Development of Scalable Biphasic Liquid Metal Stamp for Stretchable Electronics

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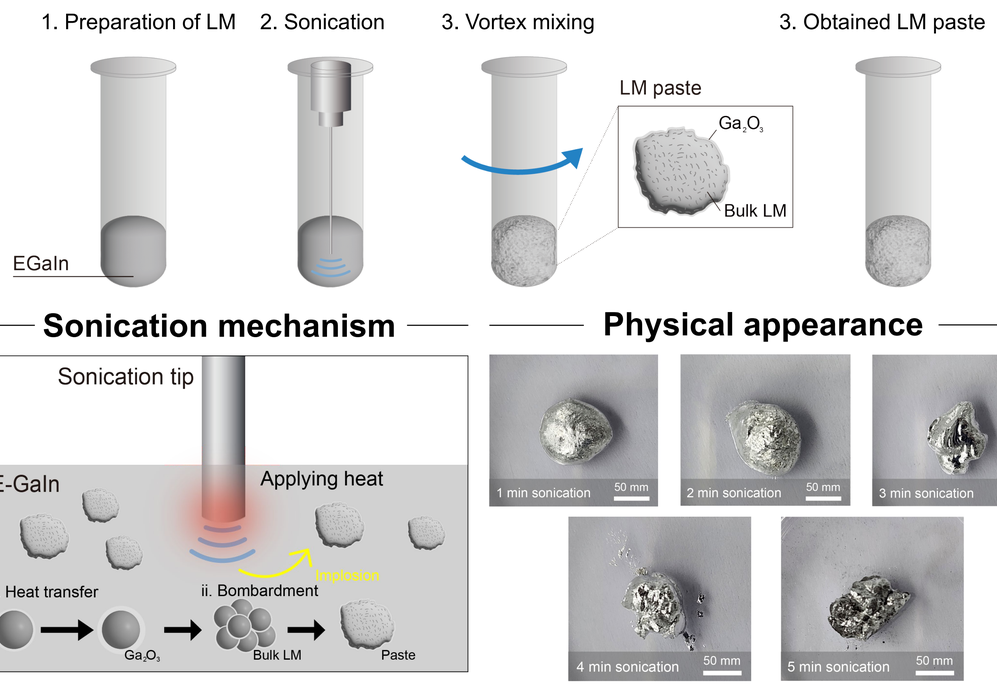
Introduction

