Prof. Gang LI

Sir Sze-yuen Chung Endowed Professor in Renewable Energy

Chair Professor of Energy Conversion Technology

Professor of Department of Electrical and Electronic Engineering

Highly Cited Researcher:

2014-2023 *Clarivate Analytics*

"Passion and perseverance can lead to amazing success, and to the reward of seeing your research being linked to applications."

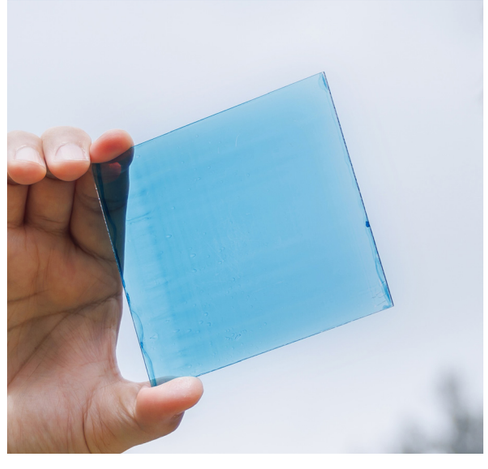
Innovation to Stimulate Cutting-Edge Science

Unwavering perseverance drives scientists to achieve groundbreaking discoveries, inspiring further advancement in frontier research.

Prof. LI Gang, Chair Professor of Energy Conversion Technology and Sir Sze-Yuen Chung Endowed Professor in Renewable Energy at The Hong Kong Polytechnic University, has contributed to research in polymer solar cells. His pioneering contributions to research in this field have brought sustainable influence on printable solar energy development with global recognition.

Prof. LI said, "Being recognised on a global level is a great honour that I deeply value. This always encourages me to continuously pursue excellency in scientific research."

Silicon-based solar cells have become ubiquitous, but their high production cost and lack of flexibility present limitations. "Plastic" photovoltaics based on organic polymers — or organic photovoltaics (OPV) — are a promising alternative with potential for cheap fabrication as thin flexible films.



Pioneering breakthroughs

In the early 2000s when interest in organic photovoltaics was starting to pick up, the field was essentially 50 years behind silicon.

"Silicon is of course a great success," said Prof. LI, who previously studied condensed matter physics before the research on OPVs. "But OPVs were always interesting because of their versatility — they can be transparent, flexible and portable, and so could be used in many different applications, such as on windows and in buildings."

When Prof. LI started research on OPVs, silicon-based cells had already reached energy conversion efficiencies of 20% or more, while researchers in the OPV field were still grappling with basic polymer morphology and fabrication challenges at efficiencies of just a few percent.

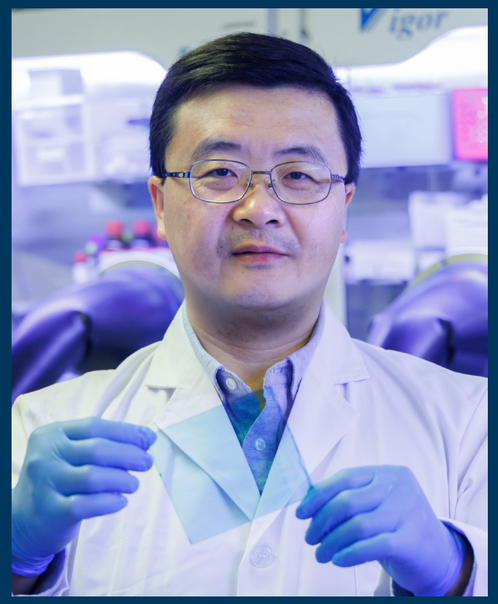
"It was then that we made the first major breakthrough, developing a replicable structure and fabrication process, and setting the standard for performance testing and efficiency, hitting a record 4.4% at the time," said Prof. LI.

His landmark 2005 paper published in ***Nature Materials***[1] enshrined OPVs as a standalone field of research and became the go-to reference and benchmark for others to follow, remaining in the journal's top-10 cited papers for more than a decade.

Prof. LI said, "Since 2005, my pioneering and ongoing research contributions in organic solar cells have had a profound influence on the rising and development of this dynamic frontier science field, inspiring younger generations of researchers globally."

Building on that research, Prof. LI led a startup aiming to scale-up to commercial production of these "first-generation" OPVs. "There is a very tight interplay between science and application, and the fabrication side is very important from a scalability perspective," said Prof. LI.

"However, we remained puzzled as to why the energy-conversion efficiency was so low. We could make a sub-micrometre-thin OPV film using inexpensive solution-based processing methods, but without higher efficiency, the technology was never going to be competitive."



Far-Reaching Impacts

Prof. LI then began work on the next generation of OPVs, exploring mixtures of different organic polymers as "co-polymer" systems, which required a completely different molecular design and fabrication approach.

"With this approach we were eventually able to start breaking efficiency records for OPVs on a regular basis," he said. "The next major step change came with the development of "non-fullerene acceptor" technology, which has finally lifted the performance of OPVs to levels competitive with silicon."

Fullerenes, soccer-ball-shaped molecules built of carbon atoms, had been part of the OPV landscape since the beginning, being the only viable "acceptor" molecules that could collect the light-excited electrons to create an electrical current. However, fullerenes only work over a very limited range of electron energies, which imposed tight restrictions on the efficiency of OPV cells.

The discovery of non-fullerene molecular systems that can be tuned over a wide range of energies has now opened the door to a new world of material options and has brought renewed acceleration in efficiency increases.

"Our review paper in ***Nature Photonics***[4] on OPVs using non-fullerene acceptors has become the second highest cited paper published in the journal since 2018, and we have just recently reported a new efficiency record for a binary system of 19.3% in ***Nature Communication***[6]," said Prof. LI. "By further evolving the materials and reducing losses via device engineering, we believe we are well on the way to 25%, which will put the efficiency on par with silicon, and really support the commercialisation of OPVs."

"Scientific research is a journey, with ups and downs, and happy and hard times," said Prof. LI. "But passion and perseverance can lead to amazing success, and to the reward of seeing your research being linked to applications."

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Reference: https://www.nature.com/articles/d42473-023-00143-3

Research Interests

Organic Semiconductor, Perovskite based Optoelectronic and Energy Devices, Solar Cells, LEDs, Photodetectors

Selected Publications

1. G. Li, V. Shrotriya, J. Huang, Y. Yao, et. al., High-efficiency solution processable polymer photovoltaic cells by self-organization of polymer blends, Nature Materials, 4, 864-868, 2005.
2. G. Li, Y. Liang, Z. Xu, J. Xia, et. al., For the Bright Future—Bulk Heterojunction Polymer Solar Cells with Power Conversion Efficiency of 7.4%, Advanced Materials, vol 22, issue 20, 2010.
3. G. Li, H. Chen, J. Hou, S. Zhang, et. al., Polymer solar cells with enhanced open-circuit voltage and efficiency, Nature Photonics, 3, 649-653, 2009.
4. G. Li, P. Cheng, X. Zhan, Y. Yang, et. al., Next-generation organic photovoltaics based on non-fullerene acceptors, Nature Photonics, 12, 131-142, 2018.
5. G. Li, X. Liu, Z. Zhong, R. Zhu, et. al., Aperiodic band-pass electrode enables record-performance transparent organic photovoltaics, Joule, 6, 1918-1930, 2022.
6. G. Li, J. Fu, WK Fong, H. Liu, et. al., 19.31% binary organic solar cell and low non-radiative recombination enabled by non-monotonic intermediate state transition, Nature Communications, 14, 1760, 2023.