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White Paper

Counterfeit Testing Methodology, Minimizing Costs While Minimizing Risks

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Introduction

While interfacing with colleagues on LinkedIn the other day I encountered a procurement manager requesting to be connected with ANYONE that could help him find obsolete or difficult to find components. He received over 20 responses from parts brokers all offering their innate ability to find and procure these long lead or obsolete components. None of the brokers were familiar to me, which, in my opinion, points to an immediate danger to the buyer of procuring counterfeit devices through these sources that were either unknown to him or had minimal contact with him. In the other paper in this issue regarding counterfeit parts DfR identified the risk of procuring these types of devices and how you should perform varying levels of test and inspection to assure compliant parts. This paper will identify the different methodologies whereby you, the procurer of these parts, can reduce your risk by having the appropriate tests performed. DfR will describe these options so that you can make the correct decision.

Visual Inspection

Most counterfeits are finally detected when they fail during use. However, visual inspection could raise the suspicion of forgery long before the component fails. Differences in manufacturing specifications such as molding die locations, ink precision or durability, font, or date or lot code standards can indicate possible counterfeit parts. Although knowledge of exterior labeling and marking standards is helpful in detecting a counterfeit, the body of knowledge required to become an expert on all standards is overwhelming. Some counterfeiters have such advanced techniques that the counterfeit marking may be of higher quality (more durable, vibrant, or sharp) than the original. Overall, visual inspection is an important tool in counterfeit detection, but by no means is it the only or best way to identify forgery. So what should you be looking for? (1+2)

Visually inspect the exterior of the components using a low power microscope (3-10X) and examine the quality of the markings. Original components tend to be clean with the markings legible and identical. Conversely, counterfeit parts may or may not be as legible due to a lack in equipment to properly remark the device. During this visual inspection you should also examine the leads on the devices. Reclaimed parts often have less co-planar leads as a function of being desoldered as the leads are very difficult to keep straight. Non-co-planarity is a good indicator that the parts have been removed from a board and reclaimed. Also, visually inspect the contact points of the leads as they should show no signs of excess solder where it would have been connected to the circuit board.

Ball Grid Array reballing is a routine operation to salvage BGAs after once being soldered to a circuit board. If done well it is extremely difficult to determine if a device has been reballed. However, using visual inspection one can look at features such as excess solder around the ball attachment area, evidence of pad wicking, signs of flux residue, or visible damage to the component package itself. These visible signs are indicators that a part may have been reballed and then sold as new. X-ray inspection is the next step and will show any size or configuration abnormalities in die, wire bonds, or bond pads. Hiding abnormalities within a circuit board or component is a popular method of counterfeiters since extra effort must be taken in order to identify them.

X-Ray

"False" counterfeits are parts that are suspected to be false, but are in fact authentic components. This situation could result from miscommunication in manufacturers' product change notices (PCNs) and are a time-consuming and costly way to discover a design or specification change in a component.

Error! Reference source not found., below shows the result of a miscommunication in a PCN that resulted in the suspicion of counterfeit. The 3 amp diodes with new date codes experienced a dramatic increase in failure rates compared to those in use with older date codes. During X-ray microscopy, the new diodes were found to have smaller die which most likely caused increased current density and therefore increased failures.

If you use X-rays as the method for identifying counterfeit components you should be able to identify: die presence/absence and dimensions, die attach material, leads and bond wire layout, and bent or deformed leads. At a higher magnification you should be able to see cracks in either the die or the package, the bonding sites (either wedge or ball), thicknesses and the bond wire placement and thickness. Figure 2 illustrates this with regard to tantalum capacitor slug dimensions where the variances are easily identified.

