# Materials Science & Engineering
# Master's Defense

## Gallium-Based Room Temperature Liquid Metals and its Application to Single Channel Two-Liquid Hyperelastic Capacitive Strain Sensors

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## abstract

Gallium-based liquid metals are of interest for a variety of applications including flexible electronics, soft robotics, and biomedical devices. Still, nano- to microscale device fabrication with these materials is challenging because of their strong adhesion to a majority of substrates. This unusual high adhesion is attributed to the formation of a thin oxide shell; however, its role in the adhesion process has not yet been established. In the first part of the thesis, we described a multiscale study aiming at understanding the fundamental mechanisms governing wetting and adhesion of gallium-based liquid metals. In particular, macroscale dynamic contact angle measurements were coupled with Scanning Electron Microscope (SEM) imaging to relate macroscopic drop adhesion to morphology of the liquid metal-surface interface. In addition, room temperature liquid-metal microfluidic devices are also attractive systems for hyperelastic strain sensing. Currently two types of liquid metal-based strain sensors exist for inplane measurements: single-microchannel resistive and two-microchannel capacitive devices. However, with a winding serpentine channel geometry, these sensors typically have a footprint of about a square centimeter, limiting the number of sensors that can be embedded into. In the second part of the thesis, firstly, simulations and an experimental setup consisting of two GaInSn filled tubes submerged within a dielectric liquid bath are used to quantify the effects of the cylindrical electrode geometry including diameter, spacing, and meniscus shape as well as dielectric constant of the insulating liquid and the presence of tubing on the overall system's capacitance. Furthermore, a procedure for fabricating the two-liquid capacitor within a single straight polydiemethylsiloxane channel is developed. Lastly, capacitance and response of this compact device to strain and operational issues arising from complex hydrodynamics near liquid-liquid and liquid-elastomer interfaces are described.

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