无铅合金较小的过程序窗口对焊接设备和检测验设备及程序步骤提出了更高的要求。质量控制取决于发现并防止所有可能的过程序问题的能力。直接影响光学检测验和组装生产线质量鉴定的重要无铅过程序问题包括：湿润和流动性能差、助焊剂电流消耗和氧化问题、基板片翘曲、高温损坏元件或改变焊接点形状的高温、助焊剂电流残留余以及“BGA”脱分层和提升离。本文讨论无铅焊接的典型问题领域以及如何处理解决质量保证和适当的“SMT”生产线质量鉴定。

Lead-Free First-Article Inspection

Mark Cannon

Typical process concerns associated with LF alloys for first-article OI and line qualification.

Process, process, process: these words are at the forefront of lead-free implementation. Smaller process windows brought on by LF alloys put greater demands on soldering equipment and first-article inspection equipment and procedures. And quality control depends on the ability to discover all possible process problems – and prevent them.

Much has been published about the smaller process windows of the LF process and their influence on reliability issues. Suffice it to say, the soldering process has been most forgiving to process problems. Large temperature deltas in current soldering processes are less problematic for solderability and reliability. Working outside the specified LF process windows, however, will diminish solder joint integrity, component safety and, ultimately, reliability.

Important LF process concerns that directly affect first-article optical inspection and line qualification include:

- Poor wetting and flow characteristics.
- Flux exhaustion and oxidation problems.
- Substrate warpage and near opens.
- High temperatures damaging components or changing the shape of the joint.
- LF flux residues and micro solderballing.
- BGA delamination and fillet lifting.

Simply put, the lead-free process is more difficult, will lead to new problems and will require improved inspection. A better understanding of typical problem areas associated with LF soldering will dictate how to address QA and proper SMT line qualification during first-article inspection.

Soldering standards have become increasingly important over the past decade. IPC-A-610 is currently generally accepted as the standard document for assembly workmanship. Up-to-date standards are as important as ever. Producing standards will become a greater challenge, however. The poor wetting characteristics and smaller process windows of LF alloys will make complete fillet formation more difficult to achieve. **Figures 1 and 2** show LF wetting and solder flow problems that do not meet prescribed standards. Ultimately, soldering processes will need better temperature control and minimized temperature delta during reflow.

State-of-the-art AOI and x-ray systems and microscopes are an integral part of in- and offline process control. They are

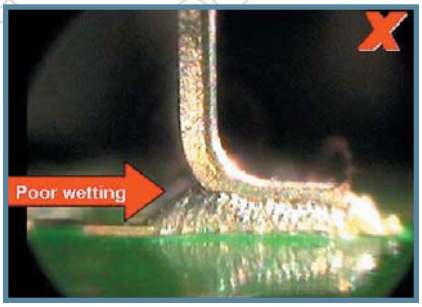

FIGURE 1: Lead-free alloy wetting defect.

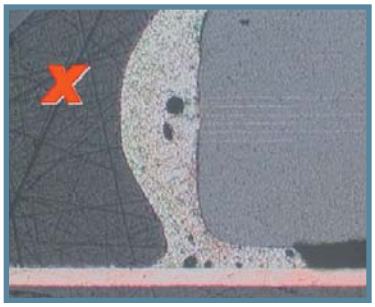

FIGURE 2: Solder flow problem in lead-free joint (Courtesty Zollner).

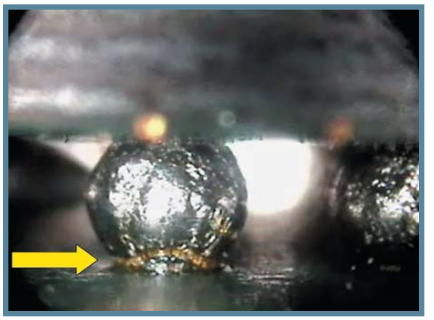

FIGURE 3: Incomplete wetting between BGA ball and pad.

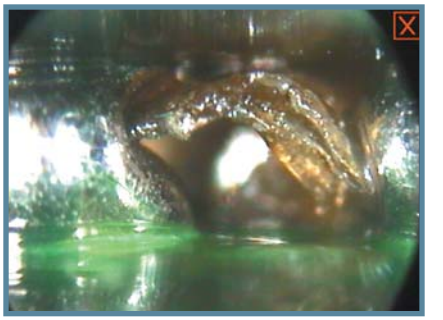

FIGURE 4: Flux residue under package.