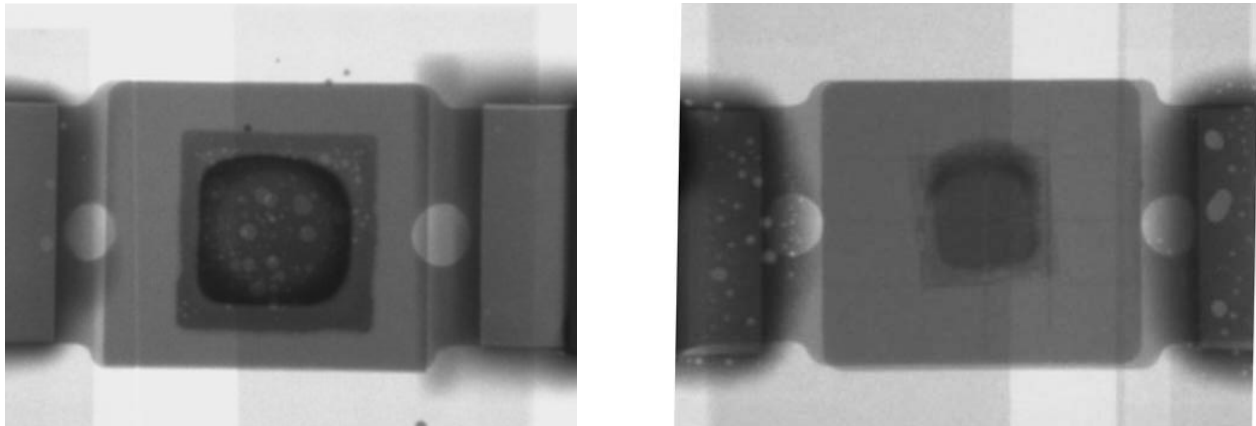


Figure 1. X-ray microscopy of two diodes with different date codes. The diode to the left came from an old, unfailed controller board. The diode to the right came from a newer failed board and shows smaller die which likely contributed to failure

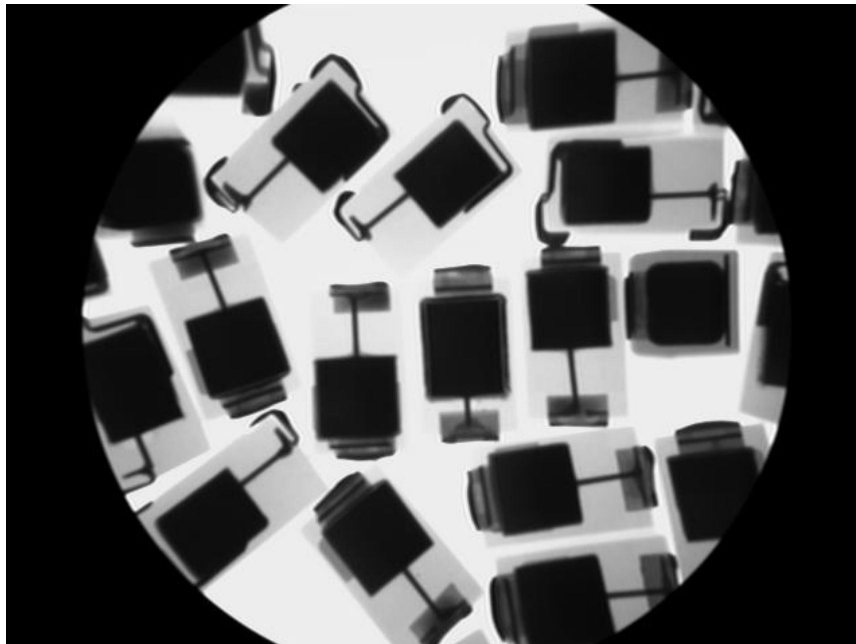


Figure 2: X-ray microscopy of tantalum capacitors with different slug sizes within the same lot. This lot experienced much higher failure rates.

X-Ray Fluorescence (XRF)

X-ray fluorescence spectroscopy (XRF) can be used to detect poor quality or counterfeit parts by measuring the elemental composition of materials present in the parts and comparing them with an authentic part. XRF can be a useful tool to detect counterfeit passives. XRF is of particular use when comparing the lead finish on parts as it will detect whether a part is RoHS and lead free compliant, or whether the part is being identified as lead free when the leads indicate that the part had been used in a tin/lead application.

Scanning Acoustic Microscopy

Scanning acoustic microscopy (SAM) can be used to detect anomalies such as popcorn cracking in molding compounds, and interfacial delamination such as delamination between die and leadframe, that are often caused due to reclamation of parts from discarded electronics. It has been most effective in uncovering distinct differences in device surface coatings which resulted in the identification of many counterfeit devices.

In addition, there are more conclusive methods to determine the authenticity of components, many of them diagnose non-destructively. Infrared imaging or SQUID microscopy can be used to identify and monitor the active parts of an IC with questionable components on it. If a known authentic IC is compared to a suspicious one, these imaging techniques will show any current location or size differences.

Infrared Thermography

Infrared Thermography uses an infrared imaging and measurement camera to visualize thermal energy emitted from an object. Infrared energy, is light that is not visible because its wavelength is too long to be detected by the human eye. In the infrared world, everything with a temperature above absolute zero emits heat and the higher the object's temperature, the greater the IR radiation emitted. Infrared thermography cameras produce images of invisible infrared or "heat" radiation and provide precise non-contact temperature measurement capabilities making infrared cameras extremely cost-effective, valuable diagnostic tools in many diverse applications.

