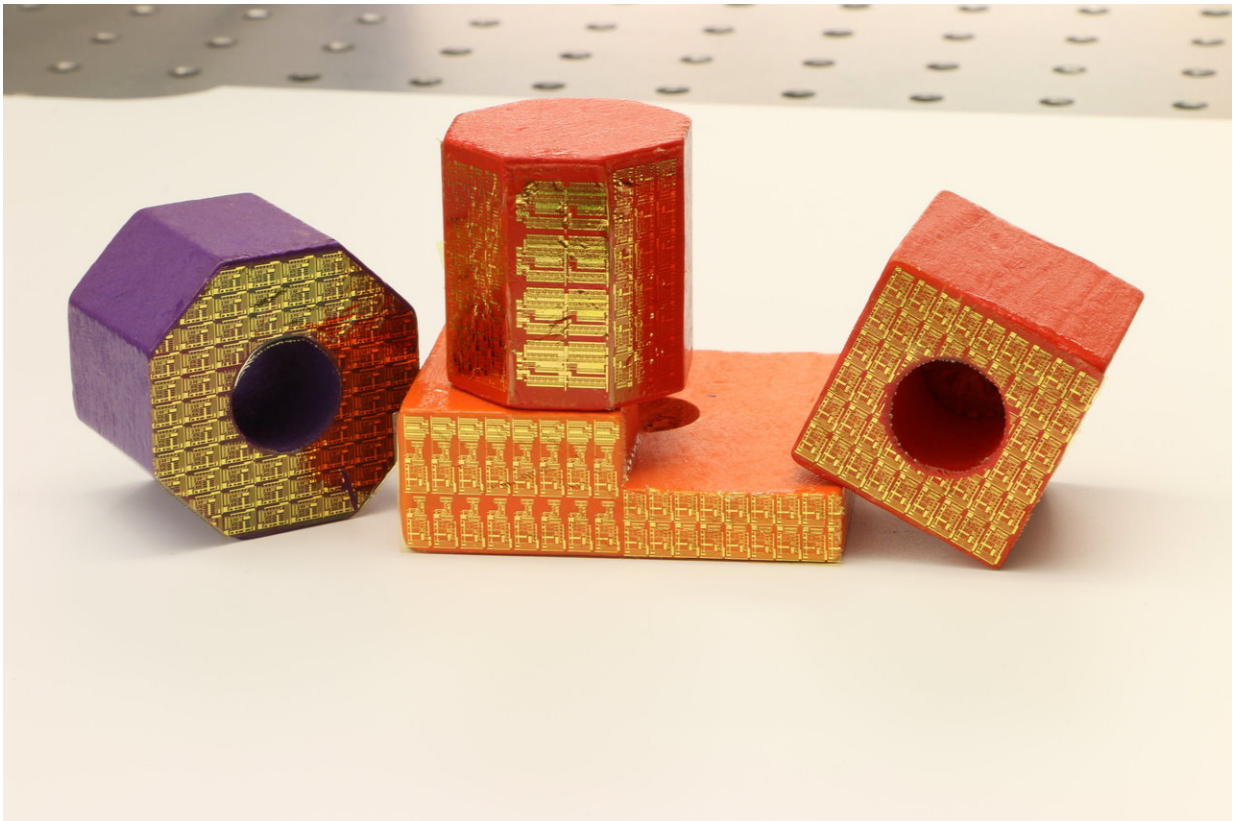


# Electronic stickers to streamline large-scale 'internet of things'

July 17 2018

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Electronic stickers can turn ordinary toy blocks into high-tech sensors within the 'internet of things.' Credit: Purdue University /Chi Hwan Lee

Billions of objects ranging from smartphones and watches to buildings, machine parts and medical devices have become wireless sensors of their

environments, expanding a network called the "internet of things."

As society moves toward connecting all objects to the internet—even furniture and office supplies—the technology that enables these objects to communicate and sense each other will need to scale up.

Researchers at Purdue University and the University of Virginia have developed a new fabrication method that makes tiny, thin-film [electronic circuits](#) peelable from a surface. The technique not only eliminates several manufacturing steps and the associated costs, but also allows any object to sense its environment or be controlled through the application of a high-tech sticker.

Eventually, these stickers could also facilitate wireless communication. The researchers demonstrate capabilities on various objects in a paper recently published in the *Proceedings of the National Academy of Sciences*.

"We could customize a sensor, stick it onto a drone, and send the drone to dangerous areas to detect gas leaks, for example," said Chi Hwan Lee, Purdue assistant professor of biomedical engineering and mechanical engineering.

