Secondary Fluid Incorporation into Liquid Metal Foams

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Motivation and Introduction

Room temperature gallium-based liquid metals (LM) show great potential in applications for soft technology but have limitations.[1] Processing LM foams is done through shear mixing in air causing surface oxide fragments to stabilize air capsules in LM.[2] LM properties (i.e. thermal, rheological, etc.) are impacted by the addition of these oxide fragments and air capsules.[3] These LM foams open a new area to study the processing of new types of novel composites.

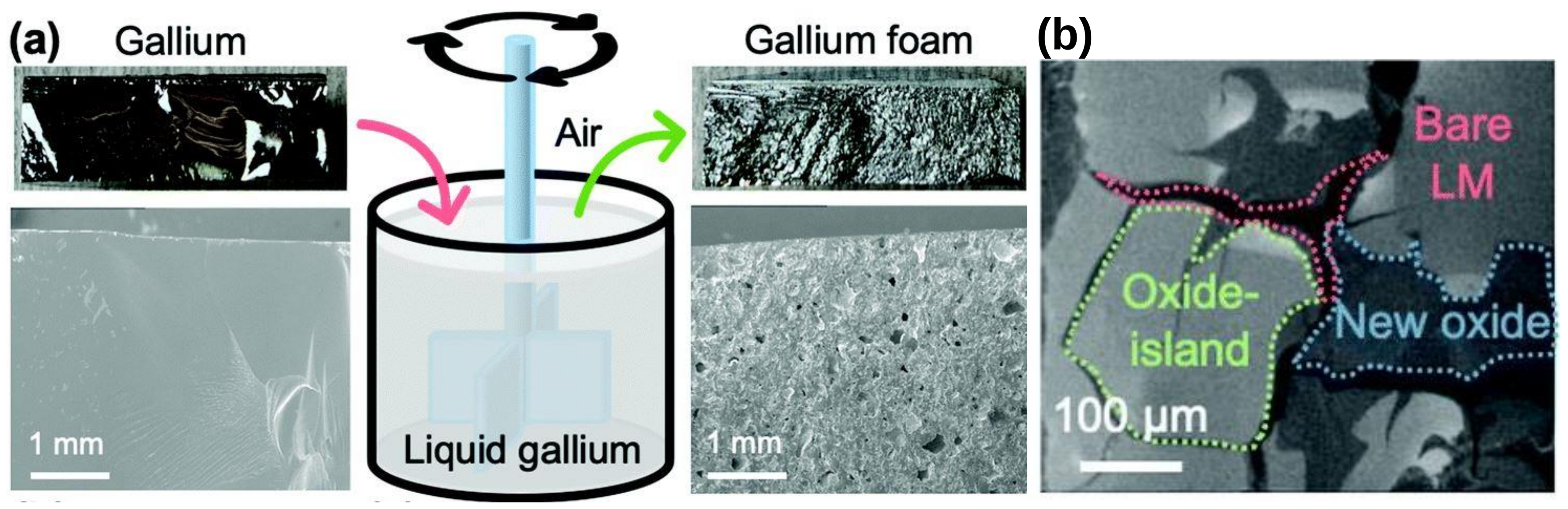

Figure 1: a). Schematic of gallium foam production b.) Formation of oxide fragments in gallium foams[3]

Objectives

I. Determine the volume fraction of secondary fluid that can be incorporated into gallium foam
II. Determine the impact of fluid viscosity on the ability of the secondary fluid to integrate into a gallium air foam

Materials and Methods

Materials

- Gallium Foam
- Silicone Oil (10-10,000 cSt)
- Hot Plate
- Wooden Stirring Rods
- Mass Balance
- Optical Microscope

Methods

- Gallium foam weighed and mixed with silicone oil to form desired ratio.
- Silicone oil mixed in on hot plate
- Wooden end of cotton swab used to slowly mix silicone oil into LM
- After integration into LM, time is noted, and cross section captured with optical microscope

