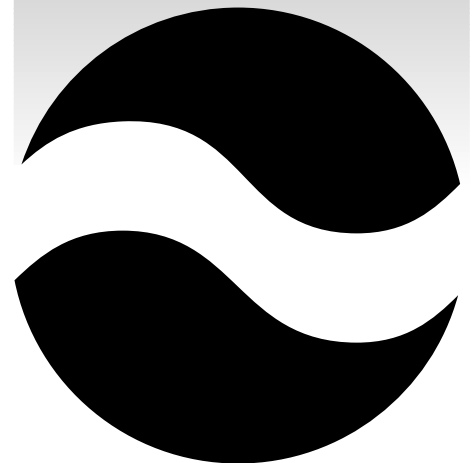
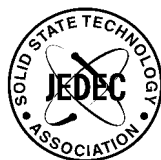


IPC/JEDEC J-STD-035  
MAY 1999

# *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 and with the IPC.)

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### 1 Scope

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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.

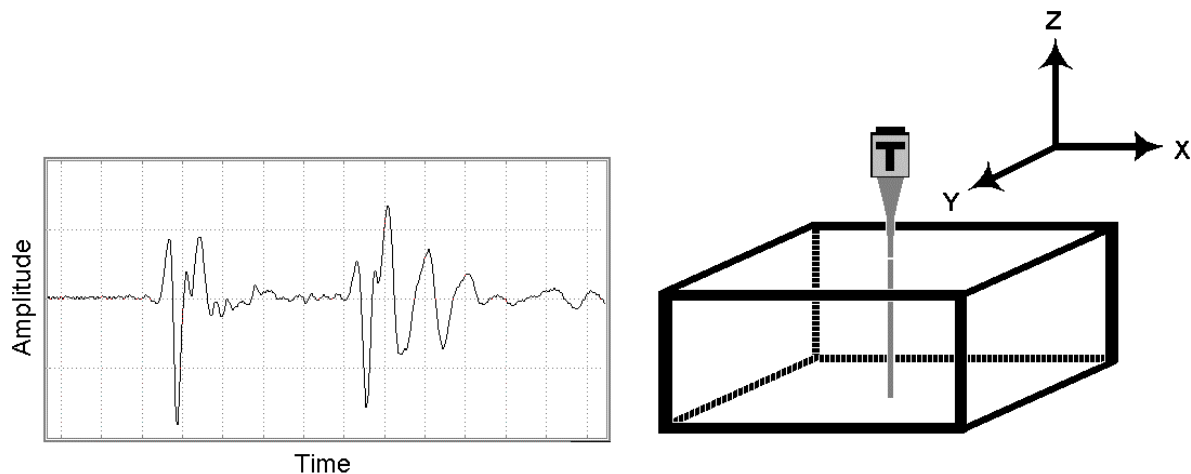
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### 2 Definitions

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#### 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)

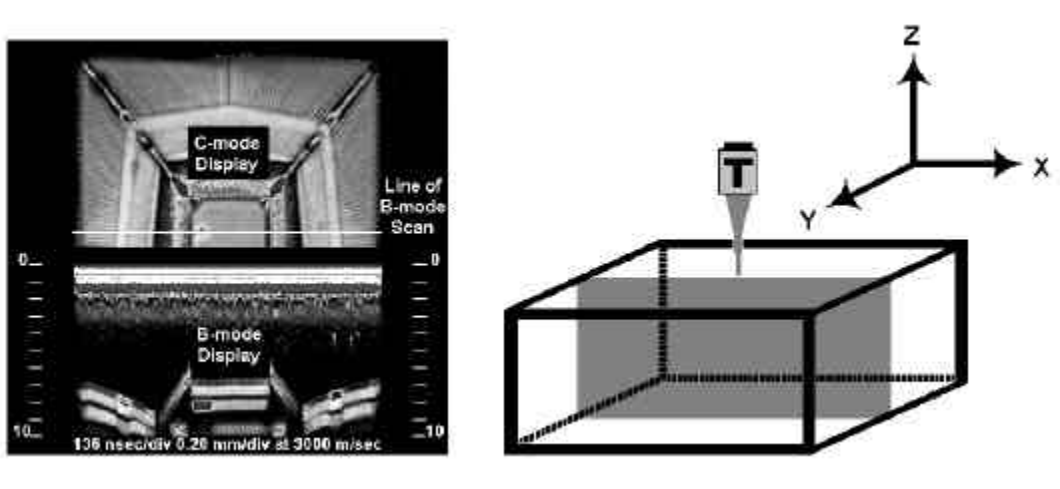


Figure 2 — Example of B-mode Display (bottom half of picture on left)

