HEAR THEM OUT
Qualifying Parts Using Acoustic Screening

Solder Paste Jetting
DfT Processes
Lossy Lines
Acoustic Screening to Remove SUSPECT PLASTIC Components

Testing parts for gaps reveals which parts are electrically intact but prone to future delamination. by TOM ADAMS

In an ideal world, plastic-encapsulated microcircuits (PEMs) would leave the component manufacturer in pristine condition. BGAs, QFNs, PQFPs, TOs and other package types would have no electrical or structural anomalies that could lead to electrical failures. The components would arrive for assembly in this condition, and would pass through handling, reflow and testing with no alteration of their ideal state. They would give years of flawless service.

In the real world, things do not always work out like this. A component may pick up a gap-type structural anomaly – delaminations, voids and cracks are the common ones – somewhere between the molding process and post-assembly shipment. Many of these gap-type anomalies make no difference in the proper functioning or lifespan of the component. Some, though, depending on size and location within the package, can expand until they break a connection. Even without expanding, gaps are the locations where moisture tends to collect, whether it has percolated through the mold compound or entered by a crack along a lead finger. The combination of moisture and contaminants, which can arrive by the same routes, can promote corrosion that may lead to electrical failure.

The least dangerous gap-type PEM anomaly is probably a small void (air bubble) in the mold compound not near to or in contact with any other surface such as a wire or the die. Generally such an anomaly is not considered a defect. Far more dangerous are defects such as delamination between the mold compound and die face. Normal thermal cycling, with repeated coefficient of thermal expansion stresses, can cause the delamination to expand across the face of the die until it shears off a wire bond.

There are numerous other gap-type anomalies, and many pose a greater or lesser threat to electrical performance. The important questions during assembly are:

- What percentage of the components in a given lot has internal structural anomalies?
- How likely are these anomalies to cause eventual electrical failure?

Sonoscan’s applications laboratory, which images lots of components for assemblers, routinely uncovers the answers to both questions. The assembler that will use the components writes the rules that will distinguish harmless anomalies from dangerous defects. Acoustic micro imaging systems image and analyze internal gap-type features, which reflect ultrasound at higher amplitude than other internal features such as the die or lead fingers.

PEMs in which a gap-type feature has already broken a connection will, of course, fail electrical tests. The purpose of acoustic screening is to identify and remove those PEMs that are electrically intact, but that have gap-type defects likely to cause field failures. For commercial products, defects of a certain size may be acceptable if the risk of failure is low. In military, aerospace and medical
products, the degree of risk permitted ranges from very low to zero.

The outcome of acoustic screening varies greatly from one lot of components to another. It is not uncommon for a lot of components to have up to 5% rejects. The accept/reject criteria are defined by the user of the part and are applied to internal anomalies visible in the acoustic images.

Acoustic images reveal all sorts of anomalous situations. The ultrasound pulsed into a component is reflected from material interfaces at many depths, but the echoes can be selected by their arrival time to limit the acoustic image to a desired depth. The acoustic image of the BGA in **FIGURE 1** captured the depth from just below the top surface of the mold compound to just above the die, and included the tops of the wires (at center). The red and yellow features are voids in the mold compound. Such isolated voids are generally considered harmless. But this BGA has a great many voids, running down to sizes so small that they get lost in the tiny white features created by the distribution of particles in the mold compound.

But by using a new technique to image the bulk of the mold compound in many sequential slices, the Sonoscan lab found the real danger: The largest void, at top, extends vertically from the substrate upward almost to the top surface. Moisture and contaminants that percolate through its thin wall have a free ride to the center of the package.

**FIGURE 2** is the acoustic image of the die surface in a BGA that would almost certainly pass electrical tests, but that is loaded with potential disaster. The red areas at each corner of the die face are small delaminations of the mold compound from the die. At this early stage, the delaminations are unlikely to have yet broken a wire bond on the die. The normal thermal cycling of service, however, is what makes die face delaminations so perilous; they may expand laterally until they find and break a wire bond.

A PEM that is being tested in a laboratory that determines Moisture Sensitivity Level (MSL) is initially dried to remove existing moisture, then moisturized to a specific level.
It next goes through reflow three times, although it is not soldered to the board, since it will later be sectioned physically. The three passes through reflow simulate the experience of a component on a board that is reflowed twice and is then reworked. After the third reflow, the PEM undergoes a basic electrical test to find opens. It is then screened acoustically to look for gap-type defects, and then physically sectioned to see the defects optically. The acoustic image is the guide for selecting the best location for physical sectioning. Some defects, though dangerous, cannot be seen after physical sectioning because they are too thin. Delaminations as thin as 1 µm reflect virtually all of the ultrasound and are imaged strongly, but such a thin gap may be invisible optically.

MSL test personnel often encounter a PEM whose acoustic image shows multiple problems - voids, delaminations, even cracks - but which passed the electrical tests. Such a PEM may be loaded with structural anomalies that will cause electrical failure under the stress of service, but none of those anomalies happens to have caused a problem yet. In a production environment, such a “train wreck” can sail through basic electrical testing and go right into production.

