

Counterfeit Electronic Parts Detection through Packaging Evaluation

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Abstract

Counterfeit electronic parts have become a significant cause of worry in the electronics part supply chain. Most of the counterfeit parts detected in the electronics industry are either new or surplus parts or salvaged scrap parts. The packaging of these parts is altered to modify their identity. The modification can be as simple as the removal of old marking and then adding new marking, or as sophisticated as recovery of the die and repackaging.

In this paper we discuss the type of parts used to create counterfeits and the defects/degradations inherent in these parts due to the nature of the sources they come from, proposed inspection standards, and limitations of these standards. The processes used to modify the packaging of these parts to create counterfeits are then discussed along with the traces left behind from each of the processes. We then present a systematic methodology for detecting signs of possible part modifications to determine the risk of a part or part lot being counterfeit.

Keywords: counterfeit, packaging, inspection

1 Introduction

A counterfeit electronic part is one whose identity (e.g., manufacturer, date code, lot code) has been deliberately misrepresented. Several factors contribute to the targeting of the electronic parts market by counterfeiters, including obsolescence; lead time (manufacturer or an authorized distributor unable to supply parts within the lead time requirement of customer); price issues (parts available at lower prices from independent distributors and brokers); absence of pedigree verification tools in the electronics part supply chain; availability of cheap tools and parts to create counterfeits; and costly inspection/testing procedures.

Easy availability of parts with the counterfeiters is one of the prominent reasons for the growing problem of counterfeit electronic parts. There are relatively few incidents of illegal manufacturing in the electronics industry due to the high costs involved in manufacturing electronic parts such as integrated circuits. Counterfeit parts are generally relabeled part (e.g., marked as higher grade or with a recent date code or as RoHS¹ compliant), refurbished parts (i.e.,

used part reworked to appear as new), or repackaged part (e.g., recovery of die and repackaging). Counterfeiters have access to reclaimed, scrapped, and excess parts, which are easily available from unauthorized sources.

Excess inventories are electronic parts that are no longer required by product manufacturers or contract manufacturers for normal production needs [7]. Excess inventories result due to a variety of reasons, such as differences between forecasts and actual production schedules, delay in discontinuations of slow moving product lines, and economic recessions. Disposal options for excess inventories include alternate use within the company; returning the parts to original suppliers (manufacturers, distributors); disposing of the parts in gray markets (unauthorized markets); and scrapping the parts. Out of the four disposal options, selling the parts in the gray market creates a source of parts for counterfeiters. Improper scrapping procedures used to scrap the excess parts (in the absence of other disposal options) can also result in counterfeiters salvaging the parts.

The pedigree of excess parts is often unknown due to the anonymous nature of transactions taking place in gray markets. The quality of excess parts depends on prior storage conditions, the duration of storage, and handling procedures. Depending on the

¹ The RoHS Directive stands for the restriction of the use of certain hazardous substances in electrical and electronic equipment.

construction, handling, and storage, excess parts can become unsolderable, contaminated, damaged, or otherwise degraded.

Part manufacturers and testing companies often scrap parts, which fail quality checks and other screening tests (e.g., electrical tests, burn-in). Often companies do not destroy the parts themselves but instead rely on third parties to do this. However, some parts escape destruction and are salvaged by counterfeiters. Examples of attributes of scrapped parts include absence of die, lifted wire bonds, missing or no bond wires, and damaged terminations (e.g., broken leads, balls, or chip-out in the terminations of passive parts).

Reclaimed parts are parts that have been recovered from assembled printed circuit boards of discarded electronic products and failed boards (scrapped by contract manufacturers). The pedigree of the discarded products is often unknown. Parts that are reclaimed from such products may have unknown defects or degradations. Reclaimed parts may also have defects induced during the reclamation procedures, such as damaged terminations, popcorn damage in the molding compound, and delamination of the molding compound from the die attach [6].

Apart from excess inventories, scrapped parts, and reclaimed parts, counterfeiters may also buy new parts and relabel or repackage them to make them appear to be a different part. Such parts may have handling or packaging related damages such as ESD² damage or poor workmanship issues.

