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Electronics Solutions

Reflow Effect on Immersion Tin Solder Wetting

Cherry Santos, Ph.D.; Tyler Banker; Ernest Long, Ph.D.; Jun Nable, Ph.D.

MacDermid Inc. 227 Freight Street, Waterbury, CT 06702

Abstract

Immersion tin is one of the widely used surface finishes in the electronics industry. Its ease of application combined with the good deposit properties make it an attractive surface finish. With its growing application, proper performance evaluation and understanding are of paramount importance. In this study, we explored the relationship of solder performance to the progressive growth of intermetallic compound in the immersion tin finish. The observed solder performance is correlated to the changes occurring within the immersion tin when subjected to reflow conditions.

Surface Finish and Immersion Tin

Surface finish is an integral part of any Printed Circuit Board (PCB) or Printed Wiring Board fabrication. It is generally applied to exposed Cu connectors and conductors on the PCB. Surface finish serves as a protective layer for the Cu substrate during storage; minimizing or reducing tarnish. Additionally, since it is the layer that comes into contact with other components during assembly, it is required that it provides good solderability between the PCB and the component during assembly. Furthermore, after assembly, the finish helps prolong the integrity of the solder joint during use.

Immersion tin (ImSn) is one of the widely used surface finishes. It is applied via a displacement mechanism wherein the metallic Sn is deposited by replacing the surface Cu atoms on the PCB substrate. Thickness requirement depends on the application and the heat treatment during assembly.

One of the main challenges of ImSn is the deterioration of solderability especially after thermal reflow. This drop in solder performance is mainly attributed to the formation of an intermetallic compound (IMC) between the Sn finish and the Cu metal substrate. In this study, we investigated the development of the IMC layer when subjected to reflow conditions and correlated the observation to solderability performance.

Thickness Measurements

X-ray Fluorescence (XRF)

- XRF is simple, fast and nondestructive method of coating thickness measurement and material analysis.
- It is based on the emission of fluorescent or secondary X-rays when the material is bombarded with high energy X-rays.

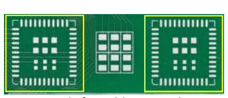
Sequential Electrochemical Reduction Analysis (SERA)

- SERA is an electrochemical technique utilized to determine a variety of coating parameters, e. g. thickness.
- A controlled current is applied on a small, isolated, well-defined area of the test material to either oxidize or reduce the surface species.
- The potential is recorded as a function of time, which shows plateaus that correspond to the reduced or oxidized surface compounds.
- The compound is identified by voltage and the amount of present species is determined by the length of time.

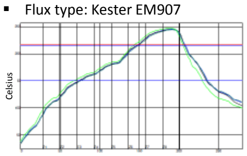
MacDermid Solder Spread Method

Equipment and Conditions

- Vitronics XPM2 Reflow Oven
- Peak temperature: 245°C
- Solder alloy: Sn96.5 Ag3.0 Cu0.5
- Flux type: Kester EM907



QFP pads for solder spread test

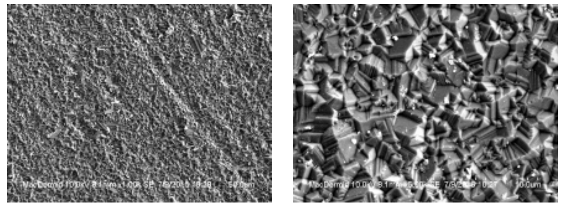


Surface finish Pb-free reflow profile

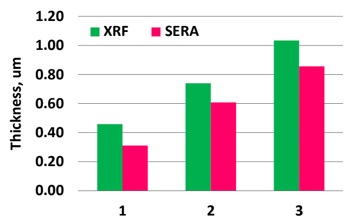
Solder Spread Test

- This test measures the Pb-free solder wetting over an area of the finish.
- A varied aperture stencil is used to print two Quad Flat Pack (QFP) on the test panel. The first pad is printed one to one, then the subsequent solder paste volume is continuously reduced across the QFP.
- The area is evaluated after reflow to determine the number of pads that spread 100 % of the pad length. Higher spread number means higher spread percentage.