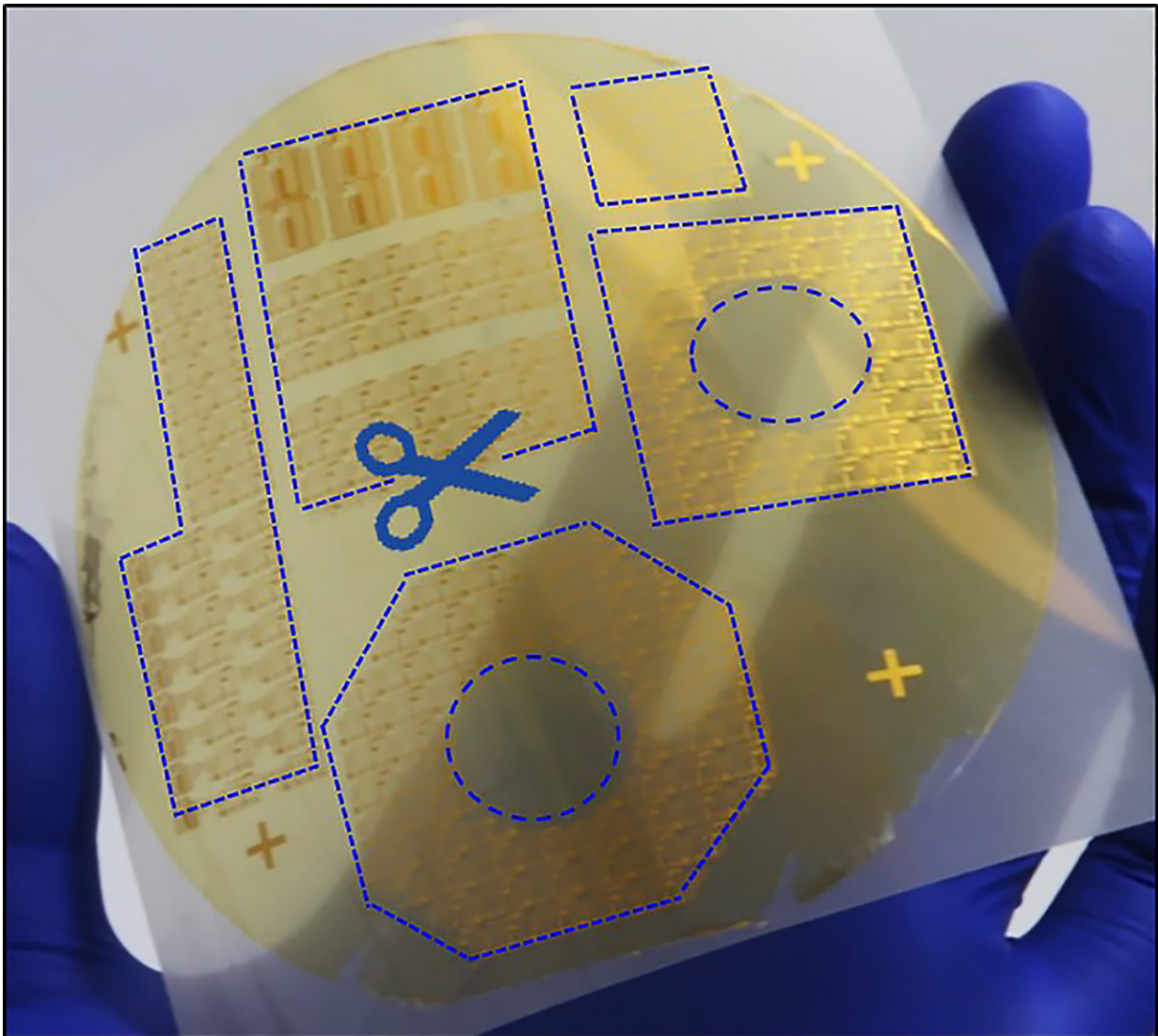
Most of today's electronic [circuits](#) are individually built on their own silicon "wafer," a flat and rigid substrate. The silicon wafer can then withstand the [high temperatures](#) and chemical etching that are used to remove the circuits from the wafer.

But high temperatures and etching damage the silicon wafer, forcing the manufacturing process to accommodate an entirely new wafer each time.

Lee's new fabrication technique, called "transfer printing," cuts down manufacturing costs by using a single wafer to build a nearly infinite

number of thin films holding electronic circuits. Instead of high temperatures and chemicals, the film can peel off at room temperature with the energy-saving help of simply water.

"It's like the red paint on San Francisco's Golden Gate Bridge—paint peels because the environment is very wet," Lee said. "So in our case, submerging the wafer and completed circuit in water significantly reduces the mechanical peeling stress and is environmentally-friendly."

