New No-Lead Solder Pastes and Reflow Techniques

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A new study evaluated the performance of SnAgBi and SnAgCu alloys with bare copper and immersion tin pad finishes.

Recently, we conducted a study to qualitatively evaluate several new no-lead solder pastes and reflow techniques. This study built upon experience we gained from previous studies of no-lead solders and our evolving industry experience.

In the previous studies, we evaluated several no-lead solder alloys in conjunction with copper pads covered with organic solderability preservatives (OSPs). These samples were reflowed in air and nitrogen atmospheres utilizing a tent profile with a maximum 240°C spike temperature and approximately 60 seconds above liquidous. The joints were then micro-sectioned to evaluate the quality of intermetallic bonding and the prevalence of voids.

The solders we evaluated gave generally acceptable results under all conditions. The only potential issue was the periodic occurrence of unacceptably large voids in the fillets of 20-mil quad flat pack (QFP) leads.

Study Parameters

This new study was intended to evaluate the latest no-lead formulations and fluxes as well as improved profile shapes and pad metallizations. The goal was to reduce the occurrence of unacceptable solder voids. The study used two common no-lead alloys: tin/silver/bismuth (SnAgBi) and tin/silver/copper (SnAgCu). Both no-clean and water soluble fluxes were used in which the component leads were plated with matte tin.

Two pad finishes were evaluated. Bare copper freshly prepared with fluoroboric acid was the control finish. Additional samples were coated with immersion tin. Research at Auburn University (Auburn, AL) indicated that a tin pad coating had wetting characteristics second only to electroless nickel/immersion gold finishes for the solders we were studying (Figure 1).[1] Immersion tin was selected for our study due to its lower cost.

A special profile, popular with several Japanese manufacturers for no-lead soldering, was also utilized in this study (Figure 2). This profile features a one-minute dwell at 150° to 170°C, a one-minute reflow plateau at 230° to 240°C and a total of 90 seconds above liquidous, which allows sufficient duration at peak temperature for excellent thermal equilibrium through the printed circuit board (PCB) assembly. In addition, the longer liquidous

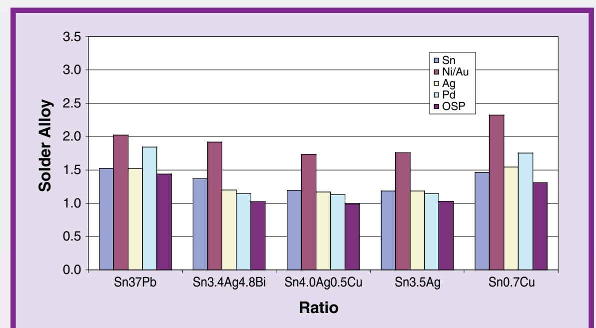

FIGURE 1: Ratio of joint diameter after reflow vs. joint diameter after printing for PCB finishes in air. Note: The higher the ratio, the better the relative wetting aspect.

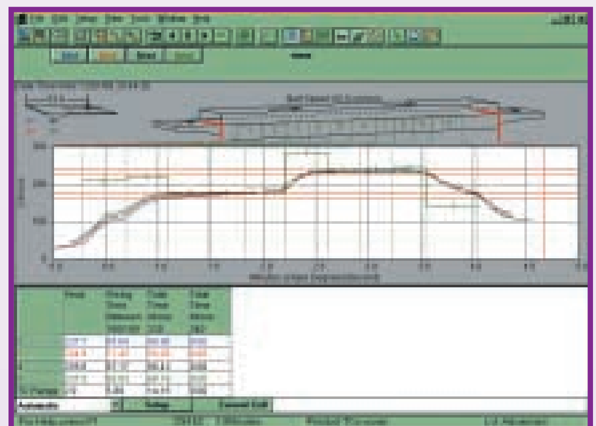

FIGURE 2: No-lead solder paste profile popular with Japanese manufacturers.

time promotes wetting and pad coverage because no-lead alloys have slower wetting speeds than traditional tin/lead (SnPb) alloys. Finally, this profile allows for more gentle heating with lower oven zone setpoints. This factor reduces the component body and bare board peak temperatures, thereby promoting improved reliability.

