Quantum Dots Could Boost Solar Cell Efficiency

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(PhysOrg.com) -- The transition to environmentally benign energy sources is one of the most significant challenges of the 21st century. Solar power, which uses sunlight to generate electricity, is one promising source. It has many benefits: sunlight is free; operating solar cells emits no greenhouse gasses; and solar power can be generated almost anywhere in the world. Unfortunately, today's solar energy technologies are inefficient, and thus significantly more expensive than traditional power sources. But hope is on the horizon. Recent results from the joint SLAC-Stanford PULSE Institute for Ultrafast Energy Science may help increase efficiency more than previously thought possible.

"This research is one step toward making solar cells more efficient," said PULSE researcher Kelly Gaffney. The finding, he continued, shows there is a significant difference between what's on the market now and what's possible.

In their recent experiment, PULSE researchers sought to confirm results of a Los Alamos National Laboratory study in which researchers observed one photon of light generating more than one electron of electricity. Scientists previously assumed that one photon could excite exactly one electron, limiting the efficiency of solar cells.

Both experiments used so-called "quantum dots." At a few billionths of a meter across, these spheres are made of only a few thousand atoms. On this scale, matter acts very differently from matter in bulk form; forcing all of the atoms' electrons into a very small area causes the electrons in a

quantum dot to interact more and increases the strength of those interactions.

Over the past five years, several research groups used quantum dots in their attempts to recreate the Los Alamos findings, but without success. "There's been a lot of controversy as to whether this [multiple excitation] actually occurs," Gaffney said. "Not everyone agreed that it's even real."

Working with researchers at PULSE, Stanford University and Lawrence Berkeley National Laboratory, Gaffney used a slightly different experimental method to confirm that a single photon can indeed excite more than one electron in a quantum dot.

The researchers found that the solar cell process could be as much as one third more efficient than previously thought if solar cells used quantum dots instead of solid bulk materials. For bulk materials, the one-to-one ratio still holds; one photon excites only one electron, with any additional energy radiating away as heat. In a quantum dot, this ratio could range from one-to-one to one-to-three, depending on the color of the sunlight.

The next step in the quest for efficient solar power is to build a solar cell that uses quantum dots to realize this efficiency.

"No one has done that yet; that research is just getting started," Gaffney said. "It's a very difficult science and engineering problem, but the opportunity is significant."

Provided by SLAC