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Quality-assurance program to sort out ICs for hidden defects in device packages

Reclamation keeps the wheel turning

Tom Adams, consultant, Sonoscan, Inc.

It's not a rare occasion when component batches sometimes suffer in quality because of hidden defects, lately revealed in board assembly, where a company can fear a production shutdown. This is the type of problem being fought by a component reclamation program. After such defects are recognized, this procedure is used to acoustically image complete lots of components, to determine which ones have defects. The assembler's work will pay off here: if only defects above a given size, or in a given location, are known to be dangerous, then devices with flaws outside of these definitions may be classified as acceptable, or at least as marginal. And manufacturing can go on.

When a quality assurance (QA) engineer receives the report of a functional failure in a board at the end of assembly, his first hope is that the defect is an isolated event, and not the first of a larger number of related failures. His second hope is that the cause of the failure is related to an in-house material or process – especially if the malfunction turns up on multiple boards. If the functional defect is, for example, a cold solder joint, then the engineer and his colleagues are working with a familiar problem that they have solved many times before. But if the source of the failure is with a supplier, the time and expense needed to diagnose and correct the problem are likely to be much greater.

If the failure turns out to be a single cold solder joint limited to a single board, the problem can be solved easily under normal conditions. The board is usually sent for rework, and the defect is immediately fixed. Even if such a cold solder joint shows up on multiple boards, it has the advantage of being a manufacturing-internal problem, and the cause (for example, surface contamination or other soldering-related difficulties are a good bet) should not be too difficult to locate and correct in the process.

A serious threat to product reliability

But the failure-analysis laboratory may find that the functional failure was caused by an anomaly within a single IC package. After probing and sectioning the IC, the FA lab may report that the IC has an internal delamination that led to the functional error. This situation is more worrisome. FA will likely be asked to examine additional samples of the IC in question. If more delaminations are found – even if they have not yet caused electrical problems – the threat to product reliability has suddenly grown.

In this acoustic image, some of the delaminations (red) along the lead fingers extend nearly half the distance from the chip core to the exterior. More serious, though, are the delaminations surrounding the die itself

If numerous samples of the IC have delaminations, it is very likely that the cause of this defect lies in the assembly of the IC package by the supplier. After delivery, an IC having an internal delamination can easily escape detection throughout the board-assembly process, especially if the delamination has not yet severed a wire or otherwise caused electrical symptoms. The reflow procedure might make the delamination a bit larger, but it still might not cause an electrical problem. The flawed package placed on a board can sail right through final inspection and go off to the customer. Here, the delamination may cause just the type of failure that QA, FA lab and other departments are working so hard to avoid.

So when a QA engineer learns of a packaging defect – a delamination, crack or void – he has to wonder: is this just the tip of the iceberg? Are there dozens or hundreds of delaminations, only a handful of which will make themselves known by electrical failures before we ship the final product? Are there scores or hundreds of latent failures, waiting to happen after the components are out of our control? In economic terms, just a few field failures in a low-cost consumer product may not have much economic impact, but many of them in such a product, or failures in a high-priced or in a medical or safety-related system where highest reliability is a great requirement, may be a very serious matter.

To avoid a horrible production shutdown

What every company fears most is a production shutdown. If the FA lab demonstrates that delaminations are numerous in a given lot of IC packages, there will surely be long discussions with the supplier in an attempt to resolve the problem, but in the meantime production may have to stop.

