Liquid Metals for Stretchable and Soft Electronics

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Abstract

This talk will discuss efforts to pattern and shape-reconfigure liquid metals as conductive inks for stretchable, soft, and reconfigurable electronics. Alloys of gallium have metallic conductivity, yet have low viscosity, low toxicity[1], and negligible volatility[2]. Despite the large surface tension of the metal, it can be patterned into non-spherical 2D and 3D shapes due to the presence of an ultra-thin oxide skin that forms on its surface[3], as shown in Figure 1.

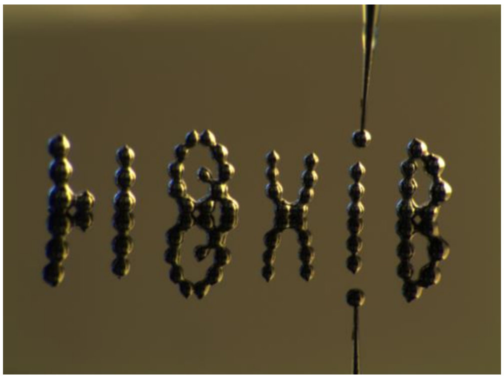

Figure 1: Liquid metals based on gallium form a thin surface oxide that allows them to be patterned into shapes typically not allowed by liquids.

Liquid metal is extremely soft and flows in response to stress to retain electrical continuity under extreme deformation[4]. By embedding the metal into elastomeric[5] or gel substrates[6], it is possible to form soft electrodes, stretchable antennas[7], and ultra-stretchable wires that maintain metallic conductivity up to ~800% strain[8]. The resulting conductors are self-healing[9]. The metals can also be filled into microchannels[10][11] or hollow fibers for capacitive touch sensors[12], and mechanically tough fibers[13]. It is also possible to 3D print the metal[14] for source and drain contacts for transistors[15] and as interconnects for energy harvesters[16].

Perhaps one of the more unique aspects of liquid metals is the ability to manipulate their shape for reconfigurable electronics[17]. Electrochemistry can deposit and remove the oxide layer to manipulate the interfacial tension—a dominante force at the microscale—over an enormous range. Reductive potentials remove the oxide layer and put the metal in a state of high tension[18]. However, oxidative potentials deposit the oxide layer on the metal and put it in a state of low tension[19]. Experiments suggest the tension could be near zero using less than one volt[20]. Unlike electrowetting, which can require hundreds of volts, here, the changes result due to electrochemically deposited species on the metal surface.

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