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METHODS USED IN THE DETECTION OF COUNTERFEIT ELECTRONIC COMPONENTS

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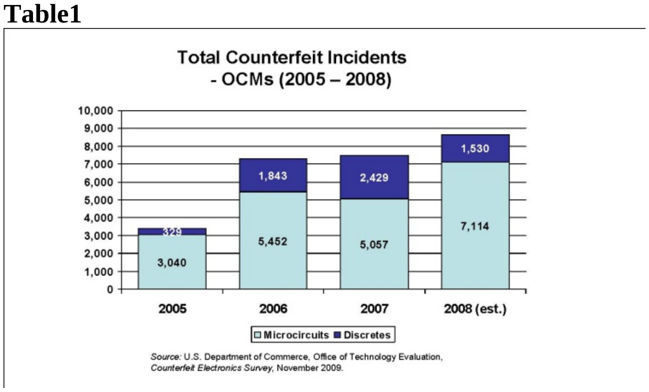
ABSTRACT
In this paper I will discuss the different methods and equipment used to detect counterfeit electronic parts, specifically integrated circuits as well as demonstrate some of the “red flags” that help to identify a part as being suspected counterfeit. We will begin with the initial receipt of the parts and the examination of the outer packaging, the basic visual inspection of the parts, the visual inspection and documentation at high magnification, permanency marking, blacktop test, scrape test, XRF (RoHS), decapsulation, X-ray, basic electrical testing, C-sam, full function testing and limited function testing.

Key words: counterfeit, integrated circuits, XRF, AS5553

INTRODUCTION
Counterfeiting is best known for the reproduction and distribution of currencies. The counterfeiting of artwork, antiquities, handbags and other expensive items is also well known and documented. It wasn’t until the early 2000’s that the counterfeiting of electronic components became widely recognized by certain sectors of the industry. . Acknowledgement of this problem by end users was finally addressed around 2007 and AS5553 which addresses risk mitigation and the detection of counterfeit electronic parts was first released in April 2009. I have been involved with the detection of counterfeit parts since 2004 and have seen the increase of instances as shown below in Table1.

Table1



When you include parts that have been used, refurbished or reclaimed, but represented as new, as defined in AS5553 [1] the numbers increase dramatically and begins in the late 1980s. Another point that needs to be addressed is that as detection methods have become more sophisticated and thorough the methods used by the counterfeiters have also become more complex. In this paper I will address the different methods that are used to detect counterfeit electronic components and how they have changed.

INSPECTION
The inspection process is a multi-stage process with each stage important. Observations should be documented and reviewed upon the completed inspection of the part. It is important that the documented observations be saved and easily identifiable as future uses of these observations are useful in the training of inspectors, reference points for the inspections of the same part, similar parts and parts from the same manufacturer. I will discuss what is sometimes called a “Known Good Device” (KGD) or a “Golden Sample" later in this paper.

Initial Inspection
What is quite often overlooked upon receipt of a delivery of parts is that the inspection should begin before the package is opened. The condition of the box, the type of box and any damage done to the box should be documented. If the package is a packsge that appears to be a box that has been used before, it can be useful in determining the level of quality that the vendor themselves complies to. Upon opening the box, the packaging material can also be used in the same way. If the parts are wrapped in old newspaper a “red flag” should be documented. If the parts are packaged in what appears to be manufacturer’s packaging then the packaging should be scrutinized. Errors in spelling, differences in font, differences in the data on the labels (if more than one label on the packaging) and differences in labels on the packaging of multiple packages that contain the same parts are indications that the parts are not what they seem. Another process that should be performed on packaging that appears to be manufacturer’s packaging and that contains bar code labels is the scanning of the bar codes and the comparison of the data printed on the labels to the data that is evident by the bar code scan (Picture1).

Picture1

There are other items that should be documented before the parts themselves are inspected such as:

1) Is the packaging ESD compliant?
2) Is the package MSL compliant?
   a. HIC card?
   b. Desiccant?
3) Are there MSL labels on the packaging and are they consistent with the part?
4) Is there any paperwork included with the shipment? These should be examined and saved with the other documentation.
   a. C of C
   b. Traceability?
   c. Test results?
   d. Invoice?

All of these items are important for determining the authenticity of the parts as well as if there is any possible damage to the parts by being improperly packaged or the packaging being damaged.

Basic Visual Inspection

Before the parts are inspected there must be a reference point to compare them with. The datasheet for the part is a great starting point. The datasheet will give you the package type, the physical dimensions (in most cases), the part markings (Picture2) and other pertinent information that can be used later in the inspection (RoHS status, electrical and functional data). In cases where the package dimensions are not on the datasheet further research is necessary and can usually be found on the manufacturer's website. The same is true for the part markings.

Picture2

Another reference point and what I consider more effective and reliable is a known good device, a device that is known to be new and authentic that is the same part. Once we have the reference points we then use this information to verify some items:

1) Is it the correct package type that is indicated by the datasheet and the part marking e.g. TSOP, QFP, SOIC, DIP, etc.?
2) Is there the correct number of contacts (leads, balls, pads)?
3) Is the part marking consistent with the reference sample? Is the logo consistent to the reference sample? Some datasheets will provide the format and placement of the part markings.

Performing the initial inspection is normally done using the naked eye or a low magnification (up to 10x) device, therefore is limited to what might be seen. Here are some of the items to look at:

1) The orientation of the parts in the package.
   a. Are they all facing the same direction?
   b. Is the pin one orientation the correct direction? This is useful when dealing with parts that are packaged in tape and reel.
2) Differences in the general appearance within the same lot.
   a. Part markings
   b. Color of the part marking
   c. Color of the surface
   d. Texture (grain) of the surface of the part
   e. Where applicable, are the top and bottom textures the same?
3) Contacts (leads, balls, pads)
   a. Are the leads bent or bowed?
   b. Are there any insertion marks?
   c. Are the leads, balls or contacts too shiny?
   d. Is the plating smooth and even? Are there any voids in the plating?
   e. In the case of BGAs, are the balls flattened or distorted?
4) Is the part marking clear?
5) Is there any foreign substance visible on the surfaces or the leads?
6) Are there any scratches or chip outs on the surfaces?
7) Is the grain even and consistent? Sometimes you can see inconsistencies or lumps on the surface even under low magnification.
8) Are the mold marks smooth? Typically the presence of a grainy mold mark indicates the part has been resurfaced.
9) Are the date codes and lot codes consistent with when and where the part was manufactured by the original manufacturer? This is especially helpful when looking at parts that are obsolete. Product change notifications can also be used to inform you when the part was first manufactured as RoHS, what manufacturing site a part was manufactured at

and when, if there was any change to the part marking or logo and if there were any changes to the die to name a few.