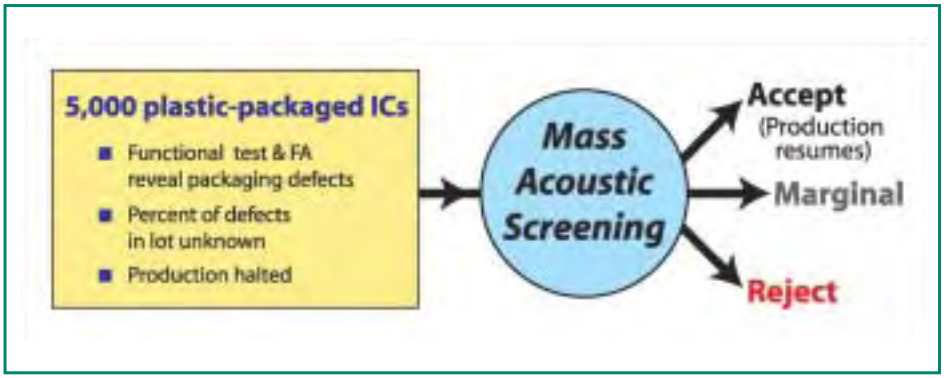
The scenario described above, although not an everyday occurrence in a board-assembly line, is not rare. It is possible that such troubles (including line shutdowns) may be on the increase, and for an interesting reason: as multiple worldwide sources of components become available, the never-ending drive to lower costs can result in components whose quality and reliability are unknown. In some cases the presumed supplier has turned out not to be the supplier at all, but simply a component broker delivering semiconductor devices from another supplier.

In the midst of such a situation, the board assembler usually winds up holding one or more lots of ICs, some of which have internal packaging defects, and some of which do not. At this point, no one knows which IC packages are bad and which are good. If they did know, at least limited production could resume.

Component-reclamation program a remedy

This is the type of problem that originally motivated Sonoscan to set up its component-reclamation program. After the FA lab characterizes the defects, a reclamation program is used to image whole lots of component packages acoustically to determine which ones have internal defects. The assembler's FA work may pay off here: if only defects above a given size, or in a given location, are known to be dangerous, then packages with defects outside of these definitions may be classified as acceptable, or at least as marginal.

Constant reduction in package dimensions can make a given defect more critical than it would have been in a larger IC package. A common location for delaminations is along the lead fingers. Historically, lead-finger delaminations are not critical unless they are likely to provide a direct path



Production specialists faced with a mixed lot of ICs, where an unknown number have internal packaging defects, use acoustic screening as a quick means to resume production

from the outside (ambient) environment to the chip. An IPC standard defines an unacceptable delamination as one that extends along 50 % or more of this distance. It is assumed that a delamination may grow in size during the thermal cycling of normal system operation.

The problem with today's smaller packages is that the distance from the external environment to the chip is greatly reduced. The process of singulating very tiny packages can cause enough stress to delaminate the lead fingers. The overall consequence is that a lead-finger delamination of a size once considered harmless can now be lethal to the device.

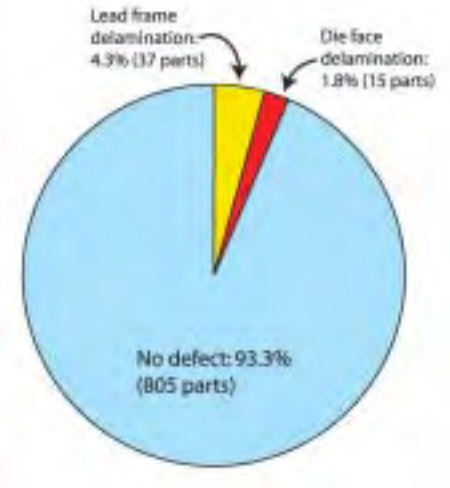
Internal device structure of interest

What happens during acoustic screening of IC packages? First, initial acoustic images are made to permit Sonoscan's laboratory engineers to see the internal structure of the device. Consultation with the board assembler determines what size defect, if any, might be acceptable. The depth of interest (for example, the interface between the lead fingers and the mold compound) is identified.

Initial acoustic imaging sometimes reveals surprises. If a supplier's manufacturing process steps have changed (or if the supplier has sub-contracted the component or its packaging/assembly), the first acoustic image may show that the lead frame has an unexpected design. Even without making an image, a C-SAM (C-mode acoustic scan microscopy) can quickly measure the acoustic impedance (velocity times density) of the molding compound. Each molding compound has its own acoustic impedance, so a significant change suggests that a different molding compound is now being used.