Visual inspection can be carried out with optical microscope, unlike electrical material characterization (e.g., XRF³) and destructive tests (e.g., delidding) that require expensive tools and equipment. Visual inspection can be a first step in the detection process, but should not be the only method. The visual inspection process also requires access to data sheets and support from manufacturers to obtain the actual attributes of parts, e.g., date code validity.

An electronic part that has been re-marked with good quality ink and without errors is hard to detect through the visual inspection method. Marking permanency tests will not work in the case of laser-marked parts. Even in case of ink-marked parts, marking permanency tests may erase the marking of an authentic part, thus giving the impression of the part being counterfeit. With the growing sophistication of technology, counterfeiters use better quality inks and laser equipment to create counterfeit parts. A salvaged scrap part, which has been scrapped because of internal quality problems, such as missing

bond wires, may not be detected through the visual inspection method or marking permanency tests. A part that has been repackaged (from the die) may have discrepancies (e.g., different date code) in the die and package markings. Such discrepancies can only be detected through destructive techniques such as delidding. Refurbishing techniques such as reballing and solder dipping may initiate failure mechanisms such as interfacial delamination or bond pad corrosion, which can only be detected through scanning acoustic microscopy. Visual inspection also cannot detect discrepancies in termination plating materials. Such discrepancies can only be detected through material characterization techniques such as XRF spectroscopy.

Table 1: Types of Parts Used to Create Counterfeits

Types of parts	Sources and attributes
Excess inventories	Sources: OEMs ⁴ , Contract manufacturers Attributes: handling, packaging, and storage related damage; defects due to aging; no traceability; unknown pedigree
Scrapped parts	Source: part manufacturers, testing companies, contract manufacturers Attributes: internal quality problems such as missing die or bond wires; die contamination; part termination damage
Reclaimed parts	Source: recyclers Attributes: damaged terminations and body; inherent defects induced during reclamation; unknown pedigree

The Independent Distributors of Electronics Association (IDEA) has developed a document for acceptability of electronic parts that are distributed in the open market [3]. The document, IDEA-STD-1010A, provides visual inspection techniques (including marking permanency tests) and acceptance criteria for open market parts. Electrical and destructive or invasive inspection techniques (e.g., delidding) are out of the scope of this document and it only covers visual inspection of the markings, surface texture, mold pin, external packaging (tray or tube), and body of a part. This document or any other methods that use only external visual inspection are not sufficient for detecting counterfeit parts.

Some test laboratories depend on electrical tests for detecting sub-standard and counterfeit parts. Electrical tests include parametric testing, board-level testing, and hardware and software functionality

² Electrostatic discharge.

³ X-ray fluorescence spectroscopy.

⁴ Original equipment manufacturers.

testing. In most cases, electrical tests are used to detect non-functional or failed parts. Counterfeit parts may function properly during the electrical tests, but they may have inherent defects (e.g., delamination) induced during refurbishing or re-marking. Inherent defects induced during the counterfeiting process can only be detected through a systematic packaging evaluation. In this paper we present a counterfeit detection process that incorporates packaging evaluation using tools and methods to detect signs of possible part modifications.

Table 2: Limitations of Using Visual Inspection Alone for Detecting Counterfeits

Types of counterfeit parts	Examples of limitations of visual inspection
Repackaged	- o Cannot detect internal discrepancies such as bond wire misalignment or missing bond wires, missing or damaged die - o Cannot detect die and package marking mismatches
Remarkd	- o Fails if markings on counterfeit parts are good quality - o Need access to datasheets or support from original manufacturer
Refurbished	- o Cannot verify RoHS compliance claims - o Cannot detect termination plating discrepancies with original parts - o Cannot detect internal failure mechanisms induced during the refurbishing processes such as interfacial delamination
Salvaged scrap parts	- o Markings may be original manufacturer's, thus difficult to detect any discrepancies - o Internal problems such as missing die or bond wires cannot be detected

2 Creation of Counterfeit Parts

With easy availability of parts to create counterfeits, counterfeiters have developed inexpensive methods of counterfeiting that rely on modifying the packaging of the parts by processes such as relabeling or refurbishing. In this section, we discuss the three most commonly used methods used by counterfeiters to create counterfeits.

