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OPTIMIZATION OF HOT AIR SOLDER LEVELING (HASL) MACHINE FOR A ROBUST SURFACE FINISH IN SOLDERING APPLICATIONS

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Abstract

Hot Air Solder Leveling (HASL) is one of the most commonly used surface finishes in the industry. HASL is also one of the least expensive types of PCB surface finishes available. This study aims to examine the influence on the solder joint microstructure of dipping time and solder temperature. During soldering process, the temperature that used were 300°C and 400°C. The dipping time was split into three batches which is 20s, 60s, and 100s. The Sn-0.7Cu-0.05Ni solder alloy was used in this analysis to shape the solder coating microstructure. In this analysis, an Optical Microscope (OM) was used to determine the microstructure of the shape of the solder coating microstructure. As dipping time and dipping speed increased, the interfacial IMC thickness was found to increase, grown up and getting thicker. This outcome results can be used as the basis in order to improve the solder joint properties.

Keywords*:* *Hot Air Soldering Levelling (HASL), Intermetallic compound (IMC), Sn-0.7Cu-0.05Ni solder alloy.*

Introduction

Hot Air Solder Leveling (HASL) is a common surface finish that has a long history of success on printed circuit boards. Since the early 1980s, the primary process used for technical boards has been the method of solder application through HASL. On the solder lands, this process generates a solder coat. The board is soaked in a pot of molten solder, removed from its edge, and then the excess solder is blasted off using intense hot air blasts, a technique known as solder levelling [1]. HASL is currently the most common Sn/Pb terminal for printed circuit boards. Much focus has been paid to choices for lead-free alternatives for HASL. Studies on the use of a composition of Sn 93-98 %, Ag 1.5-3.5 %, Cu 2-2 % and Sb 2-2 % alloy and SnCu0.7 for lead-free HASL have been recorded. Studies have shown that the coating of circuits with these alloys is efficient. An analysis that involved the use of SnCu0.7 HASL, for example, showed positive findings that are close to SnPb HASL.

The primary problems with HASL are the regulation of thickness and thermal shock encountered by the circuit board during the process. A HASL coated board is expected to have a shelf life of 1-2 years where OSP and immersion finishes last less than a year [2-4]. The HASL approach is used on the Cu substrate for the deposition of lead-free solder coating. The advantages include cheap cost, high stability, and excellent solderability. However, the disadvantages include

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coating non-uniformity, low thermal shock resistance, and the formation of brittle IMCs at the interface during the application of both processing and solder joints [5].

Experimental procedure

In this study, the Sn-0.7Cu-0.05Ni solder alloy was used and supplied by Nihon Superior Co., Japan. The ingots of Sn-0.7Cu-0.05Ni solder alloy were firstly be heated up to 250 °C by using a solder pot until fully melts. Prior to HASL process, the copper strips with dimension of 1.5 x 1.5 cm^2 and 1.0 cm thickness was cleaned using acid to remove the surface oxides. A standard of B-type solution flux based on Japanese Industrial Standards (JIS Z3198-4) was applied. The copper strip used was then positioned on the pneumatic angular gripper of an automated solder - dip machine and dipped into the molten solder with a various of immersion dwell time and temperature of solder. The dwell time used was 20, 60 and 100 s, while the molten solder temperature used for held during HASL process was 300 and 400 °C. After copper strip been dipped in the molten solder, the sample was then blown off using a compressed air knives blower in order to remove the excessive solder coating and control the thickness of coating layer. The samples were then cooled down to room temperature and rinsed with water using an ultrasonic bath. To conduct further analysis, all the samples were first mounted in epoxy resin and grounded with the SiC paper followed up with polished steps by using the colloidal silica suspension. The cross-sectional micrograph and thickness of interfacial IMC layer were observed using Optical Microscope (ECLIPSE L300N). The growth thickness of IMC in Sn-0.7Cu-0.05Ni solder joint for each parameter were measured using an Image-J software by dividing the total area of IMC and the total length of IMC. The average thickness of the IMC layer was determined at 5 different position of interfacial area.

Results and Discussion

Fig. 1 show the microstructure of interfacial IMC layer of Sn-0.7Cu-0.05Ni solder for different dipping time of 20s, 60s and 100s. The IMC showed that the scalloped-shape morphology of the Cu_6Sn_5 IMC layer was formed at the interface area between Cu substrate and solder. As the time of dipping increase from 20s to maximum time of 100s, the thickness of interfacial IMC become thicker due to longer time of copper strip interact with solder.

