Breakthrough reported in fabricating nanochips

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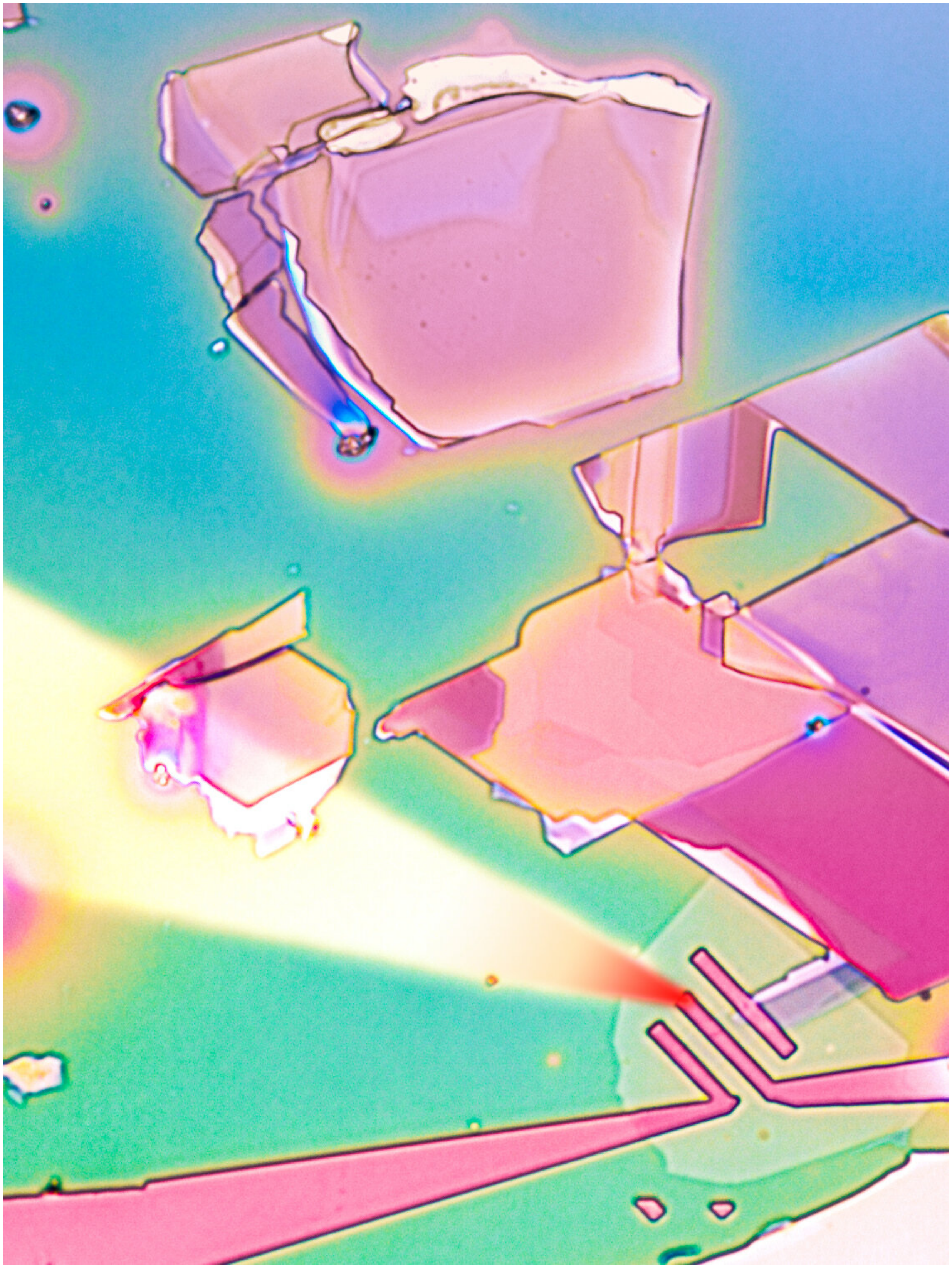


A one-atom-deep layer of molybdenum disulfide with electrodes patterned by hot nano-tip in a new process called thermal scanning probe lithography. Researchers at NYU Tandon School of Engineering invented the process to produce high-quality semiconductors at a cost significantly lower than current electron beam lithography. Credit: NYU Tandon

