Rolling out an e-sticker revolution

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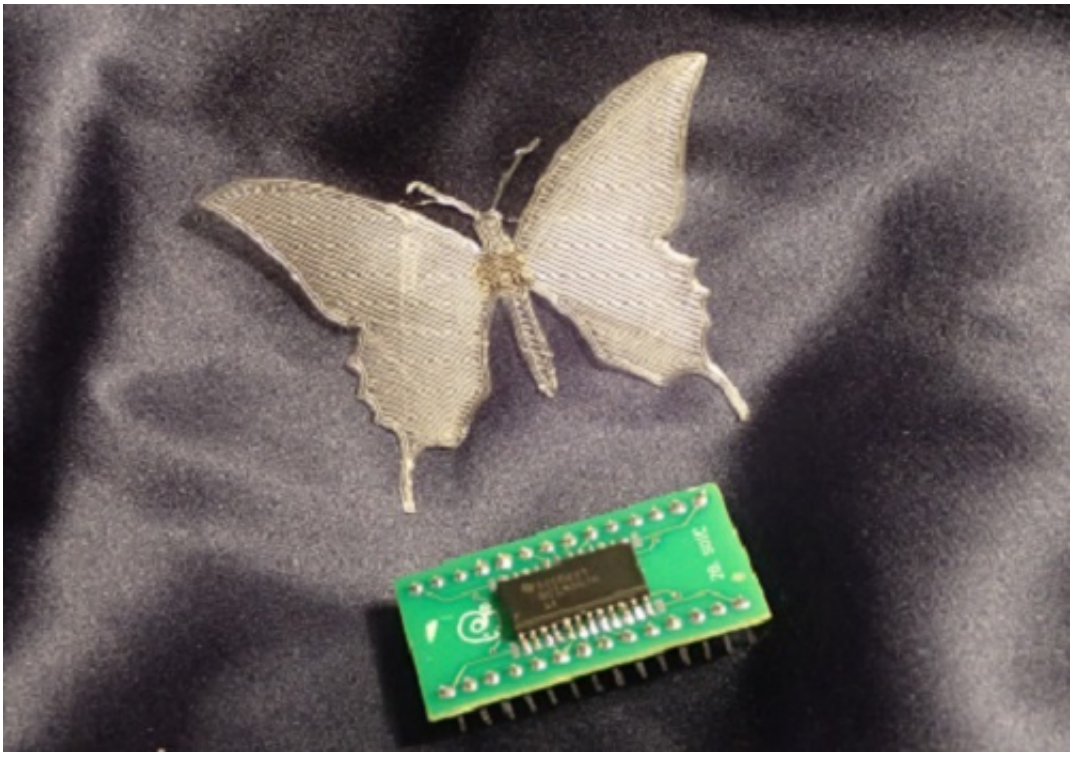

Pressure-sensitive 'e-stickers' contain all the functionality of traditional silicon circuits but can be fabricated into complex, flexible shapes such as butterflies. Credit: © 2016 KAUST

The healthcare industry forecasts that future wellbeing will be monitored by wearable, wirelessly networked sensors. Manufacturing such devices could become much easier using decal electronics. A KAUST-developed process prints these high-performance, silicon-based computers on soft, sticker-like surfaces that can be attached anywhere.

Fitting electronics on to the asymmetric contours of human bodies demands a re-think of traditional computer fabrication. One approach is to print circuit patterns on materials like polymers or cellulose using liquid ink made from conductive molecules. This technique enables high-speed, roll-to-roll assembly of devices and packaging at low costs.

Flexible printed circuits, however, require conventional silicon components to handle applications such as digitizing analog signals. Such rigid modules can create uncomfortable hot spots on the body and increase device weight.

For the past four years, Muhammad Hussain and his team from the KAUST Computer, Electrical and Mathematical Science and Engineering Division have investigated ways to improve the flexibility of silicon materials while retaining their performance.

"We are trying to integrate all device components—sensors, data management electronics, battery, antenna—into a completely compliant system," explained Hussain. "However, packaging these discrete modules on soft substrates is extremely difficult."

Searching for potential electronic skin applications, the researchers developed a sensor containing narrow strips of aluminum foil that changes conductivity at different bending states.

The devices, which could monitor a patient's breathing patterns or activity levels, feature high-mobility zinc oxide nanotransistors on silicon wafers thinned down lithographically to microscale dimensions for maximum flexibility. Using 3-D printing techniques, the team encapsulated the silicon chips and foils into a polymer film backed by an adhesive layer.

Hussain and his colleagues found a way to make the e-sticker sensors

work in multiple applications. They used inkjet printing to write conductive wiring patterns on surfaces including paper and clothing. Custom-printed decals were then attached or re-adhered to each location.

"You can place a pressure-sensing decal on a tire to monitor it while driving and then peel it off and place it on your mattress to learn your sleeping patterns," said Galo Torres Sevilla, first author of the findings and a KAUST Ph.D. graduate.

The robust performance and high-throughput manufacturing potential of decal electronics could yield a number of innovative sensor deployments, noted Hussain.

"I believe that electronics have to be democratized—simple to learn and easy to implement. Electronic decals are a right step in that direction," Hussain said.

More information: Galo A. Torres Sevilla et al, Decal Electronics: Printable Packaged with 3D Printing High-Performance Flexible CMOS Electronic Systems, *Advanced Materials Technologies* (2016). DOI: 10.1002/admt.201600175

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