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JOINT INDUSTRY STANDARD

Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components

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ACOUSTIC MICROSCOPY FOR NONHERMETIC ENCAPSULATED ELECTRONIC COMPONENTS

(From JEDEC Board Ballot JCB-98-99, under the cognizance of the JC-14.1 Committee on Reliability Test Methods for Packaged Devices an with the IPC.)

1 Scope

This test method defines the procedures for performing acoustic microscopy on nonhermetic encapsulated electronic components. This method provides users with an acoustic microscopy process flow for detecting anomalies (delamination, cracks, mold compound voids, etc.) nondestructively in plastic packages while achieving reproducibility.

2 Definitions

2.1 A-mode

Acoustic data collected at the smallest X-Y-Z region defined by the limitations of the given acoustic microscope. An A-mode display contains amplitude and phase/polarity information as a function of time of flight at a single point in the X-Y plane. See Figure 1 - Example of A-mode Display.

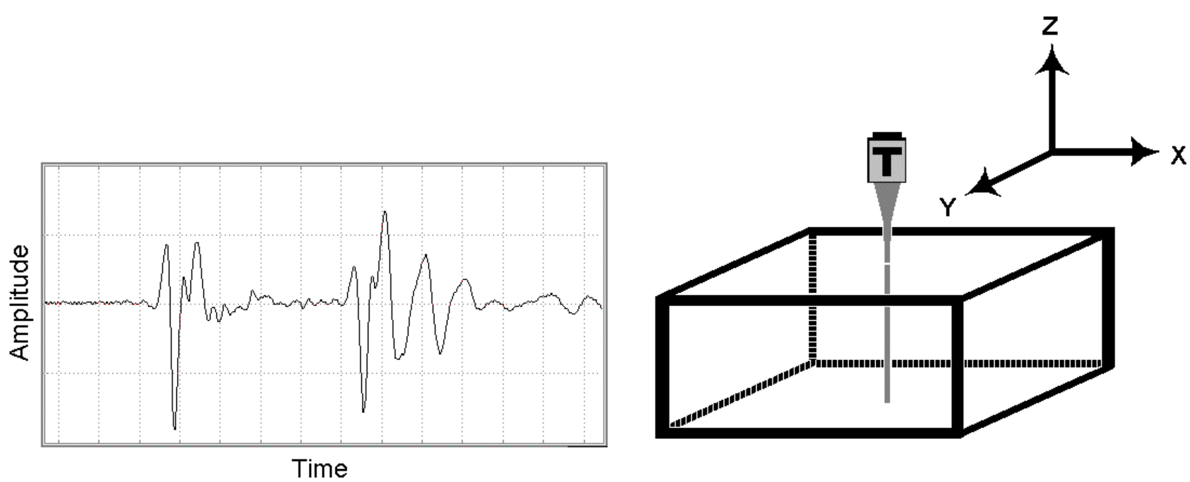


Figure 1 — Example of A-mode Display

2.2 B-mode

Acoustic data collected along an X-Z or Y-Z plane versus depth using a reflective acoustic microscope. A B-mode scan contains amplitude and phase/polarity information as a function of time of flight at each point along the scan line. A B-mode scan furnishes a two-dimensional (cross-sectional) description along a scan line (X or Y). See Figure 2 - Example of B-mode Display.