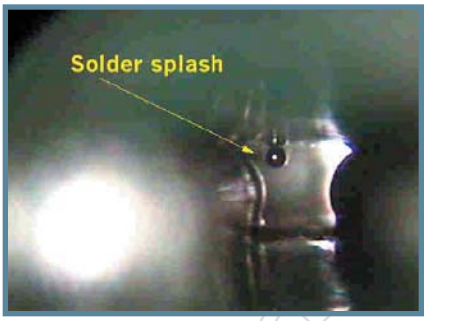

FIGURE 5: Tiny solder balls.

unable, however, to detect all the predicted LF problems, and must be augmented by board level, 90° optical inspection. The photos shown as **Figures 1 and 2** cannot be taken with the standard 0°, low magnification inspection equipment in use today for first-article inspection.

Over the years, operators have successfully used visual indicators to provide information about solder joint integrity. Yet LF joints will be characteristically less shiny. This can result from striations that occur during the solidification process or Cu6Sn5 dendrites solidifying on the joint surface. These apparent "defects" are primarily cosmetic in nature and do not necessarily indicate a problem. In short, operators must be reequipped and retrained to identify LF defects.

Among the changes LF implementation will bring:

- Incomplete wetting of the BGA ball to the pad will be more prevalent (**Figure 3**).
- More aggressive fluxes under hidden packages (**Figure 4**) leaving residues that must be properly cleaned.
- Micro solderballing under BGAs (**Figure 5**) or other hidden locations that must be detected.
- Higher process temperatures, which will put greater thermal stress on the PCB substrate and BGA package. Component shear delamination problems resulting from CTE mismatch problems will occur during cooling and solidification (**Figures 6 and 7**).
- PTH fillet lifting (**Figure 8**), a new phenomenon.

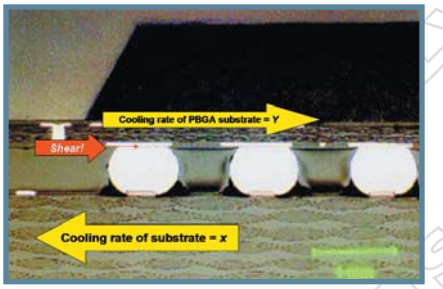

FIGURE 6: Delamination due to CTE mismatch. (Courtesy FhG ISIT)

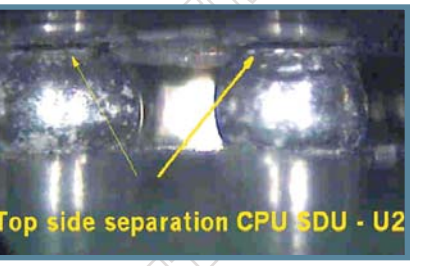

FIGURE 7: Topside separation of package and ball.

Such problems will be more prevalent in a LF process, and will require more thorough first-article inspection. Moreover, the defects shown in Figures 3 to 8 cannot be detected with standard microscopes and test equipment. If undetected, early field failures and warranty repairs will likely occur.

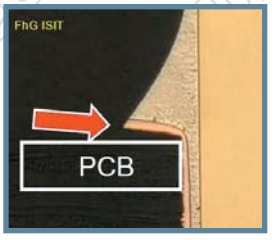

FIGURE 8: PTH fillet lifting. (Courtesty FhG ISIT)

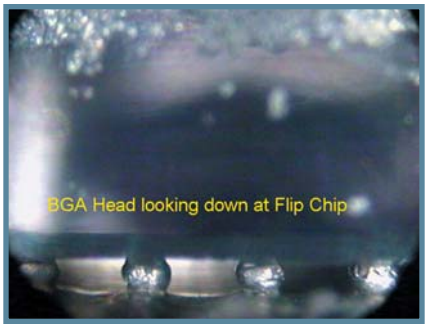

FIGURE 9: New equipment permits a "look up" view of low-profile joints.

Lead-free BGA, CSP and flip-chip soldering will experience additional problems due to smaller process windows and will require better temperature control. Low-profile CSPs and flip chips will require improved inspection capabilities. The iris of current endoscopic or mirror-based optical systems sits approximately 0.300 mm from the surface of the PCB, providing a "look down image" of a flip chip with a standoff height of 0.050 mm. For new devices, the iris is lowered to approximately 0.012 mm, permitting a "look up" view (**Figure 9**) at the topside of the flip-chip joint, and interior joint inspection of low profile µBGAs and CSPs.

Implementing lead-free will require manufacturers to seriously reexamine their QA procedures. Note that ISO 9001:2000 has now targeted core and supporting process steps, which include production, in its audit programs. A properly qualified LF SMT process will ultimately reduce the costs brought on by soldering-related process problems, higher DPMs, rework, scrap and warranty failures. ■

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