NREL Highlights

SCIENCE

NREL Certifies First All-Quantum-Dot Photovoltaic Cell; Demonstrates Stability, Performance

Work demonstrates that smaller can be better: quantum confinement can lead to increased PV efficiency and could lead to a doubling of third-generation solar cell efficiencies.

Tiny quantum dots—just a few nanometers in diameter—can do great things when it comes to generating electricity, or perhaps even solar fuels.

Researchers at the National Renewable Energy Laboratory (NREL) have certified the first all-quantum-dot photovoltaic cell, which was based on lead sulfide and demonstrated reasonable quantum dot solar cell performance for an initial efficiency measurement along with good stability. The certified open-circuit voltage of the quantum dot cell is greater than that possible from bulk lead sulfide because of quantum confinement.

These results increase the motivation to explore quantum dots for their capacity to deliver multiple electrons from each photon, a phenomenon that if applied to solar cells could greatly improve—even double—their efficiency.

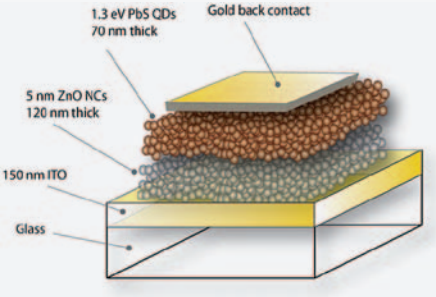
Quantum dots have such great photon-to-electricity potential because when a single photon of light of sufficient energy is absorbed by a quantum dot, it produces more than one bound electron-hole pair, or exciton. The process is called multiple exciton generation, and it was first predicted by NREL researchers. In conventional PV cells with much larger crystals and many more atoms, one photon produces only one electron-hole pair.

The key to the greater multiplication efficiency in quantum dots is that the electron-hole pair is in a confined space—the physical boundaries of the quantum dot. Therefore, they interact strongly and increase the probability of generating multiple excitons.

NREL scientists grow quantum dots via inexpensive colloidal chemistry. Quantum dots are formed when a metal ion chemically reacts with a molecule that donates a different ion.

References: Stability Assessment on a 3% Bilayer PbS/ZnO Quantum Dot Heterojunction Solar Cell. *Advanced Materials* DOI 10.1002/adma.201001148. Published online: June 8, 2010

Comparing Multiple Exciton Generation in Quantum Dots to Impact Ionization in Bulk Semiconductors: Implications for Enhancement of Solar Energy Conversion, *Nano Letters*, v10, pp. 3019, 2010



Key Research Results

Achievement

NREL scientists were the first to certify the stability and performance of an all-quantum-dot device, demonstrating that confining electrons and holes to the tiny space of a quantum dot can lead to increased PV efficiency in solar cells.

Result

The success opens the door to more directed research into the potential benefits of quantum dots and their capacity to generate two electrons from a single absorbed photon in a solar cell.

Potential Impact

The two-electrons-from-one-photon bonus exhibited by a stable quantum dot device could lead to a dramatic increase in the conversion efficiency into electricity in solar cells.

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