*Stig Oresjo*

# Pb-Free's Impacts on Test and Inspection

## Early runs show higher numbers of opens, bridges and voids.

Effective July 1, 2006, a majority of circuit board assemblies sold in Europe will be required by law to be lead-free. In the traditional tin-lead process, tin-lead paste and components with some lead is preferred. Clearly, it would be great if lead-free components could be separated from traditional ones. Many EMS providers are planning to have separate part numbers. But not all component vendors have committed to this. Therefore, some lead-free and leaded components will likely be mixed. In addition, some components will not be available initially in lead-free form, while others will come only as lead-free.

During the past few years the industry has experimented with a variety of lead-free alloys. The U.S. has angled toward the NEMI and SMTA recommendation of 3.9% silver, 0.6% copper and tin. European manufacturers have experimented mainly with 3.4 to 3.9% silver, 0.5 to 0.9% copper, and the remainder tin. Major Japanese OEMs have investigated numerous lead-free alternatives, including alloys containing bismuth and zinc such as Sn AgBiCu, Sn8Zn3Bi and Sn58Bi. The Japanese industry has also moved toward SAC alloys. Generally speaking, manufacturers worldwide are moving toward SAC alloys with small variation in the amounts of silver and copper.

The lead-free alloy melting point is 217°C, higher than the 183°C for lead alloys used today. This will have significant impact on manufacturing processes, and potentially on component reliability.

Another key issue is that wetting forces for the lead-free alloy are not as strong as for tin-lead. The mixture of lead-free and traditional components will create many issues during the transition to lead-free. The figures illustrate wetting issues of lead-free. Both figures show x-ray closeups of two gullwing joints on the same type of QFP device.

**Figure 1** is a tin-lead example. A good heel formation and toe formation can be seen. The side fillets are approximately the same, indicating that the component pins are centered on the pad. Note also that very little solder appears on the pad below the toe in the photo; all solder is around the component pins.

**Figure 2**, a lead-free example, reveals a couple of wetting issues. Solder is over the full pad. The pad sizes on both boards (Figure 1 and 2) are approximately the same. Also, note that the side fillet to the right is stronger than to the left, indicating that the component is misaligned on the pad. The toe fillet is insignificant. The heel fillet has formed correctly; however, a void can be seen in one of them. A void is also visible on the same pin further down on the pad.

During the transition to lead-free we expect to see many of these types of issues. Defect levels are expected to increase. In early experiments and production runs the following type of defects are noticable: opens, bridges, misalignment, tombstones and voids. Because of the higher reflow temperatures, component defects are also expected to increase. Large variations in defect levels should be expected. For some board types little or no increase will be seen, while for others a significant (more than 10 times) increase in DPMO (defects per million opportunities) values will be seen. These defect levels will also vary from manufacturing site to site.

The lead-free PCBA is coming and it will impact all manufacturers, mandated or exempt. The transition to lead-free is a major process change and an increase in defect levels is likely for many board types. Higher defect levels have an impact on test and inspection. It will be more important than ever to select optimal test strategies. More defects may also increase workload on test, inspection and the rework process. ■

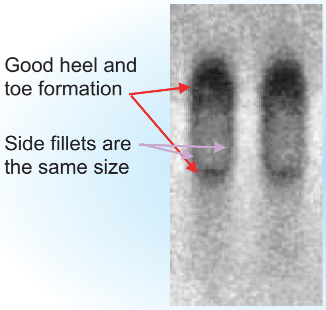

**FIGURE 1:** Tin-lead joints.

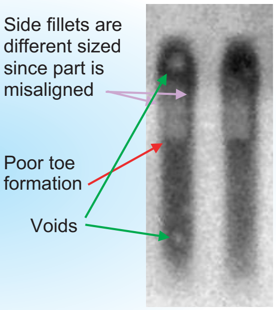

**FIGURE 2:** Lead-free joints.

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