2.1 Relabeling

Relabeling is the process of modifying/altering the markings on a part to make it appear as a different part. A typical part marking includes part number, lot number, and the manufacturer's logo. In some cases, part marking also includes the country of origin mark. The relabeling process includes erasing the

original marking by methods such as black topping or sand blasting and applying a new marking to create a different part. Sandblasting is the process of smoothing, shaping, or cleaning a hard surface by forcing solid particles across that surface at high speeds. Blacktopping is a process in which a new layer material is used to cover over the top surface of a part to cover the old marking and apply a new marking. Blacktopping may be carried out after the part has been subjected to sandblasting.

Relabeling may be carried out according to the needs of the customer to have higher grade parts (e.g., changing processor speed), different parts with the same pin count and packaging type, different vintage parts (e.g., changing date code), or different military specifications. Some cases of relabeling also include dual part marking, i.e., the presence of part marking at two different places on the part.

GIDEP issued an alert about operational amplifiers, LT1057AMJ8/883 with date code 0122 in 2006. Linear Technology Corporation (LTC) received the parts from a customer when the parts failed functional tests at the customer's facility. Destructive and physical analysis (DPA) of the parts revealed the die to be an original LTC die manufactured in October 1995 as a military lot. The parts were found to have been relabeled to make them appear to be new parts [8].

Relabeling leaves behind traces that can be detected through visual inspection or marking permanency tests. Some of the traces left behind are part marking irregularities such as spelling mistakes, different marking techniques used (e.g., X-ray marking instead of ink marking); dual part markings; part markings with invalid date codes or part numbers; parts (ink-marked) failing marking permanency tests; a filled-in or unclear pin-1⁵ cavity; die markings (date code, manufacturer) not matching with the package marking; and absence of country of origin marking.

2.2 Refurbishing

Refurbishing is a process in which parts are renovated in an effort to restore them to a like new condition in appearance. The terminations of refurbished parts are realigned and re-finished (in the case of leads) or undergo reballing (in the case of balls) to give them a new finish. Refurbishing is often carried out in conjunction with relabeling to sell used parts as new parts. Refurbishing is also carried out to

⁵ "Pin-1 cavity" is a designation used for indexing or numbering the pins and part placement.

hide defects that arise during reclamation of parts from circuit boards and improper handling. Refurbishing induces defects/degradations in parts such as bridged balls, missing balls, broken leads, popcorning, warpage, or localized delamination.

Realignment of leads (such as straightening) is often carried out on reclaimed or scrapped parts that have bent or non-aligned leads caused during reclamation of the parts from printed circuit boards or poor handling. Realignment of leads may cause damage to terminations such as broken leads or improperly aligned leads. The realignment process may also cause internal defects such as interfacial delamination and cracked passivation layer.

Solder dipping is used to change the lead finish, i.e., from Pb-free to Pb or vice-versa. It is also used to improve or restore the solderability of the parts, and can act as the primary finish for the terminations. But poor finish and thermal shock during the solder dipping process can lead to defects in the terminations such as bridging across leads, delamination leading to package cracking, a cracked passivation layer, and metallization deformation [2].

Reballing is a process carried out on ball grid array (BGA) parts to replace damaged balls or to change the termination finish from Pb-free to Pb or vice-versa. Counterfeiters often use the reballing process to refurbish the part terminations (BGA) of reclaimed or used parts (with damaged balls) to make them appear to be new parts. Improperly performed reballing can lead to defects such as missing solder balls, damaged pads, and bridged balls. Other defects caused by improper reballing are warpage, popcorning, and local delamination.

2.3 Repackaging

Repackaging is the process of altering the packaging of a part to make it appear to be a different part with a different pin count and package type (e.g., dual-in-line (DIP) or plastic leaded chip carrier (PLCC)). The process involves recovery of die (by removing the original packaging) and molding the die into the desired package type. Counterfeiters generally do not use proper handling procedures, tools, and materials for repackaging the die, which may lead to defects/degradations in the repackaged parts such as die contamination, moisture-induced interfacial delamination, and cracks in the passivation layer. There may also be workmanship issues with the repackaged parts such as missing bond wires, missing die, bond wire misalignment, or poor die paddle construction. The marking on repackaged parts also may not match with the die markings. There may also be marking irregularities such as spelling errors, discrepancies in part number, or an

incorrect logo. Counterfeiters may also use inferior quality materials to package the die, such as cheap filler materials and flame retardants.

