012, he was promoted as Chair Professor of Semiconductor Photonics at University College London. His current research interest concentrates on the nanometre-scale engineering of low-dimensional semiconductor structures by using Molecular Beam Epitaxy and the development of novel optoelectronic devices including lasers, detectors, solar cells, and modulators on Si platform. He co-authored more than 500 papers and hold on several patents on silicon photonics and quantum dot technology.

Prof. Liu first introduced the importance of silicon based photonics. He pointed out that direct epitaxial growth of III-V nanostructures on silicon substrates is one of the most promising candidates for realizing photonic devices on a silicon platform. The major issue of monolithic integration of III-V on Si is the formation of high-density threading dislocations. The propagation of thread dislocations (TDs) will cause high ratio of non-radiative recombination centre in III-V epitaxial active region. To stop the TD propagation, different epitaxial strategies, such as InGa(Al)As strain layer, Ge buffer layers and patterned substrates have been applied and compared in this presentation. As a zero-dimensional material, quantum dots (QDs) have three-dimensional quantum confinements, which create delta-function like density of states. Therefore, III-V QD lasers have low threshold currents, temperature insensitive operation, and less sensitivity to threading dislocations, which are the ideal candidate to form active region in III-V lasers grown on group IV substrates. 1300-nm InAs/GaAs QD lasers grown on Si and Ge substrates have been proposed and developed since 2011 at UCL with long lifetime and high power. In this presentation, the development milestones of InAs/GaAs QD lasers monolithically grown on a Si platform were summarised, and the potential trend in next few years is predicted.

After the talk, Prof. Liu had in-depth discussion with faculty members, postdoc researchers and graduate students.

❖ Upcoming Events

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IAPME Seminar

Decouple electron and phonon transport for high-performance thermoelectrics

20 November 2024

Prof. Jiaqing HE
Southern University of Science and Technology
Venue: N23-4018
Time: 15:00 - 16:00
Hosted by: Prof. Haifeng LI

Abstract

Thermoelectrics enable direct heat-to-electricity transformation, but their performance has so far been restricted by the closely coupled electron and phonon transport. The figure of merit, *ZT*, is the essential measure of thermoelectric performance and can be calculated by $ZT = S^2\sigma T/\kappa$, where S, σ, κ, and T are Seebeck coefficient, electrical conductivity, total thermal conductivity and absolute temperature, respectively. Although established strategies to optimize *ZT* usually treat electrical and thermal properties separately, enhancing *ZT* requires simultaneous optimization of the adversely interdependent S, σ, and κ, which is challenging because most crystal imperfections are believed to scatter both phonons and electrons. This presentation will show that the power factor ($S^2\sigma$) can be boosted by trap hole release and energy-band engineering including band convergence. The total thermal conductivity can be suppressed by the introduction of all scale defects, high entropy, quantum gap and so on, which provide general methods for boosting their thermoelectric performance. It will also illustrate three examples (PbQ, GeTe, and $AgCrSe_2$) of emerging excitements in nanostructured materials and systems for thermoelectric materials. It will highlight the role of advanced and classical electron microscopy in unravelling the hierarchical architecture of the constituents and their intimate interplay in governing key phenomena in thermoelectric materials.

Biography

Prof. Jiaqing HE is a Chair Professor in the Department of Physics at Southern University of Science and Technology and the Director of the Research Department. He is also a Fellow of the American Physical Society. He obtained his Bachelor's degree in Physics from Wuhan University in 1998 and his Ph.D. in Physics from a joint program between Wuhan University and the Jülich Research Centre in Germany in 2004. From 2004 to 2012, he worked at Brookhaven National Laboratory and Northwestern University in the United States. His primary research focuses on transmission electron microscopy, thermoelectric materials, and the correlation between structure and properties. He has published over 300 high-impact SCI journal papers, including eight in Science and three in Nature, with nearly 40,000 citations and an H-index of 93. He has applied for 52 domestic and international patents, of which 32 have been granted.

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