Researchers report new light-activated micro pump

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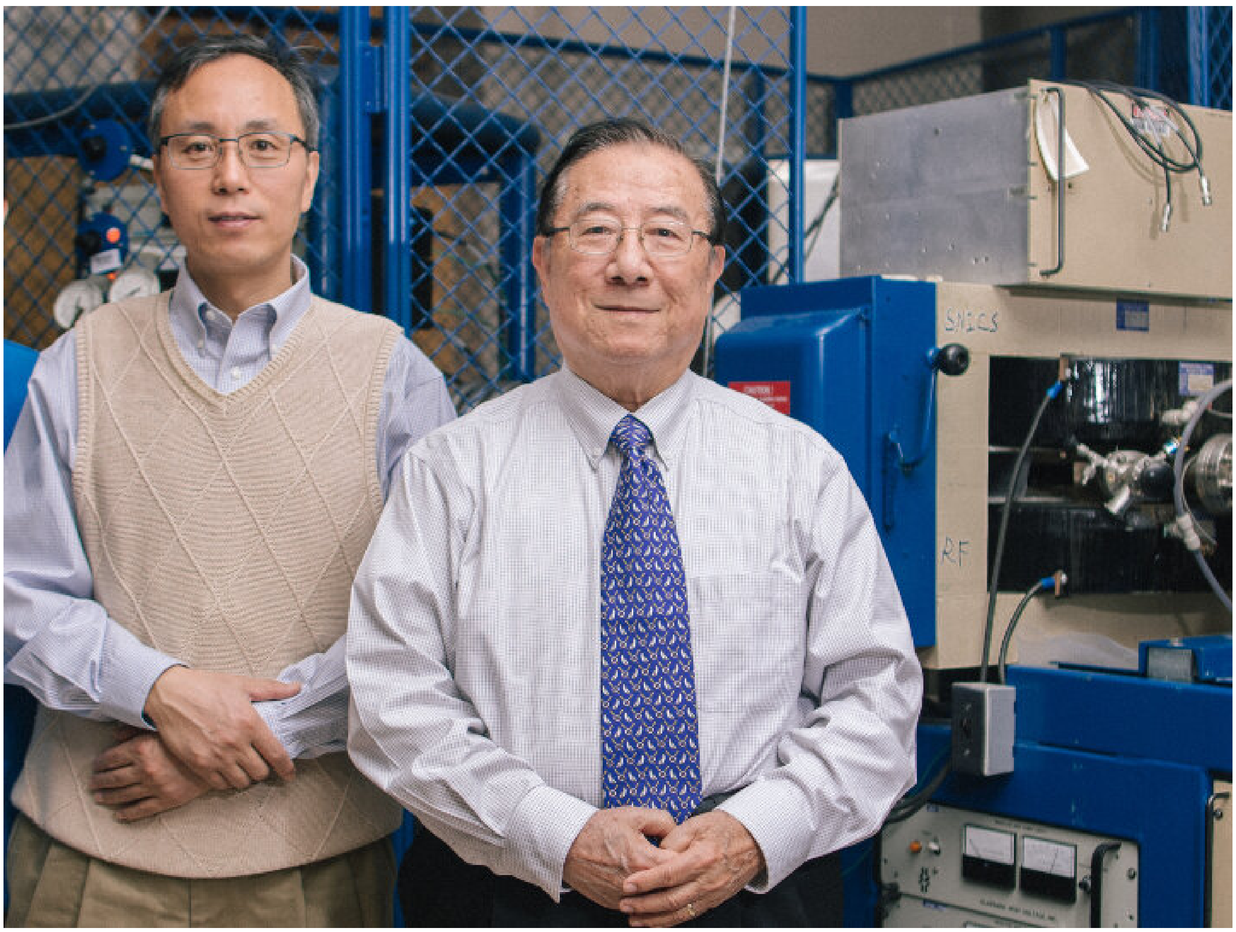

Researchers Jiming Bao, associate professor of electrical and computer engineering at the University of Houston, left, and Wei-Kan Chu, and project leader at the Texas Center for Superconductivity at UH, have reported a laser-driven photoacoustic microfluidic pump, capable of moving fluids in any direction without moving parts or electrical contacts. Credit: University of Houston

Even the smallest mechanical pumps have limitations, from the complex microfabrication techniques required to make them to the fact that there are limits on how small they can be. Researchers have announced a potential solution—a laser-driven photoacoustic microfluidic pump, capable of moving fluids in any direction without moving parts or electrical contacts.

The work is described in the *Proceedings of the National Academy of Sciences*.

Using a plasmonic quartz plate implanted with gold atoms, the researchers demonstrated the ability to move liquids by using a laser to generate an ultrasonic wave.

"We can use the laser to make liquids move in any direction," said Jiming Bao, associate professor of electrical and computer engineering at the University of Houston and lead author on the paper.

The work is based on a new optofluidics principle discovered by Bao's lab and reported in 2017. That work explained how a laser could be used to trigger a stream of liquid, coupling photoacoustics with acoustic streaming.

The latest work involved fabricating a quartz substrate implanted with 10^{16} gold atoms, or ten thousand trillion atoms, per square centimeter and testing whether a laser pulse could generate an ultrasonic wave capable of creating a liquid stream. The quartz plate—about the size of a fingernail—was implanted with gold nanoparticles; when a pulsed laser hits the plate, the gold nanoparticles generate an ultrasonic wave, which then drives the fluid via acoustic streaming.

"This new micropump is based on a newly discovered principle of photoacoustic laser streaming and is simply made of an Au [gold] implanted plasmonic quartz plate," the researchers wrote. "Under a pulsed laser excitation, any point on the plate can generate a directional long-lasting ultrasound wave which drives the fluid via acoustic streaming."

The work could have practical implications, from biomedical devices and drug delivery to microfluidic and optofluidic research. Wei-Kan Chu, a physicist and project leader at the Texas Center for Superconductivity at UH, said the true value isn't yet known. "We would like to better understand the mechanisms of this, and that could open up something beyond our imagination."

The device was fabricated in Chu's lab; he is a co-author, along with Nzumbe Epie, Xiaonan Shan and Dong Liu, all of UH; Shuai Yue, Feng Lin and Zhiming Wang of the University of Electronic Science and Technology of China; Qiuhui Zhang of Henan University of Engineering; and Suchuan Dong of Purdue University.

The nanoparticles offer an almost limitless number of targets for the laser, which can be aimed far more precisely than a mechanical micropump, Bao said.

"The mechanisms of how and why this works are not yet very clear," Chu said. "We need to understand the science better in order to develop the potential of its unforeseeable applications."

More information: Shuai Yue el al., "Gold-implanted plasmonic quartz plate as a launch pad for laser-driven photoacoustic microfluidic pumps," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1818911116