Most of these “items of interest” are also used when performing the high magnification visual inspection.
**Note:* The inspection process should be dynamic to allow for the addition of inspection items as each individual case may differ. Also, the counterfeiters and their process are not static and as they make changes so must the inspection process change.

High Magnification Inspection
High magnification inspection is basically the same as basic visual inspection with an instrument that is capable of a magnification of at least 50 times normal view (I recommend using a lens that has the capability of 200x). Under high magnification items of interest are more clearly visible and therefore irregularities are more easily recognizable. This is also where the observations should be documented in the form of pictures. We will now examine some examples of observations made at different levels of magnification, different lighting and other special features that may or may not be available depending on the equipment that is being used.

The Surface Texture
One of the first items to observe under high magnification is the surface texture or sometimes referred to as the grain of the part. Typically with a PEM (plastic encapsulated microcircuits) will have a texture that is full and consistent throughout the surface of the part (Figure1).

This is how grain should appear at 200X. Notice how the grain is full and consistent.

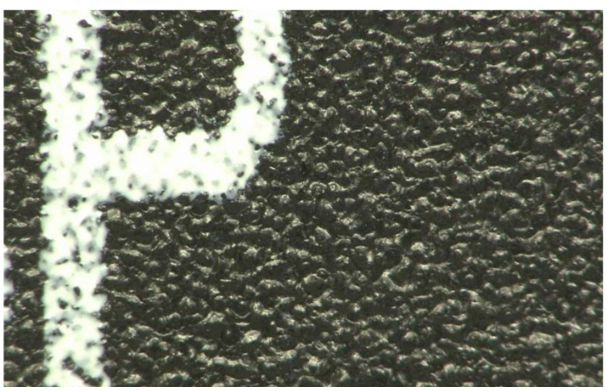


Figure 1

It is not normal for the texture to be inconsistent or smooth (Figure2). Also notice that there are laser burns in the part marking. Here are other examples of textures that are not as expected and that indicate that the part has been modified (Figure3, Figure4) as well as a side by side comparison of a known good device to a suspect part of the same part number (Figure5). As you may notice, when there is one inconsistency with a part there are quite often other inconsistencies with the same part as well.

This is how grain should not appear. Notice how the grain very spotted and inconsistent.

Figure 2

Figure 3

Figure 4

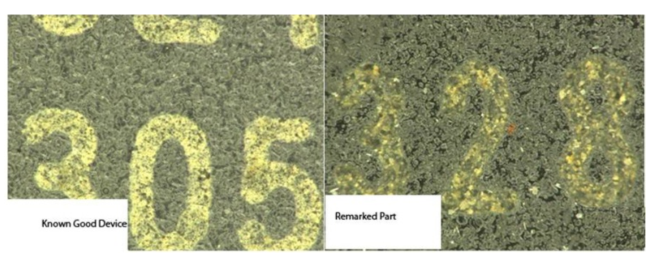


Figure 5

We also look at the mold marks. Typically the mold marks will appear smooth (Figure6). Mold marks that are grainy or contaminated are indications that the part has been altered (Figure7, Figure8).

