Rigid Electronics Stretch to New Lengths

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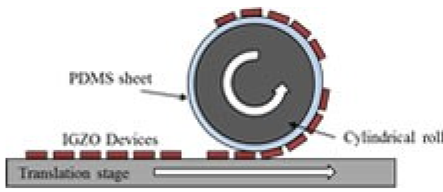

Illustration of the load-controlled roll transfer process of thin-film transistors to a PDMS substrate. Image credit: Dr. Jae-Hyun Kim and Mr. Bongkyun Jang of the Korea Institute of Machinery & Materials. Click image to enlarge.

As flexible electronic devices enter the consumer market, research focuses on devices that can stretch and twist as well. Stretchable electronics have already found use in medical applications, and new research from Sungkyunkwan University and the Korea Institute of Machinery & Materials could lead to stretchable display screens.

Researchers, in a recent publication in *Advanced Functional Materials*, have developed a method for creating transparent thin film transistors, made of rigid material, that resist deformation or breaking when stretched and twisted. "This demonstration seems to provide a bridge for rigid electronics to reach into the world of flexible electronics," said Jong-Hyun Ahn, the principal investigator from Sungkyunkwan University.

Stretching provides a new challenge with the introduction of shear stress, a force which can cause rigid materials to permanently deform or even fracture. Shear stress also arises in the torsion, or twisting, of a material. Electronic circuitry on a flexible substrate can easily bend, but the shear modulus, which describes a material's ability to handle stress, is too low for the material to recover from stretching or twisting. The device will deform or snap.

To overcome this obstacle, a transparent indium-gallium-zinc-oxide (IGZO) thin film transistor, which is currently used in commercial ultra-high definition LCD screens, was affixed to a flexible polydimethylsiloxane (PDMS) substrate. PDMS not only has a large shear modulus, which allows recovery from stretching and twisting, but is also completely transparent. These two materials merge inflexible, high performing devices with completely malleable surfaces.

The pre-fabricated transistor is applied using a load-controlled roll transfer process, which is a similar to common methods in large scale industrial fabrication and "the only transfer technique which is not limited to the size of the electronic circuitry," according to Ahn. In this process, a conveyer belt moves an array of transistors beneath a roller coated with a heated, sticky PDMS substrate. As the transistors are carried under the roller, they become attached to the PDMS. Automated actuators control the force applied from the rollers to the transistors so that devices will not crack during the transfer process.

“The roller technology is impressive here,” said Roozbeh Ghaffari, the director of medical development at MC10, a manufacturer of flexible electronics, “because you’re able to have feedback in the roller to control how well the roller is interacting with the electronics you’re trying to lift off. The contact load and actuators makes this a new kind of roller, a smart roller.”

After transfer, wrinkles in the PDMS form as interconnecting bridges over the device. These bridges, formed around the active device area, flatten when stretched to absorb the added strain. As Ghaffari describes it, the wrinkles “act like strings so the actual device doesn’t stretch but everything else does.”

Fabrication of the transistor before transferring onto the flexible surface has its own benefits. In the fabrication of the transistor, researchers must heat the inorganic material to temperatures up to 350°C in order to improve the electrical conductivity. High temperatures would degrade the soft polymer substrate, so the device is heated on a rigid silicon substrate before transfer to the soft polymer substrate.

Presently, the groups are planning for extension of this fabrication technique to large-area consumer applications. Of this Ahn said, “We are expecting that this research can broadly attract the scientific community as well as the industry to fabricate large-area real application-based flexible and stretchable devices.”

Read the abstract in *Advanced Functional Materials* here.

Link: http://www.materials360online.com/newsDetails/33620