



AEROSPACE STANDARD

AS6171™/6

Issued 2016-10

Techniques for Suspect/Counterfeit EEE Parts Detection by Acoustic Microscopy (AM) Test Methods

RATIONALE

This document provides guidance and requirements on the Acoustic Microscopy (AM) test procedures to be employed by the Test Laboratory (Lab) for the non-destructive AM testing of parts for suspect counterfeit (SC) part detection. The level of testing shall be derived by the User Organization working in conjunction with the Test Lab, taking into consideration the risk level as defined in the SC part detection flow specified herein. It shall be the responsibility of the Test Lab to conduct the AM test following the sequence of inspections for a given risk level specified herein. The creation of this document is a step in addressing the ever-increasing global problem of electronic parts counterfeiting.

INTRODUCTION

Because many methods of counterfeiting of electronics involve a change of material from the original part, AM can provide a method of inspection of parts and detecting differences in their material composition. The method has been used extensively to detect non-conforming parts in electronics and in many other product areas. The implementation of Restriction of Hazardous Substances (RoHS) requirements of the European Union and similar laws in other countries, resulted in wide spread use of AM techniques to confirm that electronic parts are not damaged while subjected to a surface mount to a PCB process. This document provides techniques based on those practices to detect Suspect counterfeit parts.

The part photographs contained herein are provided to illustrate the application of detection methods identified in the document, and are by no means intended to imply that a manufacturer identified in a photograph is involved with the suspect product.

TABLE OF CONTENTS

1.	SCOPE	3
1.1	Purpose	3
2.	REFERENCES	3
2.1	Applicable Documents	3
2.1.1	SAE Publications	3
2.2	Related Publications	3
2.3	Terms and Definitions	4
2.4	Acronyms	4
3.	DESCRIPTION OF METHODOLOGY/PROCEDURE	4
3.1	Material Control/ESD Handling	4
3.2	Additional Considerations	4
3.2.1	Microfocus Radiology versus AM	4
3.2.2	Infrared versus AM	4
3.3	General Considerations	4
3.3.1	How AM Works	4

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2016 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE AS6171_6

SAE values your input. To provide feedback on this Technical Report, please visit <http://standards.sae.org/AS6171/6>

Documents
Document Sharing Hub

3.4	AM Procedure for PEMS and BGAs	7
3.4.1	General Considerations	7
3.4.2	Exterior AM Inspection (Near Surface AM Imaging)	7
3.4.3	Interior AM Inspections	9
3.4.4	Percentage Delamination Calculations (Figure 3)	10
4.	TEST EQUIPMENT AND CALIBRATION	11
4.1	Controls and Calibration	11
5.	REQUIREMENT	11
5.1	Sampling	11
5.2	Categories of Testing/Risk Levels	11
5.3	Testing Requirements and Minimum Risk Level	11
5.4	Counterfeit Detection Test Sequence	11
5.5	Test Plan	12
5.6	Analysis and Interpretation of Results	12
5.7	Test Report	12
5.8	Certification and Training	13
5.8.1	Personnel	13
5.8.2	Laboratory/Test Facility	15
5.8.3	Proficiency	15
5.9	Data Retention Requirements	16
5.9.1	Report Retention	16
6.	NOTES	16
6.1	Revision Indicator	16
APPENDIX A	ACOUSTIC MICROSCOPY IMAGES	17
FIGURE 1	DIAGRAM OF REFLECTIVE MODE ACOUSTIC MICROSCOPY	5
FIGURE 2	DIAGRAM OF TRANSMISSION MODE ACOUSTIC MICROSCOPY	5
FIGURE 3	EXAMPLE OF PERCENTAGE DELAMINATION CALCULATIONS	10
TABLE 1	AM TEST REQUIREMENTS BASED ON RISK LEVEL	11

1. SCOPE

Through the use of ultra-high frequency ultrasound, typically above 10 MHz, Acoustic Microscopy (AM) non-destructively finds and characterizes physical features and latent defects (visualization of interior features in a layer by layer process) - such as material continuity and discontinuities, sub-surface flaws, cracks, voids, delaminations and porosity. AM observed features and defects can be indicators that the components were improperly handled, stored, altered or previously used.

