Nanowire Silicon Solar Cell for Powering Small Circuits

By **Neil Savage**

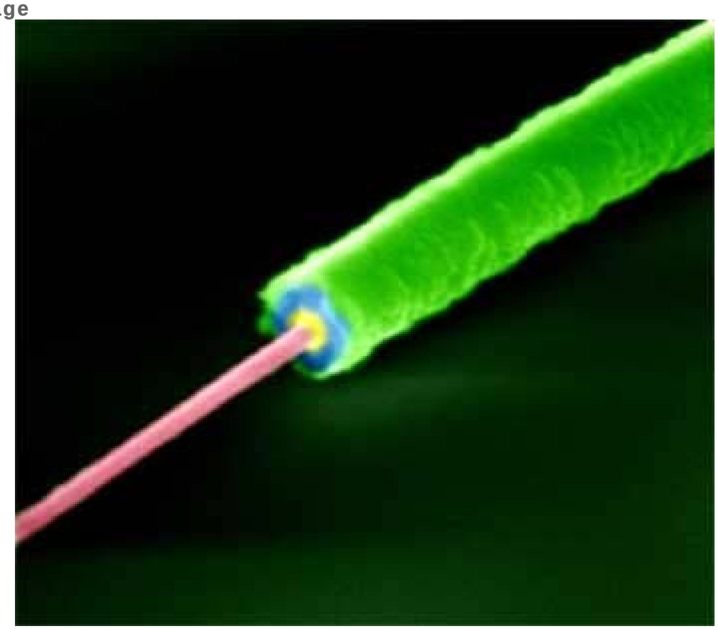


IMAGE: B. TIAN, LIEBER GROUP, HARVARD UNIVERSITY

18 October 2007—A new type of solar cell made from a nanometer-scale wire might one day provide an on-chip power source for nanoelectronic devices or run microscopic robots, say scientists at Harvard University.

The solar cell is a coaxial silicon nanowire, approximately 300 nanometers thick. In experiments, it produced 200 picowatts of electricity, a tiny amount to be sure, but enough that it was used to operate a nanowire-based pH sensor. Chemistry professor Charles Lieber and members of his research group at Harvard described the device in the 18 October issue of the journal *Nature*.

The nanowire consists of three layers of silicon: a positively charged core; a thin intrinsic, or neutrally charged, inner shell; and a negatively charged outer shell. This *p-i-n* structure is common in flat photovoltaic devices, but Lieber says that this is the first time it has been applied to a coaxial wire. When a photon hits the nanowire, it generates a pair of charges: an electron and a hole. The charges then move radially—electrons outward from the center to a contact in the shell, holes inward to a contact in the core. The advantage of the circular cross section is that the electrons and holes must move across a much shorter distance than they would in a flat cell to reach the contacts that collect them and send electricity flowing out of the device. “They only have to travel on the order of 100 nm or less, so they’re less likely to recombine before they are collected,” says Lieber.

