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Flexible Silicon Solar Cells

Thin but efficient solar cells use one-tenth the silicon of conventional cells.

By Katherine Bourzac

Flexing silicon's power: Arrays of tiny silicon solar cells like the one in this photograph are assembled using a transfer-printing technique. These arrays are as efficient as conventional solar cells, which are bulky and rigid. Each microcell in the array is about 1.5 millimeters long and 15 micrometers thick.
Credit: John Rogers

Conventional solar cells are bulky and rigid, but building lightweight, flexible cells has come with trade-offs in efficiency and robustness. A new method for making flexible arrays of tiny silicon solar cells could produce devices that don't suffer these trade-offs. Arrays of these microcells are as efficient as conventional solar panels and may be cheaper to manufacture because they use significantly less silicon. The tiny solar cells could be incorporated into, among other applications, window tinting, and they might be used to power a car's air conditioner and GPS.

Researchers led by John Rogers, a professor of materials science and engineering at the University of Illinois in Urbana-Champagne, used a combination of etching and transfer printing to create arrays of silicon cells that are one-tenth the thickness of conventional cells. They demonstrated multiple possible designs for solar panels incorporating the microcells, including dense arrays flexible enough to bend around a pencil. "You could roll them up like a carpet, transport them in a van, and unfurl them onto a rooftop," Rogers says.

The process builds on techniques for making flexible electronics that Rogers has been developing over the past few years. First, the Illinois researchers etch bars about 1.5 millimeters long, 50 micrometers wide, and 15 micrometers thick from a wafer of monocrystalline silicon. They use a stamp made of a soft polymer to pick up the microbars and place them on a substrate, use a stamp made of a soft polymer to pick up the microbars and place them on a substrate, which may be glass or a flexible plastic, and then fabricate interconnects. Rogers found that a cell thickness of 15 to 20 micrometers struck a good balance: thin enough to be flexible, but thick enough to be mechanically stable and efficient. Conventional solar cells use a layer of silicon 150 to 200 micrometers thick.

Arrays of the cells have about a 12 percent efficiency. The Illinois researchers increased the arrays' power output by about two and half times by adding concentrators in the form of a layer of cylindrical microlenses. The best solar cells on the market convert more than 20 percent of the sunlight that falls on them into energy.

"This is a nice start at using silicon wafers more efficiently," says Howard Branz, principal scientist in the silicon materials and devices group at the National Renewable Energy Laboratory, in Golden, CO. With their transfer-printing approach, says Branz, Rogers and his group have for the first time demonstrated how such thin cells could be manufactured on large areas.

Flexible solar cells made from another form of silicon, called amorphous silicon, have found a place in niche applications where low weight is critical. However, these cells haven't come into wider use because they're much less efficient than the crystalline silicon used in conventional solar cells. There are many groups working on new materials, including polymers for flexible solar cells. But these materials don't yet match the efficiency and durability of silicon, says Ray Chen, a professor in the microelectronics research center at the University of Texas at Austin. "I can't say silicon will be *the* material in the long term," says Chen. "But based on the data we have at this moment, [monocrystalline] silicon is a very robust material and has the advantage of reliability and efficiency.

A major advantage of making solar-cell arrays using his transfer-printing process, says Rogers, is the ability to control the spacing between the microcells. Sparse arrays of the cells are semitransparent and could be used as tinted, energy-producing window coatings. Rogers also hopes that the thin solar cells will replace conventional solar cells on roofs and in other places where solar cells are already found. If the Illinois technology does prove to be cheaper and easier to transport and install than conventional cells, it could remove some of the barriers to more widespread use of solar power.

Still, questions remain concerning the efficiency of Rogers's solar cells. To be game changers, these cells will need to have an efficiency closer to 15 percent, says Branz. There are existing methods for increasing the efficiency of monocrystalline silicon solar cells to more than 20 percent, says Rogers, and these methods could be applied to the microcells as well, although the University of Illinois researchers have not yet focused on optimizing the material's efficiency.

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