www.epp-online.de

konradin MEDIA GROUP

EPP EUROPE

ELECTRONICS PRODUCTION AND TEST

5/6

MAY/JUNE 2007

News & Highlights

South Africa – Powerhouse of Africa

Focus Drives Success

Full Service as an Integrated Subcontractor

PCB & Assembly

Meeting Quality Standards

PB-Free Assembly is still in its Relatively Infancy

Packaging & Bonding

Wire Bonding Process: Optimization Due to Proper Cleaning

Enhancement of Reliability

Test & QA

Listen to AOI

Optimising the Test Time per Device

Total Cleaning Solutions from one Source

Acoustic technique solves "square" capacitor problem

Shadows indicate cracks

Tom Adams, consultant, Sonoscan, Inc., Elk Grove Village, IL, USA

Acoustic imaging is used after reflow to image ceramic chip capacitors in high-reliability applications, and is also used to image production lots of ceramic chip capacitors before surface-mounting. The problem created by "square" capacitors is that the electrode plates and ceramic dielectric layers may be oriented vertically. If they are oriented vertically and if the crack or delamination is truly flat and thin, then the ultrasonic pulse may encounter a structure that is so thin and so vertical that there is essentially nothing to reflect ultrasound. The ultrasonic pulse may miss the internal defect that has the ability to degrade the long-term reliability of the capacitor. This article points out how a new technique solves the problem.

One of the constant trends in electronics manufacturing is the miniaturization of components in order to pack more functionality into a smaller area. Recently this trend has impacted some types of small multi-layer ceramic chip capacitors, chiefly those ranging in size from 02010 to 08040. The design change in this case is simply to make the capacitors thicker, without changing their x and y dimensions. The purpose is to pack more electrode plates into each capacitor, and thus give more capacitance per unit area. In some applications, the designer might be able to specify fewer capacitors, thus saving space and cost. Many of the thicker capacitors, when looked at from one end, are square or very nearly square ("square" capacitors). This minor change in dimensions has had an effect on testing and even – potentially – on reliability.

The earlier versions of these capacitors were rectangular in end view, and were always surface mounted with the long side of the rectangle parallel to the printed wiring board. This meant that the electrode plates were also parallel to the printed wiring board. The "square" capacitors, though, have no long side to serve as a reference point, and may be surface-mounted with the electrode plates either parallel to the printed wiring board or perpendicular to the printed wiring board. The orientation makes no difference for the electrical functioning of the capacitor, as long as it is firmly soldered to the board. But the orientation can make a big difference in acoustic imaging of the capacitor. The stress tolerance of the capacitor also changes with its orientation.

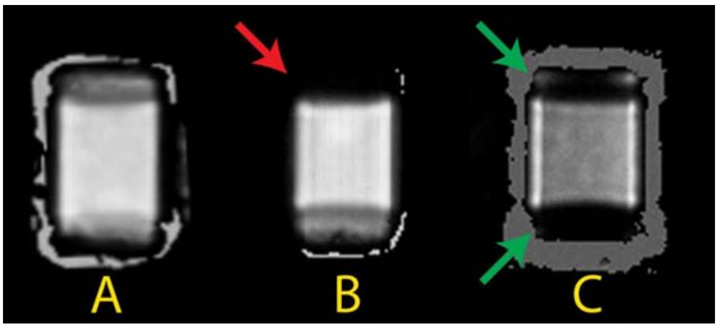

Figure 1: Acoustic images made by the "shadow" method and showing three surface-mounted "square" capacitors. A: no defects. B: vertical crack adjacent to one termination (arrow). C: vertical cracks adjacent to both terminations (arrows).

