TECHtips

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Electronics Manufacturing Insights from ACI Technologies, Inc.

Ball Grid Array (BGA) Voiding Affecting Functionality

A customer contacted ACI Technologies regarding a high failure rate of their assemblies. They provided assemblies to be X-rayed and inspected for the purpose of identifying any process related issues such as (but not limited to) solder and assembly workmanship and evidence of damage due to moisture related problems during reflow (a.k.a. “popcorning”).

Moisture damage usually appears as physical damage to the component. The first indication of moisture damage would be externally observable changes to the package in the form of bulging or fractures to the outer surface of the component, an example of which is shown in Figure 1. Internally observable indicators of moisture damage typically include fractures to the die inside the package and lifted or fractured wire bonds. These conditions would be apparent during transmissive X-ray inspection. Another symptom of moisture related damage would be inconsistent solder joint sizes that result from package deformation during the liquidus phase of the reflow process. None of these indicators of moisture related damage were present on the customer samples.

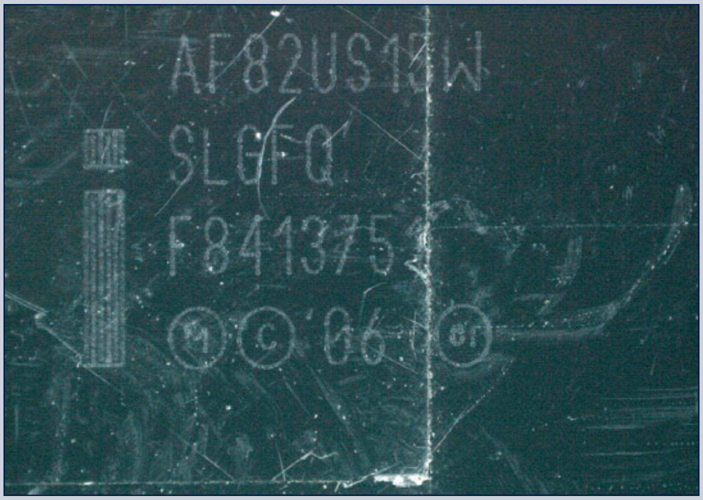

Figure 1: Image of component with fractures to the outer surface due to moisture related problems during reflow.

No issues were observed with the large BGA components on the assemblies. Representative via X-ray inspection images (Figure 2) show that the die, wire bonds, and solder balls appeared well-formed and provided no indication as to a loss of functionality.

For the smaller BGA style components, assembly and solder workmanship issues were identified as shown in Figure 3. Specifically, the elevated level of voiding in the solder joints on the 54-pin memory components was identified as a potential contributor to failures. IPC A-610 specifies voiding that exceeds 25% of the X-ray image area is a defect for all classes of production. ACI recommended that any voiding that exceeded 10% of the ball X-ray image area be treated as a process related process indicator condition (i.e. a condition that indicates excessive variation from the intended result). Although detailed voiding analysis was not performed on these samples, it was apparent from visual inspection that there were many solder joints on these parts that exceeded the 10% recommended limit. Many of the voids appeared to be at an interface which may have contributed to signal issues. The sizes of the voids also may have interfered with long term reliability.

In addition, the location of voids in a BGA solder joint can be critical, regardless of the void size. Voids that occur at the solder joint/printed circuit board (PCB) land interface (“interface voids”) can impact the reliability of the resulting solder joints. This occurs because the yield strength of a solder joint is related to the surface area of contact between the solder and the surfaces it joins. Interface voids reduce this contact area and can lead to mechanical failure of the solder joint. Some solder joints, such as those viewed in Figure 3, appeared to have voids that occurred at the interface and have reduced the wetting contact areas on the PCB.

Voiding can be a result of a variety of causes which include the properties of the flux used on the assembly and the profile used to reflow the solder paste. Interface voids can also be a result of a non-wetting or dewetting condition on the PCB land.

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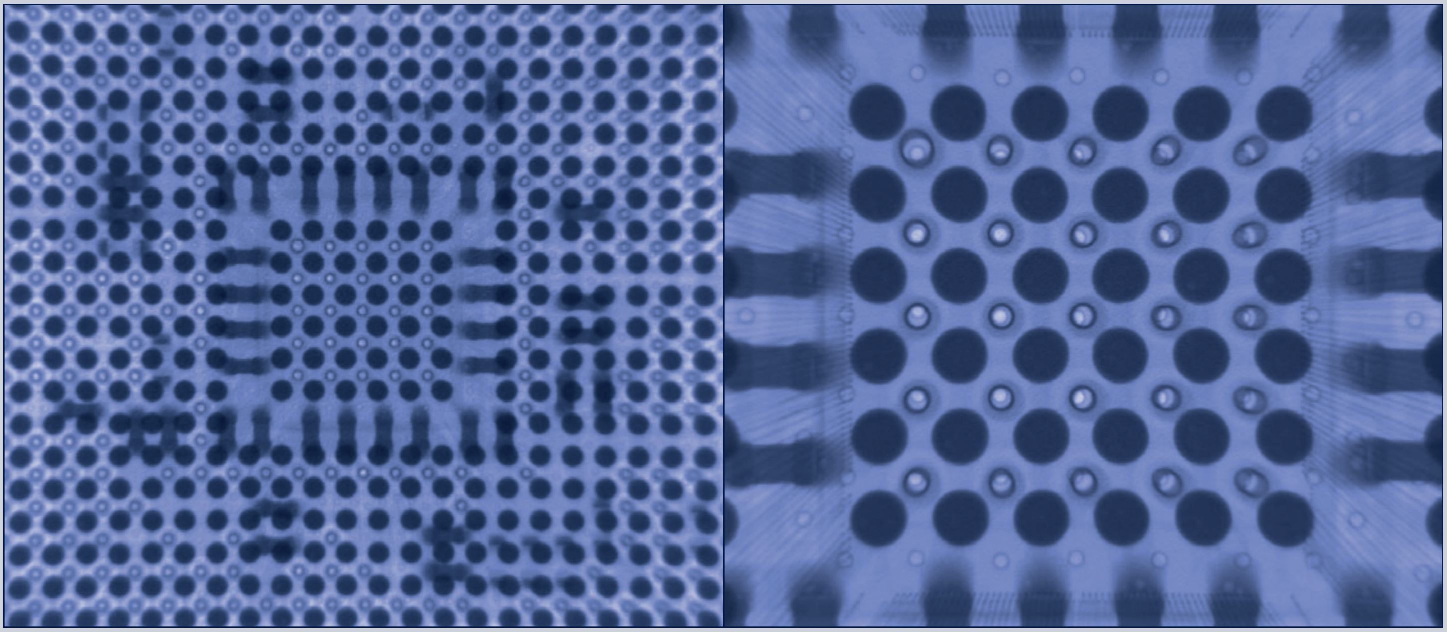

