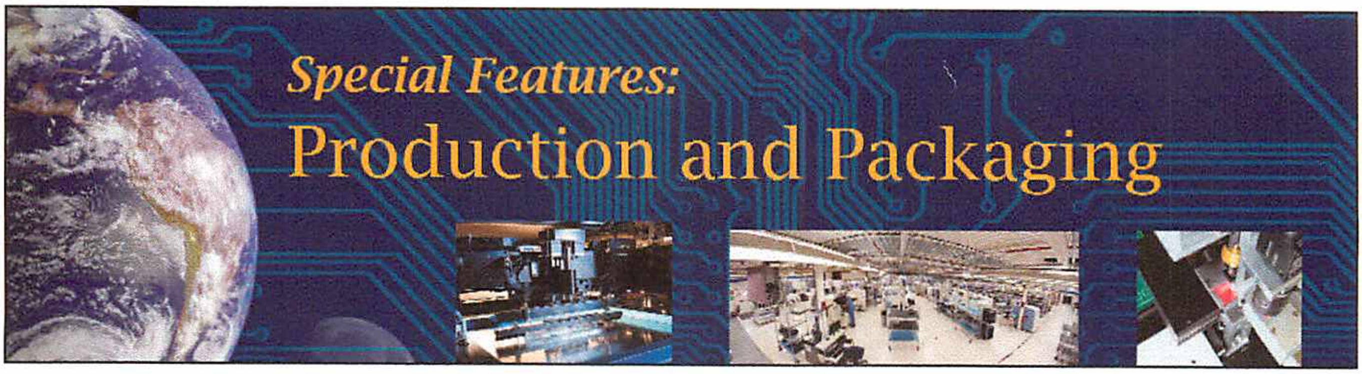
Reprinted with permission from the August, 2014 issue of ...

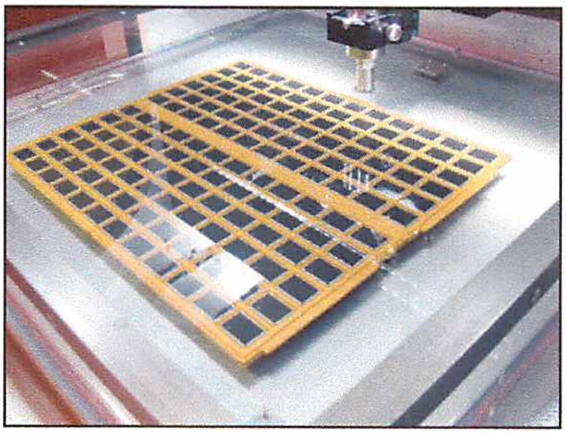


Risky Components Removed by Ultrasound

By Tom Adams, Consultant, Sonoscan, Inc., Elk Grove Village IL

Many potential failures of electronic systems in the field are avoided each year because components likely to fail were removed from the production stream before being mounted on a printed-circuit board (PCB). These ill-fated components were identified by acoustic microimaging, which can locate and screen out components with internal structural defects, such as delaminations, voids, cracks, and incomplete bonds, that can lead directly to electrical failures. Failures may occur after a delamination grows due to normal thermal cycling and breaks an electrical connection, or because contaminants collect in a crack of initiate corrosion that can form an electrical connection that was not intended.

Components that are inspected acoustically are typically plastic-encapsulated integrated circuits (ICs) or ceramic chip capacitors, although ceramic IC packages and some other component types can also be inspected by acoustic microimaging. Engineers performing moisture sensitivity level (MSL) testing on new package designs frequently come across components with extensive internal structural damage that nonetheless pass required electrical tests in the manner of fully functional components. Some heavily damaged components fail electrical testing, but some soon-to-fail components may pass simply because no connection has as of yet been broken.



This C-SAM systems is set up for a scan of two trays of components.

Acoustic microscopes, such as the Sonoscan C-SAM® models from Sonoscan, are extremely sensitive to material interfaces. When the transducer of such a microscope sends a pulse of ultrasound energy into a component under test and its material interfaces (which it does thousands of time per second while scanning), the strongest echoes are received from gap-like defects such as delaminations and cracks. Even a gap with z-dimension of only 100Ångstroms reflects more than 99.99 percent of the ultrasound energy. Well-bonded material interfaces, on the other hand, reflect a much lower percentage of the ultrasound energy — 20 or 50 percent perhaps, but much less than 99.99 percent.

Non-Critical Components

Some inexpensive, noncritical electronic products incorporate components that have not been screened acoustically because the product is inexpensive and the consequences of failure are minor. As the consequences of failure grow in importance, however, so too does the need for acoustic screening.