In previous studies, we observed that the reflow atmosphere notably impacted component wetting but did not impact void size or occurrence. In our new study, we utilized a nitrogen atmosphere with less than 1,000 ppm of oxygen due to our preference for aesthetically optimized solder joints.

Sample solder joints from the same location on each test board were x-rayed using a proprietary technology to produce an accurate x-ray image of solder voids undistorted by voltage blooming.[2] This distortion, which affects the image size of the solder voids, is present in most other x-ray inspection systems. After the sample solder joints were x-rayed, they were then micro-sectioned to evaluate the general wetting quality and occurrence of voids. Finally, these samples were compared to develop an optimal combination of variables.

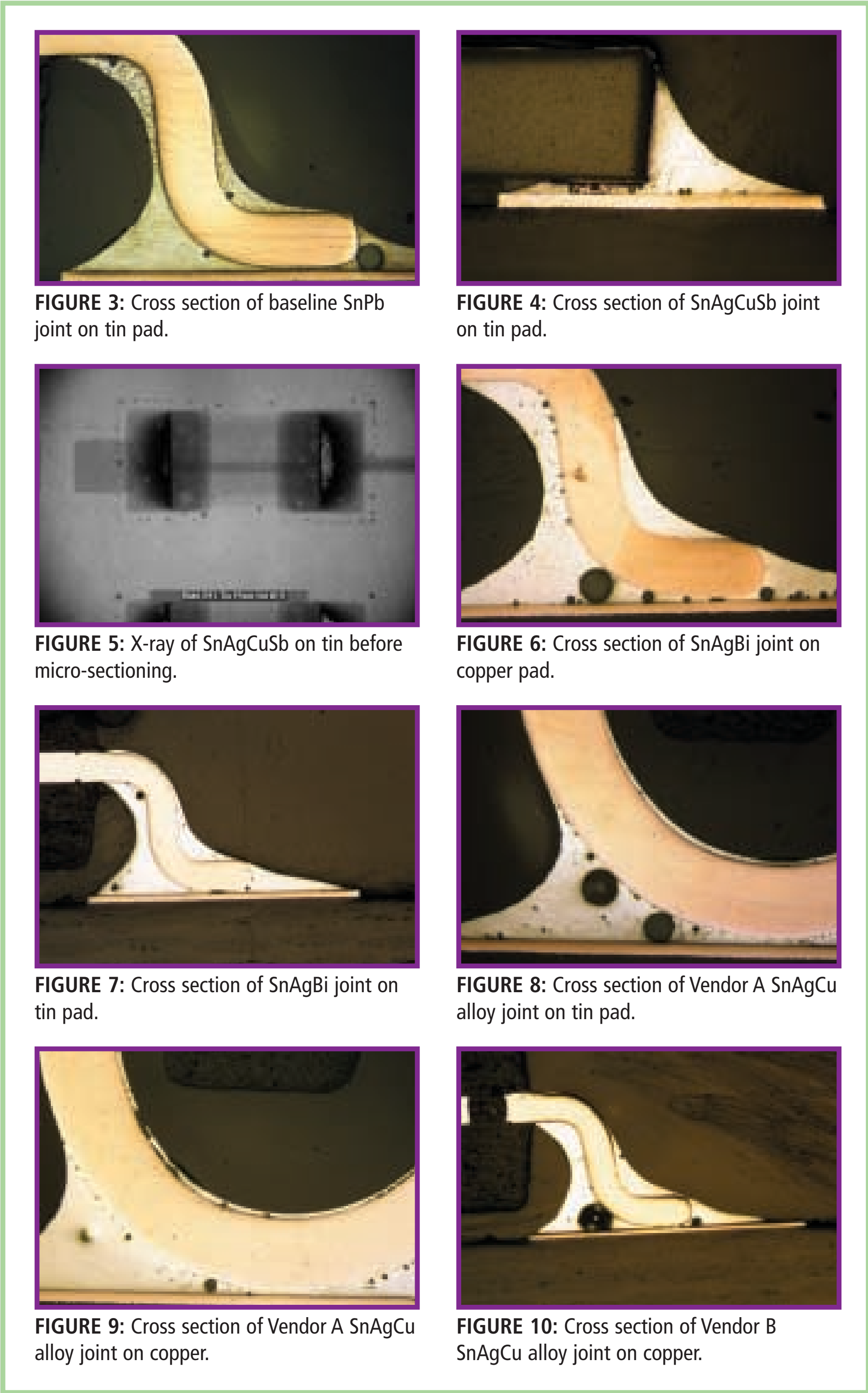
FIGURE 3: Cross section of baseline SnPb joint on tin pad.

