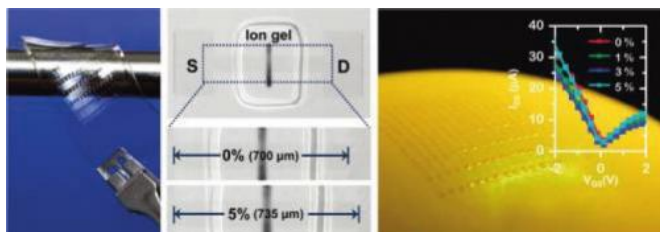


Stretchable graphene transistors overcome limitations of other materials

26 October 2011, by Lisa Zyga



(Left) Graphene-based transistor patterned on a PDMS substrate. (Center) Microscope images of the transistor undergoing stretching up to 5%. (Right) The transistor patterned on a balloon. Image credit: Lee, et al. ©2011 American Chemical Society

(PhysOrg.com) -- When it comes to fabricating stretchable, transparent electronics, finding a material to make transistors from has been a significant challenge for researchers. They've explored a variety of conventional semiconductor materials, including molecules, polymers, and metals, but these materials tend to have intrinsically poor optical and mechanical properties. These drawbacks make it difficult to realize a transistor that can maintain its optical and electrical performance under a high strain. In a new study, researchers have fabricated a stretchable, transparent graphene-based transistor and found that, due to graphene's excellent optical, mechanical, and electrical properties, the transistor overcomes some of the problems faced by transistors made of conventional semiconductor materials.

The researchers, led by Jeong Ho Cho from Soongsil University in Seoul, South Korea, and Jong-Hyun Ahn from Sungkyunkwan University in Suwon, South Korea, have published their study in a recent issue of *Nano Letters*.

"Our work includes important results compared with stretchable and transparent devices reported

in the previous literature," Ahn told *PhysOrg.com*.

"In fact, it is nearly impossible to fabricate transistors that offer both mechanical stretchability and high optical transparency on unusual substrates such as rubber slabs or balloons by using conventional materials. In particular, graphene devices have the advantage that they can be integrated using printing processes at room temperature without vacuum or high-temperature steps. The capabilities of these systems go far beyond conventional material-based systems."

To fabricate the transistor, the researchers synthesized single layers of graphene and then stacked them layer by layer on copper foil. Using photolithography and etching techniques, the researchers patterned some of the transistor's essential elements, including the electrodes and semiconducting channel, onto the graphene. After transferring these components onto a stretchable rubber substrate, the researchers printed the remaining components - gate insulators and gate electrodes - onto the device using stretchable ion gel.

The researchers found that the graphene-based transistors on rubber substrates had several attractive features. For instance, the low-temperature printing processes made the fabrication technique much simpler than techniques that require high-temperature processes. Also, transistors made of conventional inorganic semiconducting materials cannot be fabricated on rubber substrates due to their poor [mechanical properties](#), which limits their stretchable range.

The researchers' experimental results confirmed the graphene transistors' good performance. They showed that the devices could be stretched up to 5% for 1,000 times and still maintain their good electrical properties. In one experiment, the researchers fabricated the graphene transistors on a rubber balloon and measured its electrical properties as they inflated the balloon. When

stretched more than 5%, the [electrical properties](#) began to degrade, due partly to microcracks and other defects in the graphene films.

"We will make an effort to improve the range of stretchability and the electronic properties of the current graphene devices and apply them to various wearable electronics and sensory skins," Ahn said.

The researchers predict that the graphene [transistors](#) could serve as a valuable component in future transparent and stretchable electronic applications, offering a performance that would be difficult to achieve using conventional electronic materials. Applications could include rollable displays, conformal biosensors that shape themselves on an underlying surface, and others.

"Stretchable electronics could be useful for various current and future applications, such as wearable displays and communication devices, conformal and stretchable biosensors (brain sensors, balloon catheters, etc.), sensory skin for robotics, and structural health monitors and eye-ball cameras," Ahn said. "Stretchable interconnects and devices would create foldable, rollable and wearable displays. Stretchable sensors could be embedded into gloves and clothing without bulkiness. Surgeon gloves could constantly monitor blood pH and other chemical levels."

More information: Seung-Ki Lee, et al.

"Stretchable Graphene Transistors with Printed Dielectrics and Gate Electrodes." *Nano Letters* ASAP, [DOI:10.1021/nl202134z](https://doi.org/10.1021/nl202134z)

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