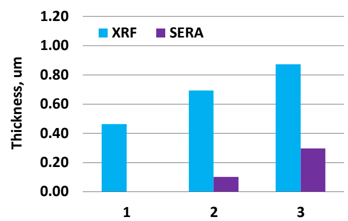
SEM Image of Sn Deposit



Different Sn Thickness



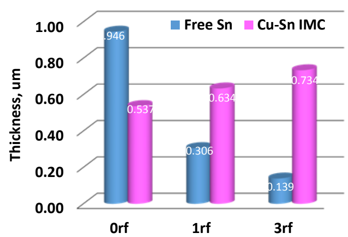
Thickness comparison of as-plated ImSn samples using two different techniques.

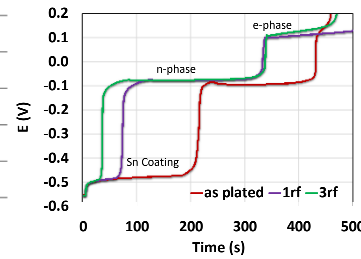


Thickness comparison of ImSn after 1 reflow (1rf) cycle using two different techniques.

- XRF thickness reflects higher values than SERA measurements. XRF is based on fluorescence emission from Sn atoms, hence it accounts for pure Sn and the Sn present in the IMC layer.
- SERA provides electrochemical response for the chemical composition of the deposit – the behavior of metallic Sn is different from the Cu-Sn IMC.
- SERA measurements reveal a distinct difference for samples before and after 1 reflow process. This indicates a conversion of pure Sn to IMC.
- Sample 1 (< 0.5 um as-plated) has no remaining Sn after 1 reflow treatment according to SERA measurements.

Sn Thickness and Intermetallic Compound

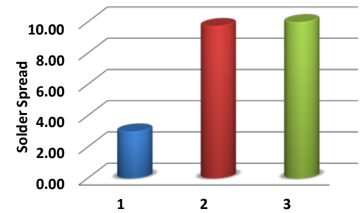




Sn thickness after multiple reflow cycles using electrochemical method measurements.

- As-plated ImSn finish contains IMC layer, which grows with subsequent reflow cycles.
- A substantial decrease in Sn thickness occurs during the first reflow cycle.
- A further decline in Sn thickness is observed between 1st and 3rd reflow cycles but not as drastic compared to the 1st reflow treatment.

Solder Wetting



Solder spread for as-plated samples with different thickness (**1** - 0.46 um, **2** – 0.74, **3** – 1.03 um)

- Sample with < 0.5 um Sn has poor solder spread (max 11).

Good solder wetting

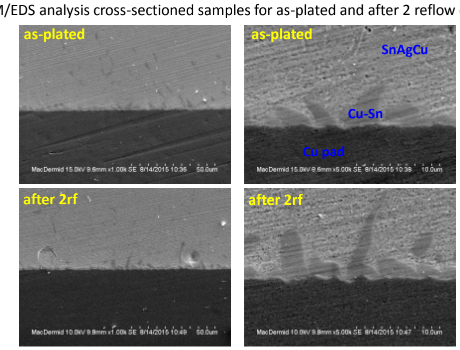
Poor solder wetting

Solder spread for as-plated and 2rf samples with ~ 1 um thickness.

- Freshly plated samples (A and B) exhibit excellent solder wetting but are severely affected after thermal reflow.
- The assessment of solder wetting after thermal reflow demonstrates a substantial reduction in spread compared to the as-plated samples.
- The poor solder wetting is attributed to the newly formed IMC, which has inferior solder wetting compared to Sn.
- In general, average spread numbers for as-plated samples range from 5 – 11 while spread numbers after 2rf are < 2.

Intermetallic Compound – Solder Evaluation

SEM/EDS analysis cross-sectioned samples for as-plated and after 2 reflow cycles.



- Closer investigation by cross section reveals that Cu-Sn layer does not form evenly across the deposit.
- Thermal reflow demonstrates the progression of the IMC layer.

Conclusions

- The reflow process dramatically affects the Sn thickness due to the formation of Cu-Sn IMC. Metallic Sn is converted to form the IMC layer.
- Degradation in solderability performance after reflow treatment is due to the progressive growth of IMC layer. This IMC has inferior solder wetting properties compared to Sn.
- As the number of reflow cycles increases, the surface contains less metallic Sn and thicker Cu-Sn IMC layer.
- A pure metallic Sn layer over the Cu-Sn IMC is essential to ensure a solderable Sn finish.
- Electrochemical (SERA) analysis is a reliable technique for detecting the pure Sn thickness.

Acknowledgements

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