Finding Counterfeits with Ultrasound

Sonoscan's Gen5 C-SAM system.

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

The vast majority of counterfeit plastic-encapsulated microcircuits (PEMs) are not counterfeit in the sense that a phony $20 bill is counterfeit. They are not made from scratch, as the phony bill is. Instead they are "recycled" — removed from recycled printed wiring boards and cosmetically refurbished until they look like new parts.

The recycling process is not delicate. A board is heated until the solder reflows, then smacked hard to make all of the components fall off. The components are washed (sometimes in a nearby river), dried, sorted, relabeled, and put onto tape, or into a tray or onto a reel. No attention at all is paid to any component's Moisture Sensitivity Level whose requirements are needed to protect the component from damage during reflow.

A smaller number of counterfeits are made from scratch. If the market is large enough, and the effort and expense involved in creating the counterfeit are small enough, this is a viable method. In extreme cases, the counterfeiter doesn't need much more than a mold machine and some lead frames to make a PEM. He may put a die and wires into the package, but neither is really necessary. The things that count are the label and the external appearance. Whoever buys that batch of SOICs may be in for some unpleasant surprises, though.

The problem with "recycled" counterfeits is not that they don't work. Many of them do work. The PEMs themselves, and the chips inside them, may be a decade or more old, so their remaining life span may be limited. The rough handling and thermal stresses they experience are likely to shorten whatever longevity they may still possess.

The real problem is that the chip inside the package, even if functional, may not match the label on the part. The components pulled off of the board are sometimes simply sorted by size and external characteristics (the number of leads), and one 64-pin QFP viewed from the outside, looks pretty much like another. Inside, the lead frames may be different and the electrical characteristics of the chip may be different. The same tube or reel may contain components having identical labels but having highly varied electrical and functional behavior. Learning to spot the counterfeits is important in heading off actually feeding these destructive components into an assembly line.

Visual Clues

"Recycled" counterfeit PEMs are usually relabeled by grinding off the existing label and applying a coat of "blacktop" onto which a new label is printed. Many counterfeits can be spotted optically by examining the top surface of the part. Some things to look for:

- Words are misspelled.
- The circular indents ("mold marks") on the top surface do not have a flat floor and

crisply defined side walls. Instead they are somewhat lumpy because of the particles included in the blacktop to make it look real.

- The blacktop can be removed by the application of acetone.
- After the blacktop is removed, the surface of the mold compound shows scratches from the grinding that removed the original label. The counterfeiters, as you might expect, are getting smarter. Some counterfeiters are now using blacktop that does not dissolve in acetone. OEMs have largely switched to laser-etching to mark their components, and now the counterfeiters are starting to use lasers as well.

The Clues May Be Internal

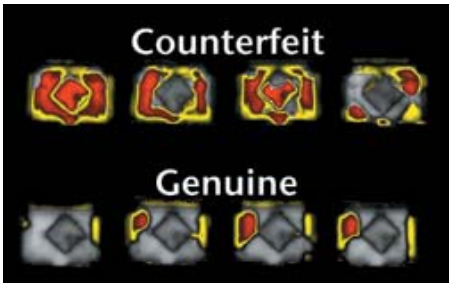
Without the dead give-away of a misspelled surface label or scratched mold compound, it becomes more difficult to make a firm determination about the authenticity of a component. What is happening is that the clues that tell you that a component is counterfeit are more likely to be found inside the part rather than on the surface. This means that they fairly beg for the application of ultrasound. Sonoscan has noted recently a strong increase in the need to examine questionable components acoustically.

It is very helpful to have known genuine parts to use for comparison with an incoming lot.

"Recycled" Counterfeits

Before imaging the interior of the component, it may pay to look acoustically at its surface. Simply imaging the surface acoustically may reveal whether some advanced blacktop material has been used. You can also use Acoustic Surface Flatness (ASF) available on Sonoscan's C-SAM® systems to make a surface profile of an indent. ASF is extremely sensitive to local variations in height, and a less-than-flat indent floor will be easy to spot.

In the interior of the part, an acoustic microscope may find some interesting features. Since the ultrasonic pulses are reflected by material interfaces, the return echoes from the various regions of the part will show the chip and the details of the lead frame. If the incoming lot of, say, QFPs were indeed "recycled," you might image 20 of these parts acoustically and find yourself looking at three or four different lead frame designs — all the same size externally, and all with the same number of leads. What has happened is that PEMs of roughly the same size were pulled from hundreds or thousands of boards, and then mixed together and given identical labels. The thickness of the mold compound over the die (which can be determined acoustically) might vary, along with the body thickness.



Seen acoustically, counterfeits have larger, more dangerous, inconsistent delaminations. Genuine parts have smaller, less dangerous, and more consistent delaminations..

Often, though, an acoustic look into questionable PEMs will reveal nothing quite so dramatic. Instead, you will begin to see internal defects such as delaminations that are uncommon in brand-new components, but more common in PEMs that have been in service for years. If you image an adequate number of known genuine PEMs and newly arrived questionable PEMs and begin to see more internal anomalies in the newly arrived batch, you may have counterfeits. Comparisons are far easier if you have a group of known genuine components of the same type.

Made-from-Scratch Fakes

A PEM that has been manufactured to mimic a genuine part will, like the "recycled"

counterfeits, probably look fairly convincing on the exterior. It is the internal details that will give it away. The crude manufacturing processes may even result in internal defects that may make the component look like an ancient "recycled" component.

This is exactly the situation shown in the illustration, imaged on a Sonoscan Gen5 C-SAM® system. The chip in these parts is rotated 45°, so it has the shape of a diamond. The four components in the bottom row are known to be genuine. They have small delaminations (red features) on the die paddle. These small delaminations are not serious defects, and are of about the same size and in the same location on three of the four parts — a strong hint that they are all from the same lot.

The four components in the top row also have delaminations, but here the delaminations are much larger and located more randomly within the component package. In two of the components, the delaminations are on the chip face — a very serious defect because the delaminations can grow and break wire bonds. Do these varied delaminations prove conclusively that the components in the top row are counterfeits? No, not without more evidence. But it's highly unlikely that components would come from an OEM with such diverse problems.

The four fakes shown were also found, by acoustic imaging of internal details, to be fairly crude made-from-scratch counterfeits. Wire bonds were in the wrong locations, for example, and some of the die were oddly placed. Other things that you might find acoustically in this type of fake: a missing die, or strange wire loops.

Fake Mold Compounds

There's one more important item: the mold compound. If you have a batch of made-from-scratch counterfeits, the counterfeiter may have gone to the trouble of making the label acceptable. But he likely didn't think about reproducing the characteristics of the mold compound. One of the easiest things to do with an acoustic microscope is a single pulse that will measure the Acoustic Impedance (acoustic velocity times density) of the mold compound. If the known genuine components have consistently had an Acoustic Impedance around 4.2, and the new lot apparently from the same OEM has an Acoustic Impedance of 7.7, there is a good possibility that you have counterfeit parts. You can sometimes even see a difference in the filler particles in the mold compound. The acoustic image of the mold compound in a made-from-scratch counterfeit may have filler particles of wildly different diameters, unlike the very consistent particles you would see acoustically in a genuine part.

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: http://www.sonoscan.com

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