## 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.

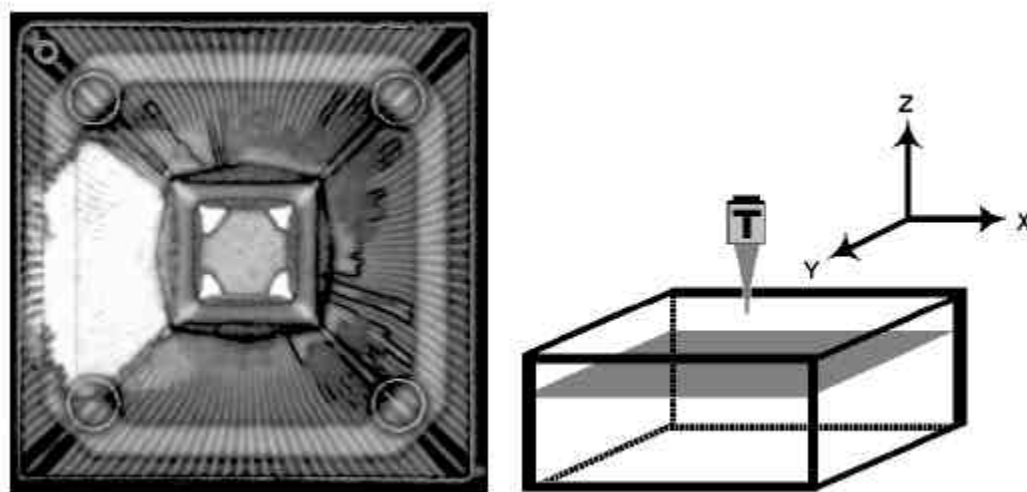


Figure 3 — Example of C-mode Display

## 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.

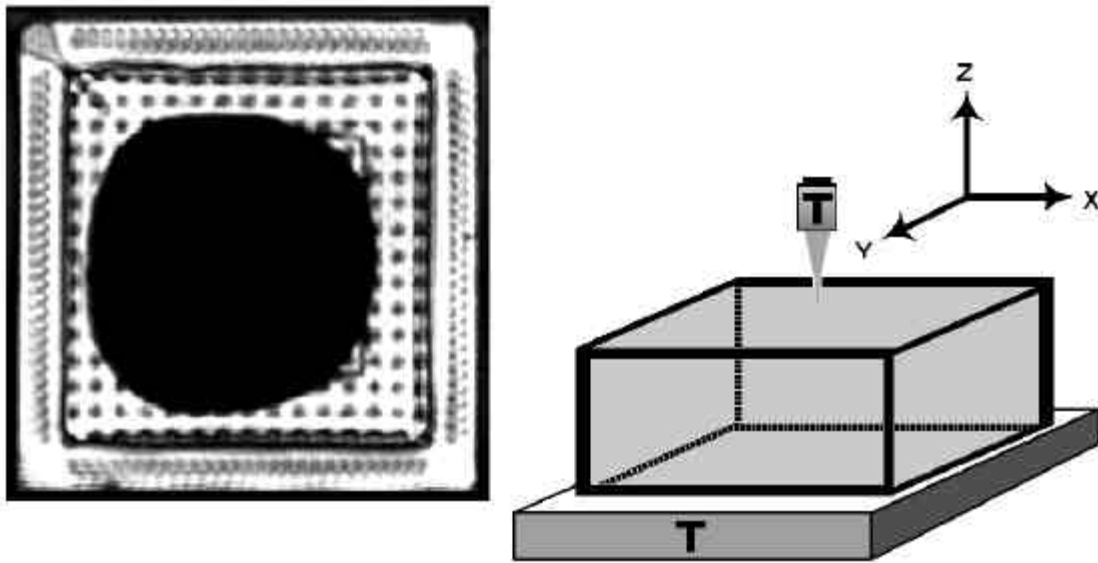


Figure 4 — Example of Through Transmission Display

## 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.

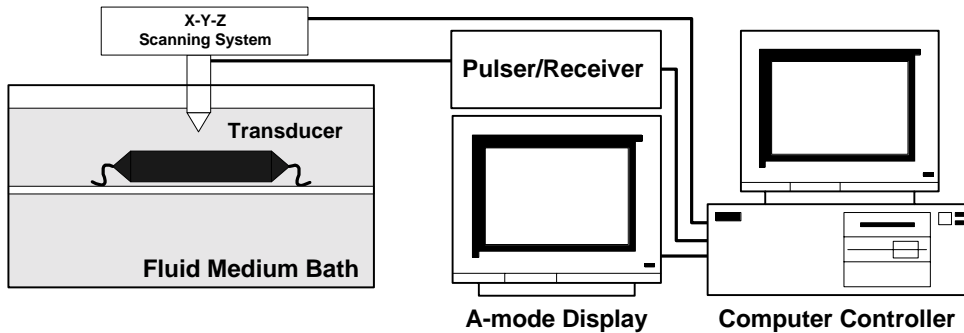


Figure 5 — Diagram of a Reflective Acoustic Microscope System

### 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.

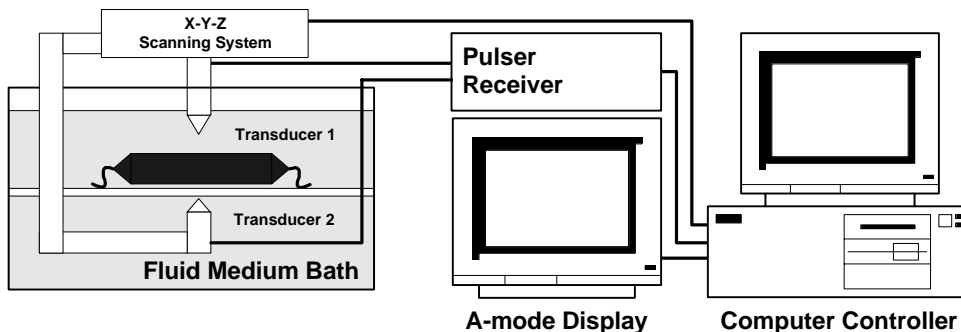


Figure 6 — Diagram of a Through Transmission Acoustic Microscope System

### 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.

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### 3 Apparatus

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#### 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.

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## **4 Procedure**

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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.

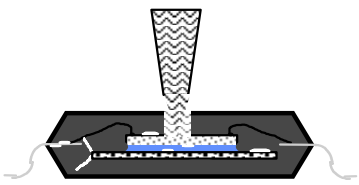
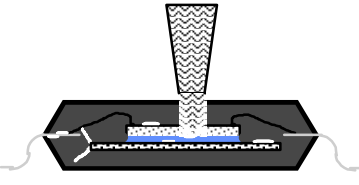