Mold mark is smooth

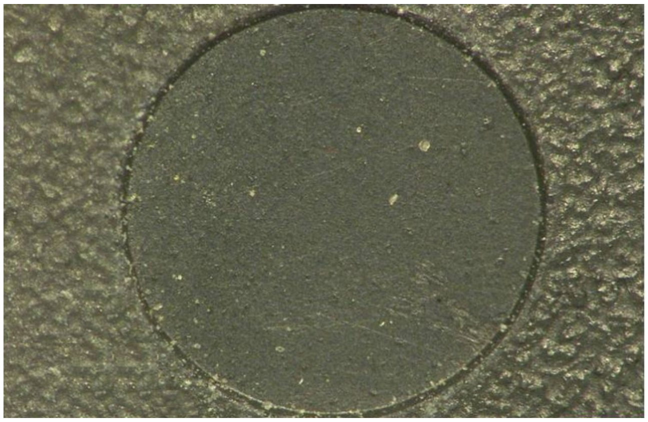


Figure 6

Mold mark is grainy

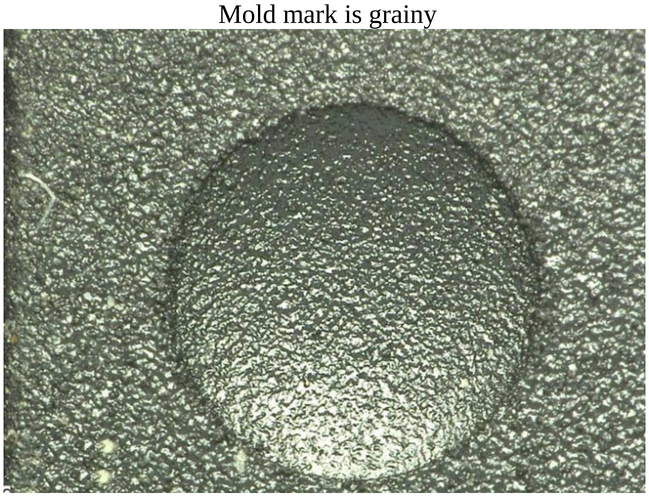


Figure 7

Mold mark is barely visible and textured

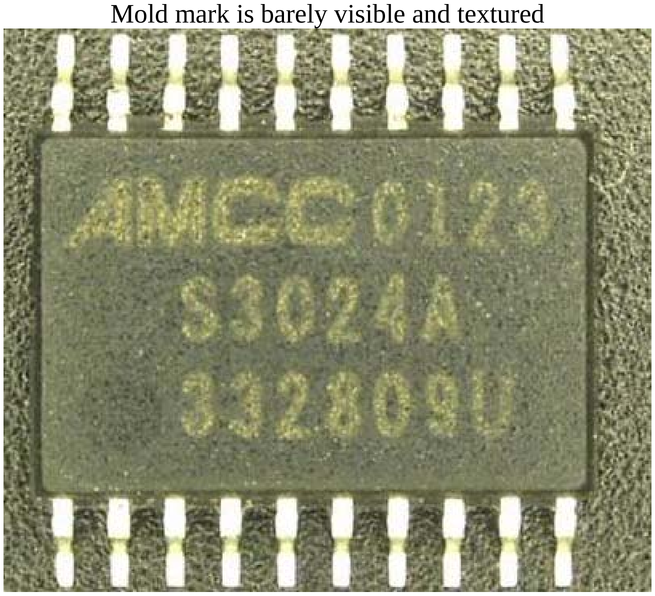


Figure 8

Not all parts will have mold marks and some of the mold marks may be questionable as to if there are textured. It varies from manufacturer to manufacture and part number to part number. This is however an item of interest that can indicate the part has been resurfaced. Another item of interest is the comparison of the top surface to the bottom surface. Normally, since the parts are made by using organic material that is either transfer molded or coated, the top and bottom surface textures will be the same or very similar. Parts that have different surface texture are an indication that one of the surfaces have been altered, usually the top surface (Figure9).

Top surface Bottom Surface

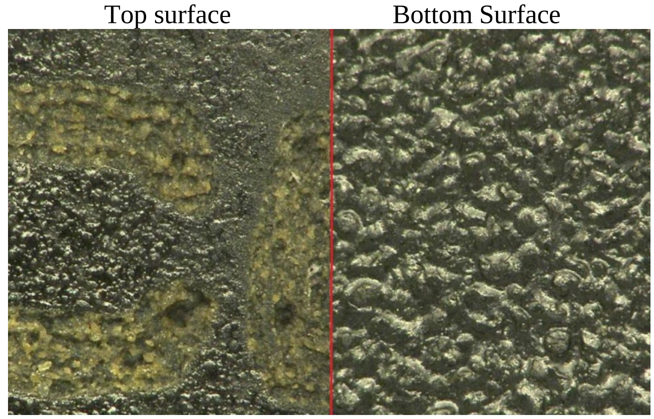


Figure 9

Chip outs can also be an indication that the part has been modified. It can also indicate that the part has been mishandled. We will address the consequences of mishandling in the conclusion of this paper.

Part Marking

Viewing the part marking of the part can also be useful in detection of modified/counterfeit parts. When parts are remarked the marking itself may not be of the same quality as parts from that have not been modified after delivery from the manufacturer. One item of interest is the manufacturer's logo. As seen in Figure4 before and Figure10 below the logos are not up to standards.

The TI logo is of poor quality

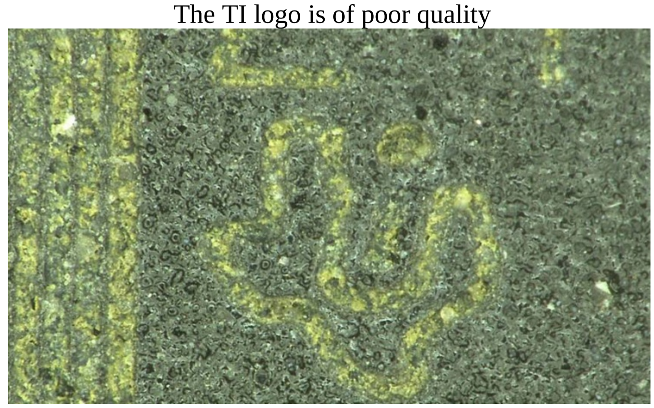


Figure 10

Parts that have been remarked may also have laser burns in the marking itself. These can generally be seen in areas of the part marking where the laser would start, stop or change direction, such as the end or start of a number or letter, corners and edges (Figure11).

Figure 11

Sometimes the same letter or number will be repeated in the part marking. A comparison of the same letter or number can sometimes reveal differences. The alignment of the part marking may also show signs of remarking (Figure12).

The two "C's" are different. Notice also that the "3" on the bottom line is smaller and the bottom is higher than the other markings on the line

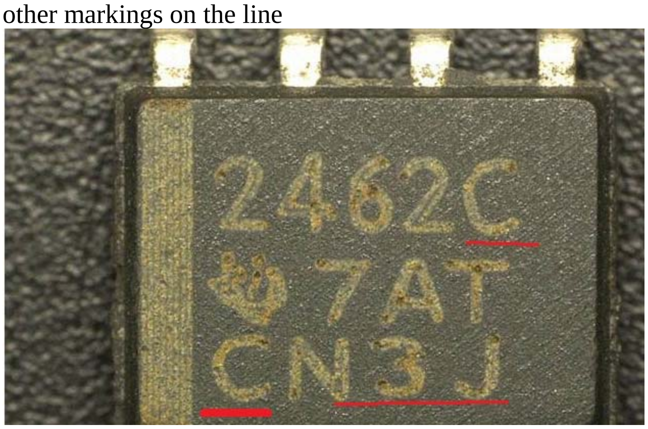


Figure 12

Another indication of part remarking is to compare samples of the same part number that have the same date code and lot code. As demonstrated in Figure13, you can observe that the orientation bars, the logos and the orientation of the part marking itself are different.