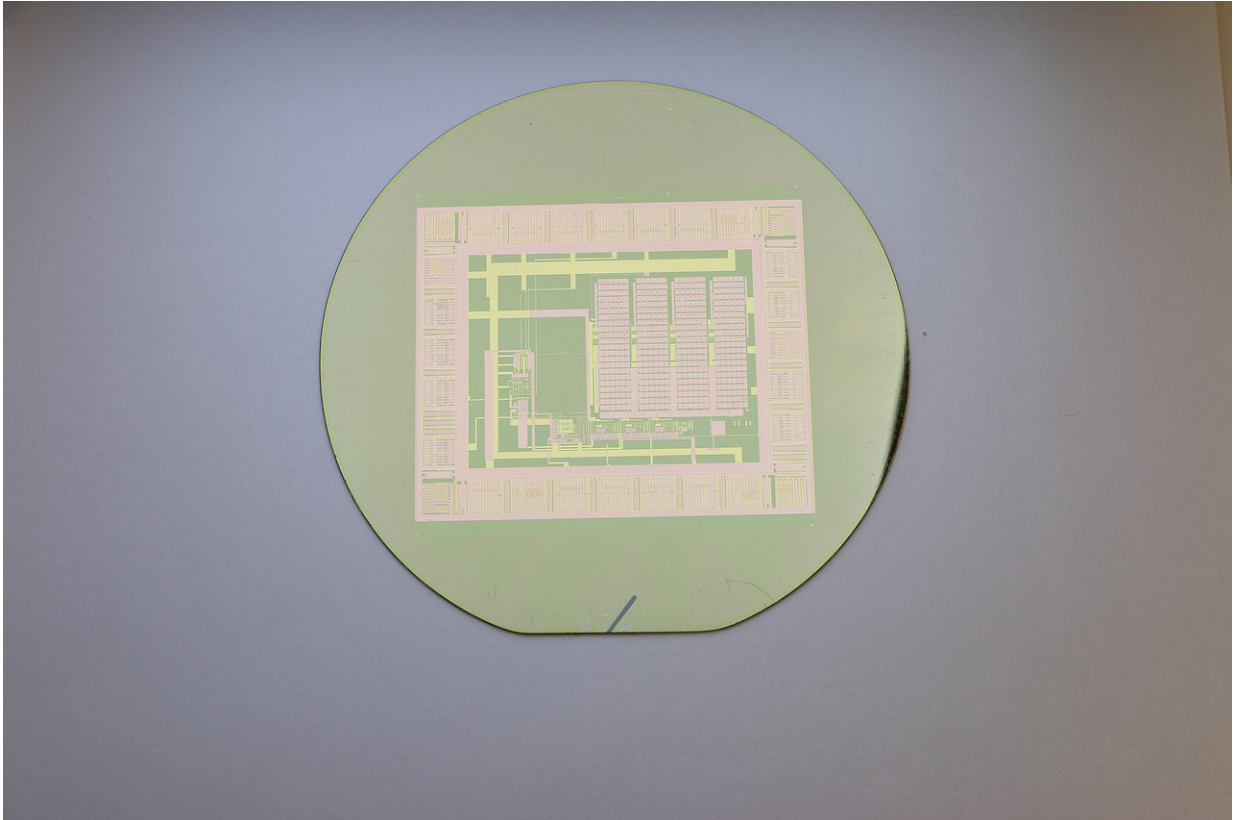


Researchers have designed peelable electronic films that can be cut and pasted onto any object to achieve desired functions. Credit: Purdue University image/Chi Hwan Lee

A ductile metal layer, such as nickel, inserted between the electronic film and the silicon wafer, makes the peeling possible in water. These thin-film electronics can then be trimmed and pasted onto any surface, granting that [object](#) electronic features.

Putting one of the stickers on a flower pot, for example, made that flower pot capable of sensing temperature changes that could affect the plant's growth.

Lee's lab also demonstrated that the components of electronic integrated circuits work just as well before and after they were made into a thin film peeled from a silicon [wafer](#). The researchers used one film to turn on and off an LED light display.



A thin-film electronic circuit can peel easily from its silicon wafer with water, making the wafer reusable for building a nearly infinite number of circuits.

Credit: Purdue University image/Chi Hwan Lee

"We've optimized this process so that we can delaminate electronic films from wafers in a defect-free manner," Lee said.

This technology holds a non-provisional U.S. patent. The work was supported by the Purdue Research Foundation, the Air Force Research Laboratory (AFRL-S-114-054-002), the National Science Foundation (NSF-CMMI-1728149) and the University of Virginia.

**More information:** Dae Seung Wie et al., "Wafer-recyclable, environment-friendly transfer printing for large-scale thin-film

nanoelectronics," *PNAS* (2018).

[www.pnas.org/cgi/doi/10.1073/pnas.1806640115](http://www.pnas.org/cgi/doi/10.1073/pnas.1806640115)

Provided by Purdue University

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