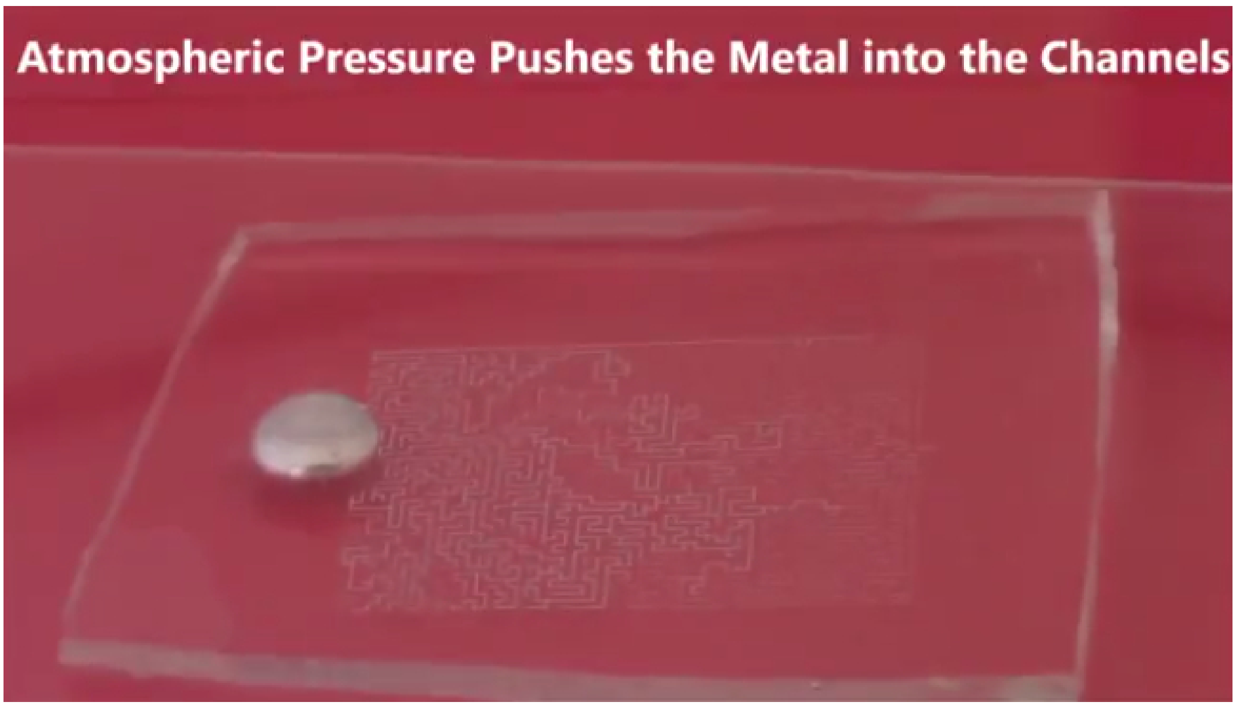
Look ma, no hands: Researchers use vacuum for hands-free patterning of liquid metal

August 15 2017, by Michael Dickey



North Carolina State University engineers have utilized vacuum to create a more efficient, hands-free method for filling complex microchannels with liquid metal. Their work addresses two of the most common difficulties in creating liquid metal-filled microchannels and may enable broader use of liquid metals in electronic and microfluidic applications.

Liquid metals are promising as soft, stretchable electrical components such as antennas, circuits, electrodes and wires. These applications often require the ability to pattern the liquid metal into different and sometimes complicated shapes at scales smaller than 100 microns, or the width of a human hair. This is accomplished by pushing the liquid metal into microchannels - small, hollow, tube-like structures within a flexible elastomer material. The most common method for creating these patterns is injection, which pushes the metal into the channels via a small hole, or inlet.

However, injection has two specific drawbacks. First, the pressure required to push the metal into the microchannel can cause the channels to rupture and leak. Second, to completely fill the channel, the air trapped within it must have a means of escape. That means each channel has to have two openings - an inlet and an outlet - which take up additional space and can cause microchannel deformation at the outlet site.

"Utilizing vacuum allows us to solve both of these problems," says Michael Dickey, professor of chemical and biomolecular engineering at NC State and corresponding author of a paper describing the work. "We place a drop of liquid metal on top of the inlet and expose the elastomer to vacuum. The air escapes the microchannel through the drop of liquid metal covering the inlet, or through the walls of the channels themselves. When the elastomer is exposed to atmosphere again, the metal gets pushed into the microchannels."

To test the efficacy of the approach, Dickey and his team created a "maze" of microchannels within poly(dimethylsiloxane), or PDMS, a silicon elastomer commonly used in microfluidic applications. The microchannels were 100 microns wide and 50 microns tall, with small cross-sections, numerous branches, and many dead ends. The small scale and limited space meant there was only one inlet and no room to punch outlets for the air to escape. Then they placed a drop of the liquid metal EGain, a mixture of gallium and indium, on top of the inlet and exposed it to vacuum.

"Using vacuum we found that that the channels completely filled with fewer defects compared to the injection method, and without the need for any outlets," says Dickey.

The paper, "Vacuum Filling of Complex Microchannels with Liquid Metal," appears in *Lab on a Chip*.

More information: Yiliang Lin et al, Vacuum filling of complex microchannels with liquid metal, *Lab Chip* (2017). DOI: 10.1039/C7LC00426E

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