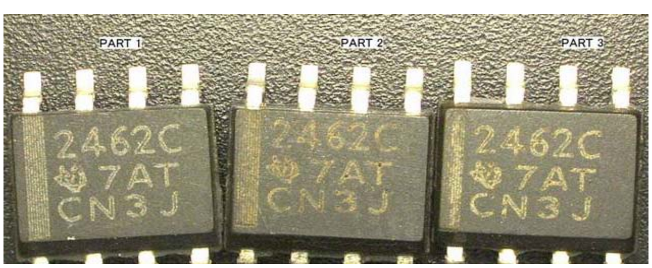
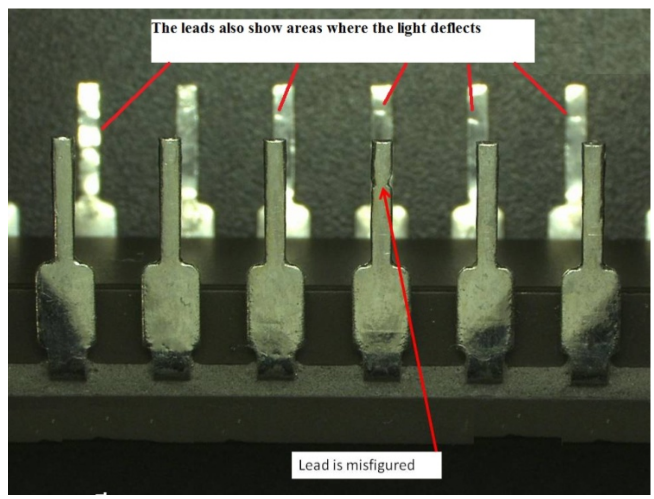
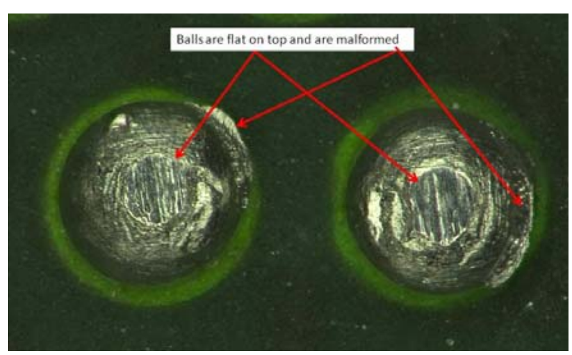


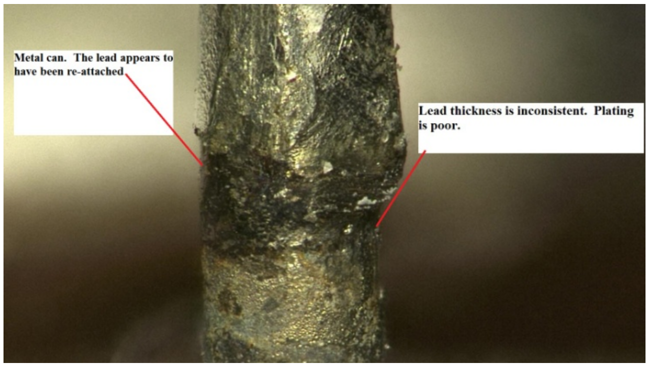
Figure 13

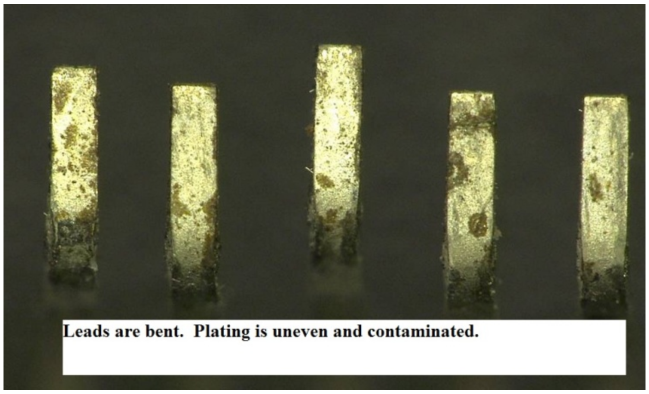
Contacts

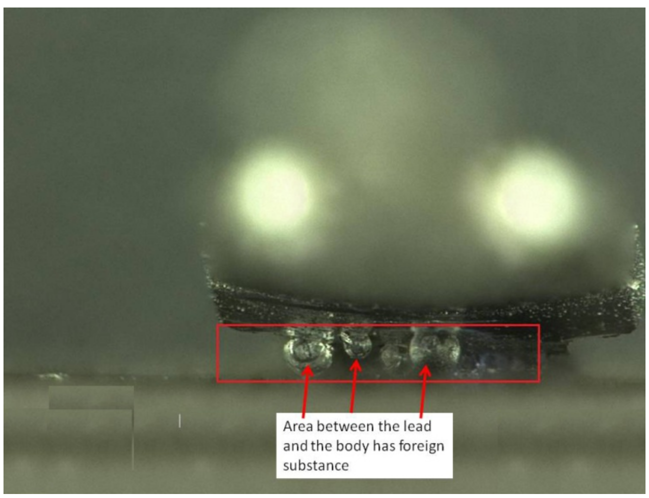
The condition of the contacts on a part can be indications that the part has been used and or mishandled. Parts that have leads should be straight and the pitch (distance between the leads) should be equal. The datasheets will typically contain the measurements for comparison. DIPs should have leads that are not bowed and are flared from the body of the part. DIPs that have leads that are at a 90 degree angle from the body of the chip have typically been modified. Insertion marks can also be an indication that the parts have been used and or refurbished. Care must be taken when determining if the marks on leads are from normal tooling used to form the leads or from insertion into a test socket or if they are from being used. Some BGAs, especially flip chips will have balls that have test indentions from testing that is done at the factory. BGAs that have balls that are misshapen are items that may indicate reballing. Another indication that a BGA has been reballed is scratches on the bottom that appear to run under the balls. Any uneven plating, corrosion or contamination may also indicate the part is not new, even though the age of the part as well as the environment is was stored in can influence these factors. Excess solder either on the leads or on the body itself is an indication that the part has been used. Another item of interest is the ends or tips of the leads, typically there should be copper showing where the lead was cut and formed. It is an indication that the part has been retinned if there is no copper showing. *Below are a few examples:*

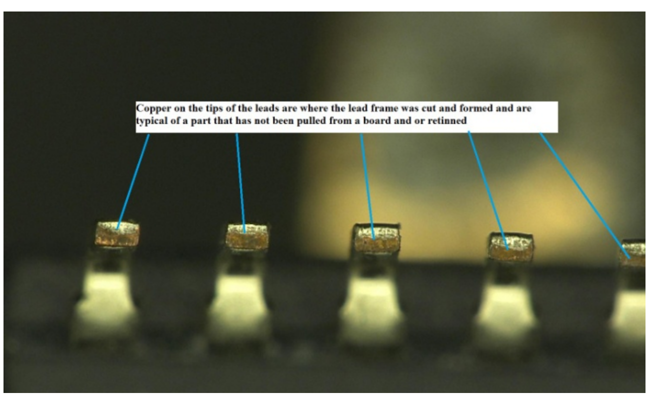












There are instances when parts may have been mishandled resulting in damage to the leads and the parts themselves are not counterfeit. Therefore, abnormalities to the leads are documented as such and other factors need to be taken into consideration before a part can be considered counterfeit. However, according to the definition of a counterfeit electronic device as stated in AS5553[1], if the leads have been tampered with the intent to deceive (such as re-attaching the leads or retinning the leads for the purpose of making a used part look new) then the part is considered counterfeit.

