Interfacial reaction between liquid tin and solid metals

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***Abstract*: Reaction between solid Cu, Al and Stainless steel substrates and liquid tin (Sn) was evaluated. All the substrate specimens were immersed (dipped) in molten Sn for duration of 1min and 3mins at a speed of 2.5mm/s by using a motor and drawn out from the liquid tin at a speed of 2.5 mm/s. The temperature of liquid Sn maintained was 350 °C. An interfacial reaction between solid metals in liquid tin and vice versa was investigated. An increase in intermetallic layer with increasing immersion time was observed. The evolution of microstructure and formation of intermetallic compounds at the interface was assessed using metallurgical microscope.**

***Keywords*: Tin, molten, base metal, substrate, alloy, intermetallic**

1. Introduction

Soldering is a low temperature metallurgical joining method using a filler metal known as solder alloy to hold the parts to be joined together [1-3]. The reliability of solder joints is influenced by the interfacial reactions between the solders and substrates [2-5]. These reaction products are called as inter metallic compounds (IMCs). Formation of a strong bond at the solder joints is due to presence of these IMCs. In microelectronic industry especially in flip chip packaging process, package undergoes repeated reflow process, due to which IMCs grow rapidly at the solder/substrate interface [6-8].

Moreover, the type of substrate material has a significant effect on solder wettability, morphology of interfacial IMCs and integrity of solder joints. So, it is important to understand the interfacial reactions between pure Sn and the substrate metallization, especially prepared by using dipping method. Thus, the pure Sn solder is considered as a possible substitute for tin – lead alloys. In the present study effect of dipping time on reaction between solid metals in molten tin is investigated.

2. Experimental

In the current research commercially available base metals Copper (Cu), Aluminium (Al), and Stainless steel were used as substrate materials. The materials were purchased from HighTech steels, Mangalore. The materials purchased in the form of bars and sectioned into required dimensions of 50mm×30mm×3mm as shown in Figure.1.

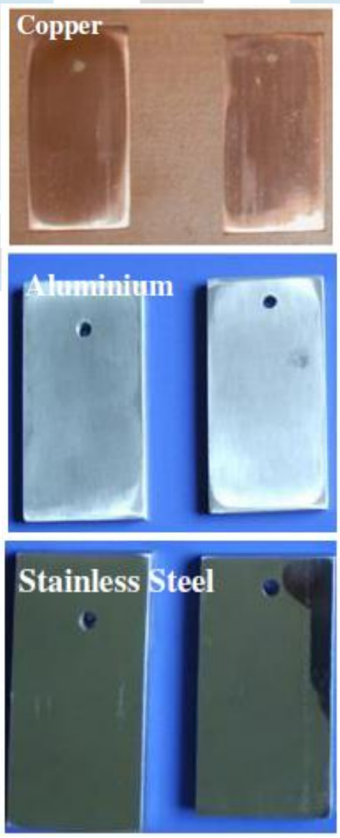

Figure 1: Coper, Aluinium and Stainless steel substrate specimens

The pure Sn (99.90%) was used for solder bath (liquid Sn). Pure Sn was purchased from Bunder, Mangalore. Substrate materials of metals and alloys after polishing were cleaned by using acetone and then dried in air. After applying a Rosin Mildly Activated (RMA, purchased from Tejas Care, Chennai) flux thoroughly, the substrates were dipped (immersed) into the bath of molten solder melt with the constant speed of 2.5mm/sec by using a motor and chain setup. The solder bath temperature maintained was 350ºC, and the immersion times chosen were 1 minute and 3 minutes respectively. The immersion depth was 25mm and the samples were drawn out from the bath with constant speed of 2.5mm/sec. Preheated graphite crucible was used to experiment to hold the liquid Sn. Crucible was heated preheated to temperature of 300°. The samples were then allowed to cool in the air. The samples after cooling were sectioned using ultra- thin diamond tip cutting blade. After polishing with different emery papers, sectioned samples were sent for interfacial microstructural study to investigate the diffusion behavior at the interface between Sn and substrate materials. For solder/substrate interfacial study, molten tin bonded to the substrate after dipping were sectioned using ultra-thin diamond tip cutting blade and polished using SiC papers of different grit sizes. The Tin/substrate interfacial region was micro-examined using Optical Metallurgical Microscope (Model NIKON Epiphot 200).

3. Results and Discussion

The macroscopic images of surface appearance of the hot dipped substrate samples are shown in Figures 2 to 3.

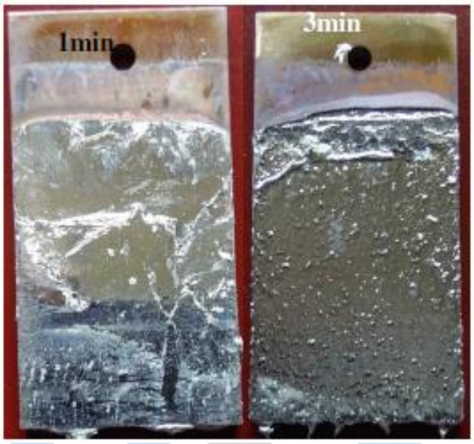

Fig. 2 Dipped copper substrates at 1min and 3min.