2.2 B-mode (cont'd)

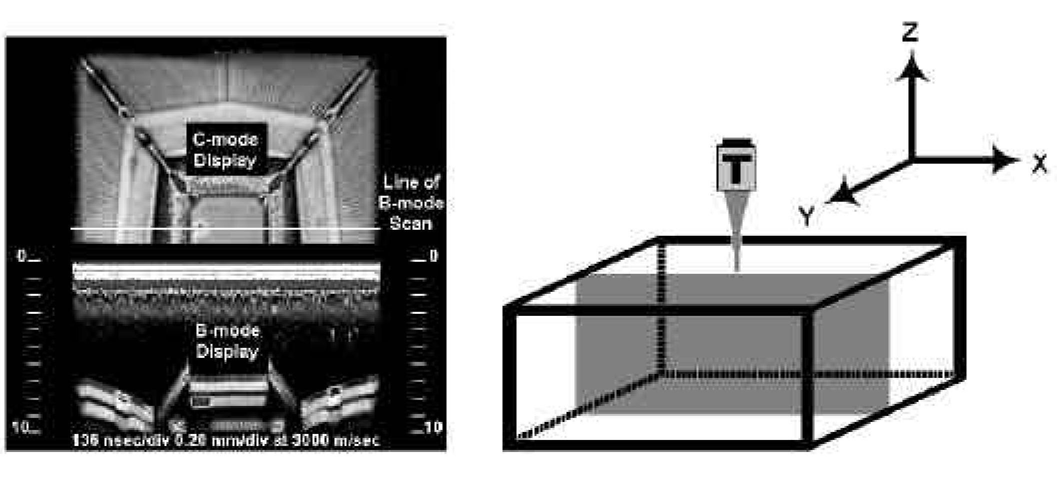


Figure 2 — Example of B-mode Display (bottom half of picture on left)

2.3 Back-Side Substrate View Area (Refer to Annex A, Type IV)

The interface between the encapsulant and the back of the substrate within the outer edges of the substrate surface.

2.4 C-mode

Acoustic data collected in an X-Y plane at depth (Z) using a reflective acoustic microscope. A C-mode scan contains amplitude and phase/polarity information at each point in the scan plane. A C-mode scan furnishes a two-dimensional (area) image of echoes arising from reflections at a particular depth (Z). See Figure 3.

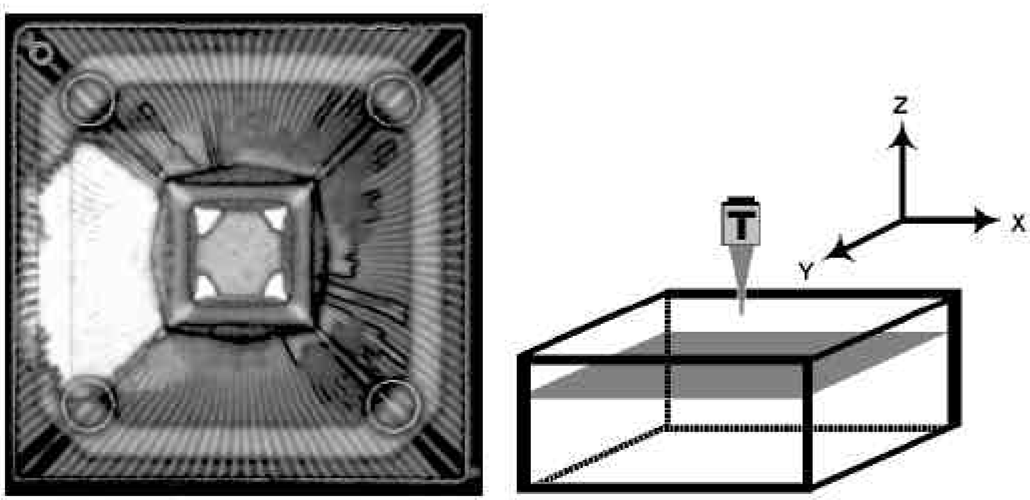


Figure 3 — Example of C-mode Display

2.5 Through Transmission Mode

Acoustic data collected in an X-Y plane throughout the depth (Z) using a through transmission acoustic microscope. A Through Transmission mode scan contains only amplitude information at each point in the scan plane. A Through Transmission scan furnishes a two-dimensional (area) image of transmitted ultrasound through the complete thickness/depth (Z) of the sample/component. See Figure 4 – Example of Through Transmission Display.

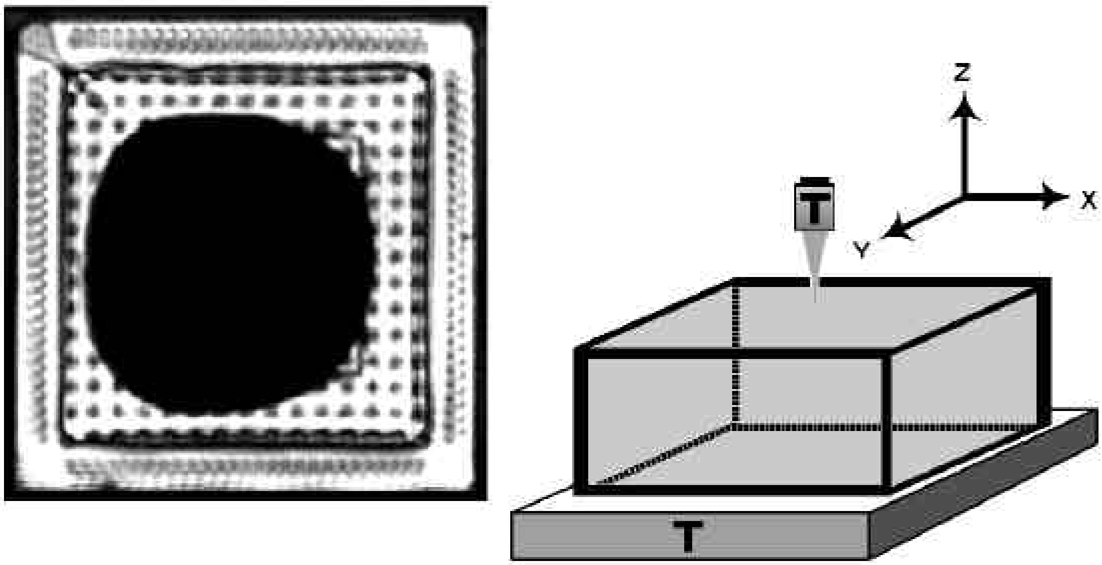


Figure 4 — Example of Through Transmission Display

2.6 Die Attach View Area (Refer to Annex A, Type II)

The interface between the die and the die attach adhesive and/or the die attach adhesive and the die attach substrate.

2.7 Die Surface View Area (Refer to Annex A, Type I)

The interface between the encapsulant and the active side of the die.

2.8 Focal Length (FL)

The distance in water at which a transducer's spot size is at a minimum.

2.9 Focus Plane

The X-Y plane at a depth (Z), which the amplitude of the acoustic signal is maximized.

2.10 Leadframe (L/F) View Area (Refer to Annex A, Type V)

The imaged area which extends from the outer L/F edges of the package to the L/F "tips" (wedge bond/stitch bond region of the innermost portion of the L/F.)

2.11 Reflective Acoustic Microscope

An acoustic microscope that uses one transducer as both the pulser and receiver. (This is also known as a pulse/echo system.) See Figure 5 - Diagram of a Reflective Acoustic Microscope.

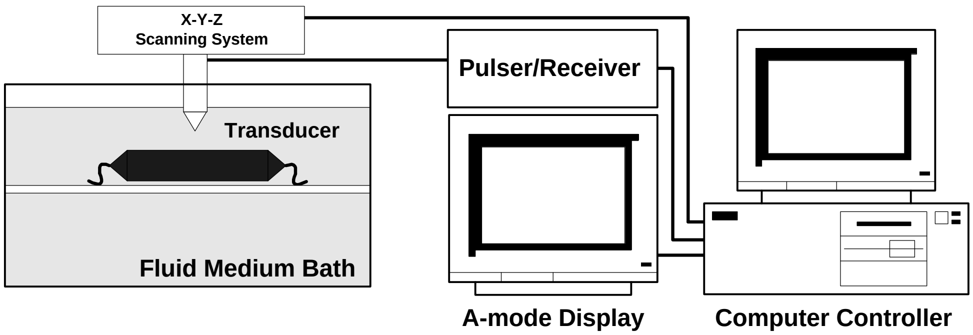


Figure 5 — Diagram of a Reflective Acoustic Microscope System

2.12 Through Transmission Acoustic Microscope

An acoustic microscope that transmits ultrasound completely through the sample from a sending transducer to a receiver on the opposite side. See Figure 6 - Diagram of a Through Transmission Acoustic Microscope System.

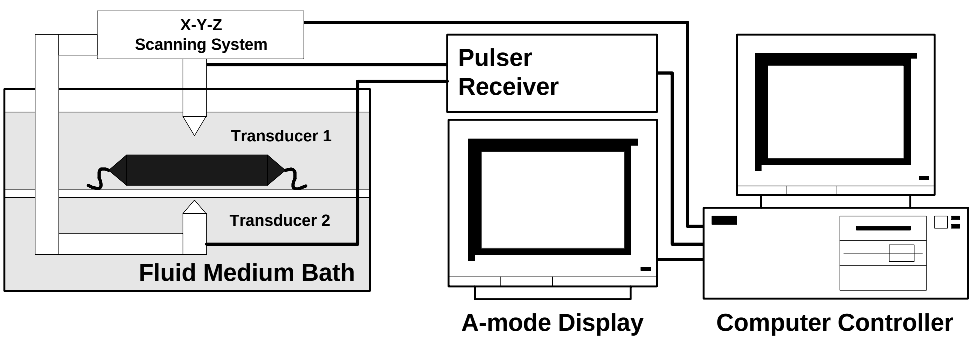


Figure 6 — Diagram of a Through Transmission Acoustic Microscope System

2.13 Time-of-Flight (TOF)

a) In reflective mode, the time of flight is the time it takes for the acoustic pulse to travel from a single transducer/receiver to the interface of interest and back.

b) In through transmission mode, the time of flight is the time it takes for the acoustic pulse to travel from the sending transducer through the sample to the receiving transducer.

2.14 Top-Side Die Attach Substrate View Area (Refer to Annex A, Type III)

The interface between the encapsulant and the die side of the die attach substrate surrounding the die.

3 Apparatus

3.1 Reflective acoustic microscope system (see Figure 5) comprised of:

1) Ultrasonic pulser/receiver

2) A display of the echo amplitude and phase/polarity versus time (A-mode display).

3) A computer-controlled display system for image display (B-mode and C-mode), storage, retrieval, printing and analysis.

4) An electromechanical X-Y-Z (typically computer-controlled) scanning system for moving the acoustic probe over the sample and for setting the focus plane within the sample.

5) A fluid medium bath, such as deionized water, to provide acoustic coupling between the sample and the transducer

6) A broad band acoustic transducer with a center frequency in the range of 10 to 200 MHz for subsurface imaging.

3.2 Through transmission acoustic microscope system (see Figure 6) comprised of:

1) Items listed in 3.1 above

2) Ultrasonic pulser (can be a pulser/receiver as in 3.1, 1)

3) Separate receiving transducer or ultrasonic detection system

3.3 Reference packages or standards

These include packages with delamination and packages without delamination, for use during equipment setup.

3.4 Sample holder

The holder should position the samples in the proper place, keep the samples from moving during the scan, and maintain planarity.

4 Procedure

This procedure is generic to all acoustic microscopes. For operational details related to this procedure that apply to a specific model of acoustic microscope, consult the manufacturer's operational manual.

4.1 Equipment Setup

4.1.1 Select the transducer

Select the transducer with the highest useable ultrasonic frequency, subject to the limitations imposed by the media thickness and acoustic characteristics, package configuration, and transducer availability, to analyze the interfaces of interest. The transducer selected should have a low enough frequency to provide a clear signal from the interface of interest. The transducer should have a high enough frequency to delineate the interface of interest.

> Note — Through transmission mode may require a lower frequency and/or longer focal length than reflective mode. Through transmission is effective for the initial inspection of components to determine if defects are present.

4.1.2 Verify setup

Verify setup with the reference packages or standards (see 3.3 above) and settings that are appropriate for the transducer chosen in 4.1.1 to ensure that the critical parameters at the interface of interest correlate to the reference standard utilized.

4.1.3 Place units in the sample holder

Place units in the sample holder in the coupling medium such that the upper surface of each unit is parallel with the scanning plane of the acoustic transducer. Sweep air bubbles away from the unit surface and from the bottom of the transducer head.

4.1.4 Align the transducer

At a fixed distance (Z), align the transducer and/or stage for the maximum reflected amplitude from the top surface of the sample. The transducer must be perpendicular to the sample surface.

4.1.5 Focus

Focus by maximizing the amplitude, in the A-mode display, of the reflection from the interface designated for imaging. This is done by adjusting the Z-axis distance between the transducer and the sample.

4.2 Perform Acoustic Scans

4.2.1 Inspect for any anomalies

Inspect the acoustic image(s) for any anomalies, verify that the anomaly is a package defect or an artifact of the imaging process, and record the results. (See Annex A for an example of a check sheet that may be used.)

To determine if an anomaly is a package defect or an artifact of the imaging process it is recommended to analyze the A-mode display at the location of the anomaly. Physical analysis of the package may also be required to confirm the nature of the anomaly.

4.2.2 Consider potential pitfalls

Consider potential pitfalls in image interpretation listed in, but not limited to, Annex B and some of the limitations of acoustic microscopy listed in, but not limited to, Annex C. If necessary, make adjustments to the equipment setup to optimize the results and rescan.

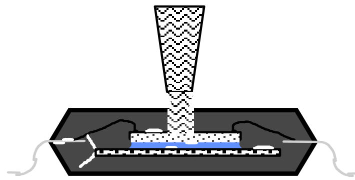
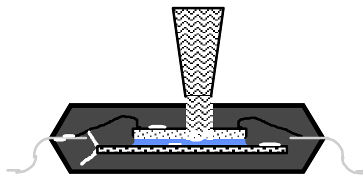
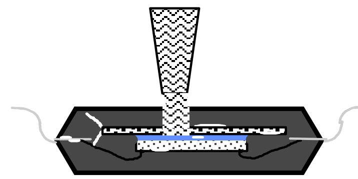
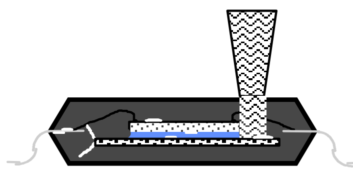
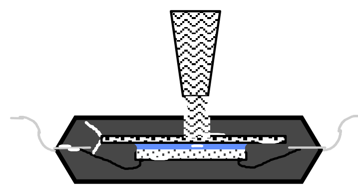
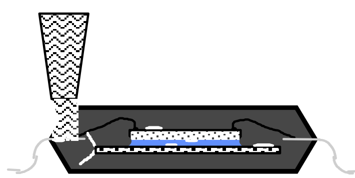
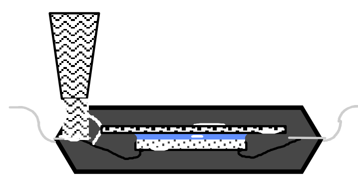
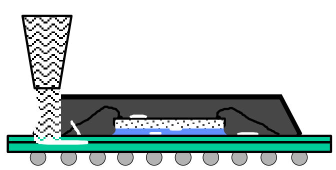
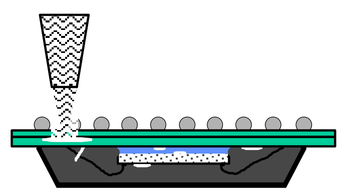
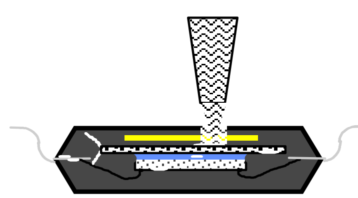
4.2.3 Evaluate

Evaluate the acoustic images using the failure criteria specified in other appropriate documents, such as J-STD-020.

4.2.4 Record

Record the images and the final instrument setup parameters for documentation purposes. An example checklist is shown in Annex D.

Annex A — Acoustic Microscopy Check Sheet

	Circuit Side Scan	Noncircuit Side Scan
Type I Delamination: Encapsulant/Die Surface		
Type II Delamination: Die Attach Region		
Type III Delamination: Encapsulant/Substrate (Die Side)		
Type IV Delamination: Substrate/Encapsulant (Backside)		
Type V Delamination: Encapsulant/ Lead Interconnect		
Type VI Delamination: Intra-Laminate (Laminate Substrates Only)		
Type VII Delamination: Heat Sink/Substrate		

Annex A — Acoustic Microscopy Check Sheet (cont'd)

CIRCUIT SIDE SCAN
Image File Name/path ____
____

Delamination
(Type I) Die Circuit Surface/Encapsulant number affected :__________ Average. % ________
Location: ☐ Corner ☐ Edge ☐ Center

(Type II) Die/Die Attach number affected : ________ Average. % __________________
Location: ☐ Corner ☐ Edge ☐ Center

(Type III) Encapsulant/Substrate number affected :________ Average. % _______________
Location: ☐ Corner ☐ Edge ☐ Center

(Type V)
Interconnect tip number affected:______________ Average % ______________________
Interconnect number affected: ______________ Max. % length ____________________

(Type VI) Intra-Laminate number affected : ________ Average. % _______________
Location: ☐ Corner ☐ Edge ☐ Center

Comments:

____

Cracks
Are cracks present: ☐ Yes ☐ No If yes:
Do any cracks intersect: ☐ bond wire ☐ ball bond ☐ wedge bond ☐ tab bump ☐ tab lead
Does crack extend from lead finger to any other internal feature: ☐ Yes ☐ No
Does crack extend more than two-thirds the distance from any internal feature to the external surface of the package: ☐ Yes ☐ No

Additional verification required: ☐ Yes ☐ No

Comments:

____

Mold Compound Voids
Are voids present: ☐ Yes ☐ No If yes:
Approx. size __________ Location _______________ (if multiple voids, use comment section)
Do any voids intersect: ☐ bond wire ☐ ball bond ☐ wedge bond ☐ tab bump ☐ tab lead

Additional verification required: ☐ Yes ☐ No

Comments:

____

Annex A — Acoustic Microscopy Check Sheet (cont'd)

NONCIRCUIT SIDE SCAN
Image File Name/path____
____

Delamination
(Type IV) Encapsulant/Substrate number affected: _______ Average. %_________________
Location: ☐ Corner ☐ Edge ☐ Center

(Type II) Substrate/Die Attach number affected: ________ Average. % _________________
Location: ☐ Corner ☐ Edge ☐ Center

(Type V) Interconnect number affected: ____________ Max. % length ___________________

(Type VI) Intra-Laminate number affected : ________ Average. % _________________
Location: ☐ Corner ☐ Edge ☐ Center

(Type VII) Heat Spreader number affected : ________ Average. % ___________
Location: ☐ Corner ☐ Edge ☐ Center

Additional verification required: ☐ Yes ☐ No

Comments:

____

Cracks
Are cracks present: ☐ Yes ☐ No If yes:
Does crack extend more than two-thirds the distance from any internal feature to the external surface of the package: ☐ Yes ☐ No

Additional verification required: ☐ Yes ☐ No

Comments:

____

Mold Compound Voids
Are voids present: ☐ Yes ☐ No If yes:
Approx. size _________ Location ______________ (if multiple voids, use comment section)

Additional verification required: ☐ Yes ☐ No

Comments:

____

Annex B — Potential Image Pitfalls

OBSERVATIONS	CAUSES/COMMENTS
Unexplained loss of front surface signal	Gain setting too low Symbolization on package surface Ejector pin knockouts Pin 1 and other mold marks Dust, air bubbles, fingerprints, residue Scratches, scribe marks, pencil marks Cambered package edge
Unexplained loss of subsurface signal	Gain setting too low Transducer frequency too high Acoustically absorbent (rubbery) filler Large mold compound voids Porosity/high concentration of small voids Angled cracks in package “Dark line boundary” (phase cancellation) Burned molding compound (ESD/EOS damage)
False or spotty indication of delamination	Low acoustic impedance coating (polyimide, gel) Focus error Incorrect delamination gate setup Multi-layer interference effects
False indication of adhesion	Gain set too high (saturation) Incorrect delamination gate setup Focus error Overlap of front surface and subsurface echoes (transducer frequency too low) Fluid filling delamination areas
Apparent voiding around die edge	Reflection from wire loops Incorrect setting of void gate
Graded intensity	Die tilt or lead frame deformation Sample tilt

Annex C — Some Limitations of Acoustic Microscopy

Acoustic microscopy is an analytical technique that provides a nondestructive method for examining plastic encapsulated components for the existence of delaminations, cracks, and voids. This technique has limitations that include the following:

LIMITATION	REASON
Acoustic microscopy has difficulty in finding small defects if the package is too thick.	The ultrasonic signal becomes more attenuated as a function of two factors: the depth into the package and the transducer frequency. The greater the depth, the greater the attenuation. Similarly, the higher the transducer frequency, the greater the attenuation as a function of depth.
There are limitations on the Z-axis (axial) resolution.	This is a function of the transducer frequency. The higher the transducer frequency, the better the resolution. However, the higher frequency signal becomes attenuated more quickly as a function of depth.
There are limitations on the X-Y (lateral) resolution.	The X-Y (lateral) resolution is a function of a number of different variables including: – Transducer characteristics, including frequency, element diameter, and focal length – Absorption and scattering of acoustic waves as a function of the sample material – Electromechanical properties of the X-Y stage
Irregularly shaped packages are difficult to analyze.	The technique requires some kind of flat reference surface. Typically, the upper surface of the package or the die surface can be used as references. In some packages, cambered package edges can cause difficulty in analyzing defects near the edges and below their surfaces.
Edge Effect	The edges cause difficulty in analyzing defects near the edge of any internal features.

Annex D — Reference Procedure for Presenting Applicable Scanned Data

Most of the settings described may be captured as a default for the particular supplier/product with specific changes recorded on a sample or lot basis.

Setup Configuration (Digital Setup File Name and Contents)

- Calibration Procedure and Calibration/Reference Standards used
- Transducer
  - Manufacturer
  - Model
  - Center Frequency
  - Serial Number
  - Element Diameter
  - Focal Length in Water
- Scan Setup
  - Scan area (X-Y dimensions)
  - Scan step size
    - Horizontal
    - Vertical
  - Displayed Resolution
    - Horizontal
    - Vertical
  - Scan speed
- Pulser/Receiver Settings
  - Gain
  - Bandwidth
  - Pulse
  - Energy
  - Repetition rate
  - Receiver attenuation
  - Damping
  - Filter
  - Echo amplitude
- Pulse Analyzer Settings
  - Front surface gate delay relative to trigger pulse
  - Subsurface gate (if used)
  - High pass filter
  - Detection threshold for positive oscillation, negative oscillation
  - A/D settings
  - Sampling rate
  - Offset setting

Annex D — Reference Procedure for Presenting Applicable Scanned Data (cont'd)

Per Sample Settings

Sample Orientation (top or bottom (flipped) view and location of pin 1 or some other distinguishing characteristic)
Focus (point, depth, interface)
Reference Plane
Nonstandard parameter settings
Sample identification information to uniquely distinguish it from others in the same group

Reference Procedure for Presenting Scanned Data

Image file types and names
Gray scale and color image legend definitions
Significance of colors
Indications or definition of delamination
Image dimensions
Depth scale of TOF
Deviation from true aspect ratio
Image type: A-mode, B-mode, C-mode, TOF, Through Transmission

A-mode waveforms should be provided for points of interest, such as delaminated areas. In addition, an A-mode image should be provided for a bonded area as a control.

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