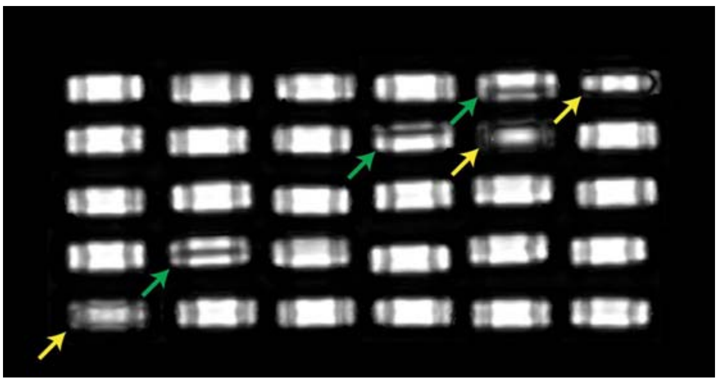

Figure 2: Acoustic "shadow" image of 30 "square" capacitors before surface-mounting, and with random orientation of the electrode plates. Six capacitors (arrows) have internal defects, and three (green arrows) are clearly vertical defects.

Acoustic imaging

Acoustic imaging is often used after reflow to image ceramic chip capacitors in high-reliability applications, and is also used to image production lots of ceramic chip capacitors before surface-mounting. The acoustic microscope uses a very high frequency or ultra high frequency ultrasonic transducer that scans the area of the capacitor while alternately pulsing ultrasound into the capacitor and receiving the return echoes. Pulsing and receiving each take place several thousand times a second while the transducer raster-scans the capacitor.

The ultrasound that is pulsed into any electronics target is reflected only by material interfaces inside the target. No reflections come back from homogeneous, defect-free materials. An engineer who is acoustically imaging a block of an advanced ceramic material, for example, generally hopes to see a featureless acoustic image.

A ceramic chip capacitor has far more material interfaces than most other targets, since each of the dozens or hundreds of electrode plates interfaces with two ceramic dielectric layers. But there are actually so many layers of material, and the individual layers are so thin, that a pulse of ultrasound acts as though it were traveling through a homogeneous material and sends back no reflections. The nearly homogeneous nature of capacitor construction is enhanced by the fact that the metal electrode plates and the ceramic dielectric material have very similar acoustic properties.

What will send back an acoustic reflection is a gap in the capacitor – a gap being a crack, a delamination, or a void. Because they are filled with a gas (such as air) rather than a solid, gaps send back an especially strong reflection that is displayed brightly in the acoustic image of the capacitor. Gaps are often between two solid layers such as an electrode and the adjacent ceramic layer, and they are often extremely thin, although they may be quite large in their x-y dimensions. As long as the electrode plates are oriented horizontally, the pulse of ultrasound will encounter an essentially flat gap, and probably thousands of strong signals will be reflected by the gap. In the acoustic image, the crack or delamination will be bright and obvious.

Problem created by "square" capacitors

The problem created by "square" capacitors is that the electrode plates and ceramic dielectric layers may be oriented either horizontally or vertically. If they are oriented horizontally, there is no problem – the ultrasonic pulse will be strongly reflected. But if these elements are oriented vertically, and if the crack or delamination is truly flat and thin, then the ultrasonic pulse may encounter a structure that is so thin and so vertical that there is essentially nothing to reflect ultrasound. In this case, the ultrasonic pulse may miss the internal defect that has the ability to degrade the long-term reliability of the ceramic chip capacitor. Also, some defects tend to follow the boundary between the body of the capacitor and the termination at the end of the capacitor, and these defects are usually vertical and are independent of the orientation of the electrode plates.

Vertically oriented cracks and delaminations may exist whether the ceramic chip capacitors being imaged are loose or already surface-mounted. If the capacitors are loose, it is customary to image dozens of capacitors at a time. If the routine imaging technique known as "bulk imaging" is used, some of the defective capacitors will be positioned horizontally and will easily be found. The microscope operator can remove these defective capacitors and then rotate each of the remaining capacitors by 90° before imaging again. While successful, this is a very time-consuming method. And if the capacitors have already been surface-mounted, they cannot be rotated.