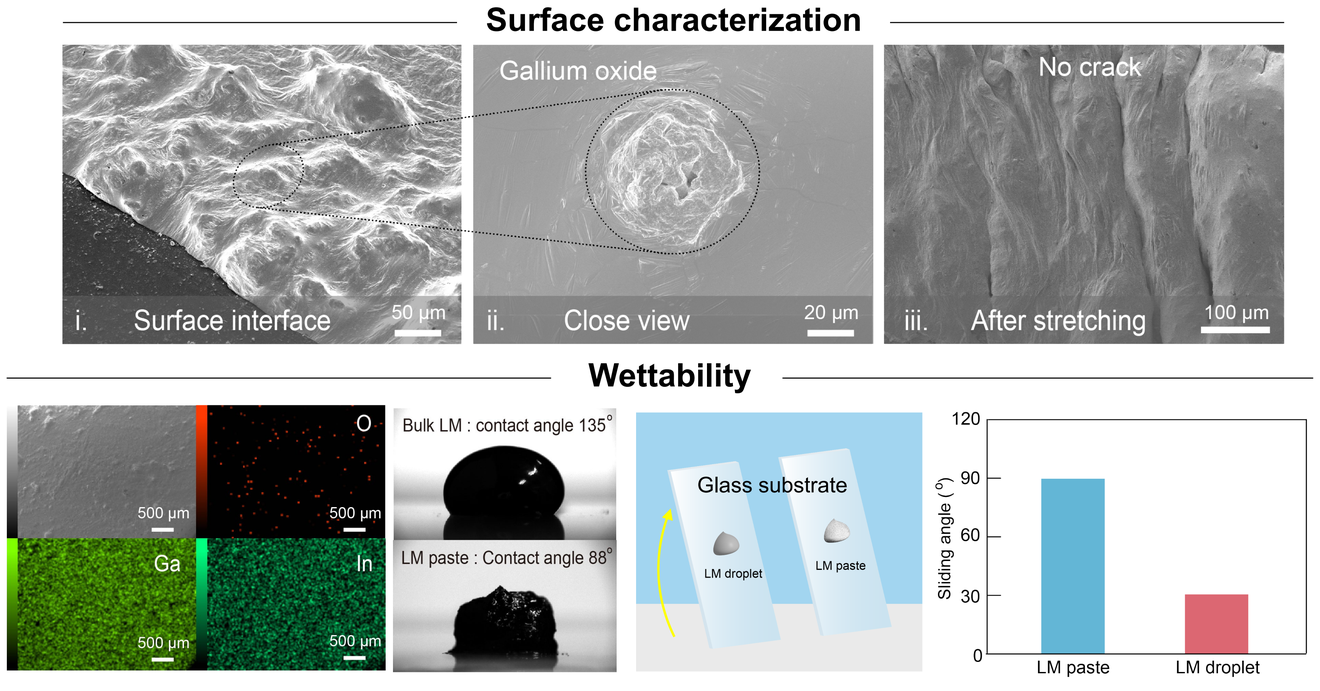
The importance of stretchable electronic circuits and systems will significantly increase for wearable devices and soft robotics to achieve practical applications like real-time health monitoring. However, current techniques using rigid conductors have some limitations that restrict their ability to deform and conform effectively. In order to functionalize stretchable devices, liquid metal is a proper solution for stretchable conductors due to its liquid state in room temperature, high conductivity, excellent stretchability, and good biocompatibility [1]. However, liquid metals have challenges in printing due to their high surface tension. Thus, it is necessary to modify the state of liquid metal for printing. Herein, we present a scalable fabrication approach using biphasic liquid metal ink made by ultrasonication process. The sonicated biphasic ink that is high viscous ink can be transferred to the other substrate with the same shape due to its biphasic characteristic [2]. The solid phase of gallium oxide particle adheres to the substrate, and the liquid metal remains on the top of substrate. As a proof of concept, we create a biphasic ink for easy printing process that can be screen printed with high resolution and reliability.

