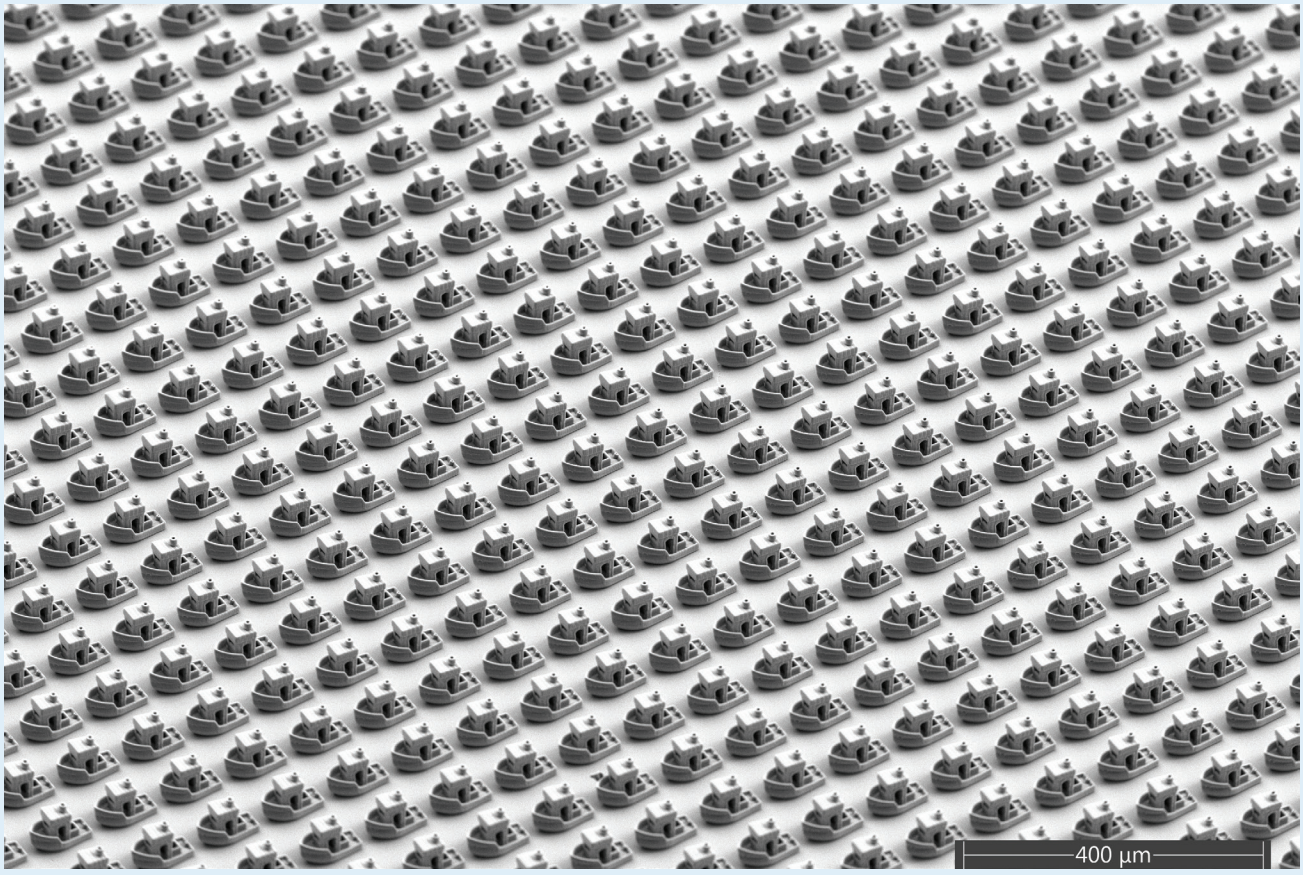

Tiny boats demonstrate a new nanolithography technique

By Sarah Wells

Each of these tugboats is 85 µm long, roughly twice the size of a human skin cell. Made from an acrylic polymer, the boats are a demonstration of a new lithography technique for 3D-printing applications. The technique was introduced by Xiaoxing Xia of Lawrence Livermore National Laboratory, Jonathan Fan of Stanford University, and their colleagues.

The new approach is an iteration of two-photon lithography (TPL), which uses a femtosecond laser to polymerize nanoscale features, such as the hull of one of the boats pictured, in a photoresin. Unlike standard photolithography, TPL does not require a photomask as a stencil. TPL has been used to demonstrate proof-of-concept applications in the lab for areas like microelectronics and biomedicine, but it can be slow and is difficult to scale. Instead of employing the standard TPL approach, which involves a laser with a single focal spot, Xia, Fan, and colleagues used ultrathin optical elements called metalenses to split the laser into up to 120 000 coordinated focal spots that can print simultaneously across an inch-scale area at about 1000 times the rate of a standard TPL technique. As part of a demonstration, the researchers used a smaller metalens array of a similar design to print this fleet of 10 000 boats in 30 minutes.

Xia says that the new technique may enable TPL to transition from a tool for labs to one useful for high-precision manufacturing. Beyond printing tiny boats, metalens TPL eventually could be used to, for example, produce fuel capsules for nuclear fusion experiments. (S. Gu et al., "3D nanolithography with metalens arrays and spatially adaptive illumination," *Nature* **648**, 591, 2025; image courtesy of Songyun Gu.) PT

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