Table 3: Processes Used to Create Counterfeits and Associated Traces and Defects

Process of counterfeiting	Associated traces and defects
Relabeling	Marking irregularities, poor quality marking, filled-in or unclear mold cavities, discrepancies in package marking with the die marking, ESD damage
Repackaging	Discrepancies in package marking with the die marking; workmanship issues such as missing bond wires or poor die paddle construction; internal defects such as moisture induced interfacial delamination; poor materials used
Refurbishing	Bridged or improperly aligned terminations; internal defects such as interfacial delamination and cracked passivation layer induced during processes such as solder dipping, reballing, and realignment of terminations; differences in termination plating material with original part

3 Detection of Counterfeit Parts

Most of the counterfeit parts detected in the electronics industry are either new or surplus parts or salvaged scrap parts that are modified. The modification can be as simple as removal of marking and re-marking or as sophisticated as recovery of the die and repackaging. All package modifications leave behind a trace and in this section we present a methodology for detecting signs of possible part modifications to determine the risk of a part or part lot being counterfeit. The evaluation methodology begins with visual inspection and marking permanency tests for external compliance and X-ray inspection for internal compliance. These inspection processes are followed by material evaluation in destructive and non-destructive manners such as XRF and material characterization of the mold compound. These processes are then followed by evaluation of the packages to identify defects and degradations in failure mechanisms that are caused by the processes (e.g., cleaning, solder dipping of leads, reballing) used in creating counterfeit parts. This method of assessment is necessary since the electrical functionality and parameters may be met by the counterfeit parts, but their authenticity can only be evaluated by the evaluation of the packaging. The latent damages caused by the counterfeiting process can only be detected by packaging evaluation and we implement the package reliability and failure mechanism information in our detection method.

Table 4: Inspection Methods, Severity and Tools or Equipment Needed

Inspection method	Severity and tools or equipment required
External visual inspection	Severity: non-destructive, may induce handling related damage such as ESD if precautions are not taken Tools/Equipment: optical microscope, solvent for marking permanency tests, part datasheet information
X-ray inspection	Severity: non-destructive, may induce handling related damage such as ESD if precautions are not taken Tools/Equipment: X-ray machine, X-ray images of an authentic part
Material evaluation and characterization	Severity: may be destructive or non-destructive depending on the type of equipment used Tools/Equipment: XRF, scanning electron microscope (SEM), electron dispersive spectroscope (EDS), differential scanning calorimeter (DSC), thermo-mechanical analyzer (TMA), hardness testers, Fourier transform infrared spectroscope (FTIR) Information on original part material may be needed
Packaging evaluation	Severity: non-destructive Tools/Equipment: scanning acoustic microscope (SAM)
Die inspection	Severity: destructive Tools/Equipment: decapsulator, can also be carried out through manual etching; information on original die markings and attributes needed

3.1 External Visual Inspection

External visual inspection is a process of verifying the attributes of parts such as package and part markings (part number, date code, country of origin marking), part termination quality, and surface quality. Visual inspection is performed on a sample of parts from a given lot. Resources required for carrying out visual inspection are standard tools for handling electrostatic sensitive parts [4], part datasheet information (part number format, dimensions, number of pins and package type), a microscope with at least 30X magnification (magnification of the microscope can be adjusted to inspect certain features of the part), a camera built into the microscope (some of the processes of determining a counterfeit require sending copies of photos to different resources for their evaluation), and a solvent to check for part marking permanence.

The visual inspection starts with the inspection of the label on the packaging in which the parts are

shipped. Things to look for are spelling errors on the manufacturer labels, validity of manufacturer codes on the labels (such as codes that contain information on manufacturing location), verification whether the date codes on the external packaging match date codes on the parts, and validity of date codes. The packaging inspection also includes any part specific requirements such as the requirement of a dry pack and a humidity indicator card for moisture-sensitive parts.