Physical Dimensions

Another tool used in the detection of counterfeit parts is the documentation of the physical dimensions of the part and comparing this to the specifications on the datasheet. A micrometer or other instrument to measure dimensions can be used. Typically it is the thickness of the part that is inconsistent with the datasheet when a part has been remarked (Figure14).

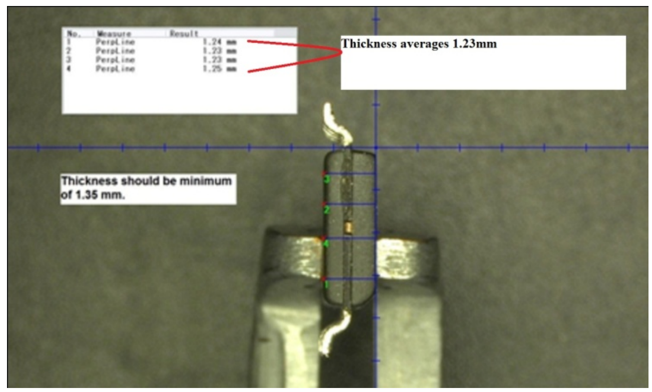


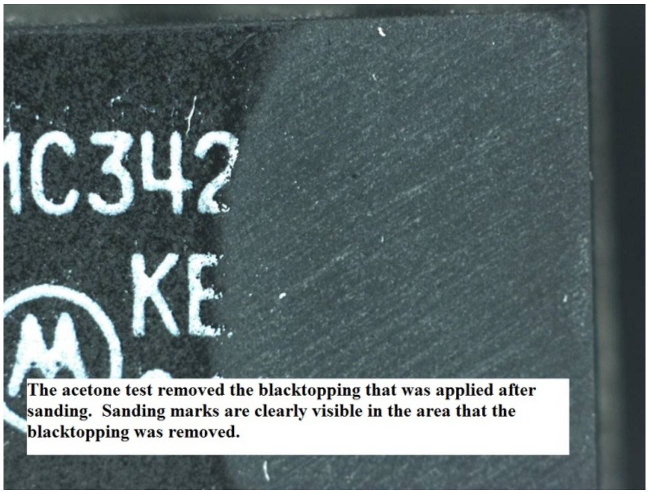
Figure 14

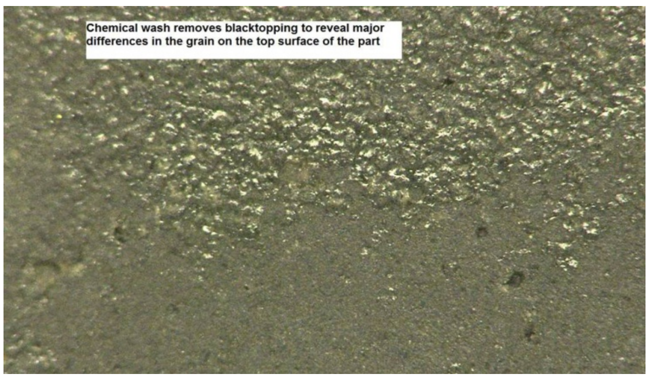
Acetone Test for Blacktopping

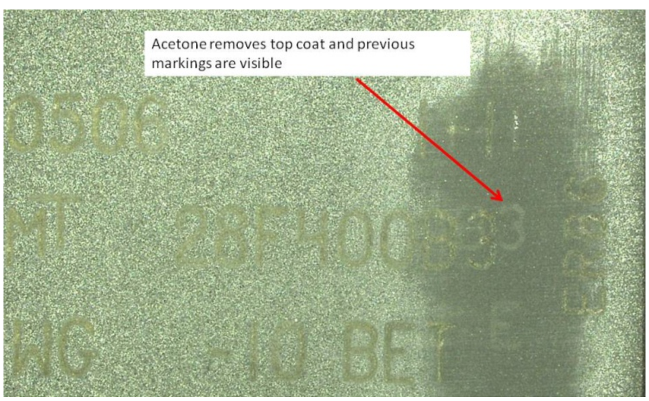
The blacktopping test using acetone was one of the first tools used to determine the authenticity of a part. It is a simple test using acetone to wipe the top surface of a PEM to detect if there is any false coating on the part. When the test is performed on a remarked part the acetone may remove what is termed as "blacktopping". This blacktopping is used to coat the surface to cover the area that has been removed by sanding or other means before the new part number it applied. It covers the sanding marks and any residual part number that may still be visible on the part if the blacktopping was not applied. Once the test is performed observations that may indicate the part has been remarked are as follows:

1) Black ink is removed
2) The texture of the surface changes where the acetone is applied
3) Previous part marking becomes visible
4) Scratches, divots or other irregularities become apparent
5) Part marking is removed. This may result in a false positive because acetone is sometimes considered to strong to determine marking permanence.

Below are some examples of parts where the acetone test reveals modification of the top surface.







It must be taken into consideration that semiconductors may sometimes remark their own parts. It is rare but it does take place. They may have parts that were marked with a different speed or temperature grade and there is a need for a different part number. In these cases the parts will be tested to the specification that is needed and the new part number is marked on the part. It is my experience that in these cases the remarking is well done. Communication with the manufacturer about this issue is necessary to validate the authenticity of the part. The workmanship of manufacturer must also be taken into consideration as some of the smaller manufacturers still use ink to mark the parts instead of laser etching and they use different materials in the manufacturing process.

Scrape Test

As the counterfeiters became aware of the use of acetone to reveal the use of blacktopping in the remarking process, they began using a different material that was impervious to acetone. As a result of this new remarking process the scrape test was developed. The test consists of using a sharp blade (I suggest using an exacto knife or a razor blade) to lightly scrape the surface. The blade is used at a 90 degree angle with little pressure applied and the area to be examined is lightly scraped. Typically, if the part has not been resurfaced it will leave a "burn" or "scar" where the surface was scraped (Figure15) and there is no evidence of flaking.