Figure 2: X-ray images of a large BGA component; left is whole component with minimal voiding, right is a view of the die with wire bonds intact and with minimal voiding of the solder balls.

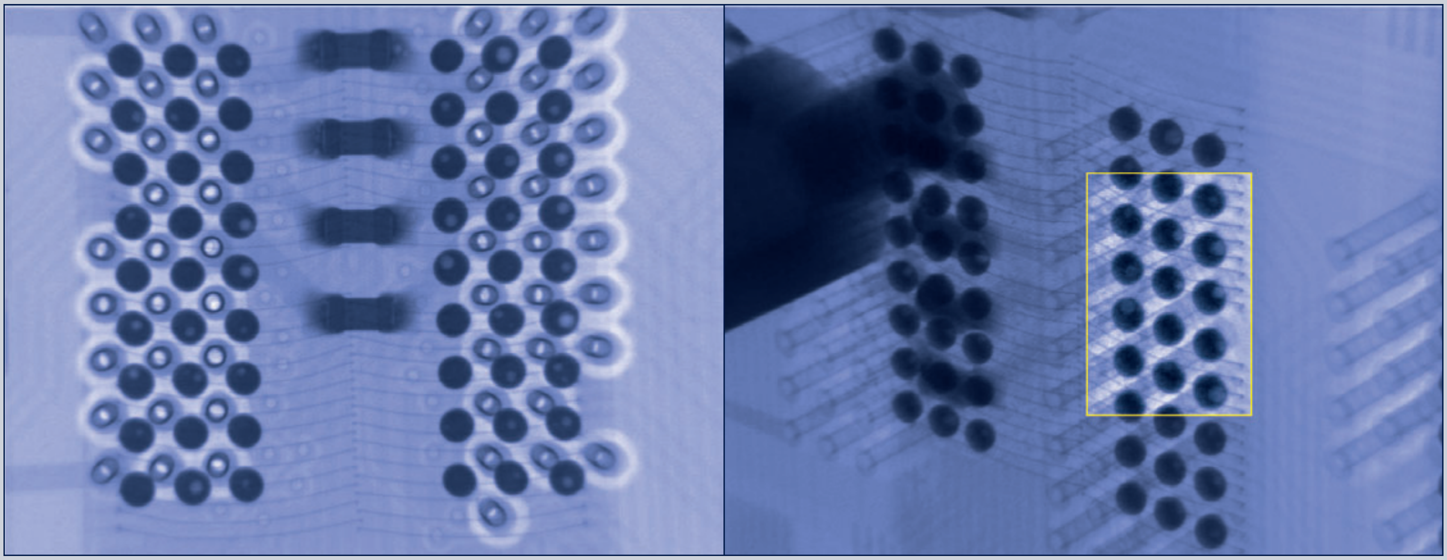

Figure 3: X-ray images of BGA voids in the smaller memory chip component; left is a view from above with significant voiding of the solder balls, right is an oblique angle view showing the voiding along the edges of the solder balls. Note the high contrast region (outlined in yellow) showing the difference between the dark and the lighter void areas.

No other assembly workmanship issues were detected during the inspection performed on these assemblies. Voiding that occurred on components other than the 54-pin memory was minor in nature and fell within the expected amount of voiding on a well-formed BGA solder joint. All solder joints (except those noted) showed evidence of good collapse and wetting to the PCB lands as would be expected on a well-formed BGA solder joint.

ACI recommended that the customer further investigate the voiding observed on the 54-pin memory components. Two areas of attention were recommended: (1) the process used to assemble and solder the memory components and (2) the interface voids that were observed.

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The interface voids should be investigated to determine if their location is actually on the interface. Cross-sectional analysis could be used to specifically examine a solder joint of interest and accurately determine the location of the void. This analysis would include evaluation of the PCB land for evidence of any contamination or metallurgical issues that would result in improper solder wetting.

The voiding level observed on the 54-pin memory should be reduced by adjusting the assembly process. One method is to test alternative solder pastes that may result in lower amounts of voiding in the resulting solder joints. Another method is to adjust the solder reflow profile to reduce the voiding present in the solder joints. Both methods can be used together or modifications to the reflow profile can be performed using the existing production solder paste.

ACI recommended cross-sectional analysis of the samples and X-ray analysis of future samples produced on a modified reflow process.

ACI can assist with all aspects of board and assembly qualifications, inspections, and failure analysis to determine the root cause of solder joint failures. ACI can further assist with surface finish analysis, cleaning processes, and cleanliness testing for ionic and organic residues, as well as provide engineering services. Contact the Helpline at 610.362.1320, via email to helpline@aciusa.org or visit us on the web at www.aciusa.org for more information.

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