Results

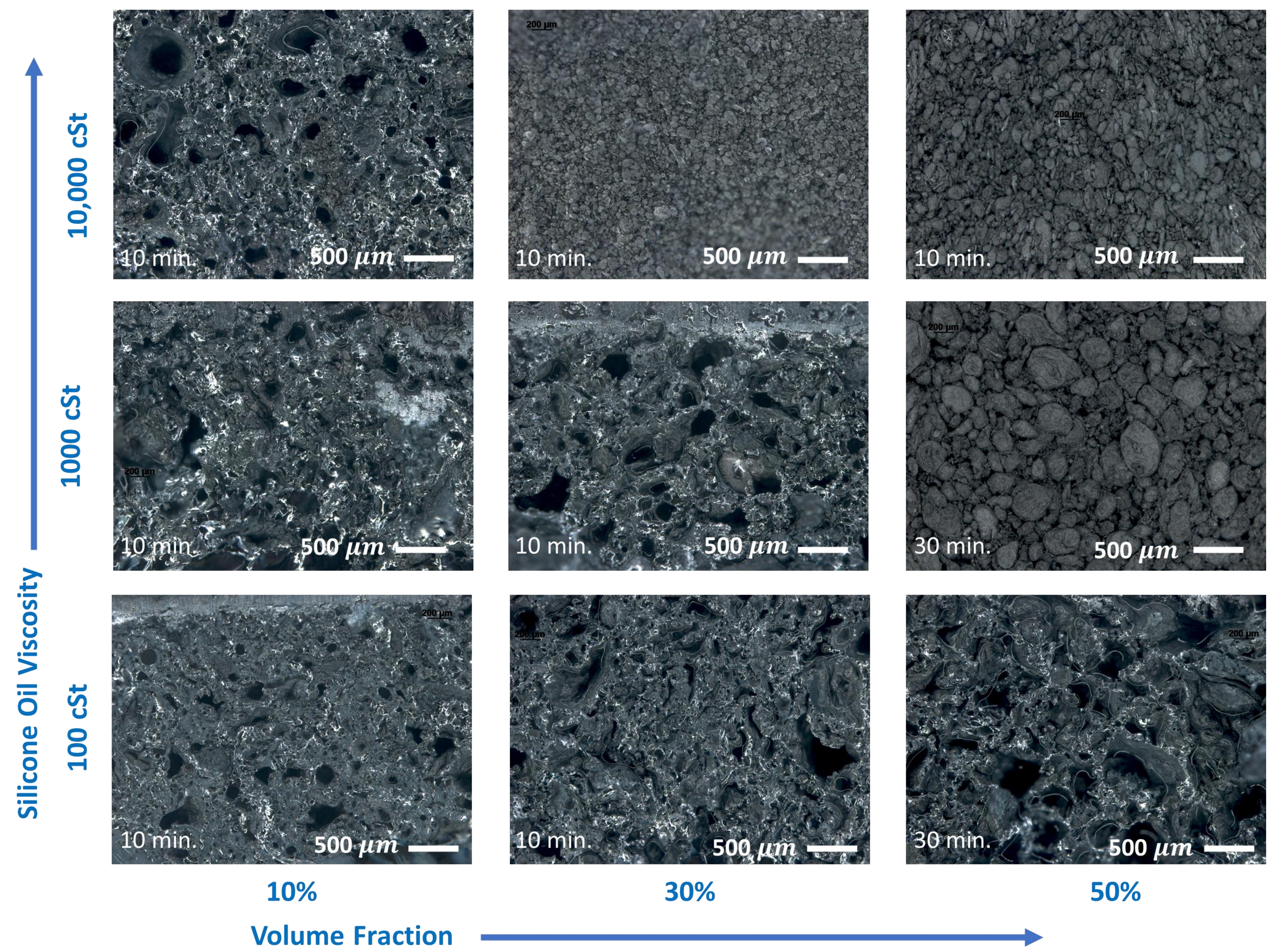

Figure 2: Cross sectional images of gallium foams with varying silicone oil viscosity and volume fraction

During mixing of silicone oil into gallium foam the oil appears to incorporate itself into the void space (Figure 3). After certain mixing times or oil volume fractions the LM foam separates into droplets. (Figure 4).

