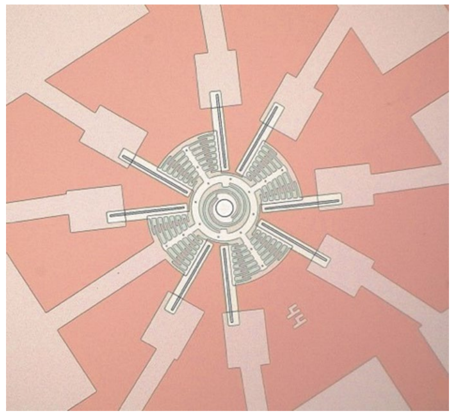
Making electronics that don't last

The development of microelectromechanical systems that decompose after use expands the toolbox of transient electronics, a technology that could help reduce electronic waste.

Microelectromechanical systems (MEMS) are a feature of numerous electronic devices and represent a global industry worth billions of dollars. They are, for instance, a key component of smartphones, helping to create the microphones, accelerometers and gyroscopes found in the devices. Such MEMS technology is designed to be tough, long-lasting and resistant to corrosion. The rationale for this during the operational lifetime of a device is clear. It does though create problems at the end of life, when the device is no longer required.

In an Article in this issue of *Nature Electronics*, Jan-Kai Chang, John Rogers and colleagues report MEMS devices that are designed to be transient: that is, they operate consistently during their intended lifetime and then decompose into non-toxic products that can be absorbed harmlessly into the environment. Using various water-soluble materials, including polysilicon layers and polymeric substrates, the researchers create a range of systems that cover all three major classes of MEMS devices: electrocapacitive sensors, electrostatic actuators and electrothermal actuators. They also develop different encapsulation materials — based, for example, on a mixture of beeswax and candelilla wax — that can be used to protect the devices in different applications.

Such transient devices offer a potential route to reduce electronic waste, but they could also be of use in temporary medical implants that avoid the need for post-use extractive surgery. And the team — who are based at Northwestern University, Washington University in St. Louis, the University of Illinois at Urbana-Champaign, the University of Illinois at Chicago, Stanford University and Tsinghua University — explore this intriguing application. In particular, they examine the biocompatibility of the implanted devices and their dissolution end products. The analysis suggests that the technology is safe to use in biointegrated systems. (See also the accompanying Research Briefing on the work.)



Optical microscopy image of a rotary electrostatic actuator made using entirely ecoresorbable and bioresorbable materials. Image reproduced with permission from the Article by Chang, Rogers and colleagues, Springer Nature Ltd.

This bioresorbable and ecoresorbable MEMS technology expands the capabilities of existing transient electronics[1], which already includes various transistors[2] and sensors[3,4], and means that more complex transient devices could now be possible. The use of transient electronics in implantable devices opens up a number of unique applications and the path to clinical use appears promising, although much work remains to be done[5]. Whether the technology has a future in consumer gadgetry is more uncertain and will likely depend on the development of transient components with performance that is competitive with established — and more permanent — counterparts.

Nevertheless, the issue that such ecoresorbable electronics aims to solve — the reduction of solid waste from discarded consumer devices — is one that must be addressed. Around 50 million tonnes of electronic waste is produced every year across the world, and, on current trends, this could potentially reach as much as 120 million tonnes a year by 2050[6]. The issue requires international cooperation and global solutions[7], including careful regulatory action[8]. But it also requires action at a more fundamental level, in the way we design and build devices. Thus, transient electronics — as well as inherently recyclable electronics[9] — may not be disappearing anytime soon. ❐

Published online: 23 August 2022
https://doi.org/10.1038/s41928-022-00834-7

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