TECHtips

aci

Electronics Manufacturing Insights from ACI Technologies, Inc.

Investigation of Through-Hole Capacitor Parts Failures Following Vibration and Stress Testing

Recently, an ACI Technologies (ACI) customer called to discuss failures that they had observed with some through-hole capacitor parts. The components were experiencing failures following vibration and accelerated stress testing.

Upon receipt of the samples, ACI performed three levels of inspection and Energy Dispersive Spectroscopy (EDS) testing to investigate the root cause of the failures. These analyses enabled ACI to verify the elements comprising the solder joints and make the following recommendations in order to prevent future occurrences. The first inspection was to investigate the capacitor leads using optical microscopy, and no anomalies were found that could indicate bad parts from the vendor or improper handling prior to assembly. However, vertical fill in the barrel of the plated through-holes was too close to the IPC-A-610 minimum specification of 75% to determine a pass/fail condition, and therefore required further investigation.

Next, the assemblies were placed in the x-ray. This non-destructive evaluation allowed technicians to see inside the solder joints before doing irreparable damage to the samples through the use of cross-sectional analysis. It was readily apparent that the solder was cracked at the source side of the failed joints; however, the x-ray images did not afford an accurate measure of the barrel fill at the failed junctions [Note: straight on images needed for accurate measurements were inhibited by ghost images of surrounding parts].

The assemblies were then cross sectioned and placed in a Scanning Electron Microscope (SEM) to examine the failures under high power magnification (over 100x). This tool allowed ACI to look for micro-cracks in the solder and the proper formation of intermetallic layers at the solder to copper junction. After cross-sectioning, it was evident that insufficient solder fill was the failure mechanism for these capacitors. The plated through-hole appeared to have very little solder on either side (Figure 1), allowing a large gap between the lead and the barrel. In addition, the opposite lead of capacitor C12, which appeared to

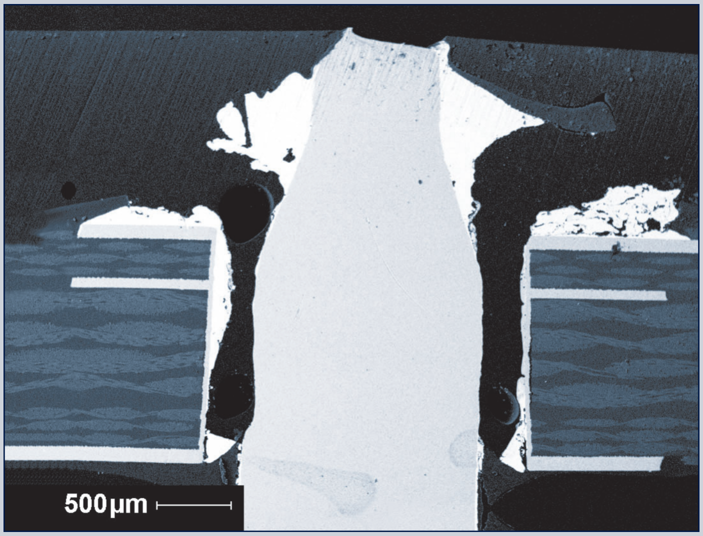

Figure 1: Insufficient hole fill caused capacitor solder joint failure (SEM image).

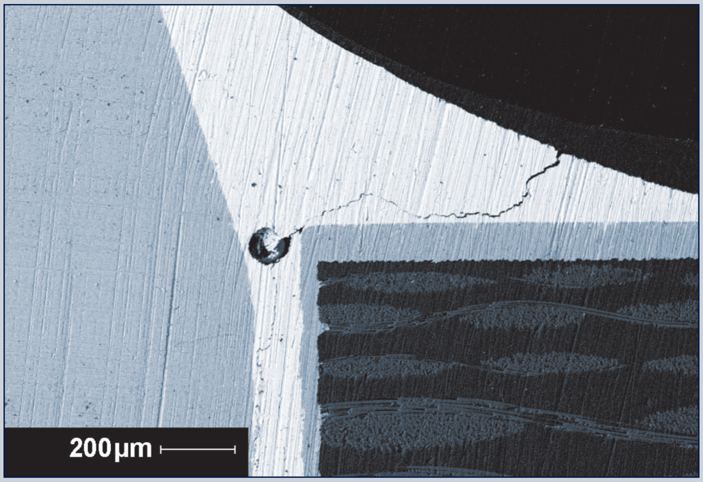

Figure 2: Hairline crack viewed in the SEM.

continued on next page

be intact during visual inspection, was found to be damaged with a micro-fracture (Figure 2). Multiple voids were observed from the cross-section in both optical and SEM images which showed several micro-fractures bridging together.

