Sonoscan INC.

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JPL submitted 15 plastic devices for nondestructive evaluation using Acoustic Micro Imaging techniques. The samples consisted of 5 different groups with 3 parts each. The groups contained SOICs, TSOPs, TO220s, and DIPs respectively. The samples were received with serialization which was used for identification in the acoustic images. The purpose of this evaluation was to analyze these devices for internal defects.

The samples were inspected for interfacial delamination, encapsulant voids and cracks using the C-mode Scanning Acoustic Microscope (C-SAM). The C-SAM instrument is described later in this report. Acoustic micrographs are included in the data section. In addition, several parts were analyzed for the percent bond versus disbond at the die attach by use of the C-SAM Digital Image Analyzer (C-DIA). This analysis is also included in the data section. Each image included in the data section contains a label at the top stating the part number and scan location.

The results of this investigation indicate the presence of disbonds in each of these samples. Please refer to the acoustic images and C-DIA analysis for the locations and extent of the defects detected.

Acoustic Micro Imaging has been shown to be an effective and reliable technique for nondestructively evaluating these devices for internal defects. A program of continued evaluation is recommended in order to aid process control and to help insure product reliability.

Inside This Report...

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Three Types of Acoustic Microscopes

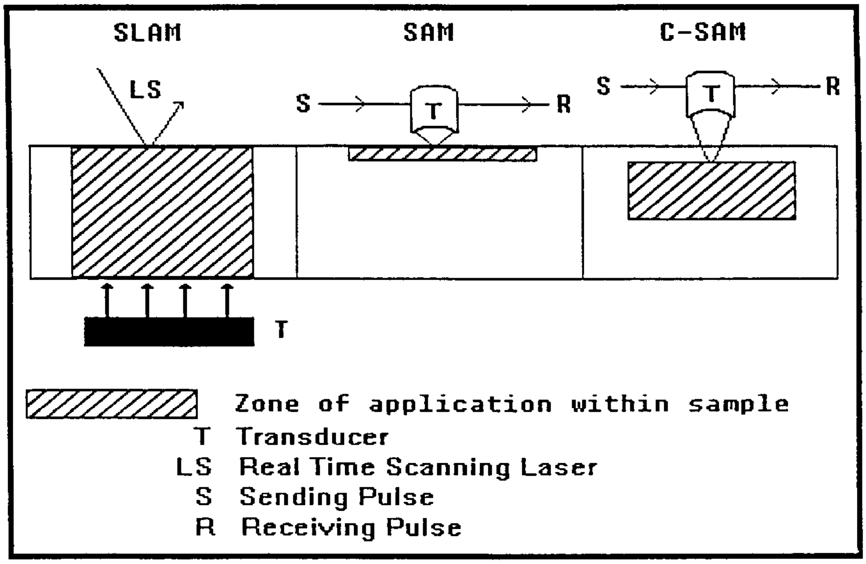
SLAM SAM C-SAM

There are three intrinsically different types of acoustic microscopes. The first one is a transmission mode instrument that generates images of a sample throughout its entire thickness. The "SLAM" or Scanning Laser Acoustic Microscope operates using a continuous plane wave of ultrasound introduced on one side of the sample. The amount of transmitted ultrasound is detected on the oppposite side by a rapidly scanning, finely focused laser beam. The amount of transmitted ultrasound is directly related to the amount of bond quality or material homogeneity present in the sample.

The other two types of acoustic microscopes are reflection mode tools that use a pulse-echo transducer focused at or below the sample surface. The focused transducer (ultrasound spot) is mechanically moved across the sample in raster fashion to create the image. A typical image may consist of tens of thousands of individual data points.

These two systems are known as "SAM" (Scanning Acoustic Microscope) and "C-SAM" (C-Mode Scanning Acoustic Microscope) and are designed for very high resolution imaging of the surface and subsurface regions of a sample.

The respective penetration zones or "application" areas within a sample are indicated in the figure above. Both SLAM and C-SAM are described in greater detail later in this report.



Sounding Out Material Defects

In an ordinary light microscope an image of a specimen is produced because of interaction between light waves and the specimen's surface. Analogously, images can be made with non-light sources such as ultrasound. The difference however, is that ultrasound will transmit through a specimen which is naturally optically opaque.

Ultrasound in the range of 10-500 MHz is typically employed to characterize internal discontinuities such as voids, delaminations, inclusions, porosity and cracks. Therefore, imaging based upon acoustic wave analysis reveals defects deep within and at the surface of most dense materials. Perhaps the most important characteristics is that these techniques are entirely nondestructive!

Why Ultrasound and not X-ray ?

When an opaque material is viewed, the two primary choices for flaw detection and material characterization are X-ray and ultrasound. X-ray's are affected by the amount of molecular mass the ray's must pass through. X-ray's are also unchanged by internal discontinuities unless these discontinuities constitute significant variation in the sample's structure, usually greater than 20%.

Ultrasound, unlike X-ray, will not transmit across an air gap. Even a submicron gap is enough to stop its transmission. This unique property makes the acoustic microscope the first choice for detecting internal flaws that are "air space" related. Because X-ray and Acoustic Micro Imaging provide uniquely distinct information they tend to be complementary analytical techniques rather than competitive.

