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Effect of Cobalt Doping on the Microstructure and Tensile Properties of Lead Free Solder Joint Subjected to Electromigration

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Rapid Cu diffusion is one of the main causes of electromigration (EM) failure in lead-free solder joints. In this study, an effort has been made to investigate the detrimental effects of EM on microstructure and mechanical performance of solder joint by introducing Co nanoparticles (NP) doped flux at the interface between SAC305 solder and copper substrate. EM tests were conducted on un-doped SAC305 and Co-doped SAC305 solder joints for different time intervals, with the maximum duration of 1,128 h. A DC current was applied to the both types of solder joints to achieve a current density of 1×10^4 A/cm^2. EM tests were performed in an oil bath maintained at a constant temperature of 80 °C. It is found that Co-doped flux significantly reduced the formation of cracks and voids at the cathode interface. Co atoms entered into the lattice of Cu_6Sn_5 leading to the formation of $(Cu, Co)_6Sn_5$. This thermodynamically stabilized the interfacial intermetallic (IMC) layers both at the anode and cathode sides and suppressed the change in their thickness. The average anodic growth rate of $(Cu, Co)_6Sn_5$ interfacial IMC in the doped sample was about one order of magnitude lower compared with that of Cu_6Sn_5 in the un-doped samples. Co-NP also improved the tensile strength considerably before and after EM. The report suggests that the reliability of solder joint during EM can be improved by using Co-NP doped flux.

Key words: Electromigration damages; Tensile strength; Intermetallic compounds; Nanoparticles; Reliability

1. Introduction

The demand for slim and light weight electronic devices with advanced functionality is driving the current miniaturization trend in the electronics industry [1]. The miniaturization of electronic devices requires that the size of solder joints in electronic packages is reduced. As a