FIGURE 4: Cross section of SnAgCuSb joint on tin pad.

FIGURE 5: X-ray of SnAgCuSb on tin before micro-sectioning.

FIGURE 6: Cross section of SnAgBi joint on copper pad.

FIGURE 7: Cross section of SnAgBi joint on tin pad.

FIGURE 8: Cross section of Vendor A SnAgCu alloy joint on tin pad.

FIGURE 9: Cross section of Vendor A SnAgCu alloy joint on copper.

FIGURE 10: Cross section of Vendor B SnAgCu alloy joint on copper.

Study Results

The first samples were run using conventional 63/37 tin/lead (SnPb) paste to develop a baseline for void occurrence (Figure 3). Acceptably small voids were consistently found, particularly attached to regions of low solderability such as the toe of a QFP lead.

A second group of samples used a tin/silver/copper/antimony (SnAgCuSb) no-lead alloy we tested last year (Figures 4 and 5). This alloy was susceptible to large voids on 20-mil QFP leads. Similar results were found with the recent test although void occurrence was moderately reduced on bare copper versus tinned pads.

The SnAgBi alloy from Vendor A was found to have very few voids with bare copper pads (Figure 6) and somewhat higher void occurrence with tin plated pads (Figure 7). Similar results were found with Vendor A's SnAgCu alloy (Figures 8 and 9). However, a considerable difference existed concerning the voids found with Vendor B's SnAgCu alloy (Figure 10).

Conclusion

Several conclusions were reached based on this study. First, qualitatively fewer voids were observed in the alloys tested in this study as compared to previously tested alloys. Second, the use of the profile popular with Japanese manufacturers resulted in improved wetting but apparently did not reduce void formation. Third, superior results were observed with bare copper pads as compared to white tin. As a result, this study will be repeated with electroless nickel/immersion gold pads. Fourth, x-ray systems are capable of finding voids in reflowed solder joints. Finally, both SnAgBi and SnAgCu alloys can give excellent results with very low void occurrence. However, important differences exist between various vendors and formulations. ■

References

1. Sattiraju, S., *et al*. 2001. Wetting characteristics of Pb-free solder pastes and Pb-free PWB finishes. Proceedings of the Electronic Components and Technology Conference.
2. IPC. Standard 705, p. 60.

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Industry Terms in this Issue

HTML .... HyperText Markup Language
IP .... Intellectual Property
LAN .... Local Area Network
OSP .... Organic Solderability Preservative
PDA .... Personal Digital Assistant
PNP .... Pick and Place
PTH .... Plated Through Hole
RA .... Rosin Fully Activated (Solder)
RMA .... Rosin Mildly Activated (Solder)
ROI .... Return On Investment
SCADA .... Supervisory Control and Data software
SPC .... Statistical Process Control
SQC .... Statistical Quality Control
XTML .... eXtensible Text Markup Language

NOTE: Some of these industry terms are from the 2000 *NEMI Technology Roadmap*. For further information, contact the National Electronics Manufacturing Initiative at www.nemi.org.

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