To avoid these difficulties, an alternate imaging technique was developed at Sonoscan. In ordinary bulk imaging of ceramic chip capacitors, the ultrasonic beam is focused halfway down in the capacitor's thickness. The gating of the ultrasound is set for the top and bottom of the capacitor – meaning that return echoes between these two depths will be used in making pixels for the acoustic image, but that return echoes from other depths will be ignored. The result is that any gap-type defect between the top and bottom of the capacitor will be imaged.

The solution

As mentioned earlier, this approach will not work with thin, vertical cracks and delaminations because there is essentially nothing for the ultrasonic pulse to bounce off of. Sonoscan solved this problem by leaving the focus at the mid-point of the depth and changing the gating to include only a very thin depth at the back surface of the capacitor. In practical terms, this means that an ultrasonic pulse first travels down into the capacitor, passing the vertical feature as it goes. It is reflected from the back surface and comes back again, passing the vertical feature again. This method creates a shadow of the vertical delamination or crack. The shadow is many times wider than the crack or delamination itself, and is simply a dark area where no ultrasound was returned to the transducer.

This method can be used both on loose capacitors and on capacitors after surface-mounting. Figure 1 shows three small "square" ceramic chip capacitors surface-mounted on different areas of the same printed wiring board. All three were imaged by the new technique. Capacitor A has no internal defects; the body of the capacitor is bright, and the terminations are grey, as one would expect. Capacitor B has a vertical crack (arrows) adjacent to the termination, and the dark shadow of the crack is so wide that it effectively obliterates the termination. Capacitor C is similar to Capacitor B, but has dark vertical cracks adjacent to both terminations (arrows).

Figure 2 is the acoustic image of a group of 30 "square" capacitors that were imaged loose, before surface-mounting. The orientation of each individual capacitor is, as in figure 1, unknown. The shadow technique was used to make this image, and six of the capacitors (arrows) have internal defects. Three of these defects (green arrows) are clearly oriented vertically.

The value of the shadow technique in imaging both loose and surface-mounted "square" capacitors is that it will find cracks and other internal gap-type defects no matter what the orientation of the capacitor is. The acoustic images make it possible to remove defective capacitors before they can degrade the long-term reliability of the entire system.

www.sonoscan.com

ZUSAMMENFASSUNG

Some multi-layer ceramic chip capacitors are square when you look at them from the end. Inspecting the capacitor with an acoustic microscope becomes more complicated. The problem is that the electrode plates and ceramic dielectric layers may be oriented either horizontally or vertically. If they are oriented vertically and if the crack or delamination is truly flat and thin, then the ultrasonic pulse may encounter a structure that is so thin and so vertical that there is essentially nothing to reflect ultrasound. The article describes the problems that occur during acoustic inspection of "square" capacitors and points out how a new technique – the shadow technique – solves these problems.

RÉSUMÉ

Blindtext Some multi-layer ceramic chip capacitors are square when you look at them from the end. Inspecting the capacitor with an acoustic microscope becomes more complicated. The problem is that the electrode plates and ceramic dielectric layers may be oriented either horizontally or vertically. If they are oriented vertically and if the crack or delamination is truly flat and thin, then the ultrasonic pulse may encounter a structure that is so thin and so vertical that there is essentially nothing to reflect ultrasound. The article describes the problems that occur during acoustic inspection of "square" capacitors and points out how a new technique – the shadow technique – solves these problems.

SOMMARIO

Blindtext Some multi-layer ceramic chip capacitors are square when you look at them from the end. Inspecting the capacitor with an acoustic microscope becomes more complicated. The problem is that the electrode plates and ceramic dielectric layers may be oriented either horizontally or vertically. If they are oriented vertically and if the crack or delamination is truly flat and thin, then the ultrasonic pulse may encounter a structure that is so thin and so vertical that there is essentially nothing to reflect ultrasound. The article describes the problems that occur during acoustic inspection of "square" capacitors and points out how a new technique – the shadow technique – solves these problems.