Methods and Results

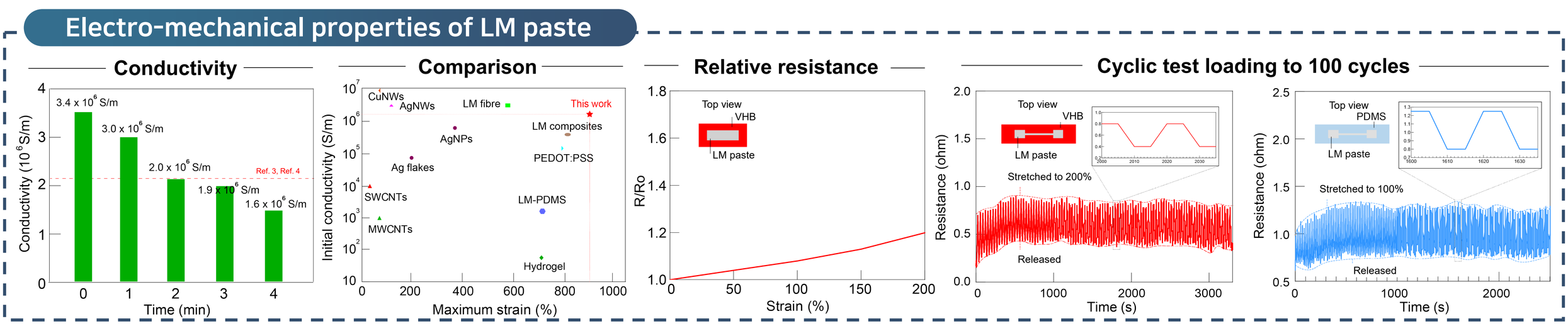
Fabrication of LM paste



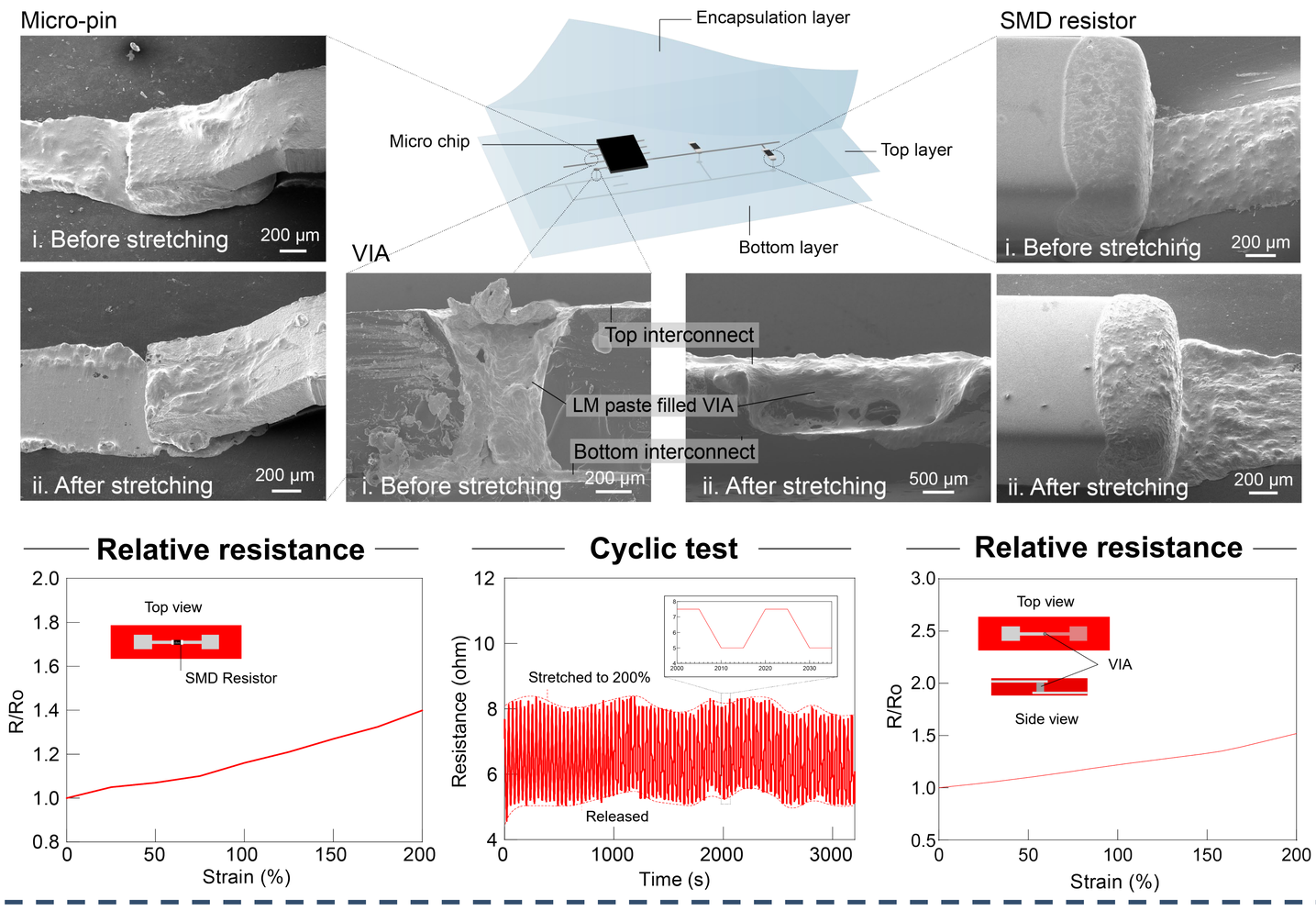
Material characteristics of LM paste



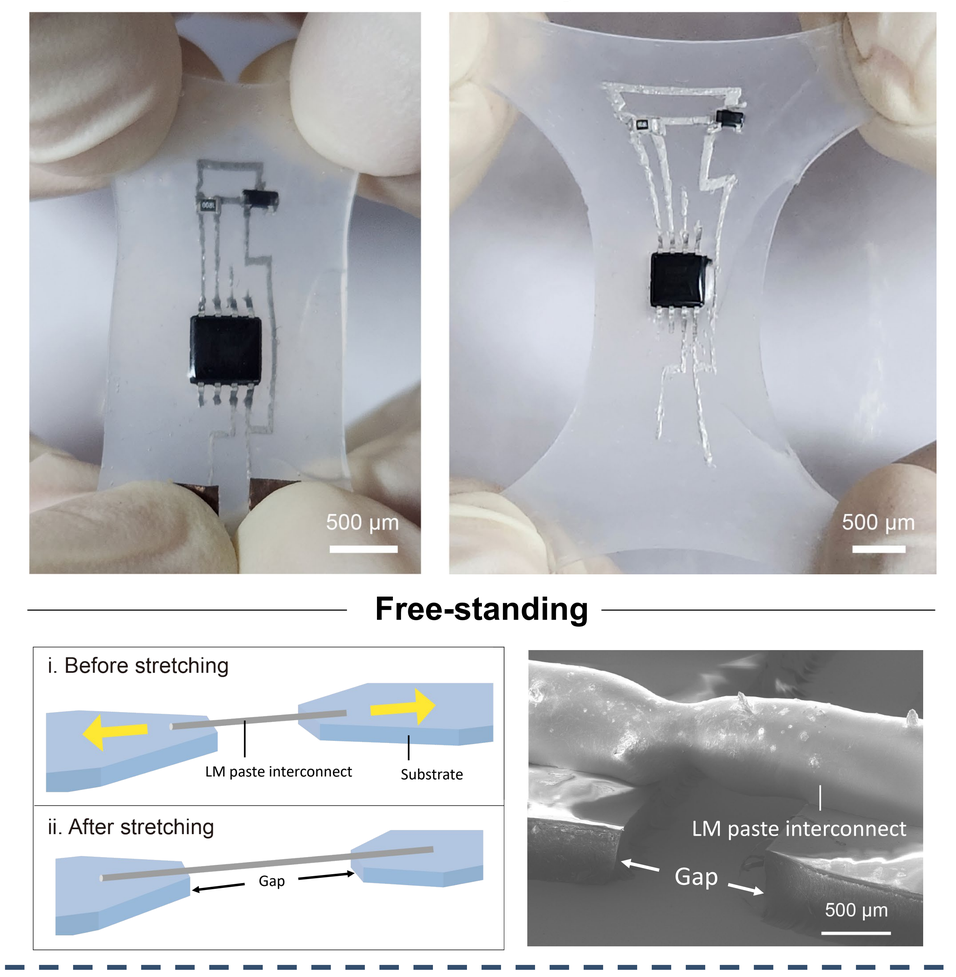
Electro-mechanical properties of LM paste



Integration with rigid micro components



Patterning



Conclusion

In summary, our approach enables conformal contact with the target substrate by the use of biphasic LM ink. Also, we employ a screen printing process to print and align to the substrate easily with high resolution, excellent performance, and reliability. We emphasize that the fabrication of stretchable circuits by biphasic liquid metal has the potential for scalable electrical device manufacturing.

Acknowledgement

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Reference

[1] Li. G, “Three-dimensional flexible electronics using solidified liquid metal with regulated plasticity,”. Nat Electron 6, 154-163 (2023).

[2] Pavel V. Ultrasonics Sonochemistry 26 (2015) 9–14

[3] Liu, S., Shah, D.S. & Kramer-Bottiglio, R. Highly stretchable multilayer electronic circuits using biphasic gallium-indium. *Nat. Mater.* 20, 851–858 (2021).

[4] Min Li, “Graded Mxene-Doped Liquid Metal as Adhesion Interface Aiming for Conductivity Enhancement of Hybrid Rigid-Soft Interconnection,”. *ACS Applied Materials & Interfaces* 2023 *15* (11), 14948-14957