INL physicist Steven Novack displays a panel of low-cost, flexible solar nanoantennas. The infrared technology could one day provide electronic devices with self-sustaining energy.

Solar Nanotechnology

Microscopic antenna technology provides potential energy supply on flexible materials

To transform the sun's rays into electricity, traditional solar cells rely on a chemical reaction that only works for about one-fifth of the energy they collect. These cells are also restricted to visible light, rendering them idle after dark. Scientists have developed more complex solar cells that can harvest energy from a wider range of the electromagnetic spectrum with higher efficiency, but these models are too expensive for widespread use.

Fortunately, scientists at the U.S. Department of Energy's Idaho National Laboratory, along with partners at MicroContinuum, Inc. and the University of Missouri, are developing a novel solar nanoantenna technology that could potentially cost pennies a yard, be imprinted on flexible plastics and draw energy from the sun even after it has set. While methods to convert the energy into usable electricity still need to be developed, the nanoantenna arrays could one day be manufactured as lightweight "skins" that power everything from hybrid cars to iPods with higher efficiency than traditional solar cells.

Finely Tuned

These nanoantennas, as wide as 1/25 the diameter of a human hair, absorb energy through resonance just like a television or cell phone antenna. But because of their size, the INL-developed nanoantennas absorb energy in the infrared part of the sun's spectrum, just outside the range of what is visible to the eye. The sun naturally radiates significant amounts of infrared energy, some of which is soaked up by the earth and later released as radiation for hours after sunset. Nanoantennas can take in energy from both sunlight

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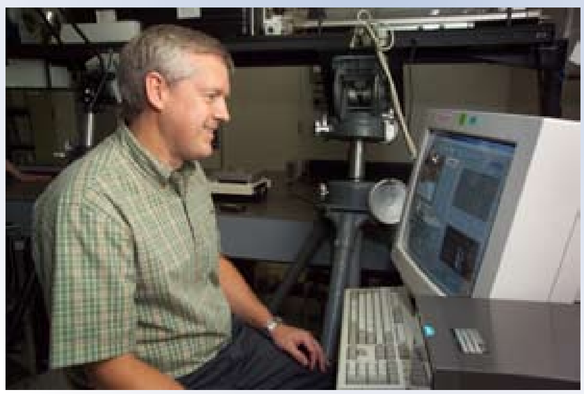

INL physicist, Judy Partin (top), displays two circular discs of nanoantenna structures, while engineer Dale Kotter (middle) uses a thermal imagery system to measure the structures' thermal absorption. The team (bottom) believes this technology has the potential to improve solar efficiency.

For more information

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and the earth's heat, as well as infrared radiation generated by industrial processes such as coal-fired plants.

Commercial solar panels usually transform less than 20 percent of the usable energy that strikes them into electricity. Each cell is made of silicon and doped with exotic elements to boost its efficiency. Globally, the supply of processed silicon is lagging and continues to get more expensive, but solar nanoantennas could one day be a more efficient and sustainable alternative.

The INL-led team has developed nanoantenna arrays that absorb close to 80 percent of the energy in the targeted infrared wavelength range. Plus, the circuits can be made of a number of different conducting metals, and the nanoantennas can be printed on thin, flexible materials like polyethylene, a plastic that's commonly used in bags and plastic wrap.

In theory, making antennas that can absorb electromagnetic radiation is simple: just engineer a smaller antenna. But finding an efficient way to stamp out arrays of atom-scale spirals took a number of years. The recent growth in nanotechnology made this technology possible. Today, the INL team envisions the antennas might one day be produced like foil or plastic wrap on roll-to-roll machinery, and used to power portable electronic devices, coat the roofs of buildings, or be integrated into polyester fabric. Using an approach that garnered two Nano50 awards in 2007, the INL team has demonstrated the imprinting process with six-inch circular stamps, each holding more than one billion antennas.

A Charged Future

While nanoantennas are easily manufactured, a crucial part of the process has yet to be fully developed: creating a way to store or transmit the electricity. Although infrared rays create an alternating current in the nanoantenna, the frequency of the current switches back and forth 30 thousand billion times a second. That's much too fast for electrical devices, which operate on currents that oscillate only 60 times a second. So researchers are exploring ways to slow that cycling down, possibly by embedding energy conversion devices like tiny capacitors directly into the antenna structure as part of the nanoantenna imprinting process.

In the future, the INL-developed nanoantennas could be tweaked to pick up other wavelengths depending on their shape and size. This flexibility would make it possible to create double-sided nanoantenna sheets that capture energy from different parts of the sun's spectrum, providing a continuous and inexpensive source of renewable energy.