From moths and cicadas come improvements to solar cells

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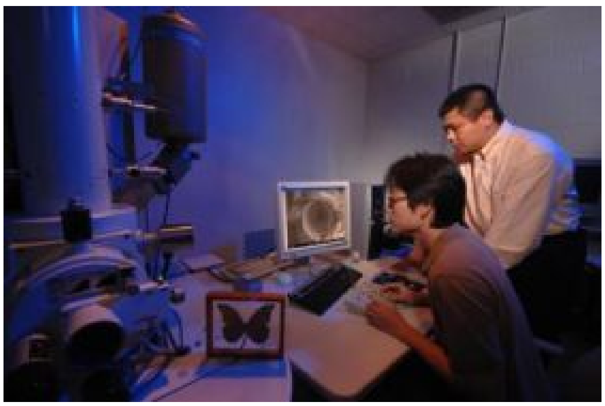

Stanley Chih-Hung Sun (left), a University of Florida chemical engineering doctoral student, and Peng Jiang, an assistant professor of chemical engineering, take images of a moth eye with a powerful scanning electron microscope. The researchers are mimicking the microscopic structure of moth eyes and cicada wings to create new anti-reflective and water-repellant coatings. These coatings could make solar cells both more efficient and self-cleaning, and they may also lead to more transparent windows, more legible computer screens and other improvements to consumer products. Photo by Ray Carson/University of Florida

Designing better solar cells might seem a question of electronics or chemistry, but for one University of Florida engineer, it starts with bugs.

Peng Jiang, an assistant professor of chemical engineering, is drawing inspiration from the eyes of moths and the wings of cicadas to create unusual new anti-reflective and water-repellant coatings — coatings that appear to have potential to make solar cells both more efficient and self-cleaning. Windows in cars and homes, computer screens and other consumer products also could improve thanks to the super-transparent coatings.

“Nature is an amazing innovator,” Jiang said. “What I’m interested in doing is mimicking the structure of some remarkable biological systems for real-world use.”

Jiang’s research, most recently reported in a September paper in the journal *Applied Physics Letters*, focuses on a new technique to manufacture a coating whose microscopic structure closely resembles that of moth eyes.

Most moth eyes are made up of adjacent hexagonal sectors. Each sector is filled with thousands of orderly rows of miniscule bumps, or nipple-like protrusions. Though formed so perfectly they appear almost manufactured, each protrusion measures less than 300 nanometers, or 300 billionths of a meter — a size that renders them invisible to all but the most powerful electron microscopes.

When moths encounter light, these orderly arrays of protrusions interfere with its transmission and reflection, rendering the light all but invisible. Biologists believe this trait evolved in moths, which are often nocturnal, because it prevents their eyes from reflecting moon or starlight, which would make them easier targets for predators.

Jiang said engineers have sought to replicate the eyes’ microscopic structure using a printing technique called lithography, but it is expensive and ill-suited to creating the extremely tiny rows of protrusions that make the moth eyes so effective. To get around this problem, Jiang developed a non-lithographic technique, called spin coating. Unlike lithography, which attempts to carve out the nipple-like pattern on the target surface, spin coating seeks to build the pattern up from scratch on the target.

Jiang places a liquid suspension of nanoparticles on a circular silicon wafer, such as that used in photovoltaic cells. A motor spins the wafer, with centrifugal force distributing the liquid. When it dries, it leaves behind the ordered particles in place.

The *Applied Physics Letters* paper reports that Jiang successfully used this comparatively low-tech technique to create a moth eye-like anti-reflective coating on glass and plastic substrates. But the researcher said he has since gone further, applying the same technique to silicon wafer surfaces to add a unique property of cicada wings.

Cicada wings are amazingly effective at rapidly shedding water and dirt, apparently because the insects often need to fly in humid environments, Jiang said. At the particle level, the wings have a structure very similar to that of the moth eyes — except that rather than deflecting light, tiny pockets of air around each nipple-like protrusion buoy water droplets.

Jiang said he and his two doctoral students, Chih-Hung Sun and Nicholas Linn, as well as a collaborator, Professor Bin Jiang at Portland State University in Oregon, have now replicated this structure using the spin coating process, also on a silicon wafer.

He demonstrated the achievement in his laboratory, placing a drop of water on a postage stamp-sized wafer coated with the cicada wing-like coating. As if electrified, the drop danced across the surface of the wafer until it reached the edge.

His research could have a number of applications, Jiang said.

The anti-reflective coating may improve the performance of solar cells because it would increase the amount of light the cells receive, he said. Current production coatings reflect more than 10 percent of the light at certain wavelengths, whereas Jiang says his coating reflects less than 2 percent at those wavelengths. The water-repelling element would be useful for keeping the cells clean – a necessity because dirt or dust easily dulls their performance. Rain or simply hosing the coated cells down would clean them adequately, he said.

Jiang added the coatings could also improve the performance of ordinary windows on cars or homes, increasing visibility and reducing the need for cleaning. That said, numerous challenges remain, including learning how to “scale up” the spin coating process so that it could be used for industrial production, he said.

Yadong Yin, an assistant chemistry professor at the University of California, Riverside, said Jiang’s research is important in part because it suggests that there is a low-cost alternative to current anti-reflection production techniques. “Importantly,” he said, “the low cost in this case did not lead to low performance.”

Source: UF

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