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Temperature- and Strain Rate-Dependent Damage Mechanics of Solder/IMC Interface Fracture in a Ball Grid Array Assembly

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Abstract:

The damage mechanics concept introduced to assess the deformation and failure process of solder interconnects in electronic assemblies with ball grid array (BGA) assembly during reflow cooling, and subsequent temperature cycles are investigated. The test assembly consists of Sn-4.0Ag-0.5Cu (SAC405) solder arrays that provide an interconnection between an electronic package and the printed circuit board. Anand model of constitutive unified inelastic strain was employed to pronounce the temperature- and strain rate-dependent response of the SAC405 solder joints. The temperature-dependent cohesive model is also used to predict the damage process of the solder and intermetallic compound (IMC) interface fracture of SAC405 solder joints. Temperature loading consists of initial cooling down from the assumed stress-free reflow temperature of 220–25 °C, followed by a temperature cycle ranging from 125 to −40 °C at heating and cooling rates of 11 °C/min. Results showed that the most critical solder joint is located underneath the silicon die corner with the highest equivalent inelastic strain and von Mises stress under reflow cooling. The different straining rates experienced by the solder joints are driven by the temperature and strain rate effects of cohesive zone model parameter values. The highest predicted inelastic strain rate of 4.5 × 10–3 s−1 is found in the solder joint at 25 °C. Throughout the reflow cooling and temperature cycles, the damage propagation at the interface of solder and IMC is minimized. However, damage is initiated at the interface of solder and IMC plane and localized at a small edge region at the side of assembly package.