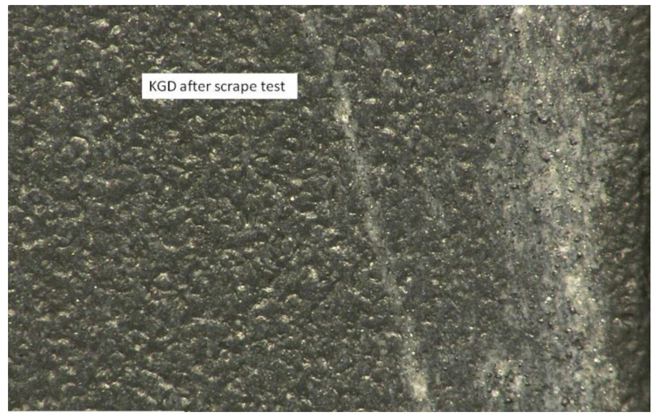


Figure 15

When the scrape test is performed on a part that has been remarked there is flaking visible on the surface where the part is scraped (Figure16, Figure17). It is also possible that previous part markings become visible (Figure18)

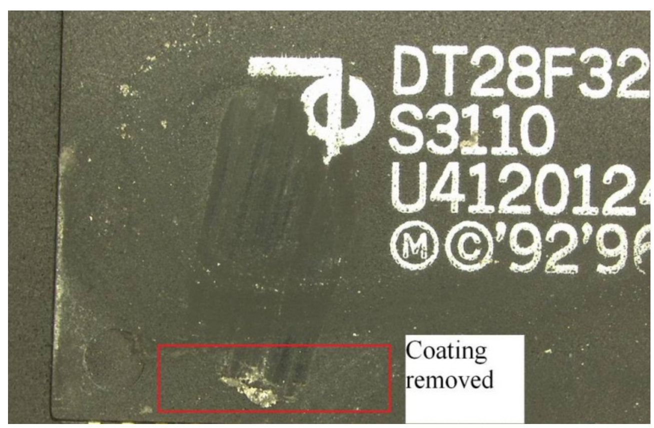


Figure 16

Figure 17

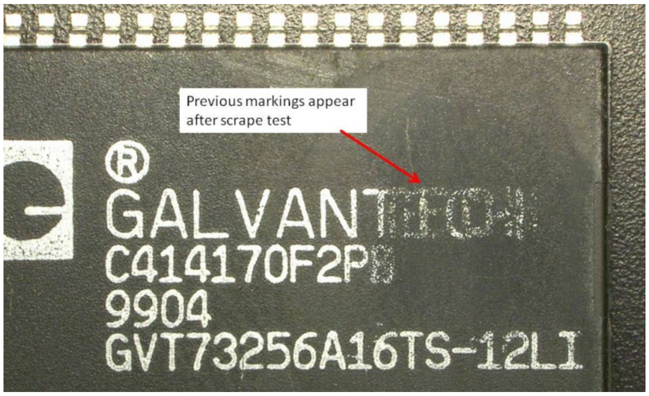


Figure 18

There are chemicals that can be used to dissolve this type of resurfacing. There are reasons that I do not recommend the use of these chemicals including the fact that the scrape test is much simpler and is nondestructive, the use of chemicals requires precise temperature and time to be reliable and the scrape test does not require the use of dangerous chemicals. When an experienced person performs the scrape it is much more reliable and safe.

Permanency Marking Test

This test is used to examine the resistance of part markings to solvents. The complete process is defined in Mil-STD-883G Method 2015.13. For the purposes of counterfeit detection it is not a reliable test as most markings on most counterfeit parts are impervious to this process. It is useful on ceramic semiconductors where the ink that is applied to the part has not been cured and to determine if a military grade part marking meets the requirement of the standard stated above. Below is an example of a military grade part that did not pass the test using solvent solution “a” as defined in the above standard (Figure19, Figure20).

Figure 19

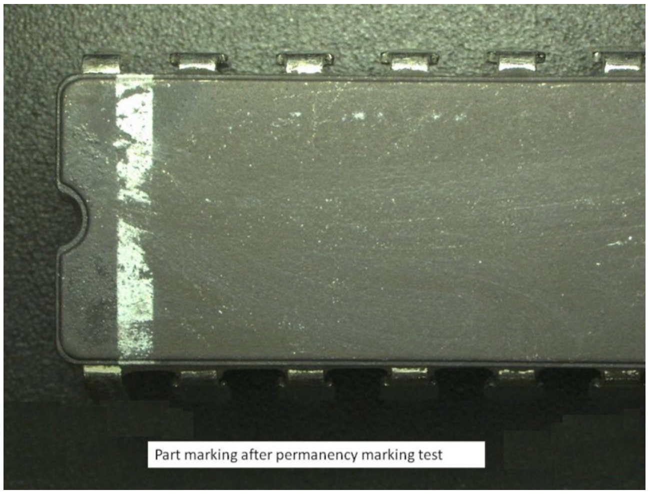


Figure 20

XRF Analysis

X-ray fluorescence is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays and is used to determine the elemental (chemical) makeup of a part. It is mainly used in the semiconductor industry to determine the “RoHS” status of a part. If the part markings indicate that a part is RoHS compliant and the part is determined through XRF analysis not to be ROHS compliant then it can be reasonably assumed that the part has been modified from its original condition (Figure21). The opposite is true as well (Figure22). The results of an XRF analysis can also be used to compare the elemental make up of a part to the manufacturer’s material declaration (when available). Since the majority of active components contain trace amounts of silver(Au) and or gold(Ag) in the die, failure to register any gold or silver when examining the semiconductor body may also indicate that there is no die in the part. This has been confirmed by me in the past when we decapped a part that did not register any gold or silver during the XRF analysis.

The part marking on this part indicates RoHS compliant.

