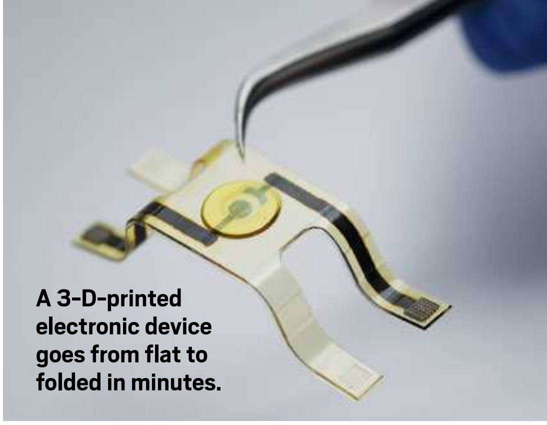
3-D PRINTING

Electronics take shape

A mechanically active ink allows flat, 3-D-printed electronic components to spontaneously fold



A 3-D-printed electronic device goes from flat to folded in minutes.

After being peeled from the platform of a three-dimensional printer, a flat electronic component begins to fold its four legs. In just a few minutes, it has folded into its desired form and can stand. Researchers can now print self-folding electronic devices like this one thanks to a new polymer ink that builds up mechanical stress during the 3-D-printing process (*ACS Appl. Mater. Interfaces* 2017, DOI: 10.1021/acsami.7b10443).

Using 3-D printing to make electronic devices with unusual shapes is quite challenging, says Subramanian Sundaram of Massachusetts Institute of Technology, who developed the new ink in collaboration with Ryan C. Hayward, a polymer scientist at the University of Massachusetts, Amherst.

Semiconductor inks, which are runny because of the solvents used to make them, must be printed on a flat surface or else they will dribble out of bounds. Researchers typically print electronic devices flat, then reshape them into a 3-D form. This reshaping involves heating and bending, or using printable materials that expand in the presence of water or another solvent. But exposure to liquids and heat isn't good for electronics, Sundaram says.

The ink he and his colleagues developed is made up of long-chain and short-chain acrylic polymers. As the 3-D printer deposits layers of the ink, the short polymer chains from the new layer migrate into the underlying, partially cured layer deposited earlier. The ink layers swell, causing mechanical stress to build up as the polymer becomes rigid. That residual stress cannot be released until the printed piece is pried off the printing platform.

By alternating layers of the ink with rigid polyacrylate and controlling different parameters, the researchers can program particular folds into a printed object and control the folding angles within a few degrees. As a proof of principle, the group made a self-folding, four-legged electrochromic device, which changes color in response to an applied voltage.

"The idea of using mechanically active substrate materials to transform planar electronics into 3-D, curvilinear shapes is interesting," says John A. Rogers, a materials scientist at Northwestern University. With further development, he says, researchers could use this method to make bioinspired devices and medical devices.—KATHERINE BOURZAC, special to C&EN

NUCLEIC ACIDS

DNA robot sorts and delivers

Nucleic acid construct picks up, moves, and drops off fluorescent cargo to predetermined locations

To deliver a package, we usually enlist the help of a postal or parcel service, which accepts the cargo, sorts it, and sees that it gets safely to its designated destination. This task becomes quite complicated in the molecular world, where our methods of manipulation are still fairly rudimentary. Now, with a single strand of DNA just 53 nucleotides long, scientists at Caltech have created a robot that picks up molecular cargo, sorts it, and delivers it to a predetermined location.

The DNA robot, developed by Lulu Qian, Anupama J. Thubagere, and colleagues, features an arm with a hand to carry cargo and a central leg with two feet that wander a DNA track studded with pegs of single-stranded DNA. The feet anchor to the track one at a time as they bind to complementary nucleotides in the pegs. When the robot encounters cargo—in this case, a fluorescent molecule covalently linked to a short single strand of DNA—it picks the cargo up and carries it until reaching a single strand of DNA on the track that's designed to snatch the cargo from the robot (*Science* 2017, DOI: 10.1126/science.aan6558).

A conceptual image of Qian and Thubagere's DNA robot carrying cargo.

Qian and Thubagere's team used two types of cargo, one bit of DNA with a yellow fluorescent dye and one with a pink fluorescent dye, to demonstrate the robot could sort the two. One robot working alone on a surface was able to sort six molecules of cargo in about a day. When the team used multiple robots at once, they were able to speed up the process.

"What's novel about this system is that it has a design that allows for an army of robots to operate independently," comments John H. Reif, an expert in DNA robots at Duke University. "The design of the whole system is incredibly elegant and simple."

Applications in chemical synthesis and drug delivery exist, but they're a long way off, Qian says. "The point of this work is toward understanding the engineering principles for building general-purpose DNA robots rather than how to use them for specific applications," she says.—BETHANY HALFORD

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