New study presents efficient, solution-processed, hybrid tandem solar cells

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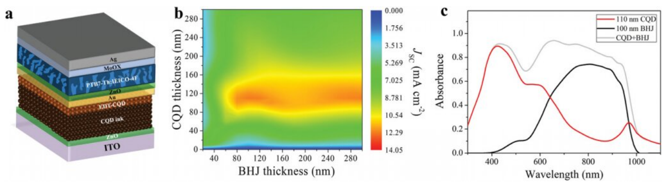

A) Structure of hybrid tandem photovoltaic device. b) Simulated JSC of hybrid tandem devices by TMF optical simulation with various sub?cell thicknesses. c) Simulated absorption of subcells in the hybrid tandem device with optimum thicknesses. Credit: UNIST

Colloidal quantum dot (CQD) solar cells have attracted considerable attention due to the advantages of being flexible and lightweight. Additionally, they are much easier to manufacture compared to commercial silicon solar cells in use today. Now, researchers report a novel technology capable of maximizing the performance of the existing CQD solar cells.

The team, led by Professor Sung-Yeon Jang in the School of Energy and Chemical Engineering at UNIST, has developed solution-processed, hybrid series, tandem photovoltaic devices with high efficiency featuring CQDs and organic bulk heterojunction (BHJ) photoactive materials. The absorption of the organic back cell effectively compensated the optical loss in the CQD front cell, which improved the overall photon harvesting.

Quantum dots (QDs) are semiconductor particles smaller than a few nanometres. As they have interesting characteristics such as size-dependent emission wavelength, the absorption spectra of the solar cell is quite changeable. In other words, the advantage of QDs is that they absorb light in the near-infrared (NIR) region, which other photoactive layers cannot. However, there are some areas in the NIR region where light absorption does not occur, even with QDs.

The researchers developed their photoactive QD technology to compensate for the external quantum efficiency (EQE) loss in the NIR region. The NIR-absorbing organic BHJ devices were employed as the back sub-cells to harvest the transmitted NIR photons from the CQD front sub-cells.

In addition, the team optimized the short-circuit current density balance of each sub-cell, and thus created a near ideal series connection using an intermediate layer to achieve a power conversion efficiency (PCE) that is superior to that of each single-junction device. Indeed, the PCE (12.82%) of the hybrid tandem device was the highest among the reported CQDPVs, including single-junction devices and tandem devices, according to the research team. The researchers write, "This study suggests a potential route to improve the performance of CQDPVs by proper hybridization with NIR-absorbing photoactive materials."

Furthermore, the new hybrid tandem solar cells are manufactured at room temperature and use a solution process for easy manufacturing. As a result, this solar cell is affordable, more economical, and lower cost compared to silicon solar cells. Their lower manufacturing costs also give them a clear advantage for mass production.

"The hybrid tandem device exhibited almost negligible degradation after air storage for three months," says Professor Jang. "Moreover, this study suggested the potential to achieve PCE > 15% in hybrid tandem devices by reduction of energy loss in CQDPVs and enhancement of NIR absorption in OPVs."

More information: Havid Aqoma et al, Efficient Hybrid Tandem Solar Cells Based on Optical Reinforcement of Colloidal Quantum Dots with Organic Bulk Heterojunctions, *Advanced Energy Materials* (2020). DOI: 10.1002/aenm.201903294

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