The IPC-A-610 standard requires a minimum of 75% solder fill for Class 3 products. The opposite lead of capacitor C12 (Figure 2) which showed adequate vertical solder fill, but displayed a micro-fracture, had been examined during visual inspection for circumferential wetting. This capacitor lead passed the IPC-A-610 standard for circumferential wetting on the solder source side, in that there was 360° wetting present [Note: the minimum wetting requirement for Class 3 is 330°]. Also, the percentage of land area covered by wetted solder on the solder source side was 100% (which exceeds the minimum 75% land area requirement). [Note: the micro-fracture was not witnessed under visual inspection with the naked eye and was found only under magnification during later inspection.]

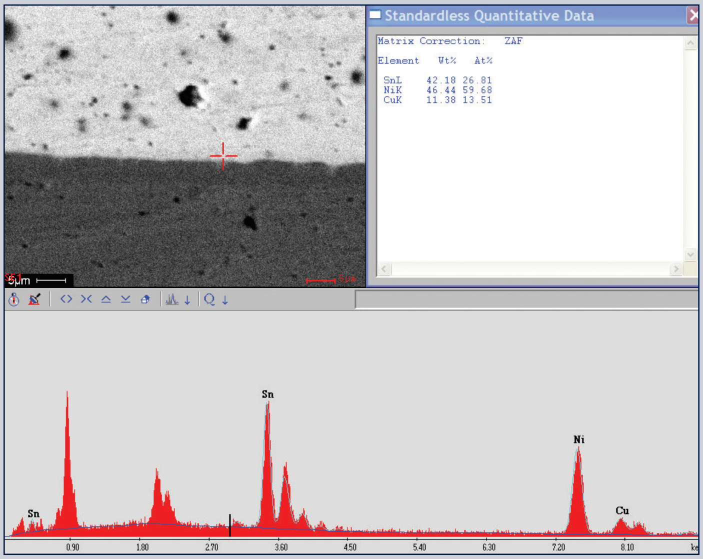

Figure 3: The EDS analysis shows an intermetallic layer from the Cu-Sn-Ni composition between the interface of the bulk solder and the plated through-hole.

ACI analyzed each micro sectioned sample using Energy Dispersive Spectroscopy (EDS) to determine the composition of the intermetallic bond in the solder joints. EDS showed the existence of a Cu-Sn-Ni intermetallic layer between the interface of the bulk solder and the plated through-hole (Figure 3). This underdeveloped intermetallic layer could be another sign that the solder dwell time was insufficient to allow the solder to wick into the plated through-hole for maximum fill.

Based on these findings, recommendations were made to the customer to aid in controlling their process.

- The plated through-hole diameter/lead diameter ratio for the electrolytic capacitors needs to be re-evaluated. Low clearance for the capacitor lead in the plated through-hole may inhibit the solder flow to fill the hole. ACI referenced the IPC-2222 design guidelines for rigid printed board with standards for hole/interconnections (Section 9). The manufacturer specification should also be consulted for the appropriate plated through-hole diameter/lead diameter ratio.

- The solder process should be re-evaluated. Insufficient solder fill in plated through-hole indicates that there are several areas to investigate. Increasing the pre-heat temperature, lengthening the solder dwell time, and increasing the amount of flux application can improve the solderability of the capacitor leads and achieve the IPC target hole fill of 100%.

For more information on through-hole manufacturing and reliability, or other classes available from ACI, including IPC certifications, please contact the Registrar at 610.362.1295 or via email to registrar@aciusa.org. For a demonstration of the X-Ray or Scanning Electron Microscope, please contact the Helpline at 610.362.1320 or via email to helpline@aciusa.org.

ACI Technologies

ACI Technologies, Inc. 1 International Plaza, Suite 600 Philadelphia, PA 19113 *phone:* 610.362.1200 *web:* www.aciusa.org

Training Center *phone:* 610.362.1295 *email:* registrar@aciusa.org

Helpline *phone:* 610.362.1320 *email:* helpline@aciusa.org