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Interfacial reactions in molten state micro solder joints under current stressing

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Abstract

The high local temperature in flip-chip solder joints of microprocessors has raised concerns that the solder, a low melting temperature alloy, might locally liquefy and consequently cause failure of the micro solder joint. This article reports the electromigration (EM) behavior when the solder is in the molten state. The electronic current was applied to the Cu/Sn-3.0Ag-0.5Cu (SAC305)/Cu molten solder joints. The growth of the intermetallic compound (IMC) and the consumption of the Cu pad were investigated. Moreover, the transition of IMC 3-D morphologies was also studied by the deep-etching method after EM test. The results of the electromigration in the molten solder joints indicate that the growth of the interface IMC and the consumption of the Cu pad present similar trends with those in the solid state micro solder joints, however, the rates of the growth and consumption are higher than those in the solid state micro solder joints. The evolution of IMC 3-D morphologies during the electromigration in the molten solder joints shows its own unique features, which are different from the electromigration in the solid state solder joints. With the increase of stressing time, the IMC 3-D morphologies transition indicates that the average grain size of cathodic Cu_6Sn_5 increases in radial direction with the increase of stressing time, but the size first increases, and then decreases in axial direction. In contrast to the morphologies transition for cathodic Cu_6Sn_5, the average grain size of anode Cu_6Sn_5 increases not only in radial direction but also in axial direction.

Keywords electromigration; intermetallic compound; element diffusion; evolution

1. Introduction

In recent years, the requirement to electronic packaging is moving towards greater performance and smaller feature size thus leading to a significant increase of the current densities in solder joints. The high current density will induce the effect of joule heating, and results in the local melting of the solder. The EM in molten solder joint has been identified as one of the main operative failure modes [1-3]. Therefore, in order to get a better understanding of the failure mechanism, it is important to investigate the EM behaviors in the molten solder alloys.

It is well known that EM is a mass transport caused by the directional electron flow, which promotes the growth of the interface IMC at the anode and accelerates the consumption of the soldering pad at the cathode [4-8]. The formation of IMC is a crucial factor for the good wetting between the solder joint and the substrate. However, excessive IMC growth and the brittle nature of the intermetallic layer

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