MATERIALS ENGINEERING SEMINAR

"Microstructural Evolution of Low Melting Temperature Sn-rich Solder Alloys by Real-Time X-ray Microscopy"

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Purdue MSE Ph.D. Final Exam

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ABSTRACT

Due to miniaturization of electronic devices, new electronic packaging strategies, such as Heterogeneous Integration Packaging (HIP), are being developed. In HIP, the space in the package is strategically mapped out to maximize the placement of components including all types of materials. Thus, there is a need to develop and understand the behavior of lower-melting point metallic interconnects as they will be located next to lower melting point materials, such as polymers.

The composition of alloying elements in Sn-rich solder plays a pivotal role in determining the microstructural properties of the solder joint. However, the complex mechanisms governing the solidification processes of Sn-In, and Sn-Bi alloys are still not fully understood. Furthermore, the experimental characterization of phase formation poses significant challenges.

This presentation will focus on understanding microstructural evolution in Sn-In and Sn-Bi alloys during reflow. A systematic approach to characterizing the microstructure of alloys was developed, utilizing electron microscopy, non-destructive x-ray tomography and diffraction techniques, ranging from lab-scale to synchrotron experiments. The influence of In addition on microstructure was correlated with the mechanical behavior obtained using nanoindentation. The experimental understanding was further correlated with the Density Functional Theory (DFT) calculations. To study the Sn-Bi microstructures, the effect of experimental parameters, such as the cooling rate during solidification was elucidated. A 4D study was conducted, involving the analysis of 3D microstructures along with time evolution, to gain a comprehensive understanding of the solidification dynamics using synchrotron white beam tomography. For the first time, we observed a regular pyramidal morphology of Bi forming in the solder alloy. The 4D analysis provided crucial insights into morphology formation, growth kinetics, defect formation during solidification. The crystallographic analysis unraveled unique insights into the solid-liquid interface stability for semi-metals. Furthermore, the simultaneous Energy Dispersive Diffraction (EDD) analysis yielded a deeper understanding into the phase formation and lattice strain evolution. A fundamental relationship between the diffraction intensity and phase fractions, from imaging, was obtained. The experimental methodology developed in this work has the potential to be extended to investigate a wide range of alloy solidification mechanisms, enabling a deeper understanding of these materials.

Date: Friday, June 30, 2023
Time: 1:00 P.M.
Place: ARMS 1028 or via Webex: https://purdue.webex.com/meet/nikc

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