Next the hundreds or thousands of parts are imaged acoustically. Unless the quantity involved is very small, the process is automated to some extent. Full automation means using JEDEC-style trays and automated-feed acoustic imaging systems with the ability to acoustically image internal details as tiny as an underfill void adjacent to one of hundreds of solder bumps on a flip chip. But full automation isn't always needed: a version of a laboratory C-SAM having an oversize scan area can verify several thousand small ICs at one time.

Experience at Sonoscan's laboratories shows that the percentage of internal defects is likely to vary dramatically from one lot of components to the next, no matter how presumably similar (lot code, date, etc.) the device batch may be. For example, if there are 5 lots of 1,000 components each, and the overall defect rate is 10 %, it is likely that the defect rate per lot will range from around 2 % to around 20 %. Roughly the same results are found when lots of ceramic chip capacitors are screened.



Actual results from one lot of 857 plastic-packaged ICs. Even among very similar lots, the percentage of defects typically varies widely

The level of defects varies in practice

The level of defects that justifies mass acoustic screening varies from one application to another. There is little incentive to resort to acoustic screening if occasional defects occur in low-priced consumer systems. As the intrinsic value of a system goes up, so does the interest in reclamation. If the IC package in question is an expensive laser diode or MEMS (micro electro mechanical system), the ability to sort the lot cleanly into good and bad (pass/fail) packages becomes critical. At plants where high reliability in the finished product is mandatory, acoustic screening is routinely performed on all incoming parts, even when there is no reason to suspect that defects might be present.

After mass acoustic screening of a mixed lot of IC packages has been completed, the board assembler can resume at least partial production because he knows which of the packages are good, which are reject, and which are marginal and perhaps usable. Acoustic screening does certainly not solve the board assembler's problem with such a supplier, but the acoustic reclamation process provides needed documentation and gets production started once more.

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ZUSAMMENFASSUNG

Immer wieder kommt es vor, dass man aufgrund von fehlerhaften Baugruppen in der Fertigung feststellt, dass gelieferte Bauelemente versteckte Defekte aufweisen. Schnell kann eine kritische Situation entstehen, die unter Umständen sogar zu einem teuren Produktionsstopp führen kann. Das Schreckgespenst aller Fertigungsmanager. Eine Prozedur auf der Basis von akustischen, visualisierten Impedanzmessungen ist in der Lage, hier rasch Abhilfe zu schaffen. Man kann damit solche Komponenten aussortieren bzw. feststellen, ob eventuelle Fehlstellen im Package die Verwendung noch erlauben oder ICs reklamiert werden müssen.

RÉSUMÉ

C'est très souvent par l'intermédiaire de sous-groupes défectueux que l'on découvre dans la fabrication que des composants livrés présentent des défauts cachés. La situation peut rapidement devenir critique et même entraîner un arrêt coûteux de la production, la hantise de tout responsable de la fabrication. Une procédure basée sur des mesures acoustiques d'impédance visualisées est à même d'y remédier rapidement. Elle permet de trier les composants en question et de constater si les éventuels défauts des CI en permettent malgré tout l'utilisation ou si une réclamation s'impose.

SOMMARIO

Purtroppo capita sempre più spesso che si deve constatare che gli elementi costruttivi forniti mostrano difetti nascosti in seguito a gruppi costruttivi difettosi nella produzione. Di conseguenza può rapidamente risultare una situazione critica, che in determinate circostanze può essere perfino molto costosa a causa di arresti della produzione. Questo fantasma spaventa tutti i coordinatori di produzione. Una procedura a base di misurazioni di impedenza acustiche visualizzate è in grado di fornire un rapido e efficace rimedio, infatti, questo procedimento consente di selezionare ossia localizzare eventuali punti di errore nel Package, per consentirne un ulteriore utilizzo o se è necessario contestare gli IC.