Flexible Electronics One Step Closer With New Circuits

Ben Harder
for National Geographic News
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New silicon circuitry can bend and stretch like rubber, without losing its ability to function.

Flexible circuits could give electronic devices—including digital cameras, iPods, and TVs—a host of new and improved capabilities.

And manufacturers might someday be able to add electronics to the surfaces of devices that currently lack them (think heart monitors built into surgical gloves or artificial limbs with "skin" that can sense touch).

"These concepts are technically feasible," said electrical engineer Sigurd Wagner of Princeton University, who was not part of the research team. "But none of them is yet practical."

University of Illinois materials scientist John A. Rogers masterminded the innovation. "Silicon is intrinsically a brittle material, and you're not going to get around that," he said. "But you can come up with tricks to avoid that problem."

Engineers can already make electronics that flex without snapping, such as the superthin microprocessors in smart cards.

Smart cards are small plastic cards that store and process data and records. The most common examples in the United States are credit cards that house their microprocessors under small, square, gold contact pads.

"Smart cards have very small integrated circuits," Princeton's Wagner said. Each circuit "is so thin that when you sit on your wallet [the microprocessor] doesn't break."

The field's ultimate goal, experts say, is to make circuits that can conform to a curved surface or that can change shape as they function.

Making Waves

"Bendability and stretchability are different mechanical

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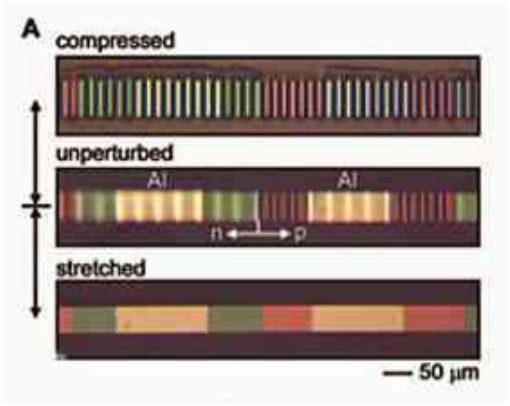

A flexible silicon circuit is shown compressed (top), at rest (middle), and stretched.

This new type of circuit continues to function even as it is bent and pulled. As such, it could pave the way to innovative products, including artificial skin with sensors that "feel," bouncing iPods, and TVs you can twist in knots.

Image courtesy *Science*

characteristics," said Illinois's Rogers. For example, paper can bend but not stretch.

To create stretchable electronics, Rogers and his colleagues first made ribbons of silicon using a standard method.

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Then they took a piece of elastic rubber, stretched it, and stuck the silicon strips to it.

When the researchers relaxed the strain on the rubber, it returned to its original size. Each silicon strip, stuck to its shrinking foundation, buckled into a wavy, accordion-like shape.

The waves in the silicon's structure were less than 50 micrometers (0.002 inch) long.

When the researchers subsequently stretched or compressed the rubber-and-silicon pieces, the wavelength in the silicon strips expanded or contracted accordingly, without breaking.

Rogers and his colleagues describe their engineering methods and follow-up testing on the wavy circuits in tomorrow's issue of the journal *Science.*

The team has done "very nice work," said Wagner. "It's a step toward any kind of flexible electronics."

Takao Someya of the University of Tokyo's School of Engineering called the advance "one of the major breakthroughs" needed for creating "wearable electronics and/or integration of electronics with biological tissues."

Applications and Obstacles

Wagner said that, by sculpting circuits, "you can build a spherical lens, like an eye." That could shrink systems of optical sensors to barely a tenth of their current sizes, he said.

"It would be a revolution in digital cameras," he added.

The Princeton engineer also imagines artificial limbs with surface sensors that deliver electrical impulses to severed nerves. And, he said, latex gloves studded with sensors could put information about a patient's vital signs literally at the fingertips of an operating surgeon.

Rogers envisions aircraft wings that sense their own structural health.

But Wagner says the team's invention falls short of

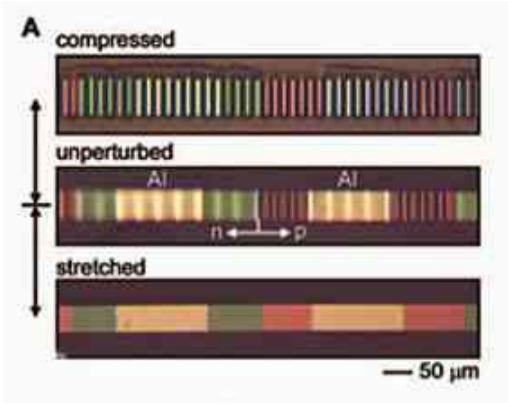

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Image courtesy *Science*

what's necessary for those futuristic uses.

Circuits have to be manufactured in flat sheets, Wagner notes. So to assume complex shapes, such as that of a partial sphere, circuits would need to be what he calls fully deformable.

The new circuitry may be bendable and stretchable, but it's not deformable, Wagner says. "It's not going from flat to a sphere."

Electronics makers such as Samsung and Philips are nevertheless working on flexible electronics.

Initially, experts say, advances are only likely to yield improvements in existing devices, for example by making them more rugged.

The conventional, rigid components in liquid-crystal displays (LCDs)—used in Apple's new video iPods as well as many TVs and computer monitors—are easily broken, Wagner notes.

If iPod video monitors and their like are someday made with bendable components, though, "the screens won't break anymore," he added.

"Flexible displays appear to be the first application likely to be commercialized," Rogers agreed. "You might see these devices in PDAs and so in the next year or two."

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