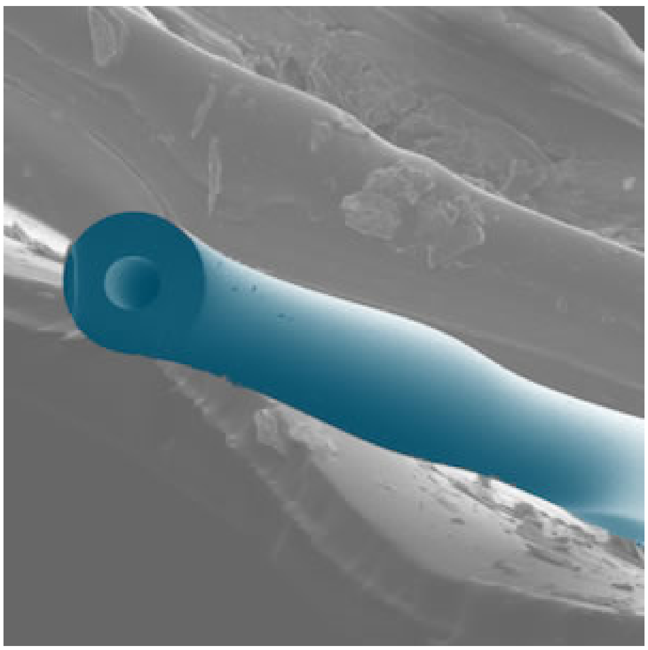
Whispering light hears liquids talk: Scientists build first-ever bridge between optomechanics and microfluidics

June 7 2013



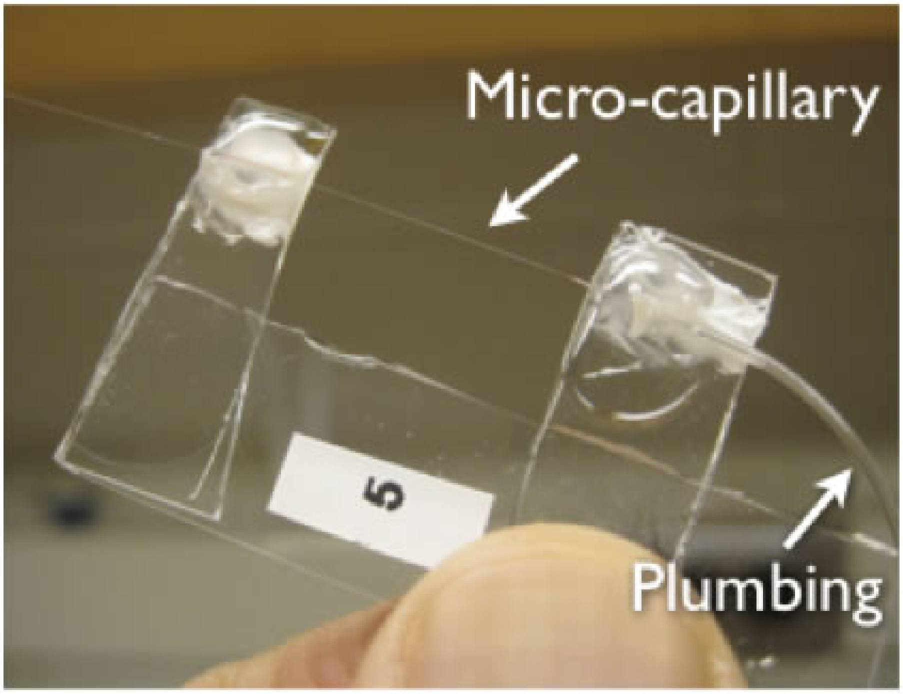
This is a false-color SEM (scanning electron micrograph) of the microfluidic optomechanical resonator. Credit: Gaurav Bahl, University of Illinois

Ever been to a whispering gallery—a quiet, circular space underneath an old cathedral dome that captures and amplifies sounds as quiet as a whisper? Researchers at the University of Illinois at Urbana-Champaign are applying similar principles in the development optomechanical sensors that will help unlock vibrational secrets of chemical and biological samples at the nanoscale.

"Optomechanics is an area of research in which extremely minute forces exerted by light (for example: radiation pressure, gradient force, electrostriction) are used to generate and control high-frequency mechanical vibrations of microscale and nanoscale devices," explained Gaurav Bahl, an assistant professor of mechanical science and engineering at Illinois.

In glass microcavities that function as optical whispering galleries, according to Bahl, these miniscule optical forces can be enhanced by many orders-of-magnitude, which enables 'conversations' between light (photons) and vibration (phonons). These devices are of interest to condensed matter physics as the strong phonon-photon coupling enables experiments targeting quantum information storage (i.e. qubits), quantum-mechanical ground state (i.e. optomechanical cooling), and ultra-sensitive force measurements past the standard quantum limit.

Researchers developed a hollow optomechanical device made of fused silica glass, through which fluids and gases could flow. Employing a unique optomechanical interaction called Brillouin Optomechanics (described previously in Bahl et al, *Nature Communications* 2:403, 2011; Bahl et al, *Nature Physics*, vol.8, no.3, 2012), the researchers achieved the optical excitation of mechanical whispering-gallery modes at a phenomenal range of frequencies spanning from 2 MHz to 11,000 MHz.



This image shows a microfluidic optomechanical capillary resonator with fluid control tubing. Credit: Gaurav Bahl, University of Illinois

"These mechanical vibrations can, in turn, 'talk' to liquids within the hollow device and provide optical readout of the mechanical properties," said Bahl, who is first author of the paper, "Brillouin cavity optomechanics with microfluidic devices," published this week in *Nature Communications*.

By confining various liquids inside a hollow microfluidic optomechanical (µFOM) resonator, researchers built the first-ever bridge between optomechanics and microfluidics.

"We found that the optomechanical interaction in the µFOM device is dependent on the fluid contained within," Bahl said. "These results are a step towards novel experiments probing optomechanics on non-solid phases of matter. In particular, the high frequency, high quality-factor mechanical vibrations demonstrated in this work may enable strongly localized, high-sensitivity, optomechanical interaction with chemical and biological samples."

Potential uses for this technology include optomechanical biosensors that can measure various optical and mechanical properties of a single cell, ultra-high-frequency analysis of fluids, and the optical control of fluid flow.

Provided by University of Illinois at Urbana-Champaign