This technique can be used to identify counterfeit components through a comparison of a known good device (possibly installed in a circuit board) to one that is considered a counterfeit. The devices will produce uniquely different thermal images. (See Figure 3)

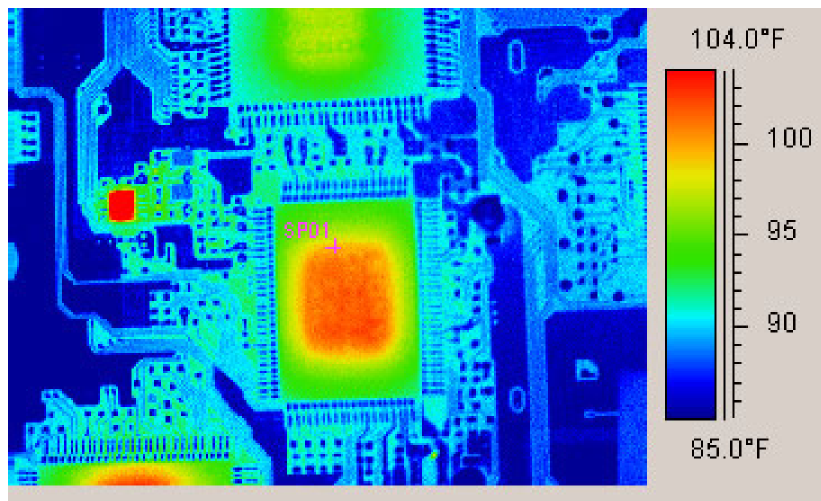


Figure 3- Thermographic Image of an IC mounted on a circuit board.

SQUID Microscopy

Magnetic current imaging using a superconducting quantum interference device (SQUID) is a technique that uses detection of magnetic fields to image current paths within electronic devices or circuit boards. This technique has been successful in non-destructively identifying the location of low leakage currents, even when the failure site was between a power and ground plane. The use of low voltage and low current is vastly superior to thermal imaging, which often results in irreplaceable damage to the failure site and masking of the true root cause of failure. (3) Figure 4 shows an example of this technology being implemented. SQUID can be used for identifying different current paths in a component or assembly as a means of identifying the difference between a viable component and a counterfeit.

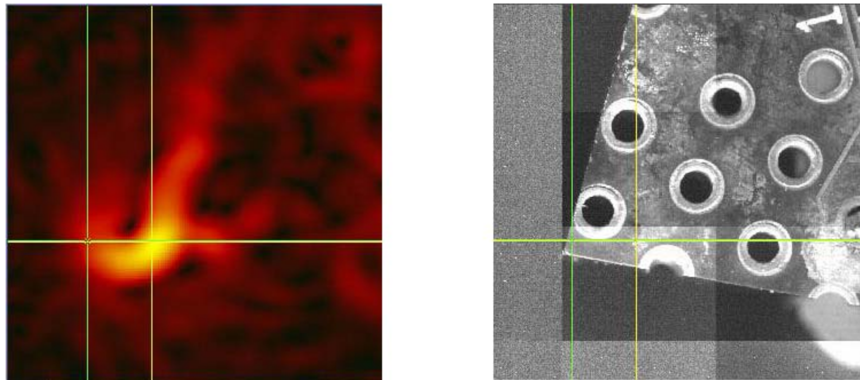
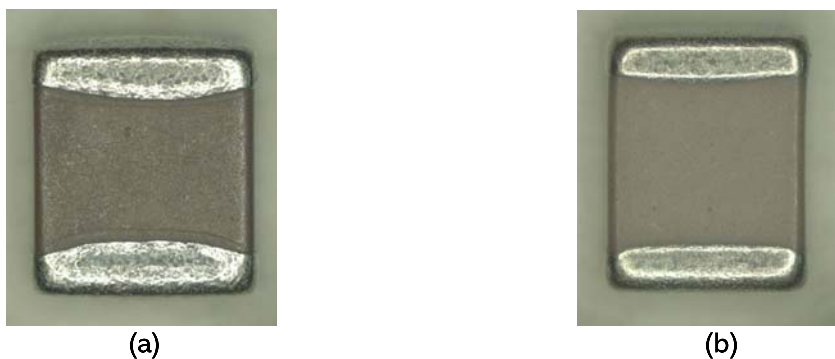


