Microstructure Evolution at the Solder Joint during Isothermal Aging

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Abstract

The intermetallic compound formation and growth between Sn-3.0Ag-0.5Cu solder and surface finish, mainly immersion Au-plated Cu and immersion Sn-plated Cu were investigated in this study. This study aimed to examine the effect of different immersion types of surface finish towards the intermetallic compound formation in terms of its thickness and activation energy. In this works, evolution of microstructure at the interfacial region was studied for after reflow and isothermal aging at 150˚C, up to 1000 hours. The thickness of the intermetallic was measured using ImageJ software and activation energy was calculated using measured data. The compositions of intermetallic compound were confirmed using Scanning Electron Microscopy-Energy-dispersive X-ray spectroscopy (SEM-EDX) and its microstructure were observed using optical microscope. The cross sectional microstructure of Sn-3.0Ag-0.5Cu/ImAu joint shows that Au layer disappears completely, suggesting that it was entirely dissolved into the molten solder. The same result obtained from reflowed Sn-3.0Ag-0.5Cu/immersion Sn. The thickness of IMC layer at Sn-3.0Ag-0.5Cu /ImAu interface is similar to that at at Sn-3.0Ag-0.5Cu /ImSn interface, especially for Cu_6Sn_5 layer. The intermetallic growths of the intermetallic structure during isothermal aging were discussed.

Keywords: Intermetallic compound formation, Surface finish, Isothermal aging, Activation energy.

1.0 Introduction

The increasing awareness of health risk associated with lead (Pb) containing solder alloys has pushed the electronics industry toward lead-free solder [1-6]. Among many developed lead-free solder alloys, the Sn-Ag-Cu (SAC) lead-free solder alloy is considered the best alternative to replace eutectic tin-lead solder [7, 8]. Besides concern on solder, it is also important issue for development of Pb-free packaging system to find an appropiate Pb-free surface finish on printed circuit board (PCB) due to its affect on intermetallic growth. Immersion surface finish is another promising option for the Pb-free surface finish since it has the advantages of lower cost and simpler operation [9]. The solder joint strength is controlled by good metallurgical bond between the component and the board. A reliable solder connection must have solderable surface to form good solder joint since interfacial reaction at solder joint are key factors in the fabrication of electronic products [10].

Generally, the thickness of the IMC layer at the interface between the solder and substrate is very important in determining the reliability of the whole package [11]. Besides that, activation energies of IMCs layer also contributed to the coarsening of IMC grains and nucleation kinetics. Therefore, as the growth of the IMC layer could degrade the reliability of the solder joint and influence it's grain structure it is essential to study the formation and growth of the IMC layer [12-15].

Many studies have been performed on the interfacial reaction between Sn-Ag-Cu solders and various surface finishes, such as Cu, Au/Ni/Cu and electroless nickel-immersion gold (ENIG), during reflow or aging. However, insufficient comparative studies have been done on the interfacial reactions of Sn-Ag-Cu/ImAu solder joints. Therefore, in this study, the effect of using different immersion types of surface finish towards the intermetallic compound formation in terms of its thickness and activation energy was investigated.

2.0 Experimental Procedure

The solder ball used in this study was Sn-3.0Ag-0.5Cu (in wt%) with diameter of 500µm. The substrate used in this study are Immersion Gold (ImAu) and Immersion Tin (Sn)-plated Cu. The coating process of ImAu and ImSn on Cu substrate were done starting from pre-treatment process, soaking the substrate in ImAu and ImSn solution respectively in plating bath and ended in solder masking process. Then, reflow process was conducted in a furnace under peak temperature 250˚C for 25 minutes. To evaluate the interfacial reactions between solder alloys substrates during the solid-state reaction, isothermal aging treatment was performed. The samples were then aged up to 1000 hours in an aging oven. After the reflow and aging treatment, the samples were prepared for the observation of the interface cross-section. The common metallographic practices, grinding and polishing, were used to prepare the samples. The compositions of intermetallic compound were confirmed using Scanning Electron Microscopy-Energy-dispersive X-ray spectroscopy (SEM-EDX) and its microstructure were observed using optical microscope. The thickness of the intermetallic was measured using ImageJ software and activation energy was calculated using measured data.

3.0 Results and Discussion

3.1 Interfacial microstructure

After solder reflow, interfacial reaction occurred. As the SAC 305/ immersion Au-plated Cu interface was reflowed for 25 minute, the topmost Au layer was dissolved completely into the molten Sn-Ag-Cu solder, leaving the Cu layer exposed to the molten solder.