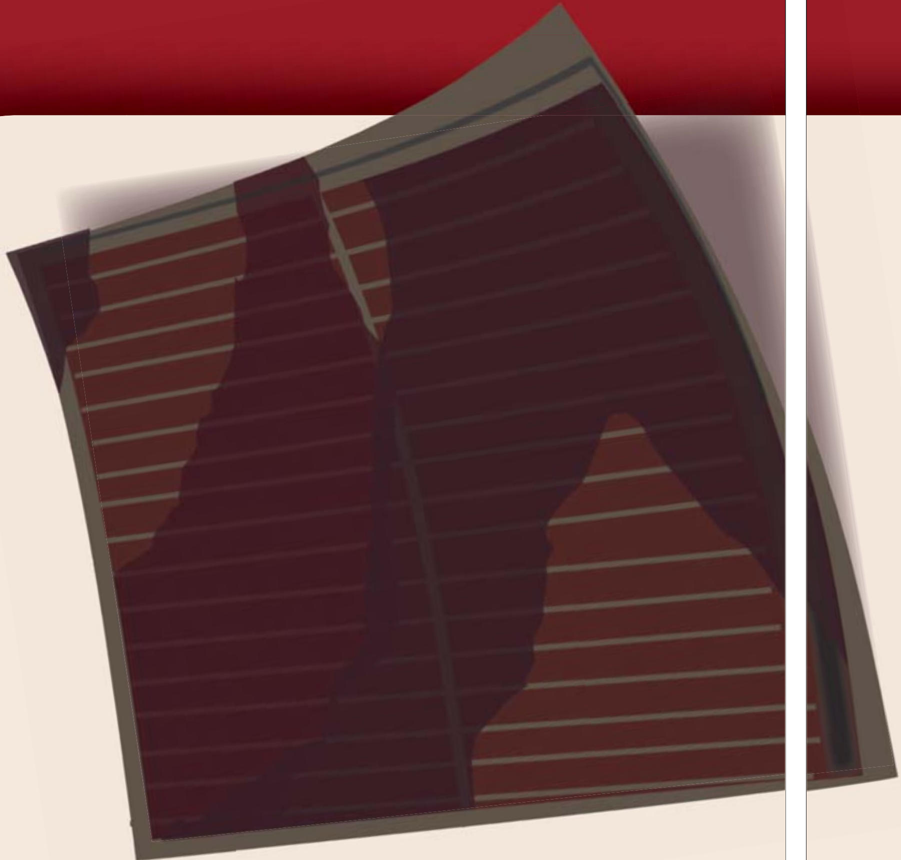

STANFORD UNIVERSITY

Peel & Stick Solar Panels

Decal-like application allows thin, flexible solar panels to be mounted on almost any surface — from business cards to window panes

By Glen Martin

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For all their promise, solar cells have frustrated scientists in one crucial regard: Most are rigid. They must be deployed in stiff — and often heavy — fixed panels, limiting their applications. So researchers have been trying to get photovoltaics to loosen up. The ideal would be flexible, decal-like solar panels that can be peeled off like band-aids and stuck to virtually any surface, from papers to window panes.

Stanford University researchers may have turned this vision into a reality. They have developed the world's first peel-and-stick thin-film solar cells, an advancement described in a paper in the Dec. 20 issue of *Scientific Reports* (*www.nature.com*).

Unlike standard thin-film solar cells, peel-and-stick solar does not require any direct fabrication on the final carrier substrate. This is a far more dramatic development than it may initially seem. All the challenges associated with putting solar cells on unconventional materials are avoided with the new process, vastly expanding the potential applications of solar technology.

Thin-film photovoltaic cells are traditionally fixed on rigid silicon and glass substrates, which severely limits their usefulness, says Chi Hwan Lee, lead author of the paper and a Ph.D. candidate in mechanical engineering at Stanford University. Xiaolin Zheng, a Stanford assistant professor of mechanical engineering and senior author of the paper, also explains that while developing thin-film solar cells promised to inject some flexibility into the technology, scientists found that using alternative substrates was extremely problematic.

"Nonconventional or 'universal' substrates are difficult to use for photovoltaics because they typically have irregular surfaces and don't do well with the thermal and chemical processing necessary to produce today's solar cells," Zheng says. "We got around these problems by developing this peel-and-stick process, which gives thin-film solar cells flexibility and attachment potential we've never seen before. It also reduces their general cost and weight."