**Figure 3** is an acoustic image of a high-risk PEM. It has two types of defects. First, the die paddle is delaminated (red) from the mold compound around the periphery of the die. This is a moderately serious condition; the delamination could expand and move under the die and the die attach material. But in two locations on the lead fingers is another dangerous condition: delaminations on adjacent lead fingers. The wall of mold compound between the lead fingers is very thin, and can easily be dissolved by corrosion, causing a short between the lead fingers.

The same result - a short between adjacent lead fingers - can be triggered by a different mechanism often encountered in Sonoscan’s laboratories. In some PEMs, the tape (white in Figure 2) looks red or yellow in the acoustic image because it is delaminated from the mold compound. Although frequently considered unimportant, corrosion along such a delamination can also put two adjacent lead fingers in electrical contact.

The locations and types of gap-type defects are largely determined by the package design. Delamination of the mold compound from a lead finger, for example, may not even be considered a defect if a package has long lead fingers on which there are a few small delaminations. They are unlikely ever to grow sufficiently to like the outside atmosphere and the die or the wire bonds. But a package design having a very small die and very long wires connected to very short lead fingers is a different story. The distance from the outside atmosphere to the outer wire bonds is very short, and can be bridged even by a small delamination. The very long wires are also vulnerable to wire sweep during molding.

One of the defects MSL test personnel expect to see in some PEMs is the popcorn crack. Popcorn cracks form when moisture within the package turns to steam during reflow and expands in volume by about 1600 times. Popcorn cracks are not as frequent in production as they were a decade or two ago, but they still occur. They usually originate at the die attach level and travel downward to the bottom surface of the package. Very few travel to the top surface, and even fewer go sideways. A popcorn crack exiting the bottom of the package is invisible during production, but over the life of the components provides a convenient path for moisture and contaminants to reach the die.

Acoustic screening uncovers all sorts of things. Die face delaminations have a reputation for being lethal, but there are a very few specific packages in which, users...
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请使用导热粘合剂作为您的热管理材料

虽然导热油脂和相变热界面材料（TIM）已成为电子器件热管理的主流产品，但某些应用的新需求促使制造商们去寻求其替代品。在诸如减小器件体积重量，逐步淘汰污染性化学品，同时改善可加工性这些要求的驱动下，电子专家们正越来越多地转向使用导热粘合剂来取代传统的热界面材料。

在过去短短几年中，消费者对体积更小、功能更强的电子设备的要求带动了很多电子产品经历了整体体积的大幅度缩减，比如移动电话和高功率发光二极管（LED）。但不是仅有这些应用发生了这样一个转变，小型化的趋势其实已经在包括汽车工业在内的几乎所有电子工业领域中盛行。事实上，汽车电子正是新一代热界面材料发展特别蓬勃的一个领域。

虽然汽车电子产品制造商在过去已经使用过导热粘合剂，但许多这些材料都存在着缺陷。这包括含硅配方存在污染问题，必要的固化温度对某些器件而言过高；以及工艺适应性低，不适用于某些器件。

为满足包括汽车工业在内的所有电子行业制造商对可替代传统材料的更好的热管理材料的需求，新型导热粘合剂已被研发出来，它具有非常优异的性能，而且性能稳定可靠。这种新一代的TIM粘合剂是高导热非导电材料，用于将散热组件粘接到电子器件上。

TIM粘合剂配方一般用于环氧树脂体系，没有与硅类材料相关的污染问题。单组分粘合剂材料的使用工艺简单，无需任何混合并通过标准的自动点胶设备来施胶。这样既简化了工序，又可利用现有设备，有助于降低生产成本。

这种新型材料最受欢迎的特性之一也许就是它能适用于多种不同的工艺条件。由于材料的固化温度低（在100℃范围内），制造商们可以把它用在温度敏感器件上而不会对其他组件造成热损伤的风险。另一方面，如果需要的话，新的TIM粘合剂也适用于加工温度高的情况，其许多配方在高达150℃的温度下显示了良好的性能和稳定性。

取决于制造商使用的什么样的生产方法，这种材料能够在线固化，也可以在其他加热工序过程中固化，从而进一步提高产量。而且，当使用粘合剂来替代传统导热油脂时，无需使用夹子或螺钉来固定器件，这也是此种应用粘合剂能够节约成本和节省时间的又一个优势。

然而，重要的是要注意到，TIM粘合剂的所有这些优点都不能以牺牲材料的热传导性能为代价。因此，在评估这些材料时，要特别关注它们的热导性，因为这关系到您的具体应用的性能。一般来说，2.3 W/m·K的导热系数对许多现代的器件标准而言应该足够了。

随着电子产品变得越来越小，在有限空间内需要将高功能部件更紧凑地组装在一起，热管理解决方案必须不断发展以解决日趋小型化的应用所产生的更高热量。新粘合剂配方让更多的小型化设计成为可能，而且不牺牲材料的热性能。尽管

热油脂和相变材料在热界面材料领域中仍然占主导地位，但新的TIM粘合剂为它们提供了一个理想的替代产品，而且该新材料是基于无硅体系。

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