Supporting Information:

Vacuum Filling of Complex Microchannels with Liquid Metal

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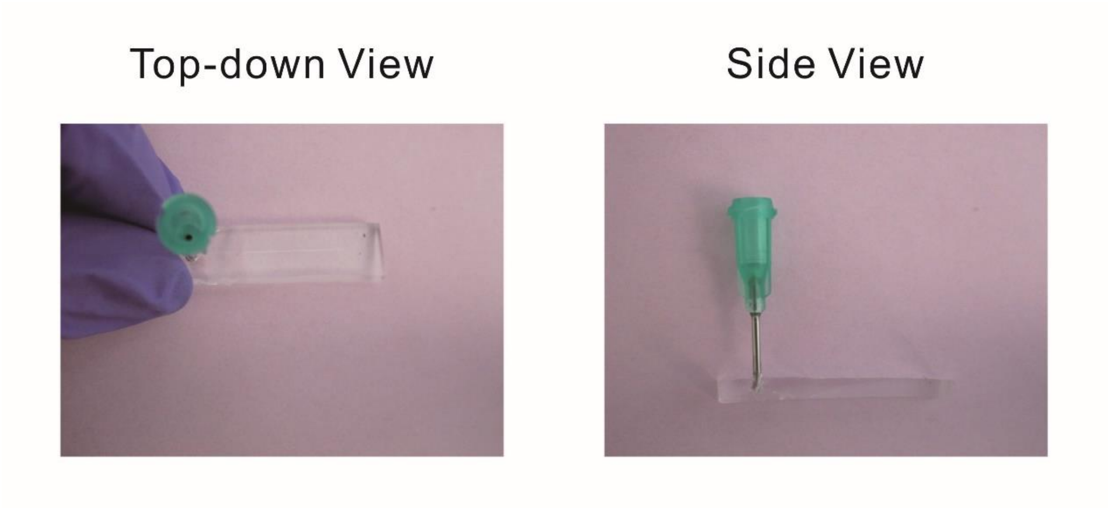

Figure S1. A microchannel device (50 µm height, 200 µm width, and 25 mm length) with a dispenser tip (18 gauge, inner diameter 0.84mm, outer diameter 1.27mm) inserted in the inlet. By sealing the tip with additional PDMS, it was impossible to inject liquid metal into these straight, "dead-end" microchannels. However, without the additional PDMS, it was possible to inject, but only by wiggling the tip. It is this latter technique that we utilized in the paper as the injection method against which vacuum filling was compared. We use this method because it gives the metal the best chance to fill via injection (i.e. it provides the best case scenario).

Injection Filling: In the paper, we compare vacuum filling to injection filling. A comment is warranted about injection filling. It is intuitive that air displaced by the liquid metal must escape for the liquid to fill the channels. Using 25 psi of gauge pressure at the inlet, we found that it was impossible to inject any liquid metal into a microchannel (50 µm tall, 200 µm wide, and 25 mm long, **Figure S1**) that lacked outlets if we properly sealed the tubing within the inlet (i.e., we snuggly inserted a dispenser tip into the inlet and sealed the perimeter with additional PDMS). [Note: In principle, a sufficiently large pressure applied to the inlet should force the metal into the channel by compressing the displaced air, but in practice, the devices delaminate before this occurs (in our case, this occurs around 40 psi). Likewise, conceptually it seems possible for the compressed air within the channel to diffuse through the PDMS and thereby allow the metal to flow into the channels, but we did not observe this on the time scales of our experiments (minutes).] We attempted to fill more than twenty samples by injection and none filled. In contrast, the liquid metal can fully fill the channels within the same setup using vacuum filling (setup shown in **Figure S1**). Note, however, if we simply insert the tubing into the inlet without additional PDMS to seal it, we found the liquid metal could fill the channels in some cases (often partially or with defects, as demonstrated herein). Interestingly, the injection only occurred while wiggling the dispenser tip back and forth within the inlet hole. This movement presumably creates gaps between the tip and the inlet hole that could allow displaced air to escape. Since injection compresses trapped air at the dead-ends of the channel (i.e. those ends furthest from the inlet), the ability of the air to escape suggests there are pathways for air to escape. We reason that due to its large interfacial tension, the metal may not be flush with the corners and edges defined by where two (or more) walls meet at a 90 degree angle; air could escape along these pathways. This observation may explain the partial filling of the dead-end in **Figure 2** (the T-shaped channel with only one outlet) and the ability to partially fill the dead-end in **Figure 3** by injection. We found that long channels were much harder to fill by injection, which is consistent with the proposed mechanism for air escape. For the sake of comparison, in the paper we report experiments in which injection was done by simply inserting tubing into the inlet to provide the most favorable conditions for injection filling.

