Thermal Preconditioning and Restoration for Microstructure and Property Improvement in Bi-containing Solder Alloys

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It has been well-established that the properties of lead-free solder alloys such as SAC 305 (Sn-3.0Ag-0.5Cu) degrade over time as the result of the coarsening of the intermetallic phases such as Ag_3Sn and Cu_6Sn_5. In earlier studies, it was shown that the inclusion of bismuth (Bi) in Sn, Sn-Ag, Sn-Cu, and SAC-based alloys leads to a stabilization of the as-solidified mechanical properties after aging at temperatures above the alloy's solvus (where all precipitates are allowed to dissolve into and diffuse through the β-Sn matrix, leading to a uniform, homogenous microstructure). Further, the β-Sn grain structure becomes more refined, transitioning from consisting of only a few large grains to having many smaller, randomly-oriented grains. However, most practical operating conditions lie below the solvus temperature. This results in Ostwald ripening of the Bi precipitates, which may become sufficiently brittle to be a reliability concern.

This paper contains details from a recently patented process which allows for the improvement of the properties of the solder joint, either post-reflow, or after some amount of product lifetime. The treatment was analyzed by considering the creep properties of Violet, an alloy containing 2.25% Ag, 0.5% Cu, and 6.0% Bi, and of SAC 305. An above-solvus aging treatment was performed on each alloy, either after solidification, or after below-solvus aging. It was found that the creep resistance of both alloys is reduced after below-solvus aging, but the creep resistance of Violet is significantly improved after above-solvus aging (regardless of prior thermal history). These results show that this aforementioned thermal treatment is a viable method to improve the long-term reliability of solder joints in electronic assemblies.