Enhancing solar cells with nanoparticles

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Deriving plentiful electricity from sunlight at a modest cost is a challenge with immense implications for energy, technology, and climate policy. A paper in a special energy issue of *Optics Express*, the Optical Society's (OSA) open-access journal, describes a relatively new approach to solar cells: lacing them with nanoscopic metal particles. As the authors describe in the article, this approach has the potential to greatly improve the ability of solar cells to harvest light efficiently.

Like plants, solar cells turn light into energy. Plants do this inside vegetable matter, while solar cells do it in a semiconductor crystal doped with extra atoms. Current solar cells cannot convert all the incoming light into usable energy because some of the light can escape back out of the cell into the air. Additionally, sunlight comes in a variety of colors and the cell might be more efficient at converting bluish light while being less efficient at converting reddish light.

The nanoparticle approach seeks to remedy these problems. The key to this new research is the creation of a tiny electrical disturbance called a "surface plasmon." When light strikes a piece of metal it can set up waves in the surface of the metal. These waves of electrons then move about like ripples on the surface of a pond. If the metal is in the form of a tiny particle, the incoming light can make the particle vibrate, thus effectively scattering the light. If, furthermore, the light is at certain "resonant" colors, the scattering process is particularly strong.

In the Optics Express paper, Kylie Catchpole and Albert Polman show what happens when a thin coating of nanoscopic (a billionth of a meter in size) metal particles are placed onto a solar cell. First of all, the use of nanoparticles causes the incoming sunlight to scatter more fully, keeping more of the light inside the solar cell. Second, varying the size and material of the particles allows researchers to improve light capture at otherwise poorly-performing colors.

In their work, carried out at the FOM Institute for Atomic and Molecular Physics in The Netherlands, Catchpole and Polman showed that light capture for long-wavelength (reddish) light could be improved by a factor of more than ten. Previously Catchpole and co-workers at the University of New South Wales showed that overall light-gathering efficiency for solar cells using metallic nanoparticles can be improved by 30 percent.

"I think we are about three years from seeing plasmons in photovoltaic generation," says Catchpole, who has now started a new group studying surface plasmons at the Australian National University. "An important point about plasmonic solar cells is that they are applicable to any kind of solar cell." This includes the standard silicon or newer thin-film types.

Paper: "Plasmonic Solar Cells," K.R. Catchpole and A. Polman, *Optics Express*, Vol. 16, Issue 6, December 22, 2008, Focus Issue on Solar Energy edited by Alan Kost, University of Arizona.

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