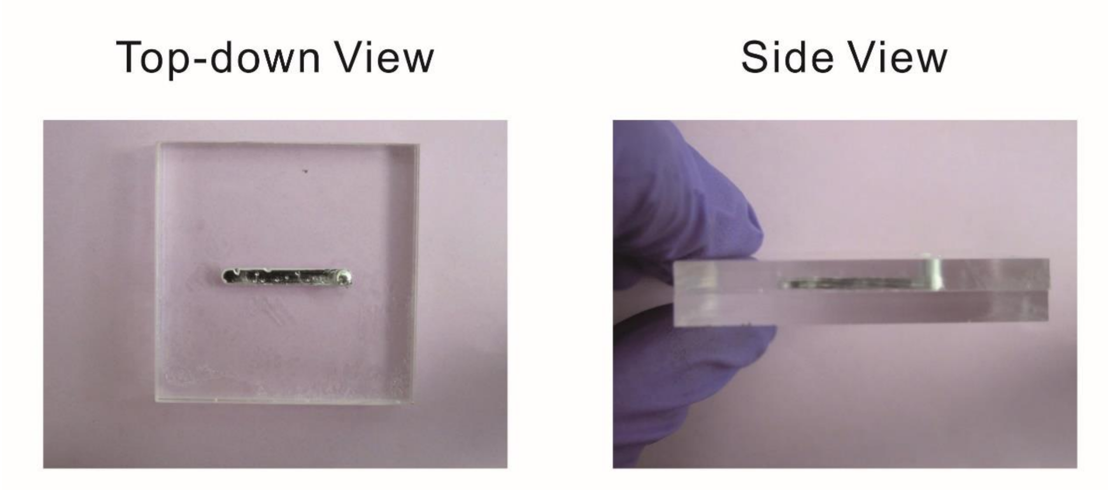

Figure S2. Photographs of a channel (1.8mm width, 1mm height and 25mm length through milling) made from poly(methylmethacrylate) (PMMA) with one single inlet. The device was placed in vacuum for 30 min with liquid metal covering the inlet. Air bubbles passed through the liquid metal during vacuum filling. Liquid metal filled the channel completely after releasing the vacuum. This experiment shows that the channels can (partially) fill even without the channels themselves being air permeable. Note that there are some defects (air bubbles) trapped in the channels, which underscores the advantage of using air permeable channels (e.g. PDMS) that can adsorb any air that gets displaced by the metal during vacuum filling.

Trapped air: It is apparent in **Figure S2** that there is some trapped air in the PMMA channels, which is not apparent in PDMS channels. After vacuum filling, we tested for the presence of trapped air by immediately placing the PDMS microchannels back into the vacuum after filling. We reasoned that any trapped air displaced by liquid metal would be compressed and therefore at a pressure higher than vacuum, these pockets of air should therefore expand during a subsequent vacuum step. The lack of bubbles within the channel suggests that very little air remained after vacuum filling. We note, however, that pulling vacuum on samples sitting in air for more than one-year results in some bubbles forming in the channels. We believe that the incomplete filling of sharp corners (due to surface tension, cf **Figure 4i**) creates small pockets that are initially under vacuum, but eventually equilibrate at atmospheric pressure over time. When vacuum is pulled, these small pockets of air expand and become observable.