New quantum dot approach can enhance electrical conductivity of solar cells

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A team led by Professor Jongmin Choi of the Department of Energy Science and Engineering has developed a PbS quantum dot that can rapidly enhance the electrical conductivity of solar cells. The findings are published in the journal *Small*.

The team identified a method to enhance electrical conductivity through the use of "pulse-shaped" light, which generates substantial energy in a concentrated manner at regular intervals. This method could replace the heat treatment process, which requires a significant amount of time to achieve the same result. This approach is expected to facilitate the production and commercialization of PbS quantum dot solar cells in the future.

PbS quantum dots are nanoscale semiconductor materials that are being actively researched for the development of next-generation solar cells. They can absorb a wide range of wavelengths of sunlight, including ultraviolet, visible light, near-infrared, and shortwave infrared, and have low processing costs because of solution processing and excellent photoelectric properties.

The fabrication of PbS quantum dot solar cells involves several process steps. Until recently, the heat treatment process was considered an essential step as it effectively coats a layer of quantum dots onto a substrate and heat-treats the material to further increase its electrical conductivity.

However, when PbS quantum dots are exposed to light, heat, and moisture, the formation of defects on their surface can be accelerated, leading to charge recombination and deterioration of device performance. This phenomenon makes it challenging to commercialize these materials.

To suppress the formation of defects on the surface of PbS quantum dots, a team led by Professor Choi proposed a heat treatment involving the exposure of the dots to light for a brief period of a few milliseconds. Conventional techniques for heat-treating PbS quantum dot layers involve heating them for tens of minutes at high temperatures using hot plates, ovens, etc.

The research team's proposed "pulse-type heat treatment technique" overcomes the shortcomings of the existing method by using strong light to complete the heat treatment process in a few milliseconds. This results in the suppression of surface defects and the extension of the traveling life of charges (electrons, holes) that generate electric current. Furthermore, it achieves high efficiency.

"Through this research, we were able to improve the efficiency of solar cells by developing a new heat treatment process that can overcome the limitations of the existing quantum dot heat treatment process," said Professor Choi of the Department of Energy Science and Engineering at DGIST.

"Furthermore, the development of a quantum dot process with excellent ripple effect is expected to facilitate the widespread application of this technology to a range of optoelectronic devices in the future."

This research was done in collaboration with Professor Changyong Lim of the Department of Energy Chemical Engineering at the Kyungpook National University and Professor Jongchul Lim of the Department of Energy Engineering at the Chungnam National University.

More information: Eon Ji Lee et al, Suppression of Thermally Induced Surface Traps in Colloidal Quantum Dot Solids via Ultrafast Pulsed Light, *Small* (2024). DOI: 10.1002/smll.202400380

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