If AS6171/6 is invoked in the contract, the base document, AS6171 General Requirements shall also apply.

1.1 Purpose

The purpose of this document is to provide recommended techniques and guidelines for the use of Acoustic Microscopy for detection of counterfeit electronic components.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS6171 Test Methods Standard; General Requirements, Suspect/Counterfeit, Electrical, Electronic, and Electromechanical Parts

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

MIL-STD-883, Method 2030	Ultrasonic Inspection of Die Attach
NASA PEM-INST-001	Instructions for Plastic Encapsulated Microcircuit (PEM) Selection, Screening, and Qualification
J-STD-020	Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices
J-STD-035	Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components
MIL-STD-1580	Destructive Physical Analysis for Electronic, Electromagnetic, and Electromechanical Parts
ESA/SCC No. 25200	Application of Scanning Acoustic Microscopy to Plastic Encapsulated Devices
GEIA-STD-006	Requirements for Using Solder Dip to Replace the Finish on Electronic Piece Parts

2.3 Terms and Definitions

See section 2.2 of AS6171 General Requirements.

2.4 Acronyms

See section 2.3 of AS6171 General Requirements.

3. DESCRIPTION OF METHODOLOGY/PROCEDURE

3.1 Material Control/ESD Handling

3.1.1 Parts subjected to handling during AM testing can be damaged by ESD. Therefore, the ESD control requirements of section 3.9.5 of AS6171 General Requirements shall be followed.

3.2 Additional Considerations

3.2.1 Microfocus Radiology versus AM

AM and microfocus radiology are complementary techniques that are frequently found in the same laboratories and they can reveal different features. Radiology relies on differential attenuation of the X-ray energy. AM relies on material change. The practical result is that AM is orders of magnitude more sensitive for detecting air space type defects such as voids, delaminations and cracks.

3.2.2 Infrared versus AM

Infrared is an inspection technique that is based on how the infrared energy transmits through a material. Since air space type defects do not transmit the infrared energy as well as continuous material, this technique is sometimes used to inspect for voids and delaminations. Although this technique can produce a picture very quickly, it is highly limited by the materials under inspection and the details achievable. AM on the other hand, takes a little longer to generate an image but the practical result is that the images are of much higher detail. Plus, AM is not limited by the materials under inspection.

3.3 General Considerations

3.3.1 How AM Works

3.3.1.1 Reflection Mode (Figure 1) - As per J-STD-035

Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components, AM has the ability to create images by generating a pulse of ultrasound, which is focused to a pinpoint spot. The pulse is directed into a sample and reflected at interfaces. The frequency of the pulses and design of the lens are chosen to optimize spot size (resolution) and depth penetration for each application. In the reflection mode of operation, the same transducer is used to send and receive the ultrasonic pulse. Return echoes arrive at different times based upon the depth of the reflecting feature and the velocity of sound in the materials. The operator positions an electronic gate to capture the depth of interest. The amount of ultrasound reflected at the interface is based on differences in the acoustic impedances of the materials at the interface. Greater differences in the acoustic impedances of the materials at the interface produce higher amplitudes of reflected ultrasound. The order of the acoustic impedances, going from one material to the other, will change the polarity/phase of the reflected ultrasound, too. In general, going from a lower to higher acoustic impedance will have a stronger positive reflection and going from a higher to lower will have a stronger negative reflection. In addition, changes in the reflected signal can provide evidence of changes in material properties. This data is often the key to determining variations in materials used and manufacturing processes.