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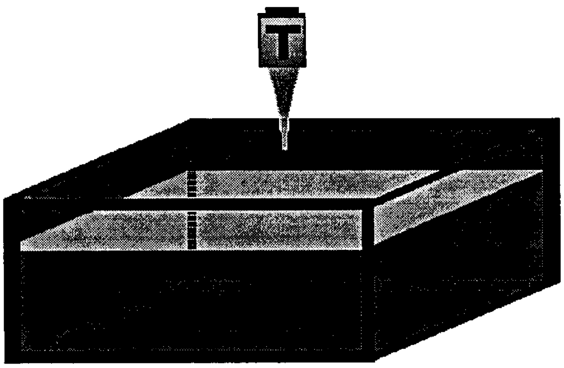
C-SAM

Principles of Operation

Very High Speed Transducer Actuator
(U.S. and Foreign patents Issued)

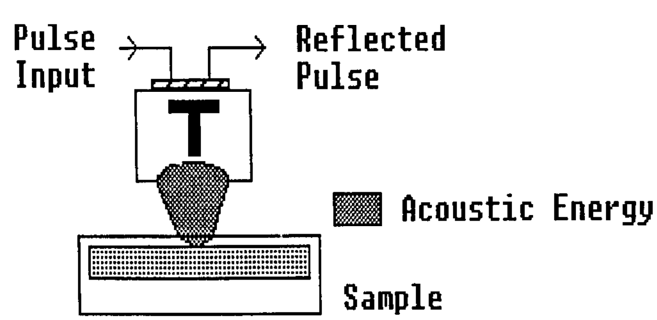


The C-Mode Scanning Acoustic Microscope is a pulse-echo (reflection type) microscope that generates images by mechanically scanning a transducer in a raster pattern over the sample. A focused spot of ultrasound is generated by an acoustic lens assembly at frequencies typically ranging from 10-150 MHz. The ultrasound is brought to the sample by a coupling medium, usually deionized water or an inert fluid. The transducer alternately acts as sender and receiver, being electronically switched between the transmit and receive modes.

A very short acoustic pulse enters the sample and return echoes are produced at specific interfaces within the part. The return times are a function of the distance from the interface to the transducer. An oscilloscope display of the echo pattern, known as the A-Scan, clearly shows these levels and their time/distance relationships. This provides a basis for investigating anomalies at specific levels within a part. *For wave form and color map interpretation see additional text.*

An electronic gate is positioned in time and controlled to open for a defined duration allowing only the information from a specific level to be imaged while excluding all other echoes. The "gated" echo modulates a CRT which is synchronized with the transducer's position. In this way images are produced in raster fashion on the CRT. Complete images are produced in about 10 seconds.

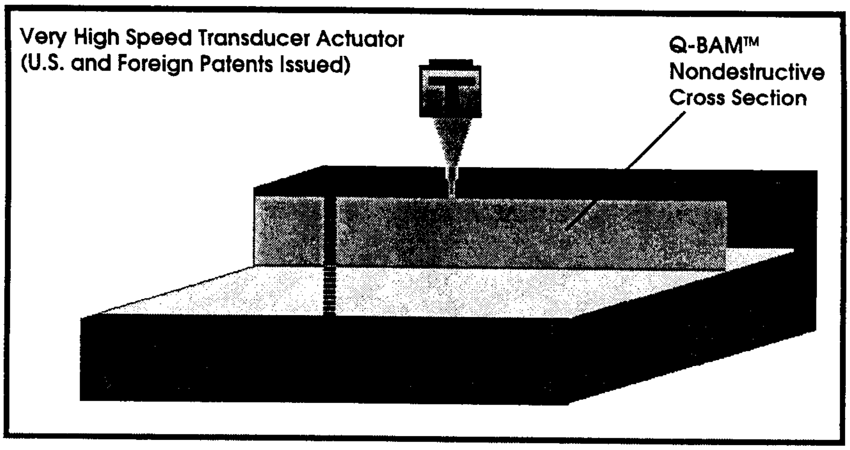
In C-SAM images the contrast changes compared to the background constitute the important information. Voids, cracks, disbonds and delaminations provide high contrast and are easily distinguished from the background. Combined with the ability to "gate" and "focus" at specific levels C-SAM is a powerful tool for analyzing the nature of any defect within a sample.



Q-BAM ™

C-SAM™ Imaging Mode # 1

Q-BAM™ is based upon the ultrasonic B-Scan principle used in medical diagnostics, but has been specially adapted for evaluation of solid materials at higher frequencies and with greater resolution and accurracy.