Batch results							
Batch 101336 109325							
Date	Sample	Procedure	Element	Counts	Intensity	Concentration	Units
4/28/2009	101336 109325 MTW32N20EG LEADS PART 1	Cu_Macro	Cr	10334	0	0	ppm
			Cd	106504	0	0	ppm
			Pb	361618	687.297	215100	ppm

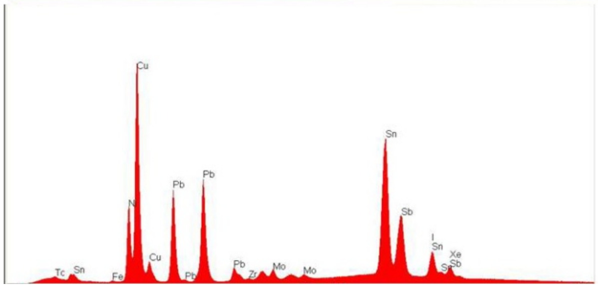


Figure 21

Batch results							
Batch 101630 109823							
Date	Sample	Procedure	Element	Counts	Intensity	Concentration	Units
7/14/2009	101630 109823 LT1461AIS8 5 CASING PART 1	PE_Macro	Cr	1276	0.0007350	93.637	ppm
			Br	138422	1.4330000	5021	ppm
			Cd	602	0.0000224	2.276	ppm
			Hg	2131	0.0000000	0	ppm
			Pb	10506	0.0000000	2.772	ppm
7/14/2009	101630 109823 LT1461AIS8 5 LEADS PART 1	Cu_Macro	Cr	10049	0.0000000	0	ppm
			Cd	205098	0.0000000	0	ppm
			Pb	28211	0.0000000	4.455	ppm
7/14/2009	101630 109823 LT1461AIS8 5 CASING PART 2	PE_Macro	Cr	1559	0.0000146	1.857	ppm
			Br	242796	1.1350000	3983	ppm
			Cd	1067	0.0000000	0	ppm
			Hg	4313	0.0010900	11.493	ppm
			Pb	16857	0.0000000	2.772	ppm
7/14/2009	101630 109823 LT1461AIS8 5 LEADS PART 2	Cu_Macro	Cr	2052	0.0000000	0	ppm
			Cd	16060	0.0000000	0	ppm
			Pb	1636	2.0640000	650.585	ppm
7/14/2009	101630 109823 LT1461AIS8 5 CASING PART 3	PE_Macro	Cr	1686	0.0000467	5.944	ppm
			Br	258058	1.5560000	5452	ppm
			Cd	998	0.0000133	1.35	ppm
			Hg	4135	0.0065000	131.252	ppm
			Pb	16781	0.0000000	2.772	ppm
7/14/2009	101630 109823 LT1461AIS8 5 LEADS PART 3	PE_Macro	Cr	1825	0.0008759	0	ppm
			Cd	440	0.0000000	0	ppm
			Pb	3858	0.0048200	82.078	ppm

The part number on this part indicates that the part is not RoHS compliant. The test results show very low amounts of lead(Pb) which is contradictory to the marking on the parts.

Figure 22

Decapsulation and Die Verification

Decapsulation is the process of removing the outer material from a semiconductor to reveal the die that is contained within the device. This can be accomplished in various ways depending on the material that the outer body of the semiconductor. PEM semiconductors are covered with a resin and the resin is generally removed by a chemical process. Chemicals such as sulfuric acid and fuming nitric acid will dissolve the resin without damaging the die when heated. Ceramic semiconductors that are hermetically sealed can be decapped by forcing or cutting the top section from the bottom. Metal cans can be decapped by the use of a cutting instrument such as a diamond saw. Decapping the part to reveal the die is only the beginning of the process. Once the die is available for optical examination the die must be viewed under a fairly high magnification for examination of the die layout, and die markings. Since not all die markings clearly identify the part, the die of a known good device for comparison is the best method to determine if the die is authentic. However, if this is not an option there are some items to look for:

1) Is the manufacturer's name or logo on the die?
2) Is there part marking on the die that is consistent with the part number on the part itself?
3) Are there trademark and or copyright marks? If so is the copyright date consistent with the part itself?
4) Is there any other marking that can be used to identify the part? Some manufacturers use a "code" to identify a part.
5) Is the die layout consistent with the part? If you have a schematic of the die layout is it comparable to the die?

One major drawback in relying on die comparisons is that they do not necessarily designate the speed or temperature grade of the part. Most commercial and industrial temp parts will use the same die for the part. The difference in the temperature or reliability of a part is usually determined by the amount of testing done to the part after it is assembled. Some manufacturers use the same die for multiple part numbers so verification can sometimes be difficult and may lead to the false identification of a part as counterfeit that is not (Figure23). Some die may be cross licensed or be manufactured by a secondary vendor where the manufacturer indicated by the die may not be the manufacturer that is indicated by the part itself.

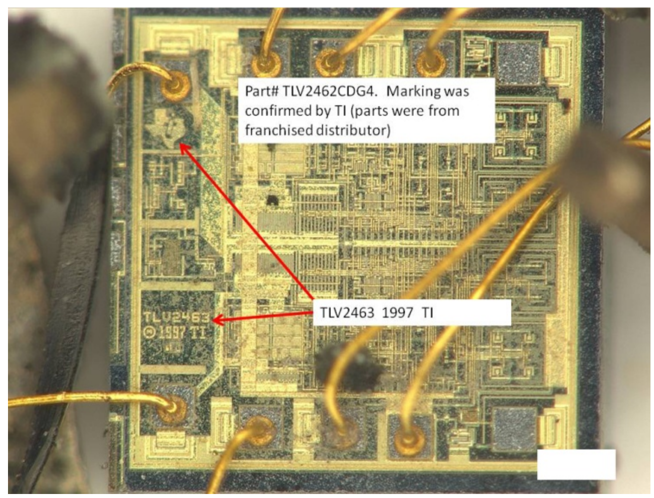


Figure 23

Figure24 and Figure25 show a ZXRE1004 that has been decapped. Figure24 is from a device that was determined counterfeit and Figure25 is directly from the manufacturer.

