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Microstructure Evolution of Cu-Cored Sn Solder Joints Under High Temperature and High Current Density

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This work investigated the microstructure evolution of Cu-cored Sn solder joints under high temperature and high current density. The Cu_6Sn_5 phase formed at both the Cu core/Sn interface and Cu wire/Sn interface right after reflow and grew with increasing annealing time, while the Cu_3Sn phase formed and grew at the Cu/Cu_6Sn_5 interfaces. Intermetallic compound (IMC) growth followed a linear relationship with the square root of annealing time due to a diffusion-controlled mechanism. Under high current density, the thickness of the interfacial IMCs of the Cu core/Sn interface at the cathode side increased and the Cu core/Sn interface at the anode side exhibited an irregular and serrated morphology with prolonged current stressing time. Finite-element simulation was carried out to obtain the distribution of current density in the solder joint. Since Cu has lower resistivity, the electrical current primarily selected the Cu core as its electrical path, resulting in current crowding at the Cu core and the region between the Cu core and Cu wire. Compared with the conventional solder joint, the electromigration (EM) lifetime of the Cu-cored solder joint was much longer.

Key words: Microstructure evolution, electromigration, Cu-cored Sn solder, current crowding

INTRODUCTION

Ball grid array (BGA) packages are used in many electronic packages because of their ability to provide higher numbers of input/output connections, higher density, as well as higher electronic performance. Generally, solder balls are used to assemble BGA packages on substrates, serving as both electrical current paths and mechanical supporting structures. However, since solder balls melt during reflow soldering, it is difficult to control the solder joint height and the coplanarity of the package. Moreover, the solder balls will also melt when they suffer high temperature in real flip-chip solder joints, resulting in serious mechanical deformation of solder joints. Use of Cu-cored solder balls may be a potential solution to solve these problems, due to their enhanced reliability for the following reasons: Firstly, owing to the high melting point of Cu, the Cu core can remain in the solid state and serve as a space holder to prevent the solder balls from touching each other due to deformation during reflow soldering. Thus, the solder joint height and the coplanarity of the package can be accurately controlled. Secondly, the high thermal conductivity and low electrical resistivity of the Cu core can enhance their heat transfer and current-carrying capacity, respectively.

Studies into Cu-cored solder joints are very limited in spite of their outstanding properties.[1–9] Kiyono et al.[5] used Cu-cored solders plated with a Pb-Sn eutectic alloy for BGA joints, where the Cu-cored solder ball showed both higher strength and high electronic conductivity in the core, and low melting point in the periphery. Chen and Lin investigated the interfacial reactions and mechanical properties of Cu-cored solder balls.[8] They found

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