Development of Printable Composite Metal Ink Based on In-Bi-Sn Ternary Eutectic Alloy for Functional Electronics via Liquid Metal 3D printing

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Liquid metal 3D printing is a promising technology in metal additive manufacturing application such as 3D printed electronics [1]. Field's metal, known as an In-Bi-Sn ternary eutectic alloy, has characteristics of low melting temperature, relatively low resistivity, and low reactivity with air and water below 373K [2] and therefore it is a good candidate material to pattern electrical routes of 3D printed electronics. To enhance the printability of the direct writing of liquid phase of metal, the composite metal was fabricated based on melted In-Bi-Sn eutectic alloy by introducing copper micro flakes as shown in Figure1. In this study, the comparative studies of the Field's metal and the fabricated In-Bi-Sn composite metal were performed and the modified thermodynamic, electrical, and rheological behaviors were analyzed. Due to the additives, the liquidus and solidus temperatures were shifted. Even though non-Newtonian fluidic behavior was enhanced, the conductivity and viscosity of the specimen were increased favorably for printing at 15 wt.% Cu flake.

A functional electronics was designed and developed by liquid metal 3D printing using the fabricated composite metal on the PLA substrate prepared by fused deposition modeling (FDM) additive manufacturing. The simple antenna pattern was successfully printed and demonstrated with a nozzle size of 300μm and a line pitch of 0.5mm and the patterned antenna was provided in Figure2.

References

[1] C. Ladd et al., Advanced Material, 25, 5081 (2013)

[2] A. Lipchitz et al., Proc. of the ASME Power Conference, (2013)

Figures

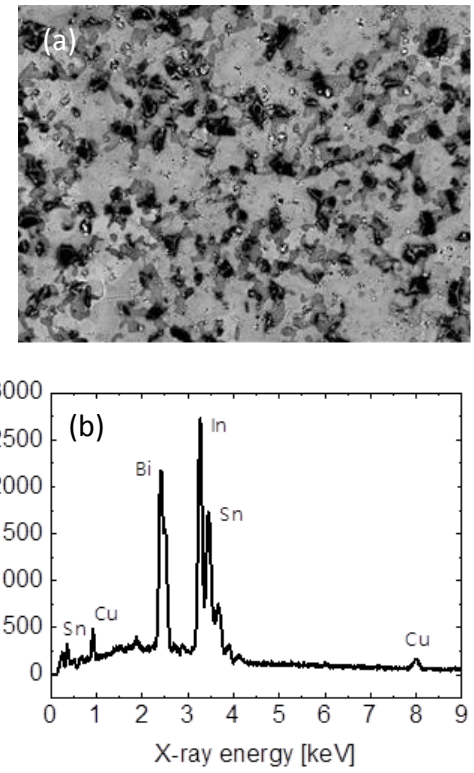

Figure 1. (a) SEM image of composite metal mixture of In-Bi-Sn eutectic alloy and copper micro flake. Note eutectic grain (light grey), Sn rich phase (dark grey), and Cu flake (black) (b) Compositional distribution by EDS analysis

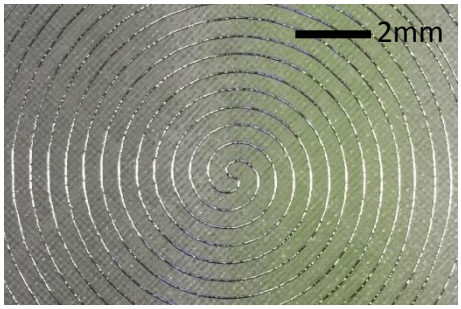

Figure 2. Printed antenna pattern on PLA substrate