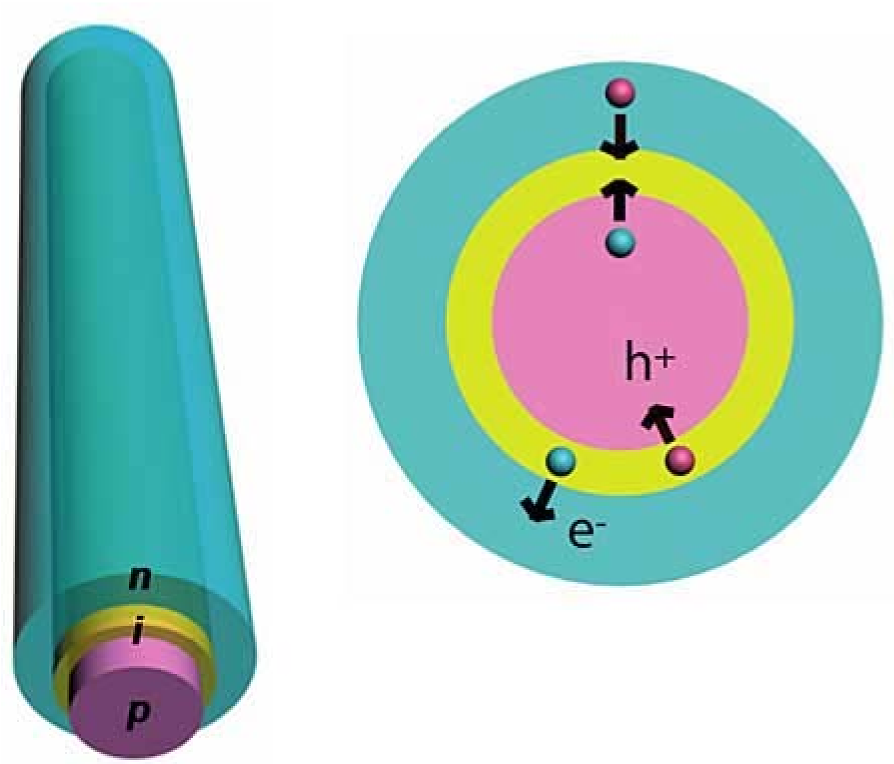


ILLUSTRATION: B. TIAN, LIEBER GROUP, HARVARD UNIVERSITY

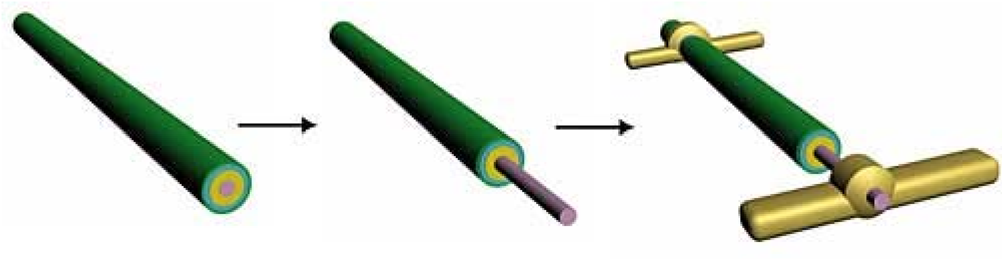
COAXIAL SOLAR CELL: The nanowire solar cell is made up of three regions of silicon: one doped with extra positive charges [*p*], one doped with extra negative charges [*n*], and one with neither [*i* When a photon strikes the solar cell, it generates an electron [e-] and a hole [h], which move away from each other to produce current.

Recombination, when an electron and a hole rejoin instead of exiting the device, is a big problem for silicon-based solar cells. Silicon does a poor job of absorbing light, particularly at infrared wavelengths. To increase the likelihood a photon will be absorbed and converted into electricity, engineers make the silicon relatively thick. But that thickness means the carriers have to travel farther and are more likely to recombine with each other and produce heat rather than electricity. Engineers use high-quality silicon with few crystal defects to decrease the recombination rate, but growing those crystals is expensive. Lieber's method works with less pure, and therefore less costly, silicon.

Other researchers have made nanoscale solar cells, but those have generally consisted of nanoparticles or rods of inorganic materials combined with an organic polymer or dye, both of which degrade with use. In contrast, Lieber says his device has been operating nearly a year with no decrease in function. He got more power out of his nanowire solar cell by using a lens to concentrate more light onto it; the same approach would quickly destroy an organic cell.

Lieber's solar cell converted about 3.4 percent of the light shone on it to electricity—too low an efficiency for a practical device, but not bad for a prototype. "While 3.4 percent is low compared with commercial solar cells, it is really remarkable for a first try," says Eray Aydil, a chemical engineer at the University of Minnesota. "Efficiencies tend to get better as people improve on these pioneering studies."

Harry Atwater, a physicist at Caltech, called the Harvard research "an important first experimental step forward." Atwater recently wrote a theoretical paper that suggested it may be possible to get the efficiency of such a nanowire above the 20 to 25 percent seen in highly ordered crystalline silicon. Lieber sees no reason that the efficiency can't be improved to at least 10 or 15 percent. At that point, he says, the lower costs that his production process entails might make large arrays of nanowires competitive with macroscale solar cells.



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MAKING CONTACT: To get current out of a nanowire solar cell, researchers first etched away its outer two layers at one end. Then they formed metal contacts at both ends.

But even if the nanowires never replace large solar cells, they could be useful in experimental nanometer-scale devices, which today lack a convenient power source. Combine memory, a processor, some sort of power-storage device, and a nanowire solar cell on a chip, and you'd have a self-powered computing device. Nanowires can also be used as logic gates, creating a simple processor to control a microelectromechanical system, such as a sensor, says Lieber.

About the Author

NEIL SAVAGE writes about lasers, LEDs, and optoelectronics and other technology from Lowell, Mass.