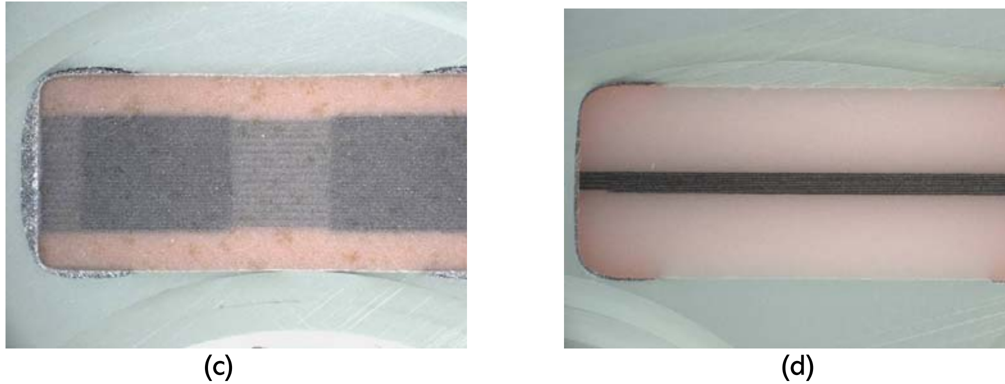
Figure 4: Current map (left) and corresponding photograph (right) of an electrically shorted printed circuit board.

Decapsulation

Decapsulation is another tool for testing counterfeits, and will allow internal visual inspection but at the cost of destroying the part. Cross sectioning / FIB is an additional destructive tool which is invaluable to counterfeit detection. Figure 5 illustrates this concept.



(a) (b)



(c) (d)

Figure 5: (a) Original Novacap capacitor, (b) Suspect capacitor, (c) Cross Section of Novacap capacitor and (d) Cross section of suspect capacitor Assessing the risk and impact of counterfeits

There are three things that impact the risk and impact of counterfeits and therefore affect mitigation decisions and the defining of a testing methodology. The first consideration is the mission risk of a counterfeit part not performing as expected. This can range from lives lost and millions of dollars of damage to no significant impact. Spending on identifying and avoiding counterfeits should increase as mission risk increases. The second major driver of consideration is the separation from the manufacturing source. Purchasing directly from the manufacturer or from the sole approved distributor of components carries relatively low risk whereas purchasing from an unknown broker would carry a high risk. A final consideration is the volume of the buy. When purchasing a few parts, the risk of counterfeit increases as compared to purchasing many thousands of parts.

These concerns tend to build on each other and can be affected by amplifying circumstances such as obsolescence and part type. For example, it may be difficult to procure 25 parts from a manufacturer or major distributor, so, the need for low volume will often drive purchasing from small unknown brokers. If a part is no longer being manufactured, there may not be any available at the manufacturer or first tier distributor. Also, the volume of purchase is relative to part types, for example, 1000 chip resistors would be considered a small lot. However, 1000 radiation hardened microprocessors would be considered a medium to large buy.

All of these variables will identify the most appropriate path to follow with regard to establishing a counterfeit mitigation program and specifying the testing methodologies to be implemented to ensure that counterfeit devices do not impact your company's products.

What is the Big Deal?

In light of all of the above analysis, it raises the question, "So what?" The answer is as varying as the sources of counterfeits themselves. If you are buying a hundred thousand parts directly from the manufacturer and they are going in a lighted yo-yo, you probably do not need to implement a robust counterfeit mitigation plan. On the other hand, if you are buying five parts to insert on a system requiring a 10 yea life span or fly it on a satellite or manned space mission, you will necessarily have a very robust counterfeit detection and mitigation plan.

Let DfR help you with your program as we can bring our extensive knowledge base and experience in mitigating counterfeit components to your assistance. For more information contact Greg Caswell at gcaswell@dfrsolutions or call him at 301-474-0607

References:

(1) Lowry, Robert K., "Counterfeit Electronic Components-an Overview," presented at the Military, Aerospace, Spaceborne and Homeland Security Workshop (MASH), 2007

(2) Federico, Joseph G, "Stopping Counterfeit Parts Before they do Damage," US Tech, October 2009

(2) Hillman, Craig, "A Novel Approach to Identifying and Validating Electrical Leakage in Printed Circuit Boards through Magnetic Current Imaging," ISTFA 2004: Conference Proceedings from the 30th International Symposium for Testing and Failure Analysis, Oct 2004, Pages: 82-87

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