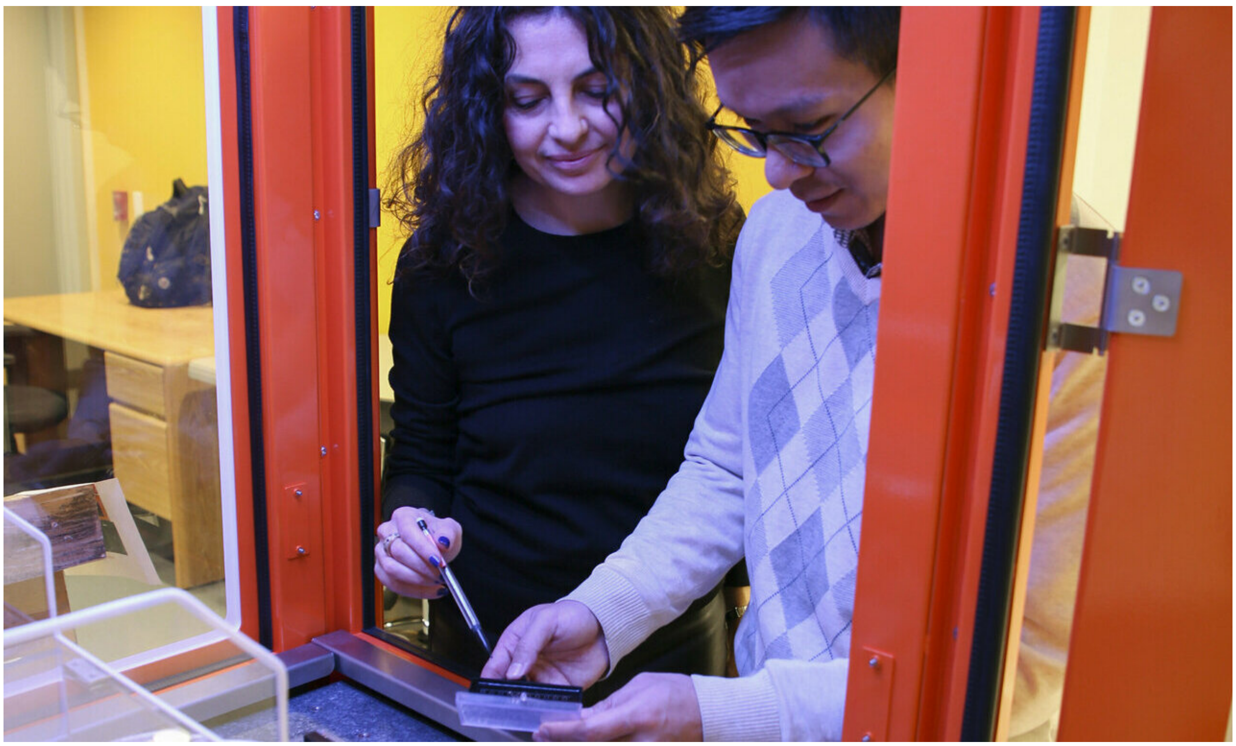
An international team of researchers has reported a breakthrough in fabricating atom-thin processors—a discovery that could have far-reaching impacts on nanoscale chip production and in labs across the globe where scientists are exploring 2-D materials for ever-smaller and -faster semiconductors.

The team, headed by New York University Tandon School of Engineering Professor of Chemical and Biomolecular Engineering Elisa Riedo, outlined the research results in the latest issue of *Nature Electronics*.

They demonstrated that lithography using a probe heated above 100 degrees Celsius outperformed standard methods for fabricating metal electrodes on 2-D semiconductors such as molybdenum disulfide (MoS2). Such transitional metals are among the materials that scientists believe may supplant silicon for atomically small chips. The team's new fabrication method—called thermal scanning probe lithography (t-SPL) - offers a number of advantages over today's electron beam lithography (EBL).

First, thermal lithography significantly improves the quality of the 2-D transistors, offsetting the Schottky barrier, which hampers the flow of electrons at the intersection of metal and the 2-D substrate. Also, unlike EBL, the thermal lithography allows chip designers to easily image the 2-D semiconductor and then pattern the electrodes where desired. Also, t-

SPL fabrication systems promise significant initial savings as well as operational costs: They dramatically reduce power consumption by operating in ambient conditions, eliminating the need to produce high-energy electrons and to generate an ultra-high vacuum. Finally, this thermal fabrication method can be easily scaled up for industrial production by using parallel thermal probes.



In the NYU Tandon School of Engineering PicoForce Lab, Professor Elisa Riedo and doctoral student Xiangyu Liu fabricate high-quality 2D chips using the thermal scanning probe lithography process they invented and NanoFrazor equipment by SwissLitho. The process holds promise as an alternative to today's electron beam lithography. Credit: NYU Tandon

Riedo expressed hope that t-SPL will take most fabrication out of scarce clean rooms—where researchers must compete for time with the expensive equipment—and into individual laboratories, where they might rapidly advance materials science and chip design. The precedent of 3-D printers is an apt analogy: Someday these t-SPL tools with sub-10 nanometer resolution, running on standard 120-volt power in ambient conditions, could become similarly ubiquitous in research labs like hers.

"Patterning Metal Contacts on Monolayer MoS2 with Vanishing Schottky Barriers Using Thermal Nanolithography" appears in the January 2019 edition of *Nature Electronics* and can be accessed at http://dx.doi.org/10.1038/s41928-018-0191-0 with a "News & Views" analysis at https://www.nature.com/articles/s41928-018-0197-7.

Riedo's work on thermal probes dates back more than a decade, first with IBM Research—Zurich and subsequently SwissLitho, founded by former IBM researchers. A process based on a SwissLitho system was developed and used for the current research. She began exploring thermal lithography for metal nanomanufacturing at the City University of New York (CUNY) Graduate Center Advanced Science Research Center (ASRC), working alongside co-first-authors of the paper, Xiaorui Zheng and Annalisa Calò, who are now post-doctoral researchers at NYU Tandon; and Edoardo Albisetti, who worked on the Riedo team with a Marie Curie Fellowship.

More information: Xiaorui Zheng et al, Patterning metal contacts on monolayer MoS2 with vanishing Schottky barriers using thermal nanolithography, *Nature Electronics* (2019). DOI: 10.1038/s41928-018-0191-0

Provided by NYU Tandon School of Engineering