Electrochemically Induced Actuation of a Liquid Metal Alloy for Shape Reconfigurable Microsystems

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The ability to control, actuate and manipulate liquids is important for many applications including MEMS devices (e.g., sensors, actuators, and RF electronics), micro-total analysis systems, and patterning. The aim of this research is to study, control, and manipulate the shape of a room temperature liquid metal alloy, eutectic gallium indium (EGaIn), by electrochemically controlling the interfacial properties of a passivating surface oxide layer (skin). The skin provides mechanical stability to the liquid metal such that it can be molded into non-spherical shapes such as wires. The ability to flow and stabilize the liquid metal on demand for shaping it into useful and responsive structures (e.g., antennas, switches, sensors, electronic filters) relies on the rupture and reformation of the oxide skin and this is critical for tunable reconfigurable micro systems. Here, we describe a simple approach to withdraw a fluidic metal wire from microfluidic channels in response to an applied potential and in presence of an electrolyte. This electrochemical approach reduces the passivating oxide skin and induces capillary motion of the metal from the microfluidic channels. Our approach relies on changing the physicochemical properties of EGaIn interface. Figure 1a shows the photograph of a stable PDMS microfluidic channel that is filled with the liquid metal by hand. Once the metal is injected in the microfluidic channel it assumes a mechanically stable shape within the channel because of the rheological properties of the oxide skin. Figure 1b and c shows that it is possible to withdraw the metal from micro channels instantaneously by applying a reducing bias to a preferred interface which is submerged in an electrolyte (i.e, water or salt solution).

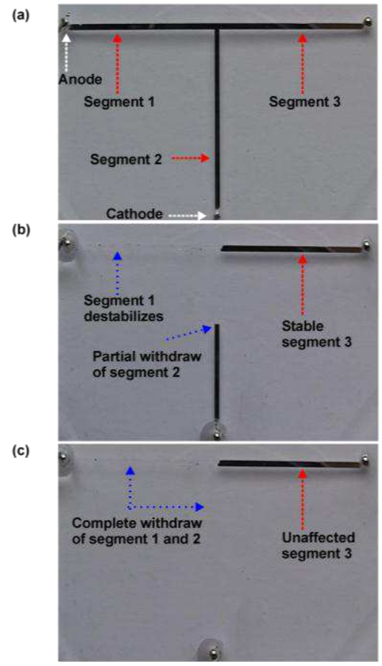

Figure 1: Top down Photographs of a T-shape microfluidic channel A) The channel is filled with liquid metal, B) The surface oxide skin is electrochemically etched by applying a reducing bias and the liquid metal has started to move away from anode to catode. C) The metal continues to withdraw till the voltage applied and we stopped applying the bias as it withdrew till the cathode.

This reducing potential electrochemically removes the oxide and the metal instantaneously flows to the direction of the other electrode where it can minimize surface energy. We will also describe simple approaches to induce the liquid metal to flow into microchannels using modest voltages. Combinations of these two techniques are capable of producing electrochemically reversible and tunable sensors, actuators, RF antennas, Filters and micromixers.

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