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Overcoming Lower Wetting Forces of Pb-Free Alloys

Severe process changes mean more defects – and call for greater test measures.

Several types of defects are likely to increase with lead-free processes, defects that can be mitigated through certain test and inspection methods. The defects that are expected to increase are misalignments, bridging, opens, tombstoning, voids and barrel fill (through-hole fill). There is also an economic impact of these process changes and their related effects on defect levels.

We have experienced this sort of process change in the past, and have certainly learned to expect higher defect rates during the transition. In the early 1990s, a “no-clean” process was implemented to remove Freon from the assembly process. Initially, defects increased by as much as a factor of 10 for some manufacturers. For the lead-free process, similar results can be expected. The specifics of the shift will likely vary by types of boards and manufacturers, but initially most will see an increase in defects and a shift in the defect spectrum.

One of the major changes associated with the new alloys is the decreased wetting force compared to that of tin-lead alloys. The wetting characteristics of molten solder and the surfaces that it is joining determine how well the solder covers pads and leads, and determines the shape of solder joints. The wetting force of lead-free solders is not as strong as for tin-lead solders. This decreased wetting force creates several issues for manufacturing, as the tin-lead process is more forgiving than the new lead-free processes.

Decreased wetting force means that solder exhibits a greater tendency to stay where it is first placed. This can cause increased defects in many ways. If parts are misaligned, they will not self-align as easily during reflow. We also expect to see more bridging since the new alloys do not reposition as much during reflow. With tin-lead solder, the wetting forces clear solder bridges during reflow, while the lower wetting forces of the newer alloys will tend to leave solder bridges in place. Both effects raise the importance of pre-reflow optical inspection to verify that parts and solder are accurately placed. To maintain yields will require more accurate placement of parts and solder prior to reflow.

We also expect to see more problems with bent leads. Because of reduced wetting forces, heel fillets may not form as well around any bent leads. This causes a more complicated issue because while there may be electrical connectivity at first, it will not be a strong joint. Vibration and heat could cause failures over time. The x-ray image in **Figure 1** illustrates the problem with bent leads. The two leads on the far lower left of the image show opens, the middle leads show the wetting-related problems as described. The far right lead shows an acceptable solder connection. Many voids can also be seen.

It is likely that wave solder through-hole fill defects also will increase. The reduced wetting force of lead-free solder may cause poor fill, because the new alloy has less tendency to flow into the hole.

The use of test and inspection is critical to finding these defects as early as possible in the process. With solder paste and optical inspection pre-reflow, many of these defects can be corrected at the most inexpensive phase. Many defects may not be detectable until after reflow, so effective test and inspection methods are also important after reflow. ■

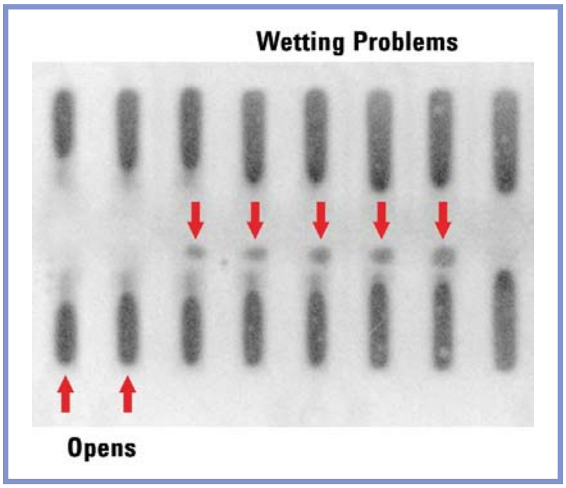

FIGURE 1: The decreased wetting force of lead-free alloys increases the opportunity for opens (lower left), wetting problems (middle) and voiding.

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