NREL Highlights

SCIENCE

Improving PbS Quantum Dot Solar Cell Power Conversion Efficiency to an NREL-Certified 4.4%

Transition metal oxide improves overall efficiency and maintains performance with inexpensive metals.

A research team at the National Renewable Energy Laboratory (NREL) has demonstrated that inserting a transition metal oxide (TMO) between the lead sulfide (PbS) quantum dot (QD) layer and the metal electrode eliminates the Schottky barrier that impedes efficient hole extraction and thereby improves the overall conversion efficiency. This allows for inexpensive metals such as Al to be employed without loss of performance.

n-type TMOs consisting of molybdenum oxide (MoO_x) and vanadium oxide (V_2O_x) were used as an efficient hole extraction layer (HEL) in heterojunction ZnO/PbS QD solar cells. A 4.4% NREL-certified device was reported based on the MoO_x HEL with Al as the back contact material, representing a more than 65% efficiency improvement compared with the case of Au contacting the PbS QD layer directly. The team finds the acting mechanism of the HEL to be a dipole formed at the MoO_x and PbS interface, which enhances band bending to allow efficient hole extraction from the valence band of the PbS layer by MoO_x. The carrier transport to the metal anode is likely enhanced through shallow gap states in the MoO_x layer.

Key Research Results

Achievement

An NREL research team developed a new process that improves the efficiency of PbS quantum dot solar power conversion.

Key Result

By using a transition metal oxide in the quantum dot solar cells, the Schottky barrier was eliminated, allowing for efficient hole extraction.

Potential Impact

By using this process, the overall conversion efficiency of solar cell power is significantly increased. In addition, cost is decreased due to the ability to use less expensive metals without a reduction in performance.

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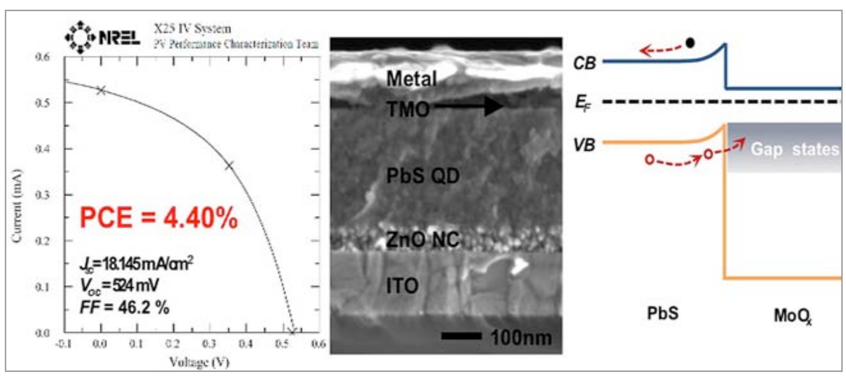
Reference: Jianbo Gao; Craig L. Perkins; Joseph M. Luther; Mark C. Hanna; Hsiang-Yu Chen; Octavi E. Semonin; Arthur J. Nozik; Randy J. Ellingson; Matthew C. Beard. "n-Type Transition Metal Oxide as a Hole Extraction Layer in PbS Quantum Dot Solar Cells." *Nano Letters* 11, 3263 (2011).



Measured I-V characteristics of a 4.4% certified device by NREL (left); scanning electron microscope image of a typical device (middle); schematic energy diagram of interfacial layers PbS/MoO_x, indicating carrier transport directions (right). Images by Jianbo Gao and Matthew Beard, NREL

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