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Impact of Electrical Current on the Long-Term Reliability of Fine-Pitch Ball Grid Array Packages with Sn-Ag-Cu Solder Interconnects

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The interaction between electrical current and the long-term reliability of fine-pitch ball grid array packages with Sn-3.0Ag-0.5Cu (wt.%) solder ball interconnects is investigated. In this study, 0.4-mm fine-pitch packages with 300-μm-diameter Sn-Ag-Cu solder balls are used. Electrical current was applied under various conditions to two different package substrate surface finishes to compare the effects of chemically unmixed and mixed joint structures: a Cu/SAC305/Cu structure and a NiAu/SAC305/Cu structure, respectively. To study the thermal impact on the thermal fatigue performance and long-term reliability, the samples were thermally cycled from 0°C to 100°C with and without current stressing. Based on Weibull plots, the characteristic lifetime was degraded for the mixed joint structure, but little degradation was observed for the unmixed joint structure. The microstructure evolution was observed during constant current stressing and current stressing during thermal cycling. Accelerated intermetallic precipitation depletion at the package-side interface was observed in NiAu/SAC305/Cu structures due to current stressing, which was identified as the potential reason for the degradation in the thermal cycling performance.

Key words: Pb-free solder, current stressing, isothermal aging, microstructure, NiAu surface finish, OSP surface finish

INTRODUCTION

In recent years, electronic components have begun to be incorporated into smaller, higher-functionality, higher-density packages, which require increased power within a given number of interconnections in a given area.[1–3] This trend has brought the attention of researchers to interconnects with higher electrical current flow, which ultimately causes electromigration. Electromigration in solder joint interconnects has become increasingly important as joints have decreased in size and the current densities within them have increased in magnitude.[4–9] Several failure mechanisms have been identified, several detailed studies have been conducted, and the topic is still under active investigation. The identification of potential failure modes in Cu-Sn systems is particularly important in light of the trend toward Pb-free solder systems.[10] Several factors affect the diffusion induced by electrical current flow through a solder joint. This includes not only the back-stress caused by electrical current flow but also the Joule heating from localized hot spots.[11] These can affect the overall microstructure of the solder joint and the vacancy formation and migration, among other factors. This focus on the high current density per interconnect has resulted in understanding of well-studied phenomena such as void formation and current crowding, which are crucial to determine the lifetime of solder interconnects subjected to relatively high current density stressing.[12] However, at the same time, it has become important to identify the current stressing impact of relatively low current densities on long-term solder joint stability and reliability. It is reported that electrical current can

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