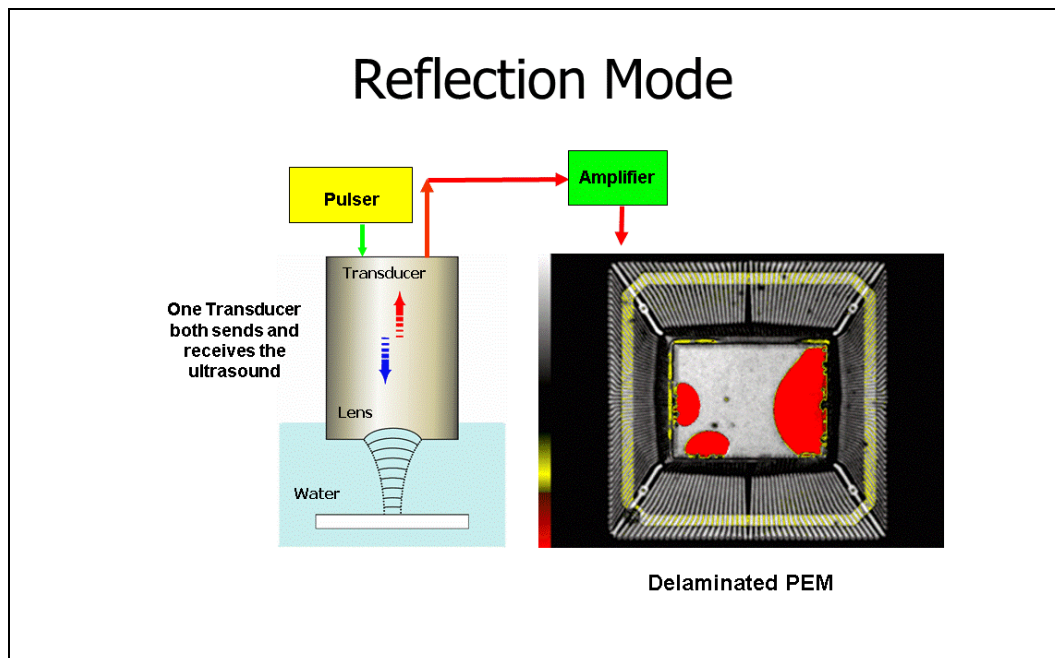


Figure 1 - Diagram of reflective mode acoustic microscopy

3.3.1.2 Transmission Mode (Figure 2) - As per J-STD-035

Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components, AM also has the ability to create images based on how the ultrasound transmits through the entire sample thickness. Since air space defects such as voids, delaminations, cracks and porosity cannot transmit ultrasound, the loss of transmitted signal indicates the presence of these types of defects. In addition, changes in the transmitted signal can provide evidence of changes in material properties. This data is often the key to determining variations in materials used and manufacturing processes.

