New Electrowetting Phenomena Using Liquid Metal

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This talk will discuss the use of gallium-based alloys for various electrowetting phenomena. These alloys, which have both metallic and liquid properties, are notable because they have low toxicity, zero vapor pressure, and react with air to form a native oxide 'skin'. We have studied this material for electrowetting in three ways:

1. Liquid metal can simply be 'painted' on a substrate (i.e. no vacuum processing) to create soft, stretchable electrodes for electrowetting-on-dielectric (EWOD), as shown in Fig. 1a-c. The native oxide, which is ~3 nm thick, serves as a self-healing dielectric while maintaining the liquid in the shape of a flat electrode[1]. EWOD occurs without external voltage via short circuiting due to the built in open circuit potential (Fig. 1, d-e)[2].
2. Normally the native oxide adheres to the walls of capillaries and limits the ability of the metal to flow. Prefilling capillaries with water creates a 'slip layer' between the oxide-coated metal and the capillary walls. This slip layer enables continuous electrowetting of a plug of liquid metal as a means of translating it back and forth[3].
3. Perhaps most surprising, electrochemical oxidation of gallium alloys significantly lowers the interfacial tension using 1 V[4]. At this potential, the metal spreads into fractal shapes (Fig 1. f), suggesting the interfacial tension approaches zero[5]. Reversing the potential removes the native oxide and returns the metal back to a state of high tension[6]. Thus, it is possible to rapidly and reversibly modulate the tension by ~500 mN/m using only 1 V.

Taken in sum, these techniques represent simple and effective ways to move and manipulate liquid metals for reconfigurable electronics, optics, and switches[7].

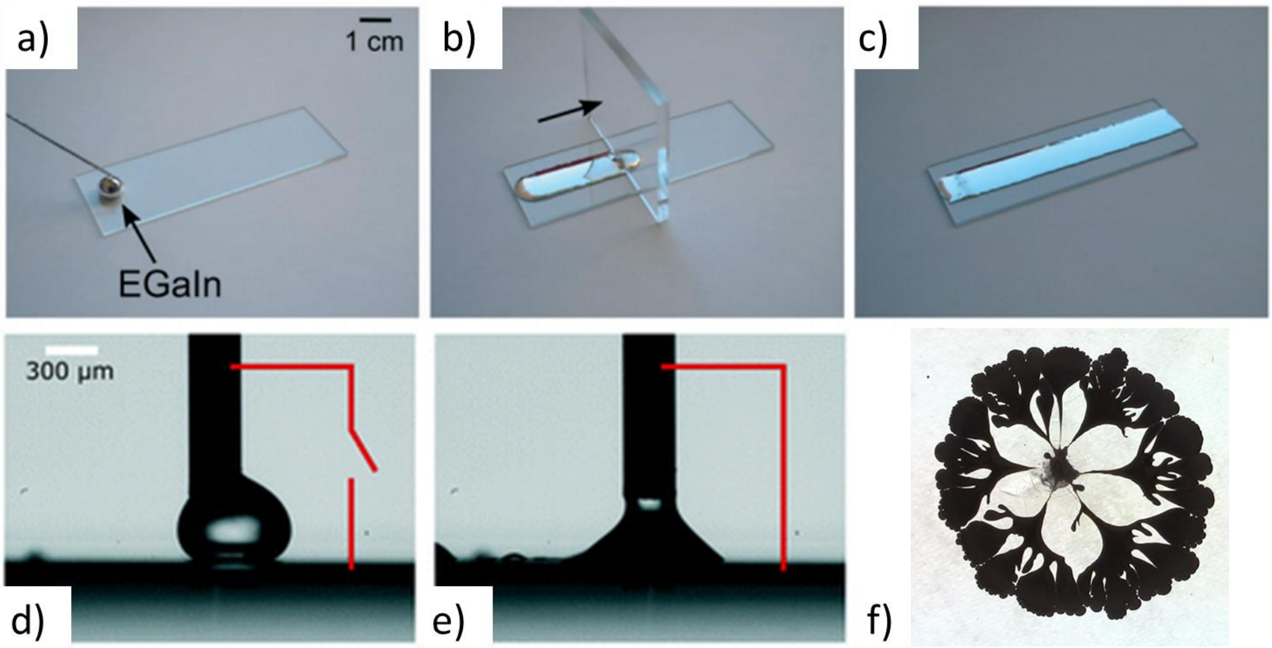

Figure 1. (a-c) "Paint-on" EWOD electrodes composted of eutectic gallium indium (EGaIn). (d-e) EWOD of a droplet of water without external potential achieved via short circuiting the needle and liquid metal substrate. (f) Liquid metal forms fractals at 1 V due to oxidation.

References

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