Effect of Thermal Treatment on the Microstructure, Properties, and Reliability of Lead-Free Bismuth Containing Solder Alloys

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One major reliability concern in the SMT industry is the reduction in reliability of lead-free solder alloys such as SAC 305 (Sn-3.0Ag-0.5Cu) over time as a result of the coarsening of intermetallic phases. Recent studies have shown that the addition of bismuth (Bi) to the alloy results in superior performance over SAC and Sn-Pb in ATC and vibration. Furthermore, after aging, the mechanical properties of Bi-containing alloys are preserved and do not degrade. However, typical in-service temperatures lie below the alloy's solvus (the temperature above which all Bi will dissolve in β-Sn) and Bi precipitates tend to coarsen, which may reduce reliability. However, above-solvus aging allows all Bi in the alloy to diffuse through the β-Sn matrix to produce a more desirable microstructure consisting of small, uniformly sized and spaced Bi precipitates.

In our previous work, the creep properties of Violet (Sn-2.25Ag-0.5Cu-6.0Bi) and SAC 305 were evaluated both before and after the application of a patented above-solvus thermal treatment. It was shown that the creep resistance of Violet was significantly improved and that of SAC was reduced after this treatment. In this work, the aforementioned treatment was performed on a series of PCBs which had been assembled using either SAC 305 or Violet. A subset of these boards underwent below solvus aging prior to mimic in-service conditions; the remainder were left in the as-assembled state. After the thermal treatment, all boards underwent accelerated thermal cycling (ATC) between -55C and 125C according to IPC 9701. Weibull analysis was conducted to evaluate the efficacy of the thermal treatment on improving device reliability. Failure analysis was also performed to investigate the evolution of the microstructure and determine the combined effects of the treatment and ATC on the failure mode.