Technology PUBLISHED BY MIT Review

Friday, May 21, 2010

High-Performance Electronics without the High Price

A method for printing exotic semiconductors brings down the cost of high-performance solar cells and microchips.

By Katherine Bourzac

Compared to silicon, semiconductors like gallium arsenide can be made into solar cells that convert more sunlight into electricity and transistors that are faster than their silicon counterparts. But devices made from these materials are expensive.

Now a new method for making large-area devices from gallium arsenide promises to bring down costs by eliminating manufacturing steps and wasting less materials. Researchers have used the method to make high-performance image sensors, transistors, and solar cells. Semprius (http://www.semprius.com/index.htm) , a Durham, NC, company, is using it to make solar modules that should be on the market by the end of the year.

Gallium arsenide solar cells convert twice as much of the energy in sunlight into electricity compared to silicon cells, says John Rogers (http://www.matse.illinois.edu/faculty/rogers/profile.html) , professor of materials science and engineering at the University of Illinois at Urbana-Champaign, who led the research. Gallium arsenide is also being eyed by microchip manufacturers such as Intel as a potential replacement for silicon (http://www.technologyreview.com/computing/25142/) .

The problem with gallium arsenide, however, is its price tag. To make a gallium arsenide solar panel today, manufacturers grow a semiconductor crystal on an expensive template in a high-vacuum, high-temperature chamber. The gallium arsenide is then diced into thin pieces, assembled, and bonded. This process destroys the underlying template, which is necessary to create a high-quality crystal. And making only a single layer of gallium arsenide at a time is inefficient--it takes more time to load and unload the vacuum chamber than it does to grow the crystal.

To address the problem, Rogers developed a method for growing multiple layers of devices at one time, and a way to release them from the substrate without destroying it.

"Once the substrate is in the chamber at the right temperature, we grow a multilayer stack," explains Rogers. The stack alternates a device layer with a sacrificial layer. After all the layers are put down, the stack is etched in a chemical bath that eats away at the sacrificial layer, made of aluminum arsenide, releasing thin rectangular films of gallium arsenide. As the gallium arsenide films are released, they're picked up and placed on a substrate.

These films, which are thin and flexible, can be placed on flexible substrates such as plastic, and then packaged to create high-performance solar cells, image sensors, and transistor arrays. The method and the devices are described this week in the journal *Nature*.

"A lot of other low-cost approaches don't produce high-performance devices, but in this case great performance is maintained," says Yi Cui (http://www.stanford.edu/group/cui_group/yicui.html) , professor of materials science and engineering at Stanford University. "And in the end it's flexible, something you can't get with conventional processing," he adds. Rogers developed a similar method for making large area, flexible silicon (http://www.technologyreview.com/computing/20481/?a=f) electronics a few years ago, and adapted the chemistry to work with gallium arsenide. Cui says that the latest work shows that the method should work with any crystalline semiconducting materials, as long as the right chemistry can be found so that the etching step affects only the sacrificial layer.

The multilayer technique "is quite attractive since it makes the process highly scalable and potentially cost-effective, making the potential use of gallium arsenide for large-scale photovoltaics a reality," says Ali Javey (http://www.eecs.berkeley.edu/Faculty/Homepages/javey.html) , professor of electrical engineering and computer science at the University of California, Berkeley.

Semprius (http://www.technologyreview.com/energy/24504/) is using the process to make multilayer, microscale concentrated solar modules with efficiencies as high as 37 percent. These modules should produce power at a cost of about $2 to $3 per watt after installation. Joe Carr, the company's CEO, says Semprius's pilot plant will be operational by the end of this year, at which time it will begin making its first products. The company has funding from the U.S. Department of Energy and a development agreement with Siemens.

Rogers says he pursued solar power as an initial application because photovoltaic sales are so cost-sensitive. His research group will continue to develop other devices, and it also plans to adapt the technique to other materials. He also hopes to adapt the method to gallium nitride, which works well in the visible spectrum and can be used to make solid-state lighting.

Upcoming Events

Tech Connect World (http://www.techconnectworld.com)
Anaheim, CA
Monday, June 21, 2010 - Friday, June 25, 2010
http://www.techconnectworld.com (http://www.techconnectworld.com)

2010 IEEE Conference on Innovative Technologies for an Efficient and Reliable Electricity Supply (http://www.ieee-energy.org/)
Waltham, Massachusetts
Sunday, September 27, 2009 - Tuesday, September 28, 2010
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