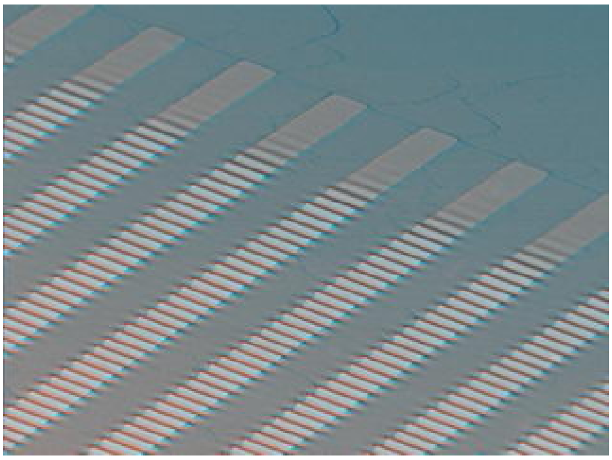
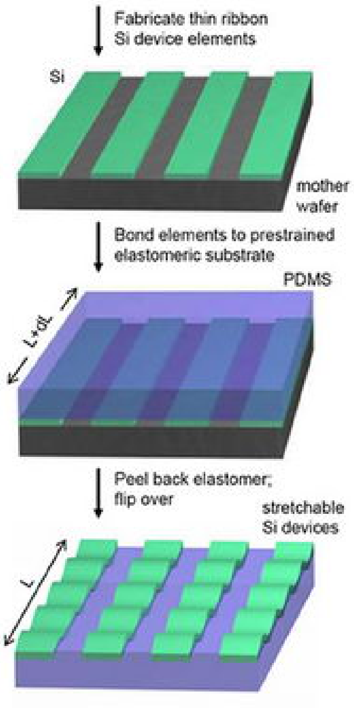
Stretchable silicon could be next wave in electronics



The next wave in electronics could be wavy electronics.
Researchers at the University of Illinois at Urbana-Champaign have developed a fully stretchable form of single-crystal silicon with micron-sized, wave-like geometries that can be used to build high-performance electronic devices on rubber substrates.



Schematic illustration of the process for building stretchable single crystal silicon devices on rubber substrates.

Image: Scanning electron micrograph of 'wavy' single crystal silicon ribbons on an elastomeric substrate. This form of silicon has the unusual property that it is fully stretchable, with mechanics similar to an accordion bellows.

"Stretchable silicon offers different capabilities than can be achieved with standard silicon chips," said John

Rogers, a professor of materials science and engineering and co-author of a paper to appear in the journal Science, as part of the *Science Express* Web site, on Dec 15.

Functional, stretchable and bendable electronics could be used in applications such as sensors and drive electronics for integration into artificial muscles or biological tissues, structural monitors wrapped around aircraft wings, and conformable skins for integrated robotic sensors, said Rogers, who is also a Founder Professor of Engineering, a researcher at the Beckman Institute for Advanced Science and Technology and a member of the Frederick Seitz Materials Research Laboratory.

To create their stretchable silicon, the researchers begin by fabricating devices in the geometry of ultrathin ribbons on a silicon wafer using procedures similar to those used in conventional electronics. Then they use specialized etching techniques to undercut the devices. The resulting ribbons of silicon are about 100 nanometers thick -- 1,000 times smaller than the diameter of a human hair.

In the next step, a flat rubber substrate is stretched and placed on top of the ribbons. Peeling the rubber away lifts the ribbons off the wafer and leaves them adhered to the rubber surface. Releasing the stress in the rubber causes the silicon ribbons and the rubber to buckle into a series of well-defined waves that resemble an accordion.

"The resulting system of wavy integrated device elements on rubber represents a new form of stretchable, high-performance electronics," said Young Huang, the Shao Lee Soo Professor of Mechanical and Industrial Engineering. "The amplitude and frequency of the waves change, in a physical mechanism similar to an accordion bellows, as the system is stretched or compressed."

As a proof of concept, the researchers fabricated wavy diodes and transistors and compared their performance with traditional devices. Not only did the wavy devices perform as well as the rigid devices, they could be repeatedly stretched and compressed without damage, and without significantly altering their electrical properties.

"These stretchable silicon diodes and transistors represent only two of the many classes of wavy electronic devices that can be formed," Rogers said. "In addition to individual devices, complete circuit sheets can also be structured into wavy geometries to enable stretchability."

Besides the unique mechanical characteristics of wavy devices, the coupling of strain to electronic and optical properties might provide opportunities to design device structures that exploit mechanically tunable, periodic variations in strain to achieve unusual responses.

In addition to Rogers and Huang, co-authors of the paper were postdoctoral researcher Dahl-Young Khang and research scientist Hanqing Jiang. The Defense Advanced Research Projects Agency and the U.S. Department of Energy funded the work.

Source: University of Illinois at Urbana-Champaign