New 3-D printing method creates complex micro objects

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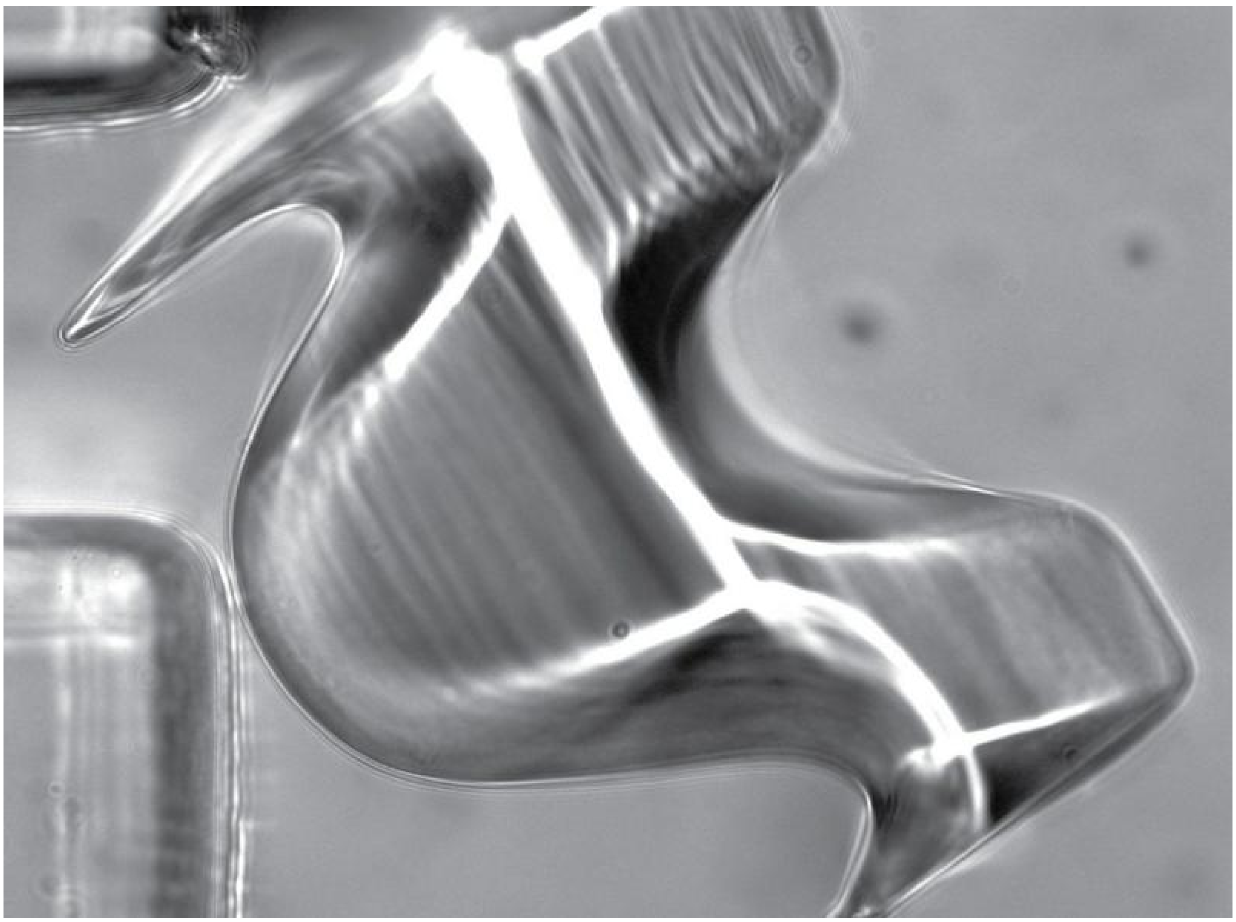

A 3-D printed microparticle about 500 micrometers in length. Credit: Chueh-Yu Wu/ UCLA

Bioengineers from the UCLA Henry Samueli School of Engineering and

Applied Science have developed a new method of 3-D printing that allows production of complex micro-scale objects smaller than the width of a human hair. The technique, using patterned ultraviolet light and a custom-shaped flow of polymer material, creates 3-D objects that can be first designed with software and could be used in a variety of biomedical and industrial applications.

The research was published online in the journal *Advanced Materials*.

The authors suggest that producing 3-D shapes at the micro scale could be useful for designing custom biomaterials such as interlocking particles that self-assemble to help tissue regenerate, or for industrial applications such as creating new coatings and paints with unique light-reactive properties.

"We know that shape often determines material function, so while we have a few ideas of what this could lead to, this fundamental capability to produce made-to-order 3-D microparticles could be applied in ways we have not contemplated," said Dino Di Carlo, the principal investigator on the research and a professor of bioengineering at UCLA. "There are so many potential applications—in that sense, it's really exciting."

In 3-D printing, a digital blueprint is used to fabricate a wide range of products. The most common method, known as additive fabrication, uses a liquid precursor material that squeezed out of a nozzle, drop by drop. As the liquid hardens, new layers are added until the object is finished. While this and other 3-D printing methods can make shapes with incredible complexity, researchers have not been able to make similarly complex objects smaller than a millimeter because the drops of material are too big.

To make smaller custom objects with folds, holes and other precise features, the UCLA team developed a new technique called optical transient liquid modeling. It uses a series of microfluidic and optical technologies, including a technique previously developed by Di Carlo's research group that simplifies designing the shape of fluid flows.

First, two different types of fluids are combined in a series of tiny pillars that control the shape of the merged fluids. One fluid is a liquid polymer that is the precursor material for the object. The other essentially acts as a liquid mold for the polymer stream. The arrangement of the pillars determines how the two flows mix and intertwine. The researchers used software that they previously developed to rapidly predict what shape will be produced by altering the pillars' location and sequence. It can be downloaded for free here.

When the flow of materials is stopped rapidly, an outlined pattern of ultraviolet light—somewhat like a cookie cutter—slices into the precursor stream. So the object is shaped first by the stream, then again by UV light. The UCLA researchers have reached printing speeds of nearly one object every five seconds.

"It's like we squeeze dough through a mold, which is the liquid mold, to make a noodle and then cut the noodle into pieces using another mold—the patterned UV light," said Chueh-Yu "Jerry" Wu, the lead author of the research and a graduate student in in Di Carlo's biomicrofluidics lab.

The objects the team has produced are about 100–500 micrometers in size, with features as small as 10–15 micrometers. With this method, they have produced objects composed of organic materials as well as particles whose movements and position could be precisely controlled by magnetism.

More information: Chueh-Yu Wu et al. Rapid Software-Based Design

and Optical Transient Liquid Molding of Microparticles, *Advanced Materials* (2015). DOI: 10.1002/adma.201503308

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