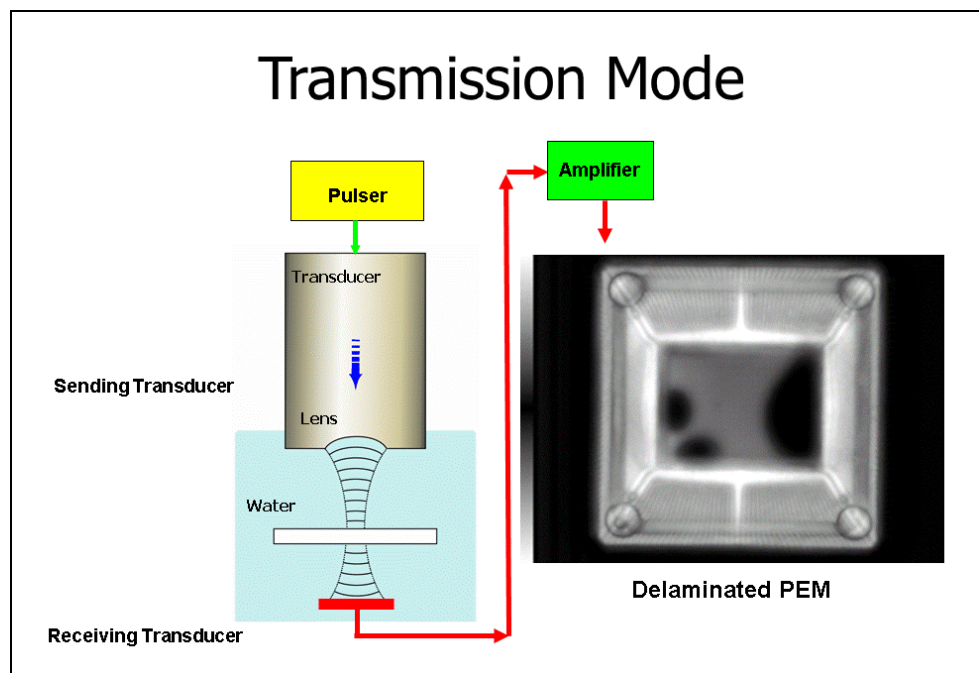


Figure 2 - Diagram of transmission mode acoustic microscopy

3.3.1.3 AM Microelectronic Product Applications Relative to Counterfeit Detection

1. Plastic Encapsulated Microcircuits (PEMs)
2. Plastic Ball Grid Arrays (BGAs)
3. Ceramic Chip Capacitors
4. Die Attach
5. Chip Scale Packages (CSPs)
6. Flip Chips
7. Stacked Dies
8. Ceramic Ball Grid Arrays (CBGAs)
9. Tape Automated Bond (TAB)
10. Hybrids, MCMs, SIPs
11. Flex Circuits
12. Printed Circuit Boards (PCBs)
13. Smart Cards
14. Bonded Wafers
15. Thermo Electric Coolers (TECs)
16. Power Modules

3.3.1.4 Materials AM Technology is Effective for Relative to Counterfeit Detection

1. Glass
2. Ceramics
3. Plastics
4. Adhesives
5. Metals
6. Fiberglass
7. Polymers
8. Graphite
9. Metal Matrix
10. Composites

3.4 AM Procedure for PEMS and BGAs

3.4.1 General Considerations

The following shall be considered prior to and after obtaining the AM image; refer to the equipment manufacturer's instructions for optimum equipment settings.

1. Transducer selection
 - a. Frequency (MHz)
 - b. Focal Length (FL) in water
 - c. F# (FL/Diameter of Piezoelectric Element)
 - d. Reflection and/or Transmission Mode imaging
 - e. Parallelism of transducer scan plane and surface of part being scanned
2. Focal Depth(s) desired within the sample
3. Are there any AM "Reference" images of known good parts available from the manufacturer or other reliable source?
4. Examine image for anomalies (refer to 3.4.2 and 3.4.3)
5. Calculate percentage of defects per critical interfaces (refer to 3.4.4)
6. Record all information required in the Test Report (refer to 5.7)

3.4.2 Exterior AM Inspection (Near Surface AM Imaging)

3.4.2.1 Metal Lead Frame Based Packages

This section defines the potential exterior defects which may indicate that a device is counterfeit. These defects do not necessarily mean the devices are counterfeit and should be used with other available data to determine whether a device is counterfeit. In some cases, additional visual or other testing (electrical, DDPA, etc.) may need to be done to conclusively determine if a device is a counterfeit.

There are several indicators that a device may be counterfeit. These indicators are listed in 3.4.2.1.1 through 3.4.2.1.8. For each of these indicators, the evidence which could be obtained from an acoustic image is identified. Wherever possible, a visual example of this type of defect using AM is referenced in Appendix A.