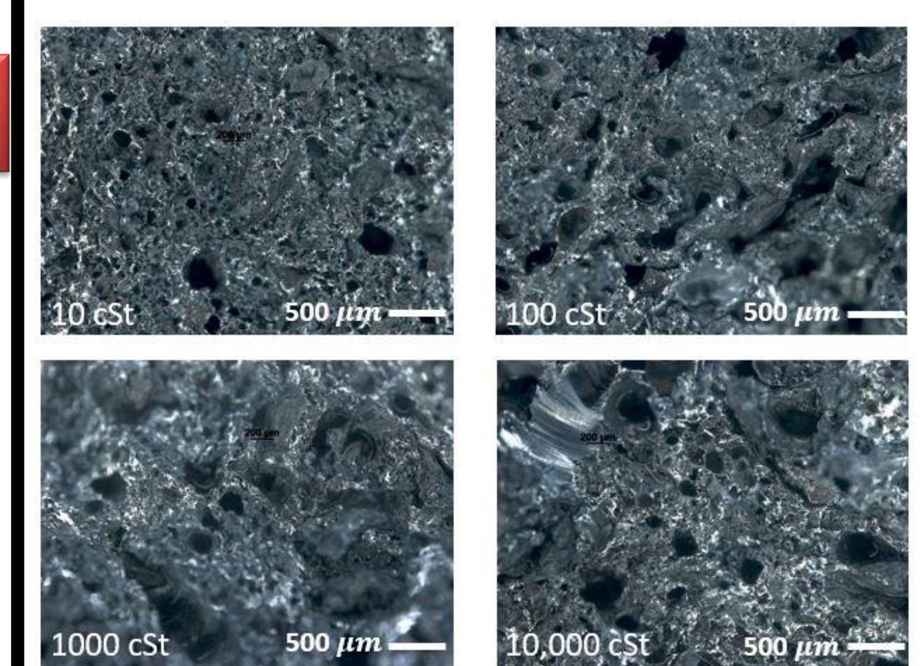

Figure 3: Cross sectional images of gallium foams mixed with 20% vol. fraction of silicone oil

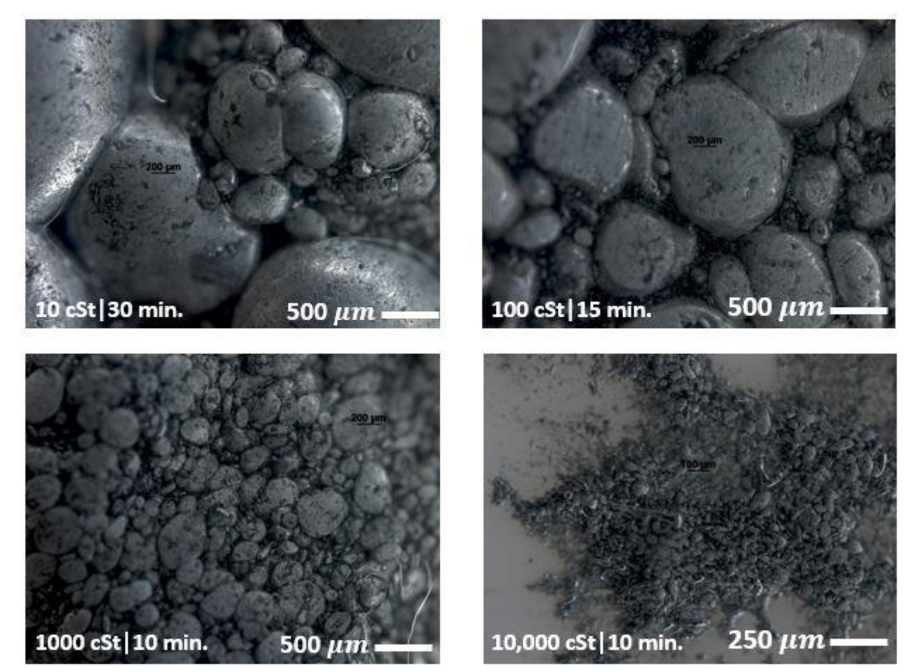

Figure 4: Cross sectional images of gallium mixed with 20% vol. fraction of silicone oil