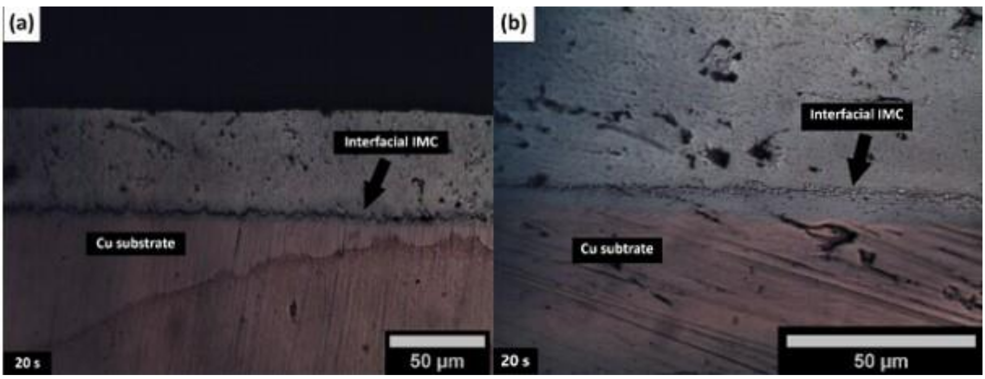

Fig. 1. Microstructure of interfacial IMC of Sn-0.7Cu-0.05Ni solder joints at various dipping time (a-b) 20s;

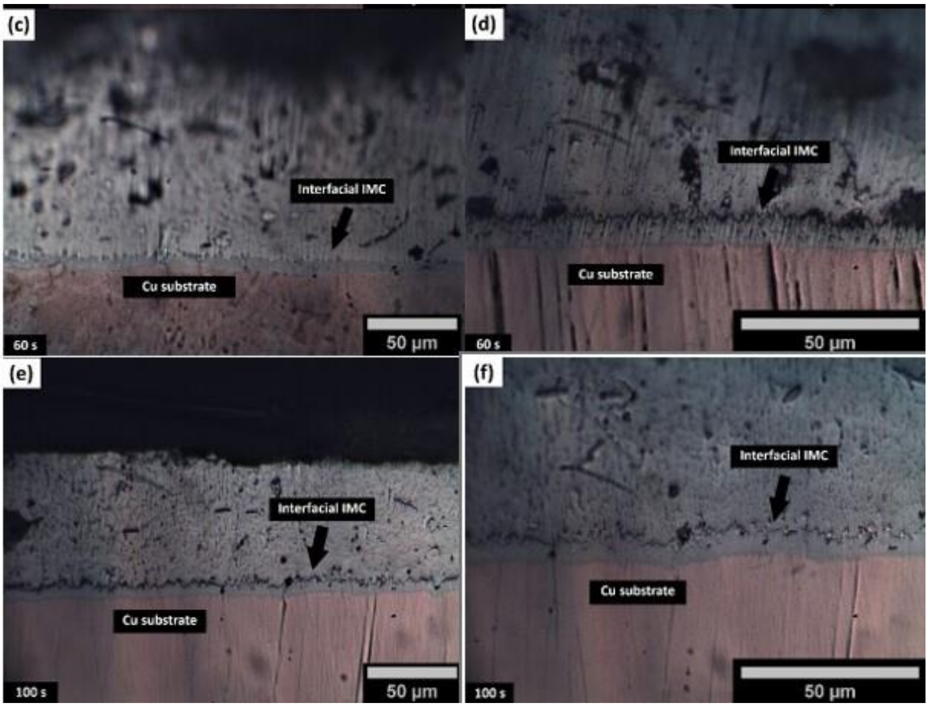

Fig. 1. Microstructure of interfacial IMC of Sn-0.7Cu-0.05Ni solder joints at various dipping time: (c-d) 60s and (e-f) 100s with different magnifaction

To study the effect of IMC thickness towards the dipping time, the graph of average thickness IMC layer was plotted against dipping time as depict in Fig. 2. The thickness of Cu_6Sn_5 IMC layer was slightly increased from 7.19 µm for 20s dipping time to maximum thickness with 8.04 µm for 100s dipping time. The increase in the thickness of interfacial IMC indicates the presence of small Cu_6Sn_5 at the interface of solder and copper substrates. As the thickness of the IMC increases, the thickness of free-solder decreases. Free solder thickness is important because it can help determine effective solderability in the assembly of electronic components over the course of a long process [6].

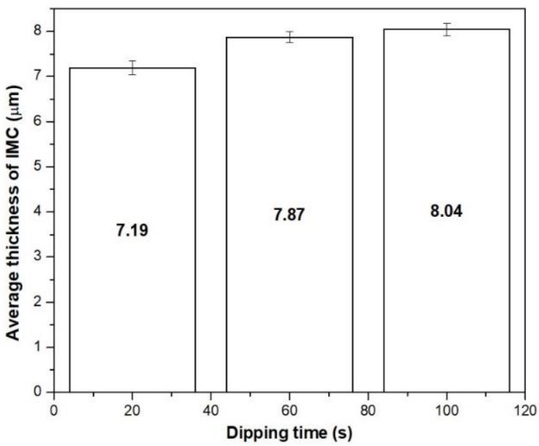

Fig. 2. Average thickness of interfacial IMC of Sn-0.7Cu-0.05Ni solder joints at various dipping time

In this study, the effect of thickness IMC of Sn-0.7Cu-0.05Ni solder towards different molten solder temperature was also been discovered. As per Fig. 3, the results show the micrograph of interfacial IMC after been dipped at 300 and 400 °C. Similar with the effect of dipping time, as the temperature of molten solder increase during dipping process, the interfacial IMC had grown up and getting thicker.

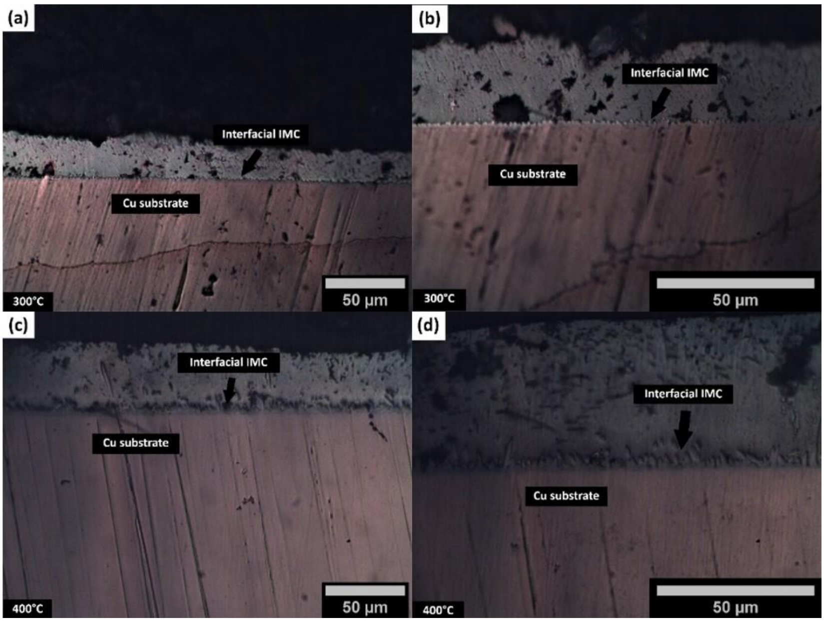

Fig. 3. Microstructure of interfacial IMC of Sn-0.7Cu-0.05Ni solder joints at different molten solder temperature (a-b) 300 °C and (c-d) 400 °C with different magnifaction

The thickness of IMC layer was measured and plotted as the average of thickness IMC versus the solder temperature as per Fig. 4.

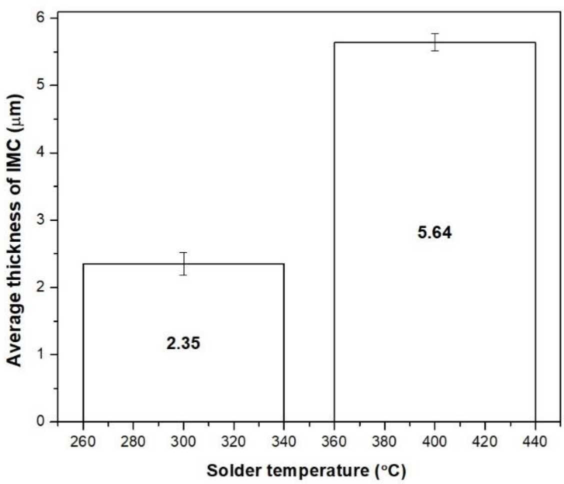

Fig. 4. Average thickness of interfacial IMC of Sn-0.7Cu-0.05Ni solder joints at (a) 300 °C and (b) 400 °C molten solder temperature

This relationship had clearly shown that the thickness of IMC increases from 2.35 μm at 300 °C molten solder temperature to 5.64 μm thickness at 400 °C. The results found was similar to the study done by Kumar et al. [7], where they also found that the IMC layer become thicker as the temperature of solder used is higher. Several studies also reported that the IMC layer's thickness at the solder/Cu interface increases with increased annealing temperature [8-10].

Conclusions

In this study, the influence of the interfacial intermetallic compound (IMC) layer of the Sn-0.7Cu-0.05Ni solder alloy with varying the dipping time and molten solder temperature were investigated. The conclusion was summarized as follows:

- the results revealed that the thickness of IMC layer become thicker by 10.57% as the dipping time increase to 100 s. This occurs due to the longer time interaction between the copper (Cu) and molten solder;
- the morphology of the Cu_6Sn_5 IMC layer formed in the scalloped-shape type at the interface between solder and the Cu substrate;
- the thickness of IMC layer increase by 58.33% when the molten solder temperature increases to 400 °C, due to the increasing Cu diffusion and tends to react with the Sn from the Sn-0.7Cu-0.05Ni solder alloy to formed the Cu_6Sn_5 IMC layer.

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