Cotton candy capillaries lead to circuit boards that dissolve when cooled

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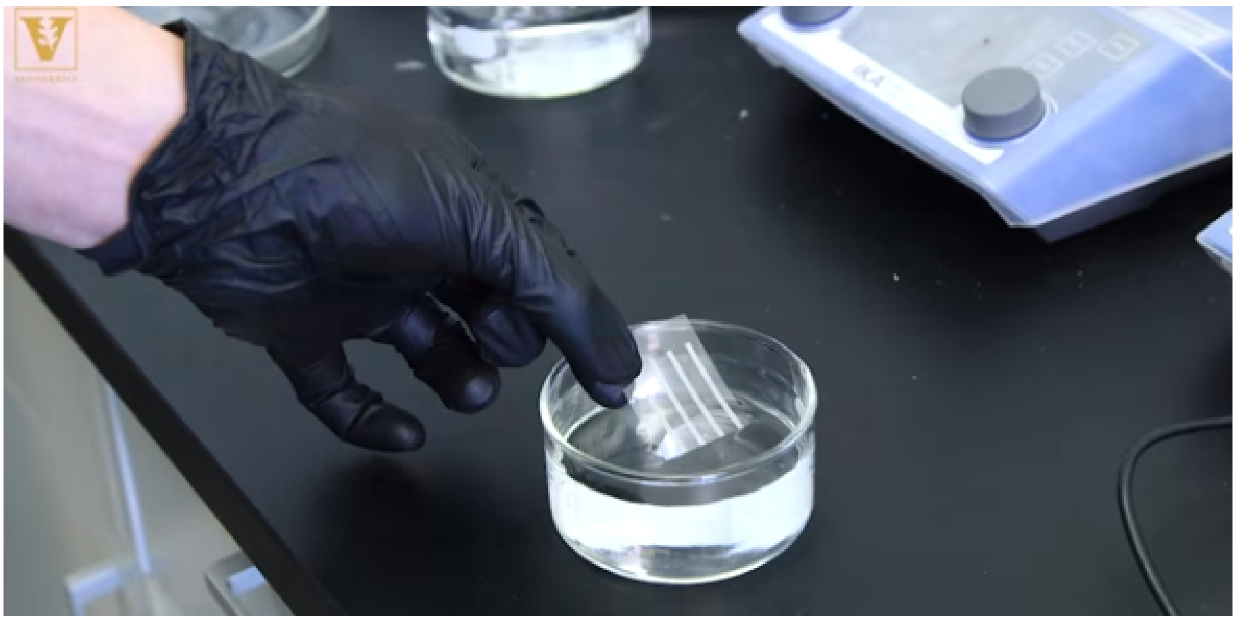

Building transient electronics is usually about doing something to make them stop working: blast them with light, soak them with acid, dunk them in water.

Professor Leon Bellan's idea is to dissolve them with neglect: Stop applying heat, and they come apart.

Using silver nanowires embedded in a polymer that dissolves in water below 32 degrees Celsius—between body and room temperature—Bellan and mechanical engineering graduate student Xin Zhang made a simple circuit board that, so far, just turns on an LED light. Its potential applications are far more promising. "Let's say you use this technology to make an RFID wireless tag," said Bellan, assistant professor of mechanical and biomedical engineering at Vanderbilt University. "You could implant important information in a person, and body temperature would keep it intact. If the tag were removed or the bearer died, it would dissolve. You could use it for implanted medical devices as well - to cause them to disintegrate, it would only require applying ice to the skin."

In the lab, his tiny circuit boards stay operational in water warmed by a hot plate. Turn off the hot plate, and they start dissolving in minutes.

The duo's paper, available online and soon to be published in the journal *ACS Applied Materials and Resources*, represents an application of technology Bellan developed last year. Using a special polymer and a cotton candy machine purchased from a department store, he spun networks of threads comparable in size, density and complexity to capillaries - the tiny conduits that deliver oxygen and nutrients to cells.

Bellan's cotton candy-like fiber networks can be embedded in materials that mimic the extracellular matrix and then be triggered to dissolve away, potentially producing capillary systems for artificial organs. He's using the same triggering system to produce transient electronics.

In this system, the silver nanowires are held together in the polymer so that they touch, and as long as the polymer doesn't dissolve, the nanowires will form a path to conduct electricity similar to the traces on a circuit board. Trigger the polymer to dissolve by lowering the temperature, and the nanowire network disintegrates, destroying the conductive path.

"Transient electronics are cool, and once you start coupling that to a stimulus-responsive material, you start coming up with really sci-fi ideas," Bellan said. "You could have any cascade of events that results in a very unique stimulus that causes it to degrade or prevent it from falling apart. Temperature is just the beginning."

The next steps are integrating semiconductors to make transistors and ensuring users can interact wirelessly with the device.

More information: Xin Zhang et al, Composites Formed from Thermoresponsive Polymers and Conductive Nanowires for Transient Electronic Systems, *ACS Applied Materials & Interfaces* (2017). DOI: 10.1021/acsami.7b04748

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