Discussion and Future Applications

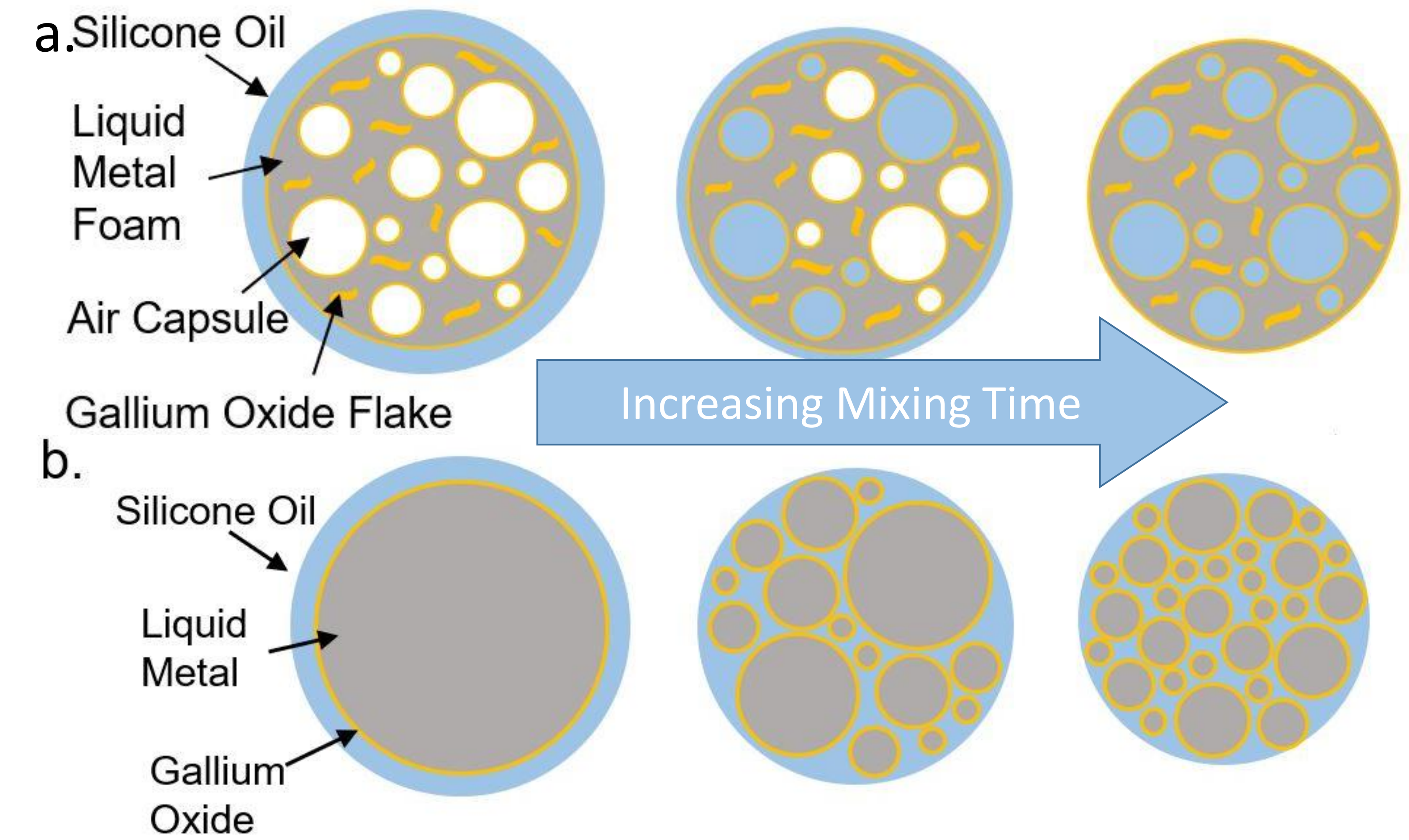

Figure 5: a.) Mixing diagram for LM air foams and silicone oil over increasing time. b.) Mixing diagram pure liquid metal with silicone over increasing time.

This mixing process acts much like an oil-in-water and water-in-oil emulsion in products like milk and butter, respectively. However, with LMs only one way was previously possible, suspending LM droplets in oil. Our research has found a way of achieving the inverse: **suspending oil in LM**. This allows the retention of continuous metallic transport properties, an important step towards future applications of these materials.

Future Goals

I. Determine onset time of secondary fluid incorporation
II. Quantify amount of silicone oil in air pockets of gallium foams
III. Determine a method to control air bubble sizes within foams

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1. K. Doudrick et. al "Different Shades of Oxide: From Nanoscale Wetting Mechanisms to Contact Printing of Gallium Based Metals," *Langmuir,* vol. 30, no.23 pp. 6867-6877, 2014.
2. W. Kong et. al "Oxide-mediated mechanisms of gallium foam generation and stabilization during shear mixing in air," *Soft Matter;* vol. 16, no. 25, pp.5801-5805, 2020.
3. W. Kong et al. "Oxide-Mediated Formation of Chemically Stable Tungsten-Liquid Metal Mixtures for Enhanced Thermal Interfaces" *Advanced Materials,* vol. 33, no. 44, 2019