3.4.2.1.1 Evidence of Mishandling

1. Voids
2. Pits (see Appendix A, Figure A11)
3. Scratches (see Appendix A, Figure A12)
4. Pry Marks

3.4.2.1.2 Evidence of Ghost Marking (see Appendix A, Figure A13)

3.4.2.1.3 Evidence of Sanding

1. Sanding marks seen through blacktop layer (see Appendix A, Figure A1)
2. Inconsistent edge shape distortions seen at a corner(s) (see Appendix A, Figure A2)
3. Partial removal of Pin-One dimple

3.4.2.1.4 Evidence of Blacktop Coating

1. Uneven blotchy surface image (see Appendix A, Figure A14)
2. Overspray in Pin-One cavity (see Appendix A, Figure A15)
3. Significant, measurable contrast (gray scale gain) between front and back component scans (see Appendix A, Figure A16)
4. Foreign particles encapsulated within the coating

3.4.2.1.5 Evidence of Microblasting

1. Polished glass beads exposed in surface image
2. Significant color/gray scale contrast between front and back component scans

3.4.2.1.6 Evidence of Chemical Etch

1. Polished glass beads exposed in surface image
2. Significant color/gray scale contrast between front and back component scans
3. Signs of chemical reaction/indications of fluid ingress or gaps where leads enter package

3.4.2.1.7 Evidence of Original Marking

1. Original paint markings seen through blacktop layer (see Appendix A, Figure A13)
2. Partial etch marking (ghost image) left after removal by sanding (see Appendix A, Figure A3)

3.4.2.1.8 Acoustic Impedance Measurement (AIM)

NOTE: Can be performed on suspect counterfeit part itself, front versus back surface, or in comparison to known good part.

1. AIM value compared to known authentic AIM of same component
2. AIM front surface value compared to back surface value

3.4.2.2 Substrate Based Packages

Same procedures as Metal Lead Frame Packages (3.4.2.1) with the exception of comparisons between the front and back surfaces, since the back surface is a substrate, not encapsulant.

3.4.3 Interior AM Inspections

3.4.3.1 Plastic Encapsulated Microcircuits

This section defines the potential interior defects which may indicate that a device is counterfeit. The defects described in 3.4.3.1.1 through 3.4.3.1.3 do not necessarily mean the devices are counterfeit. There are many occasions when the devices may have an acceptable level of inherent internal delaminations as supplied by the manufacturer.

3.4.3.1.1 Evidence of Delamination

If it is determined that the delamination has been caused by heat treatment or pop-corning effect (due to reflow, de-soldering, etc.), it should be looked at closely. The manufacturers do not ship products that have been already subjected to heat treatment. Delamination and pop-corning effect occurs when heat treatment is applied and it is a strong indicator that the product was removed from a circuit board or recycled. Parts with this type of defect should be considered suspect counterfeit (see Appendix A, Figures A6, A8, A18, A19, A20, A21, A22, A23, and A24).

1. Internal crack that intersects a bond wire, ball bond, or wedge bond.
2. Internal crack extending from any lead finger to any other internal feature (lead finger, chip, die attach paddle).
3. Internal crack extending more than 2/3 the distance from any internal feature to the outside of the package (see Appendix A, Figure A4).

3.4.3.1.1.1 Detailed Evidence of Delamination (see Appendix A, Figures A7, A9, A10, and Figures A20 through A24)

A. Metal Lead Frame Based Packages

1. No delamination on the active side of the die.
2. No delamination on any wire bonding surface including the downbond area or the leadframe of lead on chip devices.
3. No delamination along any polymeric film bridging any metallic features that is designed to be isolated.
4. No delamination/cracking >50% of the die attach area in thermally enhanced packages or devices that require electrical contact to the backside of the die.
5. No surface-breaking feature delaminated over its entire length. A surface-breaking feature includes: lead fingers, tie bars, heat spreader alignment features, heat slugs, etc.

B. Substrate Based Packages

1. No delamination on the active side of the die.
2. No delamination on any wire bonding surface of the laminate.
3. No delamination along the polymer potting or molding compound/laminate interface for cavity and overmolded packages.
4. No delamination along the solder mask/laminate resin interface.
5. No delamination within the laminate.
6. No delamination/cracking >50% of the die attach area in thermally enhanced packages or devices that require electrical contact to the backside of the die.