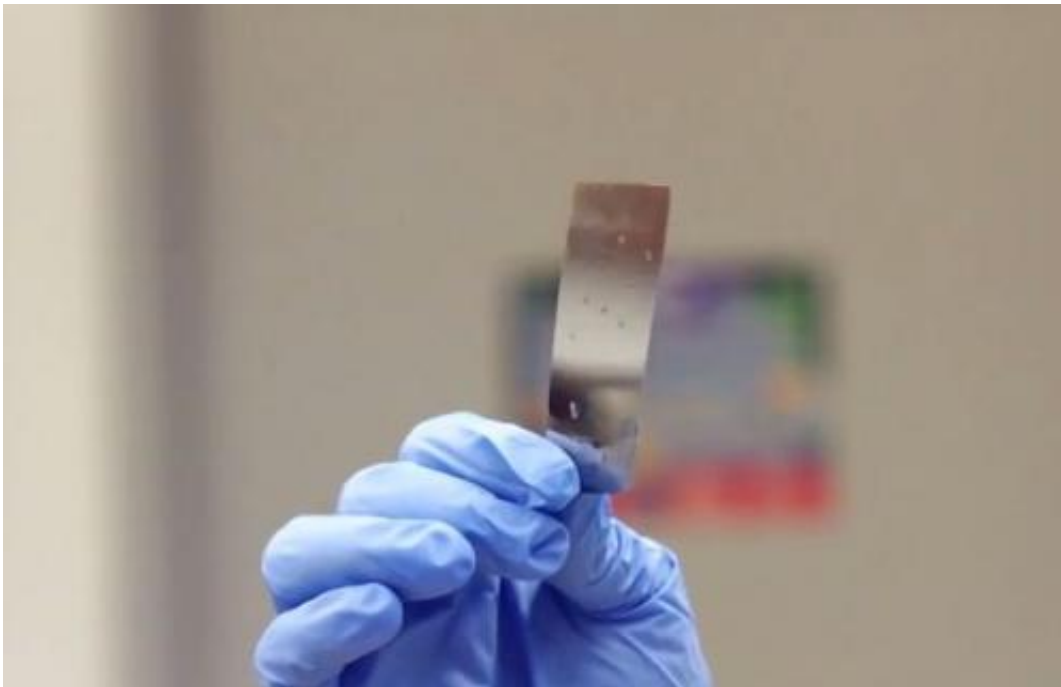


Like a hall of mirrors, nanostructures trap photons inside ultrathin solar cells (w/ Video)

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In the quest to make sun power more competitive, researchers are designing ultrathin solar cells that cut material costs. At the same time they're keeping these thin cells efficient by sculpting their surfaces with photovoltaic nanostructures that behave like a molecular hall of mirrors.

"We want to make sure light spends more quality time inside a solar cell," said Mark Brongersma, a professor of materials science and

engineering at Stanford and co-author of a review article in *Nature Materials*.

Brongersma and two Stanford colleagues—associate professor of [materials science](#) and engineering Yi Cui and professor of electrical engineering Shanhui Fan—surveyed 109 recent scientific papers from teams around the world.

Their overview revolves around a basic theme: looking at the many different ways that researchers are trying to maximize the collisions between [photons](#) and electrons in the thinnest possible layers of [photovoltaic materials](#). The goal is to reveal trends and best practices that will help drive developments in the field.

Solar energy is produced when photons of light collide with the electrons in a photovoltaic crystal. As loose electrons move through the crystal, they generate an electrical current.

Today's [solar cells](#) are already thin. They are made up of layers of photovoltaic materials, generally silicon, that average 150 to 300 micrometers, which is roughly the diameter of two to three human hairs.

As engineers continue to shave down those dimensions they have to develop new molecular traps and snares to ensure that photons don't simply whiz through their ultrathin solar cells before the electrical sparks can fly.

"A lot of the excitement now is about using the principles of photonics to manage light waves in the most efficient way," Fan said. "There are perhaps hundreds of groups in the world working on this."

The review article provides a high level view of how scientists are trying to design structures to facilitate interactions between the infinitesimal

instigators of solar current, the photons and the electrons.

Research face enormous challenges in trying to architect nanostructures attuned to catch light. Sunlight consists of many colors. When we see rainbow, what we see is result of atmospheric moisture acting as a prism to bend light into its constituent colors. Creating different nanostructures to catch the pot of photons at the end of each color of the rainbow is part of what this research is about.

Nevertheless, scientists are already reporting some success

"We are seeing systems that use one one-hundredth as much photovoltaic material as today's solar cells while getting 60 percent to 70 percent of the electrical output," Brongersma said.

The most common photovoltaic material is a refined form of silicon similar to that found in computer chips. This material accounts for 10 percent to 20 percent of a solar cell's cost. Lowering those expenses 100-fold would therefore have a considerable effect on the overall cost-efficiency of [solar energy](#) production.

But Cui says lowering material costs is only part of the push behind ultrathin solar. Another benefit is flexibility. Because of the thickness of the light-catching silicon layer, today's solar cells must be kept rigid lest their crystal lattice be damaged and the flow of electrons disrupted.

"But at 10 micrometers of thickness silicon has a high degree of mechanical flexibility," said Cui, citing a dimension less than one-tenth the thickness of the photovoltaic layer inside today's solar cells.

Cui, who has made just such an experimental material, shows a movie of

flapping this thin silicon like a piece of paper and cutting it with a scissors (see separate videos; flapping /above/ and cutting /below/). Those thin silicon strips incorporate some of the photon-trapping nanostructures described in the *Nature Materials* article. Cui says the light-to-energy conversion efficiency of thin silicon is approaching that of the rigid silicon in today's solar cells.

Flapping silicon isn't just a science project. Such flexibility would pay a dividend when it comes to installation, which accounts for roughly one-third of the total cost of a rooftop solar array. "These thin silicon cells can be embedded into flexible plastic, making installation like rolling out a carpet," Cui said.

Yet even as researchers succeed in getting more from less, many hurdles remain according to Fan, who develops computer models to study how different nanostructures and materials will affect photon-electron interactions.

"There are an infinite number of structures, so it isn't possible to model them all," he said, alluding to what he called the "theoretical bottlenecks" that impede scientific understanding of this ethereal realm where light and matter intersect.

"For instance, right now, we really don't have a way to know when we've gotten the most out of our photons," Fan said.

Provided by Stanford University

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