

**Studying the Reliability of Low-Temperature Solder Joints**: Low-temperature solders (LTSs) are growing in popularity in surface-mount architectures for their lower melting points, which reduce reflow temperatures and minimize warpage, cost and energy consumption. However, failure analyses of joints made with LTSs are ongoing. A team of investigators from Auburn University, NXP Semiconductors, and Binghamton University will describe their analyses of hybrid joints consisting of ball grid array (BGA) packages containing Sn-Ag-Cu (SAC) solder balls, mounted onto printed circuit boards (PCBs) with LTS paste. These joints tend to have varying concentrations of bismuth (Bi) from the PCB copper pad to the component’s copper pad. Bi diffusion potentially increases reliability during thermal cycling by restricting the coarsening of intermetallic compound particles/layers. However, excessive Bi concentrations at the PCB side can lead to Bi-embrittlement, making it a prevalent failure location.

The researchers performed creep tests to study solder deformation over time, including a modified Garofalo creep model to account for Bi diffusion in hybrid joints. They also developed a finite element model of a BGA assembly with hybrid joints. The modeling results were correlated with experimental board-level failure data, and the Bi distribution in the joints was modeled across multiple layers. The Bi-concentration gradient in each layer was chosen to replicate observations in the actual joints, which were mapped by energy-dispersive X-ray spectroscopy (EDS). At ECTC, the researchers will describe the results of these studies, and how they can be used to predict PCB-end failure in hybrid joints under various thermal conditions.

In the images above, each SAC-LTS hybrid joint within the finite element model was discretized into five distinct layers. Each layer was characterized by a specific Bi-concentration, based on the average Bi-concentration obtained from the EDS analysis:

1. is an EDS view of a SAC-LTS hybrid joint, showing the average Bi concentration in the layers
2. is a corresponding image from the FEA model

**(Paper 12.6, “*Analysis of Mechanical Behavior of Hybrid SAC-LTS Joints under Temperature Cycling with a Modified Garofalo Creep Model Based on Bi Concentration*,” S. Chakraborty et al, Auburn Univ/NXP Semiconductors/Binghamton Univ.)**