Using the process, researchers attached thin-film solar cells to paper, plastic and window glass, among other materials.

"It's significant that we didn't lose any of the original cell efficiency," Zheng says.

The new process involves a unique silicon, silicon-dioxide and metal "sandwich." First, a 300-nm film of nickel (Ni) is deposited on a silicon/silicon dioxide (Si/SiO2) wafer. Thin-film solar cells are then deposited on the nickel layer using standard fabrication techniques and covered with a layer of protective polymer. A thermal release tape is then attached to the top of the thin-film solar cells to augment their transfer off of the production wafer and onto a new substrate.

The solar cell is now ready to peel from the wafer. To remove it, the wafer is submerged in water at room temperature and the edge of the thermal release tape is peeled back slightly, allowing water to seep into and penetrate between the nickel and silicon dioxide interface.

The solar cell is thus freed from the hard substrate but still attached to the thermal release tape. Zheng and her team heat the tape and solar cell to 90°C (194°F) for several seconds. The cell can then be applied to virtually any surface using double-sided tape or other adhesive. The thermal release tape is finally removed, leaving just the solar cell attached to the chosen substrate.

Tests have demonstrated that the peel-and-stick process reliably leaves the thin-film solar cells wholly intact and functional.

"There's also no waste," Zheng says. "The (Si) wafer is typically undamaged and clean after removal of the solar cells and can be reused."

Xiaolin Zheng, *assistant professor of mechanical engineering at Stanford University*

(Photo courtesy of John Todd)

Chi Hwan Lee, *doctoral candidate at Stanford University*

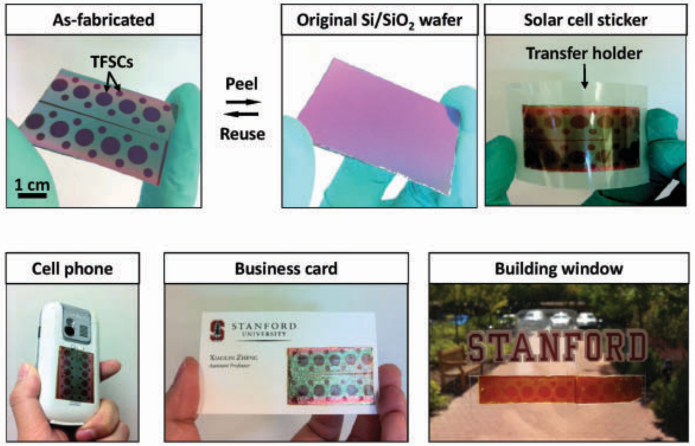

Photo Courtesy of Chi Hwan Lee

While others have been successful in fabricating thin-film solar cells on flexible substrates, those efforts have required modifications of existing processes or materials, Lee says.

"The main contribution of our work is that we have done so without modifying any existing processes, facilities or materials, which makes them viable commercially," Lee says. "We have demonstrated our process on a more diverse array of substrates than ever before."

"Now you can put them on helmets, cell phones, convex windows, portable electronic devices, curved roofs, clothing — virtually anything," says Zheng.

Moreover, peel-and-stick technology isn't necessarily restricted to thin-film solar cells. The researchers believe the process can also be applied to thin-film electronics, including printed circuits, ultra-thin transistors and LCDs.

"Obviously, a lot of new products – from 'smart' clothing to new aerospace systems, might be possible by combining both thin-film electronics and thin-film solar cells," Zheng says. "For that matter, we may be just at the beginning of this technology. The peel-and-stick qualities we're researching probably aren't restricted to Ni/SiO2. It's likely many other material interfaces demonstrate similar qualities, and they may have certain advantages for specific applications. We have a lot left to investigate." SPW

The authors of the Scientific Reports paper "Peel-and-Stick: Fabricating Thin-Film Solar Cell on Universal Substrates" include Chi Hwan Lee, In Sun Cho and Xiaolin Zheng from Stanford's Department of Mechanical Engineering, Dong Rip Kim from Hanyang University in Seoul, Korea, and Nemeth William and Qi Wang from the National Renewable Energy Laboratory in Denver.

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