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A Study on the Physical Properties and Interfacial Reactions with Cu Substrate of Rapidly Solidified Sn-3.5Ag Lead-Free Solder

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A rapidly solidified Sn-3.5Ag eutectic alloy produced by the melt-spinning technique was used as a sample in this research to investigate the microstructure, thermal properties, solder wettability, and inhibitory effect of Ag_3Sn on Cu_6Sn_5 intermetallic compound (IMC). In addition, an as-cast Sn-3.5Ag solder was prepared as a reference. Rapidly solidified and as-cast Sn-3.5Ag alloys of the same size were soldered at 250°C for 1 s to observe their instant melting characteristics and for 3 s with different cooling methods to study the inhibitory effect of Ag_3Sn on Cu_6Sn_5 IMC. Experimental techniques such as scanning electron microscopy, differential scanning calorimetry, and energy-dispersive spectrometry were used to observe and analyze the results of the study. It was found that rapidly solidified Sn-3.5Ag solder has more uniform microstructure, better wettability, and higher melting rate as compared with the as-cast material; Ag_3Sn nanoparticles that formed in the rapidly solidified Sn-3.5Ag solder inhibited the growth of Cu_6Sn_5 IMC during aging significantly much strongly than in the as-cast material because their number in the rapidly solidified Sn-3.5Ag solder was greater than in the as-cast material with the same soldering process before aging. Among the various alternative lead-free solders, this study focused on comparison between rapidly solidified and as-cast solder alloys, with the former being observed to have better properties.

Key words: Lead-free solder, rapidly solidified solder, wettability, IMCs, Ag_3Sn

INTRODUCTION

It is well known that solder materials play an important role in the reliability of joint assemblies in electronic packaging because they provide thermal, electrical, and mechanical continuity in electronic assemblies.[1] At the same time, their performance and qualities also determine the integrity of solder joints.

Lead-based solders have been in use for a relatively long time due to their excellent welding process properties, low melting point, good wetting properties, and low price. Since the toxicity of lead-based solders affects and threatens the environment and human health, several countries have recently introduced strict legislation to ban use of lead-based solders and promote development of lead-free solder alloys.[2,3]

Although some Pb-free solder alloys have been in use for years, none of them can meet all of the requirements satisfied by Sn-Pb alloys in common use for low-cost commercial microelectronics.[4] Compared with traditional lead-based solders, the major problems with lead-free solders are: (1) the melting point (liquidus temperature and solidus temperature) is higher or lower, or the temperature of liquidus and solidus varies greatly. For example,

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