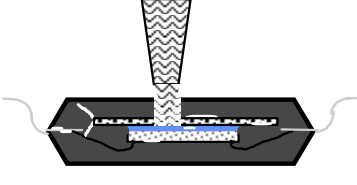
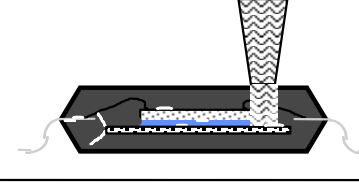
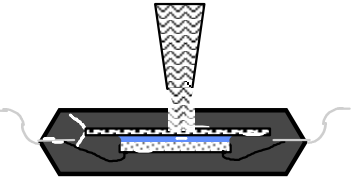
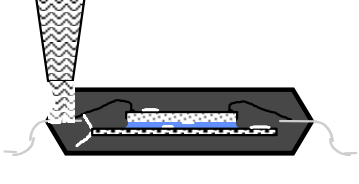
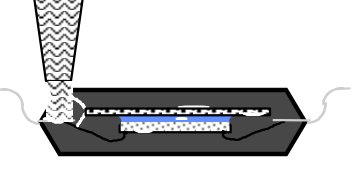
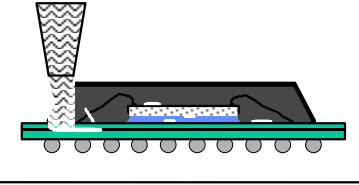
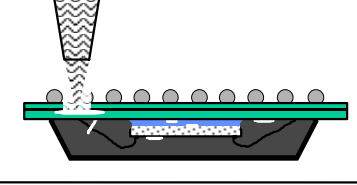
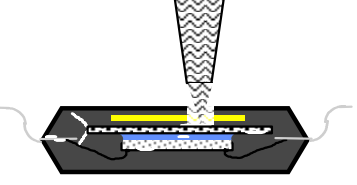
### **4.2.3 Evaluate**

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**

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<b>OBSERVATIONS</b>	<b>CAUSES/COMMENTS</b>
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

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## Annex C — Some Limitations of Acoustic Microscopy

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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

Acoustic microscopy has difficulty in finding small defects if the package is too thick.

### REASON

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.

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**Annex D — Reference Procedure for Presenting Applicable Scanned Data**

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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.