The next step in the inspection process is the verification of whether the part markings, such as logo, part number, lot code, date code, and Pb-free marking (if any), conform to the shipping and purchase order information. This is followed by verification of the validity of the part number, date/lot codes, and Pb-free marking (if any) with the original part manufacturer requirements. In some cases counterfeiters may not place Pb-free marking on the parts (when they relabel the parts with newer date codes), though the original manufacturer may have shifted to Pb-free manufacturing. The part should also be inspected for any dual part marking, such as marking on the top as well as on the side of a part with different and often conflicting information. The markings should also be inspected for any irregularities such as spelling mistakes, font size differences compared with the original part, and the marking technique used on the part. For example, an authentic part may have ink marking, whereas the counterfeit part may have laser marking. Figure 1 provides examples of items to look for during visual inspection of a part.

Marking with inferior quality inks or laser equipment can be detected by conducting marking permanency tests on the parts or looking for any laser-induced defects on the parts, such as holes on the surface. Acetone is a common chemical used to determine if a part has been remarked, but a less harsh solvent is a combination of 3 parts mineral spirits and one part alcohol. This is the mixture that MIL-STD-883 (Method 2015.13) [9] requires part markings to withstand. If the result of the marking permanency test is a change in the surface texture or wiped-off marking, this is a possible sign of the part's being counterfeit.

The pin-1 cavity and other mold cavities (part of the plastic mold process) present on a part should be inspected for uncleanness or unevenness, because sandblasting or blacktopping leaves the mold cavities unclean or filled in. Verification of the pin-1 or other mold cavities on a part is a critical way to determine signs of relabeling on a part. In some cases, counterfeiters also etch a new pin-1 cavity in place of the filled-in cavity. Also, the presence of marking

over the pin-1 cavity is a sign of the part's being counterfeit.

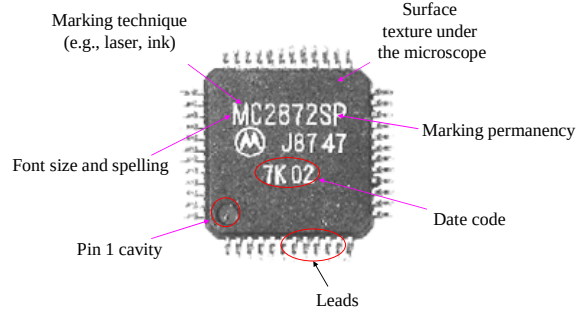


Figure 1: Examples of items to look for during visual inspection

The surface texture of a relabeled part is different from an authentic part. The surface of an authentic part when looked at with a microscope is usually sharp and rough (due to the presence of glass particles), whereas surface of a relabeled part is smooth because of relabeling methods such as sandblasting or blacktopping. Sandblasting also leaves marks that have a directional pattern on the surface of a part. Sandblasting also leads to rounded corners and edges.

Visual inspection also includes inspection of the part termination (leads or balls) quality to detect possible signs of counterfeiting. Part terminations should be inspected for any signs of refurbishing (solder dipping or reballing) or damage (broken or bent leads, bridged balls) due to reclamation. If the termination type is leads, things to look for are straightness, coplanarity, scratches, or other defects caused by reclamation or prior use. Termination refurbishing techniques such as solder dipping and reballing leaves behind traces that can be detected through visual inspection, such as bridged terminations and missing solder balls.

3.2 X-ray Inspection

X-ray inspection is carried out to conduct internal inspection on parts to verify the attributes of parts such as die size and bond wire alignment. X-ray inspection is also used to detect anomalies such as missing bond wires, missing die, or the presence of contamination (Figure 3). Counterfeit parts are sometimes packaged without a die or with a different die. Finding a different die does not necessarily indicate a counterfeit since manufacturers sometimes will institute a process change on a particular product (but production protocol requires a change in lot/date code). The resolution of commonly available X-ray imaging is not sufficient to resolve markings on the die surfaces to authenticate the device.

