The Development of Record-high Efficiency in Perovskite/Silicon Tandem Solar Cells

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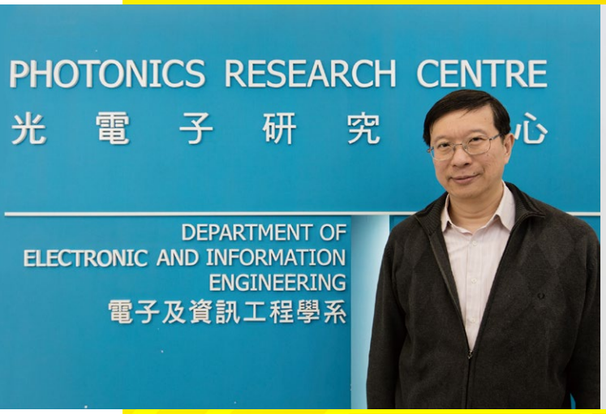
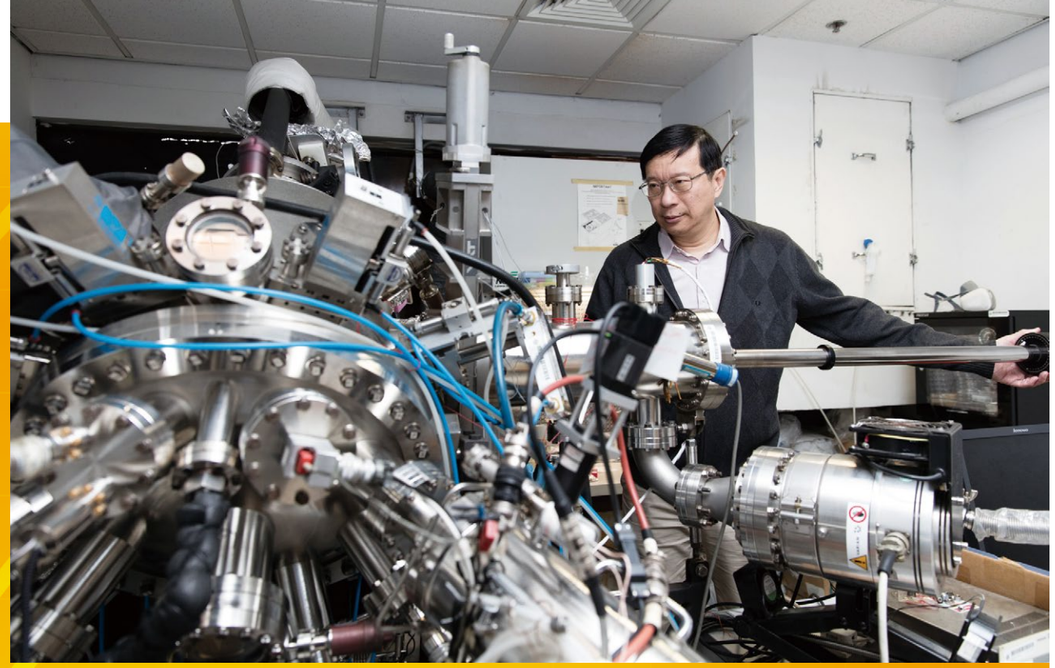


The development of cost-effective solar cells is one of the most important grand challenges for the 21st Century. This is because continued reliance on fossil fuels for power generation will result in serious contamination of the environment with devastating consequences. It is this sense of urgency that has prompted our research group to dedicate our effort to the investigation of energy-related optoelectronic materials and devices.

Professor Charles Surya, Clarea Au Endowed Professor in Engineering, and his colleagues at the Thin Film Optoelectronics Research Group have taken on this challenge through the study of high-efficiency solar cells. The team has successfully developed perovskite-silicon tandem solar cells with the presently highest power conversion efficiency of 25.5% in the world. With perovskite solar cells first appeared in 2009 with an efficiency of just 3.8%, it has become a subject of vigorous research for sustainable power generation, with researchers around the world finding new ways to increase its energy conversion efficiency. It has established itself as one of the most promising solar cell materials. The research team in the Department of Electronic and Information Engineering led by Professor Surya made this world record with innovative means to enhance energy conversion efficiency. With this innovation, solar energy can be generated much more cost effectively.



As there are different wavelengths for solar energy, a combination of different materials for making solar cells would work best for energy absorption. For example, methylammonium lead tri-halide perovskites and silicon solar cells can form a complementary pair with the large-bandgap perovskite solar cell functioning as a top cell responsible for harvesting the short wavelength photons while the bottom Si solar cell is designed to absorb the long wavelength photons. PolyU's research team maximizes efficiency by making use of this feature with three innovative approaches. Firstly, the team discovers a low-temperature annealing process in dry oxygen to reduce perovskite defects. Secondly, together with Dr Zijian Zheng of the Institute of Textiles and Clothing of PolyU, they develop a haze film, which includes extracts from rose petals to be "painted" as the top layer of the solar panel, to trap more light and improve the current of the solar cells. Finally, the team fabricates a tri-layer of molybdenum trioxide / gold / molybdenum trioxide with optimized thickness of each layer, making it highly transparent for the bottom Si solar cell. All three innovative approaches help enhance energy conversion efficiency. Another important aspect that contributes significantly to the success of the project is through the collaboration with Professor Shen Hui of Sun Yat-sen University and Shun De SYSU Institute for Solar Energy, who excelled in the fabrication of high-efficiency silicon cells, as he was responsible for the design and fabrication of the high efficiency bottom silicon cell.

The team will continue to improve the performance of large-scale fabrication for perovskite-silicon solar cells.