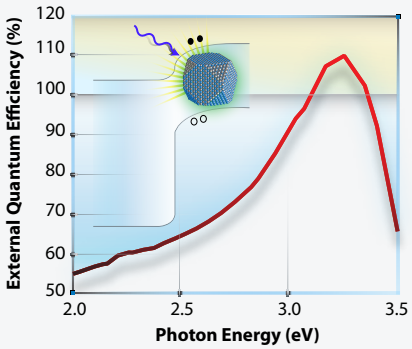
NREL Highlights

SCIENCE

NREL Researchers Demonstrate External Quantum Efficiency Surpassing 100% in a Quantum Dot Solar Cell

A new device that produces and collects multiple electrons per photon could yield inexpensive, high-efficiency photovoltaics.



External quantum efficiency of photon-to-current conversion. Present-day technologies are limited to 100%, whereas this new technology proves that limit can be exceeded.
Illustration by Josh Bauer, NREL

A new device developed through research at the National Renewable Energy Laboratory (NREL) reduces conventional losses in photovoltaic (PV) solar cells, potentially increasing the power conversion efficiency—but not the cost—of the solar cells.

Solar cells convert optical energy from the sun into usable electricity; however, almost 50% of the incident energy is lost as heat with present-day technologies. High-efficiency, multi-junction cells reduce this heat loss, but their cost is significantly higher. NREL's new device uses excess energy in solar photons to create extra charges rather than heat. This was achieved using 5-nanometer-diameter quantum dots of lead selenide (PbSe) tightly packed into a film. The researchers chemically treated the film, and then fabricated a device that yielded an external quantum efficiency (number of electrons produced per incident photon) exceeding 100%, a value beyond that of all current solar cells for any incident photon.

Quantum dots are known to efficiently generate multiple excitons (a bound electron-hole pair) per absorbed high-energy photon, and this device definitively demonstrates the collection of multiple electrons per photon in a PV cell. The internal quantum efficiency corrects for photons that are not absorbed in the photoactive layer and shows that the PbSe film generates 30% to 40% more electrons in the high-energy spectral region than is possible with a conventional solar cell.

While the unoptimized overall power conversion efficiency is still low (less than 5%), the results have important implications for PV because such high quantum efficiency can lead to more electrical current produced than possible using present technologies. Furthermore, this fabrication is also amenable to inexpensive, high-throughput roll-to-roll manufacturing.

Technical Contacts: Joey Luther, *joey.luther@nrel.gov*; Matt Beard, *matt.beard@nrel.gov*

Reference: Semonin, O.; Luther, J.; Choi, S.; Chen, H.-Y.; Gao, J.; Nozik, A.; Beard, M. "Peak External Photocurrent Quantum Efficiency Exceeding 100% via MEG in a Quantum Dot Solar Cell." *Science* (2011). DOI: 10.1126/science.1209845.

Key Research Results

Achievement

NREL researchers demonstrated a new approach for higher-efficiency, inexpensive solar cells.

Key Result

The primary research result is a quantum dot solar cell with external quantum efficiency greater than 100% for high-energy photons, demonstrating that incident photons can generate multiple electrons.

Potential Impact

The findings have important implications for future photovoltaics because such high quantum efficiency leads to the increased production of electrical current. Additionally, such inexpensive solar cell designs are potentially able to be mass-produced in a roll-to-roll style.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

1617 Cole Boulevard | Golden, Colorado 80401 | 303-275-3000 | www.nrel.gov

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