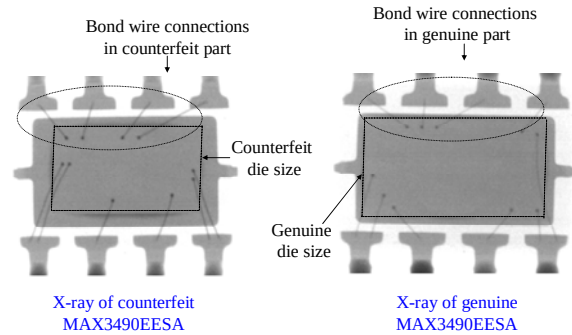


Figure 2: Example of X-ray inspection⁶

3.3 Material Characterization

Counterfeit parts often have discrepancies in termination material or molding compound material when compared with an authentic part. A part that has been relabeled with a newer date code may have SnPb as the termination material, whereas the authentic newer version of the part has no Pb in the termination. Similarly, the same counterfeit part may have halogen in the mold compound, whereas the authentic newer version of the part may be halogen-free to comply with RoHS directives. Similarly, a counterfeit part may also claim to comply with RoHS directives but may actually have Pb or halogens in the termination finish or mold compound.

X-ray fluorescence spectroscopy (XRF) can be carried out on the parts to evaluate the material composition of the terminations and the molding compound in order to detect the presence or absence of Pb and any other discrepancies with an authentic part. XRF can also be a useful tool to detect counterfeit passives. CALCE conducted an analysis on customer-returned multi-Layer ceramic (MLCC) capacitors using X-ray fluorescence spectroscopy. The capacitors were found to be similar to an authentic part except for low concentration of a critical element, Yttrium.

Another method of evaluating the material composition is through scanning electron microscopy (SEM) and electron dispersive spectroscopy (EDS). SEM is conducted on parts after removing the encapsulants (decapsulation) or after delidding. For example, SEM microscopy can be used to verify the elemental composition of the metallization layers. SEM microscopy can also be used to verify the solder plating composition on the part termination.

If a non-authentic raw material is used in a part, polymeric materials such as the component molding compounds, attach materials, coatings, and laminate

⁶ GIDEP: Government industry data exchange program.

or substrate materials need to be evaluated in comparison with the authentic parts in order to detect counterfeit parts. Tools and equipment that aid in material characterization includes differential scanning calorimeter (DSC), thermo-mechanical analyzer (TMA), dynamic mechanical analyzer (DMA), hardness testers, and Fourier transform infrared spectroscopy (FTIR). These tools can be used on the parts and their constituent materials to measure the material properties such as glass transition temperature, coefficients of thermal expansion, and thermal conductivity.,.

3.4 Packaging Evaluation to Identify Hidden Defects/Degradations

Processes used to create counterfeits such as relabeling, refurbishing, and repackaging often induce internal defects/degradations in parts due to a lack of proper equipment/tools used and improper handling procedures. In this section we provide techniques and procedures for packaging evaluation to identify hidden defects/degradations.

Delamination, voids, and cracks in plastic-encapsulated microcircuits lead to failure mechanisms such as stress-induced passivation damage over the die surface, wire bond degradation due to shear displacement, accelerated metal corrosion, reduction in die attach adhesion, intermittent outputs at high temperature, popcorn cracking, die cracking, and device latch up (hot spot formation). Defects such as delamination, voids, and cracks can be caused due to thermal and mechanical shocks during reballing, solder dipping, realignment of leads, and repackaging.

Moisture-induced interface delamination can occur during each of the processes of relabeling, refurbishing, and repackaging. Moisture-induced interface delamination begins with the package absorbing moisture from the environment, which condenses in micropores in polymer materials such as the substrate, die-attach, molding compound, and various adhesives along the interfaces. During the PCB assembly process, when the part is exposed to high temperatures associated with the soldering process, popcorning may occur.

Scanning acoustic microscopy (SAM) is a non-destructive method which can be used to detect delamination of the molding compound from the lead frame, die, or paddle (top side and bottom side separately); voids and cracks in molding compound; and unbonded regions and voids in the die-attach material. SAM can detect hidden defects such as delamination growing along the die, isolated voids (bubbles or from outgassing), lack of die attach

material between die and substrate, and delamination growing along substrate. Procedures for acoustic microscopy for non-hermetic encapsulated electronic parts are provided in JEDEC Standard J-STD-035 [5] and NASA Standard PEM-INST-001 [1]. Examination of the package for voids, cracks, and delamination should be performed at multiple locations including the interface between the die surface and molding compound (top view), and interface between the lead frame and molding compound (top and back view).