Acoustic screening of electronic components can be performed in a number of different ways. When the test volume is low, such as less than 1,000 components, screening will likely be performed manually on a laboratory-type acoustic microscope. For larger test volumes, a fully automated in-line test system is more likely to be used, where the handling of components, the imaging process, and identification of rejects are fully automated. A semi-automated acoustic microscope system may be more appropriate for applications that fall between small and large volumes.

To perform acoustic microscopy, components to be scanned are placed in JEDEC-style trays or, in the case of ceramic chip capacitors, arranged on a flat plate. Typically, the whole tray or plate is scanned at once. Recently, advanced acoustic microscopy systems have been developed that increase throughput by scanning only the critical region of each component, without scanning other areas of the component or the tray.

Successful mass screening is achieved when the greatest number of possible rejects is identified and removed in a reasonable time and for reasonable cost. For a given component type, accept/ reject criteria depend on a user's requirements. Screening for a plastic-encapsulated IC being used in a moderately priced consumer product might simply look for relatively large defects, those with a high probability of causing electrical failure. In a military application, however, the same component type might be rejected for relatively innocuous defects such as isolated small voids in the mold compound.

A pulse of ultrasound energy will return the strongest echoes from gap-like defects such as delaminations and cracks.

Knowledge Aids Screening

Knowledge of the structure and failure history of different components can make screening more effective. One plastic-packaged IC may be subject to delamination of the mold compound from die paddle in the area around the die. By itself, this may not be a high-risk defect. But in a given part type, delamination at this device location may follow a history of expanding under the die, blocking heat flow from the die, and causing overheating that leads to die failure.

Knowing the structure of the component can also be helpful in defining simple but effective accept/reject criteria. Very complex criteria mean that analysis of the results will be slower and take longer, whether performed by a technician or by computer controlled with analysis software.

Another component may frequently form delaminations between the mold compound and the top of the die. Delaminations at this spot are rarely, if ever, innocuous because they can expand and break lead bonds on the die.

These components were rejected due to excessive lead finger delaminations (shown in red).

Successful screening of electronic components also involves careful gating. The gate is the depth, set by the operator, from which echo signals are used to make the acoustic images that will show the locations and the sizes of the defects. Only the echoes whose arrival time means that they are from the gated depth are used to make the acoustic image. Gating on the whole thickness of a component may not give good results because the viewer of the acoustic image can't tell the depth of a defect; it might be in the mold compound far above the die, or it might be on top of the die.

In most components, critical defects tend to occur in specific locations at specific depths, and gating includes those depths. New software from Sonoscan makes it possible to image multiple (to 100 or more) depths separately during the same scan by means of gating. In scanning devices in DPAK (TO-252) surface-mount-technology (SMT) packages, for example, the output could consist of one image for the die and one for the top of the post. In flip-chip packages, significant defects occur at the depth of the mold compound and solder bumps, but even this narrow depth may be imaged with multiple gates. In plastic ball-grid-array (BGA) packaged components, the significant defects may be at the die depth or in the substrate.

Plastic BGA components are somewhat different from other components because significant defects are often caused by delaminations within the substrate. A BGA device has multiple layers that may be beyond the range of ordinary reflection-mode imaging. Such substrate-level delaminations can be found, however, through the use of a C-SAM acoustic microscopy system in its Thru-Scan mode. In this mode, ultrasound energy is pulsed into the top side of the component and detected by a sensor below the component. Since substrate delaminations block ultrasound transmitted from above, the delaminations appear at the sensor as black acoustic shadows.

Using a pixel size appropriate to the size of a defect of interest can boost the effectiveness of a acoustic microscopy system. The C-SAM acoustic microscopes are capable of detecting defects with diameters of 5µm or smaller, although crucial defects in most electronic components are much larger than this.

Larger pixel sizes means that fewer x-y coordinates have ultrasound energy pulsed into them, and scanning can take place much more rapidly than when using smaller pixel sizes and a greater number of x-y coordinates. Since acoustic microscope pixel sizes can now be adjusted to meet precise requirements, a user does not need to overscan a component and slow down a scan by using a too-small pixel size, or miss defects by underscanning and using too large a pixel size for a particular component to be tested.

Careful gating depth, set by the operator, provides echo signals that are used to make the acoustic images that will show the locations and the sizes of the defects.

Contact: Sonoscan, Inc., 2149 E. Pratt Blvd., Elk Grove Village IL 60007
☎ 847-437-6400 fax: 847-437-1550
E-mail: info@sonoscan.com
Web: www.sonoscan.com ❒