SEPTEMBER 11, 2025

Circuits invisible to the naked eye: New technique shrinks microchips beyond current size limits

by Johns Hopkins University

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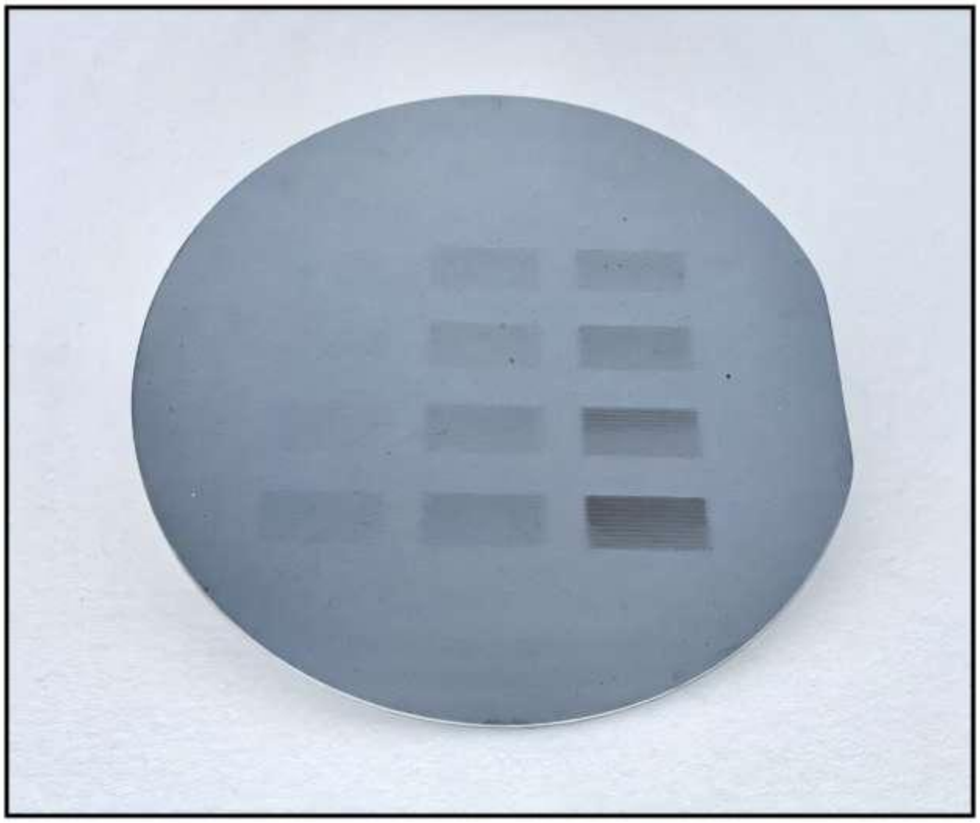

A silicon wafer with large visible patterns created using B-EUV lithography.

Johns Hopkins researchers have discovered new materials and a new process that could advance the ever-escalating quest to make smaller, faster and affordable microchips used across modern electronics—in everything from cellphones to cars, appliances to airplanes.

Using a process that is both precise and economical for manufacturing, the team of scientists has discovered how to create circuits that are so small they're invisible to the naked eye. The findings are published in the journal *Nature Chemical Engineering*.

"Companies have their roadmaps of where they want to be in 10 to 20 years and beyond," said Michael Tsapatsis, a Bloomberg Distinguished Professor of chemical and biomolecular engineering at Johns Hopkins University. "One hurdle has been finding a process for making smaller features in a production line where you irradiate materials quickly and with absolute precision to make the process economical." The advanced lasers required for imprinting on the minuscule formats already exist, Tsapatsis added, but researchers needed new materials and new processes to accommodate ever smaller microchips.

Microchips are flat pieces of silicon with imprinted circuitries that execute basic functions. During production, manufacturers coat silicon wafers with a radiation-sensitive material to create a very fine coating called a "resist." When a beam of radiation is pointed at the resist, it sparks a chemical reaction that burns details into the wafer, drawing patterns and circuitry.

However, the higher-powered radiation beams that are needed to carve out ever-smaller details on chips do not interact strongly enough with traditional resists.

Previously, researchers from Tsapatsis's lab and the Fairbrother Research Group at Johns Hopkins found that resists made of a new class of metal-organics can accommodate that higher-powered radiation process, called "beyond extreme ultraviolet radiation" (B-EUV), which has the potential to make details smaller than the current standard size of 10 nanometers. Metals like zinc absorb the B-EUV light and generate electrons that cause chemical transformations needed to imprint circuit patterns on an organic material called imidazole. This research marks one of the first times scientists have been able to deposit these imidazole-based metal-organic resists from solution at a silicon-wafer scale, controlling their thickness with nanometer precision.

To develop the chemistry needed to coat the silicon wafer with the metal-organic materials, the team combined experiments and models from Johns Hopkins University, East China University of Science and Technology, École Polytechnique Fédérale de Lausanne, Soochow University, Brookhaven National Laboratory and Lawrence Berkeley National Laboratory. The new methodology, which they call chemical liquid deposition (CLD), can be precisely engineered and lets researchers quickly explore various combinations of metals and imidazoles.

"By playing with the two components (metal and imidazole), you can change the efficiency of absorbing the light and the chemistry of the following reactions. And that opens us up to creating new metal-organic pairings," Tsapatsis said. "The exciting thing is there are at least 10 different metals that can be used for this chemistry, and hundreds of organics."

The researchers have started experimenting with different combinations to create pairings specifically for B-EUV radiation, which they say will likely be used in manufacturing in the next 10 years. "Because different wavelengths have different interactions with different elements, a metal that is a loser at one wavelength can be a winner at the other," Tsapatsis said. "Zinc is not very good for extreme ultraviolet radiation, but it's one of the best for the B-EUV."

More information: Spin-on deposition of amorphous zeolitic imidazolate framework films for lithography applications, *Nature Chemical Engineering* (2025). DOI: 10.1038/s44286-025-00273-z. www.nature.com/articles/s44286-025-00273-z
Journal information: Nature Chemical Engineering
Provided by Johns Hopkins University