MATERIALS ENGINEERING SEMINAR

"Microalloying for Stable Low Temperature Solder Microstructure and Reliable Heterogeneous Integration: Sb and Ag addition to LTS Sn-Bi"

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ABSTRACT

Low-temperature, lead-free solders mitigate heating-induced warpage caused by the differences in coefficient of thermal expansion between printed circuit boards (PCBs), substrates, and dies during package assembly. Eutectic and near-eutectic Sn-Bi solders are promising low temperature candidates because they show high reliability at low strain rates during thermal cycling. However, Sn-Bi low temperature solder (LTS) has poor performance at high strain rates during drop-shock testing. Alloying additions such as Ag, Cu, and Sb have been shown to increase the ductility and strength of eutectic Sn-Bi and therefore improve the overall reliability during both thermal cycling and drop-shock. Small Sb additions to Sn-Bi LTS are of particular interest because these additions significantly increase ductility while maintaining the tensile strength. This increase in ductility was previously attributed to small SnSb intermetallic particles that form within the Sn phase on the interface of Sn and Bi in 1.0wt% Sb containing samples. Despite the fact the no SnSb intermetallic compound (IMC) particles have been found in 0.5Sb-42Sn-Bi samples in any previous studies or in our own studies, it was thought that the SnSb IMC particles were responsible for the improved reliability and ductility of Sn-Bi.

This work encloses our efforts to understand how small Sb additions to eutectic Sn-Bi impact the solder microstructure and the resulting mechanical properties of the solder alloy. We began by studying possible solidification pathways through phase diagram analysis in Thermo-Calc to understand how the microstructure is predicted to develop and compared these models to the literature data. Next, we analyzed the microstructures of our custom Sb-containing alloys through a combination of scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and electron probe microanalyzer-wavelength dispersive spectroscopy (EPMA-WDS) and determined that no SnSb IMC particles were found in the 0.5Sb-42Sn-Bi alloy and at 0.5 wt% the Sb remained in solid solution with Sn. Nanoindentation was then used to evaluate the strain rate sensitivity of Sn-Bi LTS with Sb additions and we found that, while the alloy hardness remains sensitive to different strain rates, the Sb in solid solution with Sn altered the deformation behavior of the alloy and decreased the amount of planar slip during indentation. To study the stability of the microstructure and the alloy behavior in use, shear testing was performed before and after isothermal aging. Our results suggest that Sb in solid solution with the Sn-rich phase contributes significantly to the changes in the eutectic microstructure and the mechanical properties.

Date: Friday, July 7, 2023
Time: 9:00 A.M.
Place: ARMS 1028 or via Webex: https://purdue.webex.com/meet/blendell

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