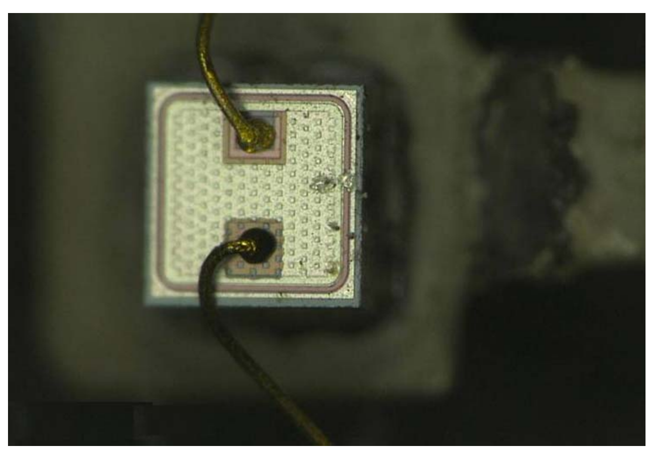


Figure 24

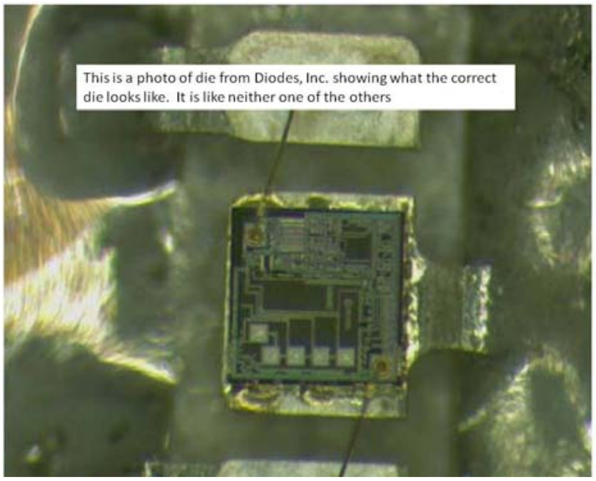


Figure 25

X-ray

There are a variety of ways that x-ray inspection of a semiconductor device can be useful. First is that they can determine that there is a die in the device. Second, it can be used to compare the die size, layout and wire bonds to a known good device or schematic of the die. It can also detect any wire bond damage that may have been caused by the mishandling of the device which in turn can be an indication that the device is counterfeit (if there is wire bond damage the part would be considered bad and would not be used in production). X-ray inspection of the leads can show inconsistencies of the lead plating. The x-raying of BGAs may reveal excess voids in the solder spheres which may indicate reballing of the parts. Though the x-raying of a device is not foolproof method for determining if a part is authentic it has two advantages; it is non-destructive, the parts can be examined in their original packaging and can show other issues with the part that would make the part unusable.

C-SAM

C-mode scanning acoustic microscopy (C-SAM) is a non-destructive inspection method that is used to detect any delamination of the device. It can also be used to detect any previous part markings that are on a part that has been remarked.

Testing

There are different levels of electrical testing that can be useful in determining if a part is counterfeit. Basic electrical testing can measure parameters such as voltage in, voltage out, continuity and pin correlation of a part. Limited function testing is designed to test specific function parameters of a part. Full function testing does a complete function test of a part. All electrical testing is performed to the specifications on the manufacturer's datasheet. There are a few problems with having testing done. First is the cost. Even the most basic DC test may cost thousands of dollars just for the test fixture. As you progress to the more complete function testing the costs go higher (I have been quoted as high as $25,000 just for the non-recurring engineering charge). Another is the time it takes to set up a test fixture and develop the software for testing. Then there is the time that it takes to test the parts. Even after all the electrical and functional testing is completed there is still a possibility that the part is counterfeit and this may lead to latent failures. In the case of a mission critical or life dependent device the failure of even a two cent part could be catastrophic.

History

Since the 1980's parts were recycled and sometimes sold as new. They were handled in ways today that would cause un-repairable ESD, thermal stress and or moisture damage to parts that are in use today. In the early to mid 2000's the counterfeiters were less sophisticated than they are today. They would package a part with a lead frame and no die, a mechanical sample so to speak, and sell them as new fully functional parts. They then began pulling parts from boards and refurbishing them. They would sort the parts by package type, lead type and lead count and size and sand the top surface to remove the original part markings. In this case they did not sort by part number or part type and electrical testing could reveal that the part was counterfeit. As they evolved, they would pull the parts, separate them by part number and sometimes similar function. They would then sand the tops and remark them. This was even a bigger concern for manufacturers as the parts may pass a full function test but there could be reliability issues in the life of the part. They would also mark a commercial grade part as an industrial grade part or even military grade. Other sources of the material that was being used were what is sometimes called the "third shift" where employees were manufacturing the product without authorization or any testing and from test failures, where parts would fail lot testing and be designated as scrap would somehow re-enter the market. In the beginning, parts that had been remarked had been resurfaced with an ink type material to hide any damage done by the sanding. Once the acetone test became widely used they changed to a blacktopping material that was impervious to the blacktopping and therefore this was combated by the use of the scrape test and other the other methods discussed earlier. There is also "true" counterfeiting taking place in the electronics industry where a non-authorized manufacturer manufactures it's own part and label it with a false label that indicates it was made by another manufacturer. This is mostly done with passive components (capacitors resistors, diodes, inductors to name a few) and mechanical components (wire, sockets, housings, pins, etc.).

CONCLUSION

As technology changed and parts became smaller, used less power and were more susceptible to static discharge and moisture, most manufacturers and distributors put ESD and MSL compliant processes in place. There is no evidence that the counterfeit parts that are in the market today have been handled with such scrutiny, quite the opposite. The methods used to store the circuit boards and to remove the parts from the circuit boards are less than desirable. We have all seen instances where there are piles of circuit boards laying on the ground outside. We have also seen the uncontrolled heat source that is used to remove the parts from the circuit board. The act of sanding the parts also puts physical stress on the parts. With these issues in mind, it is imperative that processes be put into place to detect counterfeit parts before they go into manufacturing. AS5553 has addressed this as well as risk mitigation but until there is not a market place for the counterfeit parts there will be counterfeiting. A complete, diligent incoming inspection process will cut down the number of incidences where a counterfeit part is used in production. That being said, there are a few things that are important when performing the inspections:

1) Known good device-this is the most desirable tool for determining the authenticity of a part.
2) Training-the personnel performing the inspection must be properly trained and retrained as needed
3) Experience-there is no substitute for experience. The more an individual sees the more he can learn from.
4) Tools-having the correct tools for the job is always important
5) Documentation-all observations should be documented and easily accessible.
6) Review-since it is not necessarily just one item that indicates a part as being counterfeit it is important that all observations and documents be review.
7) The inspection process must be dynamic-as we discover new methods to identify counterfeit parts the counterfeiters change what they do. We must be willing and able to change.

REFERENCES

[1] SAE AS5553 Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition