A transistor that can be stretched to twice its length with minimal loss of conductivity

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Fully stretchable transistor as a secondary e-skin on hand knuckle. Credit: Jie Xu, Sihong Wang

(Phys.org)—An international team of researchers has developed a transistor that can be stretched to twice its length and still maintain most of its conductivity. As the group notes in their paper published in the journal *Science*, such a transistor could prove very useful in the design of wearable electronic devices, particularly those affixed directly to the skin.

As the researchers note, use of transistors in bendable products has been slowed by high production costs, which has led to continued interest in finding a way to make the transistors themselves bendable. In this new effort, the researchers have used polymers instead of silicon to create a transistor that could not only be bent, but stretched, all while maintaining a high degree of conductivity.

To make the transistor, the researchers started with a polymer called DPP-TT, which is a semiconductor—they put it inside of another polymer called SEBS, which is elastic. The trick is that the two polymers do not mix with one another, they coexist. As part of the process the DPP-TT was formed into packets inside of a SEBS matrix. The result was a stretchy, thin-film transistor with a thickness of just tens of nanometers that could be produced using a printer and without the extremely high temperatures used to create silicon-based transistors—a relatively inexpensive process.

The researchers tested the transistors by using machines to bend, pull and stretch them multiple times and other machines to test their limits. They found that stretching some of their transistors to twice their length resulted in a drop of conductivity from 0.59 cm2/Vs on average, to just 0.55 cm2/Vs and that cracks did not develop in the polymers even after bending 100 times. They further demonstrated the resilience of one of their transistors by affixing it to the knuckle of one of the researchers who wore it like a Band-aid for a length of time. They note that the same process could be used for a wide variety of semiconductors to create a host of products. An official with Samsung Electronics Institute of

Technology spoke to the press regarding the new transistors and suggested the company was interested in using such technology to develop novel wearable devices.

More information: Jie Xu et al. Highly stretchable polymer semiconductor films through the nanoconfinement effect, *Science* (2017). DOI: 10.1126/science.aah4496

Abstract
Soft and conformable wearable electronics require stretchable semiconductors, but existing ones typically sacrifice charge transport mobility to achieve stretchability. We explore a concept based on the nanoconfinement of polymers to substantially improve the stretchability of polymer semiconductors, without affecting charge transport mobility. The increased polymer chain dynamics under nanoconfinement significantly reduces the modulus of the conjugated polymer and largely delays the onset of crack formation under strain. As a result, our fabricated semiconducting film can be stretched up to 100% strain without affecting mobility, retaining values comparable to that of amorphous silicon. The fully stretchable transistors exhibit high biaxial stretchability with minimal change in on current even when poked with a sharp object. We demonstrate a skinlike finger-wearable driver for a light-emitting diode.