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Sheets of Stretchable Silicon

Researchers have shown that ultrathin sheets of silicon can stretch in two dimensions--opening up the possibility of electronic eyeballs and smart surgical gloves.

By Kate Greene

Silicon waves: A thin film of silicon has been affixed to a prestretched sheet of rubber. When the strain on the rubber is released, the silicon buckles to form a herringbone pattern. After the initial pattern has been created, the silicon and rubber are horizontally and vertically stretched and released.
Credit: John A Rogers

Silicon usually comes in rigid chips. But while these chunks of semiconductors are good in computers and applications, such as wearable electronics and bendable computers. Meanwhile, new types of polymer-based electronics are flexible but don't offer the performance of silicon.

Researchers at the University of Illinois at Urbana-Champaign recently showed how silicon can stretch in one dimension, like a rubber band. (See "Stretchable Silicon.") Now, in the group's most recent work, the researchers have made sheets of silicon that can stretch in two dimensions as well, which could make it possible to put electronics on spheres and surfaces with complicated shapes.

Over the past few years, there have been efforts in research labs and companies to make electronics flex and stretch. Flexible displays, for instance, are currently available. (See "Plastic Electronics Head for Market.") But these displays rely on the circuits made of organic polymers, which don't have the speed of silicon, so they can't be used for computationally intensive tasks. In addition, flexible electronics are limited in the shapes that they can form. They can be rolled and bent, but they can't conform to the shape of a hand, for instance.

The new results from the Illinois team, led by John

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Rogers, a professor of material science and engineering, build on the group's earlier research with one-dimensional stretchy ribbons of silicon, in which they affixed ultrathin ribbons to a prestretched piece of rubber. When the strain on the rubber was released, the silicon ribbons buckled. Subsequently, the ribbons could be stretched again, pulling the silicon taut. However, these ribbons could only stretch in one dimension. A truly conformable sheet of electronics needs to stretch in two directions so it can, for instance, cover a sphere or some other three-dimensional object.

So, instead of using ribbons of silicon, the researchers affixed sheets of silicon--ranging in size from three to five square millimeters and in thickness from 55 to 320 nanometers--to a stretched-out sheet of rubber. When the stretch was released, the silicon buckled to form complicated waves and zigzags, creating a never-before-seen silicon geometry (see multimedia video). Rogers says that his team was surprised by the actual geometry, a herringbone pattern, which resembles the varying diagonals of the fish's backbone. Essentially, the snaking patterns of waves allow the sheets of silicon to stretch to two dimensions.

So far, says Rogers, his team has made functional diodes out of the two-dimensional stretchy silicon. The researchers have fabricated an array of square silicon pads that are connected to one another via ribbons of wavy silicon. This device design, Rogers says, could be used in a smart surgical glove that would measure the concentration of hormones or pH in the body, for instance.

In addition, the team is building an array of photo detectors on the stretchy silicon and placing it around a sphere to create an electronic eye. Such an application is many years down the road, says Rogers, but if researchers can get electronics and photo detectors onto a sphere, people can have a much more advanced and powerful camera that could be used in cell phones or by the military.

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