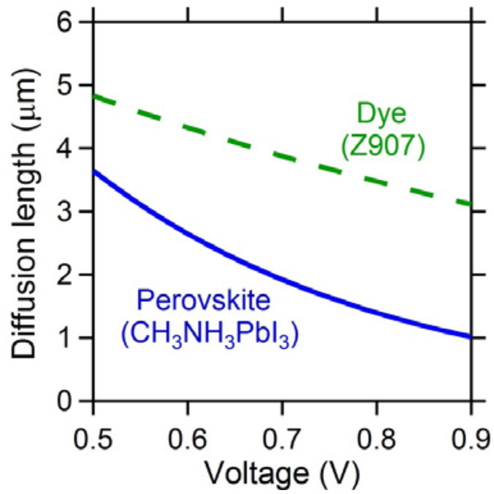
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Investigates Critical Properties of Perovskite Halides Solar Cells

Highlights in Science

Results give insight on a novel, promising class of photoactive materials for solar conversion applications.

Organometallic halide perovskites (e.g., $CH_3NH_3PbI_3$) are a novel class of light-absorbing materials that have demonstrated exceptional progress in solar cell performance. But despite rapid progress in device performance, understanding the structural and electronic properties of halide perovskites is just in its infancy—and obtaining information on charge diffusion length is critical for the development of perovskite solar cells with balanced light harvesting and charge collection. To address this need, researchers at the National Renewable Energy Laboratory (NREL) have reported on the effect of TiO_2 film thickness on charge transport and recombination in solid-state mesostructured perovskite $CH_3NH_3PbI_3$ solar cells using spiro-MeOTAD as the hole conductor.



Comparison of the electron diffusion length for a mesostructured perovskite solar cell and a solid-state dye-sensitized solar cell using 650-nm TiO_2 films.

Intensity-modulated photocurrent/photovoltage spectroscopies show that the transport and recombination properties of solid-state mesostructured perovskite solar cells are similar to those of solid-state dye-sensitized solar cells. Charge transport in perovskite cells is dominated by electron conduction within the mesoporous TiO_2 network rather than from the perovskite layer. Although no significant film-thickness dependence is found for transport and recombination, the efficiency of perovskite cells increases with TiO_2 film thickness from 240 nm to about 650–850 nm, owing primarily to the enhanced light harvesting. Further increasing film thickness reduces cell efficiency associated with decreased fill factor or photocurrent density. The electron diffusion length in mesostructured perovskite cells is longer than 1 micron for over four orders of magnitude of light intensity. The knowledge gained from this study should be valuable for the development of halide perovskite absorbers for solar conversion applications.

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Reference: Zhao, Y.; Nardes, A.M.; Zhu, K. (2014). "Solid-State Mesostructured Perovskite $CH_3NH_3PbI_3$ Solar Cells: Charge Transport, Recombination, and Diffusion Length." *Journal of Physical Chemistry Letters* (5); 490–494. DOI: 10.1021/jz500003v.

Key Research Results

Achievement

NREL investigated the effect of TiO_2 film thickness on charge transport, recombination, and device characteristics of solid-state mesostructured perovskite solar cells.

Key Result

NREL first reported electron diffusion length in mesostructured perovskite solar cells longer than 1 micron for over four orders of magnitude of light intensity.

Potential Impact

The knowledge gained from this study gives insight on a novel class of photoactive materials for high-efficiency solar conversion applications.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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