Using quantum dots to reduce the cost of solar power

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Using two types of quantum dots, Los Alamos National Laboratory researchers are creating double-pane solar windows that generate electricity with greater efficiency and also offer shading and insulation.

It is made possible by a new window architecture which utilizes two different layers of low-cost quantum dots tuned to absorb different parts of the solar spectrum.

Quantum dots are clusters of atoms ten thousand times smaller than the width of a human hair. These nanoparticles are made of semiconductor materials, and can be created and adjusted to exhibit particular characteristics, including absorbing and emitting light of particular colors.

“Because of the strong performance we can achieve with low-cost, solution-processable materials, these quantum-dot-based double-pane windows and even more complex luminescent solar concentrators offer a new way to bring down the cost of solar electricity,” says lead researcher Victor Klimov. “The approach complements existing photovoltaic technology by adding high-efficiency sunlight collectors to existing solar panels or integrating them as semitransparent windows into a building’s architecture.”

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The key to this advance is “solar-spectrum splitting,” which allows the processing of higher– and lower–energy solar photons in different ways. The higher-energy photons can generate a higher photovoltage, which could boost the overall power output. This approach also improves the photocurrent as the dots used in the front layer are virtually “reabsorption free.”

To achieve this, the Lab team incorporates into quantum dots ions of manganese that serve as highly emissive impurities. Light absorbed by the quantum dots activates these impurities. Following activation, the manganese ions emit light at energies below the quantum-dot absorption onset. This trick allows for almost complete elimination of losses due to self-absorption by the quantum dots.

To transform a window into a tandem luminescent sunlight collector, the Laboratory team deposits a layer of highly emissive manganese-doped quantum dots onto the surface of the front glass pane and a layer of copper indium selenide quantum dots onto the surface of the back pane. The front layer absorbs the blue and ultraviolet portions of the solar spectrum, while the rest of the spectrum is picked up by the bottom layer.

Following absorption, the dot re-emits a photon at a longer wavelength, and then the re-emitted light is guided by total internal reflection to the glass edges of the window. There, solar cells integrated into the window frame collect the light and convert it to electricity.

Learn more about this science.