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Breakthrough nano-technology solar cell achieves 18.2% efficiency, eliminates need for anti-reflection layer

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(Phys.org)—Scientists at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) have produced solar cells using nanotechnology techniques at an efficiency – 18.2%—that is competitive. The breakthrough should be a major step toward helping lower the cost of solar energy.

NREL tailored a nanostructured surface while ensuring that the light-generated electricity can still be collected efficiently from the solar cell. The researchers made nano-islands of silver on a silicon wafer and immersed it briefly in liquids to make billions of nano-sized holes in each square-inch of the silicon wafer surface. The holes and silicon walls are smaller than the light wavelengths hitting them, so the light doesn't recognize any sudden change in density at the surface and, thus, don't reflect back into the atmosphere as wasted energy. The researchers controlled the nanoshapes and the chemical composition of the surface to reach record solar cell efficiencies for this 'black silicon' material.

The paper, "An 18.2%-efficient black-silicon solar cell achieved through control of carrier recombination in nanostructures" by NREL's Jihun Oh, Hao-Chih Yuan, and Howard Branz, currently appears on *Nature Nanotechnology*'s website.

Typically, solar cell manufacturers must add an extra anti-reflection layer, or two, to their cells, which boosts costs significantly.

NREL previously had demonstrated that their nanostructures reflected less light than the best anti-reflection layers of a solar cell. But until now, they hadn't been able to achieve overall efficiency with their black silicon cells that could approach the best marks for other silicon cells.

Oh, Yuan, and Branz, first had to determine why the increased surface area of the nanostructures dramatically reduced the collection of electricity and hurt the voltage and current of the cells.

Their experiments demonstrated that the high-surface area, and especially a process called Auger recombination, limit the collection of photons on most nanostructured solar cells. They concluded that this Auger recombination is caused when too many of the dopant impurities put in to make the cell work come through the nanostructured surface.

This scientific understanding enabled them to suppress Auger recombination with lighter and shallower doping. Combining this lighter doping with slightly smoother nanoshapes, they can build an 18.2%-efficient solar cell that is black but responds nearly ideally to almost the entire solar spectrum.

The Energy Department funded the research grant through the American Recovery and Reinvestment Act.

Branz, the grant's principal investigator, said, "This work can have a big impact on both conventional and emerging solar cell based on nanowires and nanospheres. For the first time it shows that really great solar cells can be made from nanostructured semiconductors."

Branz added, "The next challenges are to translate these results to common industrial practice and then get the efficiency over 20%. After that, I hope to see these kinds of nanostructuring techniques used on far thinner cells to use less semiconductor material."

"Now we have a clear study that shows how optimizing the surface area and the doping together can give better efficiency," Yuan said. "The surface area and the doping concentration near the surface affect nano-structured solar-cell performance."

First author, Oh, an NREL Postdoctoral Fellow said the NREL study "clearly shows that the right combination of a carefully nano-structured surface and good processing can reduce the cost while cutting unwanted reflection of sunlight."

More information: www.nature.com/nnano/journal/v … /nnano.2012.166.html

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