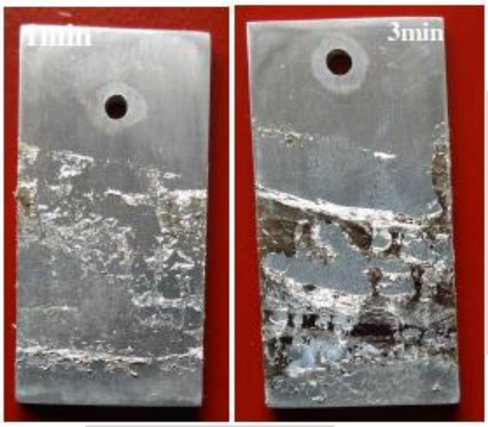

Fig. 3 Dipped Al substrates at 1min and 3min

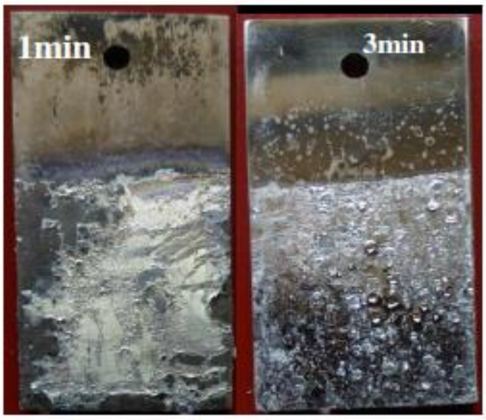

Fig. 4: Dipped Stainless steel substrates at 1min and 3min.

The wetting of liquid tin was increased with increasing immersion time. The trend was same for all the substrates. However, the wetting of copper surface exhibited excellent wetting compared to other two substrates surface. The wetting of aluminium surface was found to be poorer than that of all substrates surface. The inspection results showed that there were no leads in wetting of Al at two different dipping times. The reason for poor wetting of Al is the surface is covered with a thin invisible coating aluminium oxide [9]. Thin oxide film makes it difficult to solder the dissimilar materials. Similarly a thin tenacious self-repairing protective coating of chromium oxide film on stainless steel inhibited liquid tin for wetting [10].
The optical microscopic photographs shown in Figures 5 indicate the extent to which Sn dissolution and IMC development occurred at the interface of all substrates.

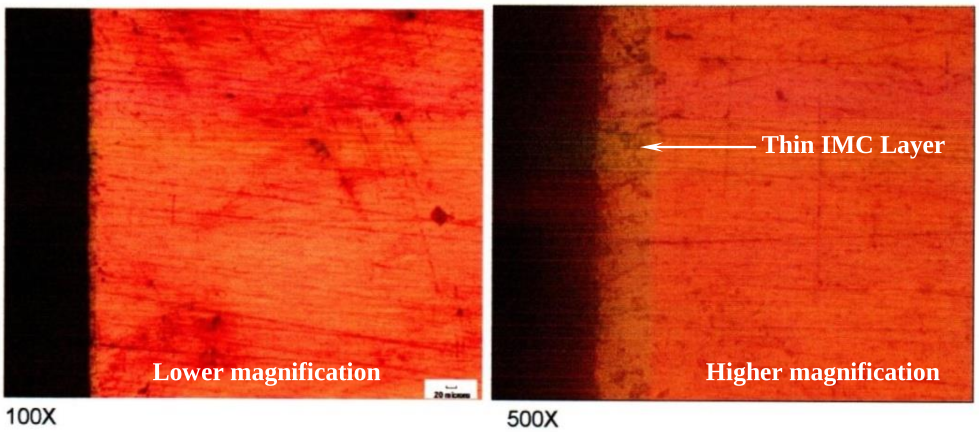

Fig 5. Copper dip in molten tin for 1 min

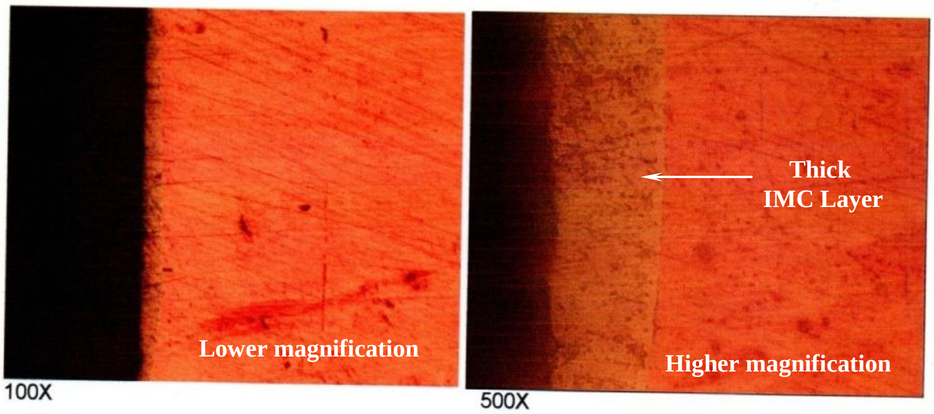

Fig 5. Copper dip in moltrn tin for 3 mins

The cross-section interfacial microstructure between tin and Cu exhibited a minimal tin dissolution due to shorter dipping time i.e. 1min. Conversely, longer dipping time caused considerable dissolution of liquid Sn into Cu, the IMC layer found to be slightly thicker. The IMC layer was slightly thin for shorter dipping time and transformed into a continuous thick layer at longer dipping time. As per the Sn – Cu phase diagram [7], the chemical composition were composed of Cu and Tin, which is Cu_6Sn_5 for reaction between liquid tin and Cu. Since wettability of molten tin with Al and stainless steel was poor the interfacial microstructures did not exhibited growth of IMCs at the interface. Therefore substrates were not sectioned.

4. Acknowledgment

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