3.5 Die Inspection

For die inspection, a preparatory method to access the die is necessary. Once the die is exposed, the attributes of the die, such as die markings (e.g., manufacturer logo, date code), passivation layer quality, and interconnection quality, can be verified using a high power microscope (Figure 3). A part that is counterfeited using relabeling and repackaging will usually have discrepancies in the die and package marking. Defects induced during the refurbishing process due to thermal and mechanical shock such as metallization layer damage (due to ESD, corrosion), contamination, bond wire defects, and cracks in the passivation layer can be detected by inspecting the die features. Repackaging-induced defects, such as chip-to-substrate attachment failure leading to voids and thermal stress problems, deformation of bond wires due to improper bonding, and cracks at the bond pad–bond wire junction, can also be detected by inspection of the die area.

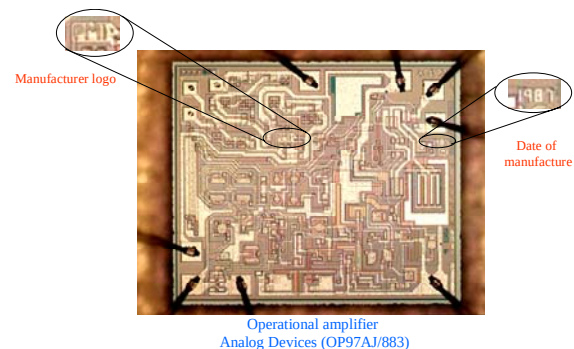


Figure 3: Example of die inspection⁷

4 Summary and Recommendations

Often there is damage inherent in parts that are used to create counterfeits. The damage may result from improper handling, storage, or packing procedures, as in the case of new or excess

⁷ GIDEP: Government industry data exchange program

inventories or overruns. Damage may also occur when parts are reclaimed from assembled printed circuit boards. Parts may also have failed even before they were counterfeited, as in the case of parts that are scrapped by the part manufacturer during quality control (QC) checks. Parts may be counterfeited using processes such as relabeling, refurbishing, and repackaging, each of which leaves behind traces in some form or other.

A systematic methodology for detecting counterfeit parts has been presented in the paper. The methodology consists of external visual inspection, marking permanency tests, X-ray inspection, and material evaluation and characterization, followed by identification of defects or degradations that may have been induced during the counterfeiting process, and die-marking inspection. This methodology helps in detecting signs of possible part modifications to determine the risk of a part or part lot being counterfeit. Table 5 summarizes the methodology and tools.

Table 5: Inspection Methods and Traces or Defects to Inspect

Inspection method	Items of Review
External visual inspection	Spelling errors in part markings or labels; validity of logo, part number, lot code, date code, and/or Pb-free marking; marking technique; quality of marking; mold cavities; straightness, coplanarity, scratches, bridging or other defects in terminations; surface texture
X-ray inspection	Die size; bond wire alignment; anomalies such as missing bond wires, missing die, or presence of contamination
Material evaluation and characterization	Termination plating materials, molding compound, attach materials, coatings, laminate or substrate materials
Packaging evaluation	Delamination of the molding compound from the lead frame, die, or paddle; voids and cracks in molding compound; and unbonded regions and voids in the die-attach material
Die inspection	Die markings (e.g., manufacturer logo, date code), passivation layer quality, interconnection quality, metallization layer damage (due to ESD, corrosion), contamination, bond wire defects

We expect that organizations will evaluate the sources of parts prior to purchasing parts from them and thereby eliminating the biggest risk factor of obtaining counterfeit parts. To be effective, the inspection process needs to come to a conclusion within a relatively short period of time and hence a

logistics plan of performing the evaluations needs to be in place since all the equipment and expertise may not reside in the same location.

The inspection methodology presented in this paper is a tool of last resort and it is no substitute for sound supply chain management methods. The cost of inspection can add up to be significant in relation to the cost of parts. The possibility of damage of parts from additional handling associated with inspection remains even when the parts are determined not to be counterfeit. All things considered, a strict and effective inspection method will help in finding suspect counterfeit parts but it will not necessarily save time and money for an organization.

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