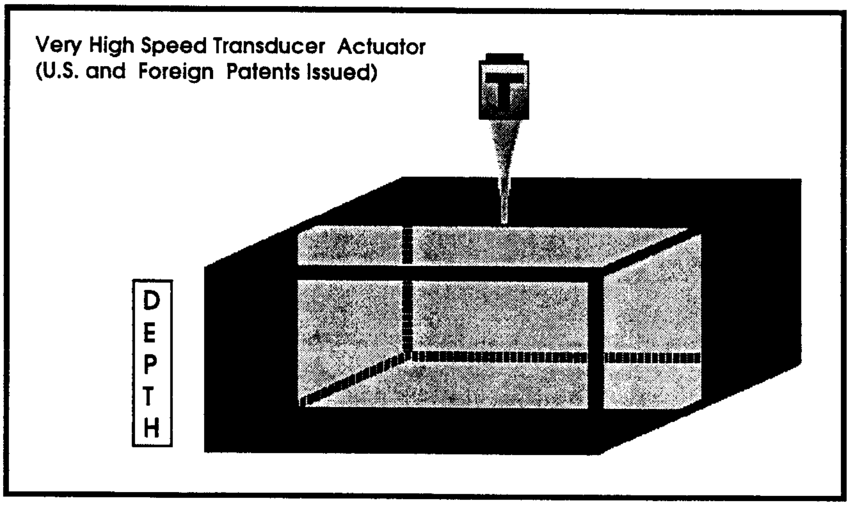


To use Q-BAM™ a normal C-SAM™ (interface scan) image is created. The location for the nondestructive cross-section is then chosen by the operator. Often the line chosen by the operator is through the center of a suspected flaw. However, any line across a sample can be selected to make the nondestructive cut. When the Q-BAM™ function is activated the C-SAM™ (interface scan) image below the cut line is automatically cleared, leaving the top part of the image to serve as a frame of reference. In the bottom portion of the image the "side view" (x, z) Q-BAM™ image is created.

It is important to note that Q-BAM™ continuously scans and focuses the ultrasound through the entire part, thereby generating precise quantitative depth information. This is in sharp contrast to conventional B-Scans which are either unfocused or focused to only one narrow zone within a sample. The result is a loss of detail.

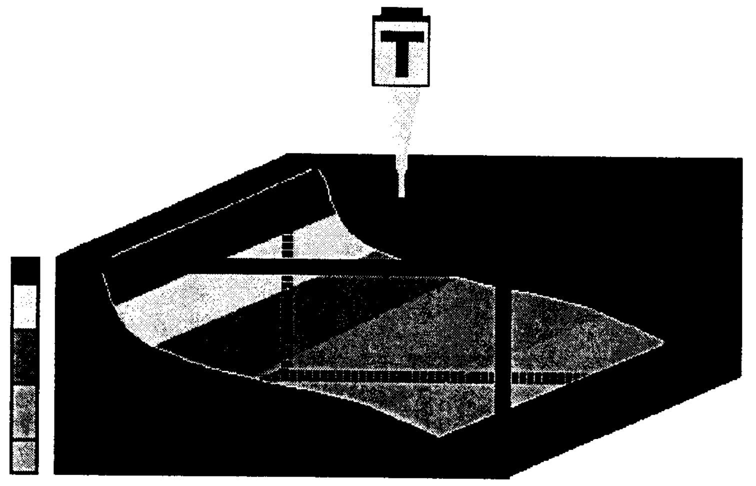
In the Q-BAM™ image, the defects appear just as they would if the sample had been physically sectioned and inspected optically. Generating the sectioned image takes less than 30 seconds.

In the completed display the top and the sectioned views are seen. The value of this information goes far beyond what can be obtained from destructive physical analysis (DPA) because the Q-BAM™ process is both quick and entirely nondestructive. Additionally, the same part can be sectioned in as many vertical planes as desired. Vertical scales on the left and right borders of the image make it simple to measure the depth of a feature in both millimeters and round trip transit time of the ultrasound.



Time of Flight 3-D Imaging (TOF)

C-SAM™ Imaging Mode # 2



Time-of-Flight (TOF) 3-D imaging provides an additional perspective for sample evaluations. TOF images provide a dramatic 3-D representation of voids, crack profiles and nonplanarity of internal elements. TOF images are easy to understand and interpret. These images display the internal construction of a sample with respect to the level of each internal feature, thereby providing true 3-D information.

TOF is another reflection mode imaging technique, meaning that it uses a pulsed transmitter/ receiver which alternately beams ultrasound into the part and receives the return echoes. The return echoes carry valuable information regarding the internal structure and integrity of the sample.

The specific parameter measured is the time of flight of the return echo. Knowing how long the ultrasound took to return from an internal feature gives a measurement of distance traveled. It is this information that the TOF 3-D Hardware Software translates into a visible image. The information is displayed both topographically (relative height) and by color.

The vertical color map at the left side of the TOF image provides orientation. The higher a color is on the scale, or the greater the intensity of the color, the nearer the feature is to the part's surface. The very top of the color scale corresponds to the surface of the sample. It follows then that the changes in depth of a vertical feature, such as a crack, are apparent as color and brightness variations in the TOF image.

The true value of TOF 3-D imaging is in its ability to provide a visual perspective of voids, crack profiles and nonplanarity of internal elements. The TOF image is displayed in less than five seconds once the 2-D C-SAM™ (interface scan) image has been generated. The TOF image provides a composite view of all features in the sample from the top surface of the part to the chosen level of interest.

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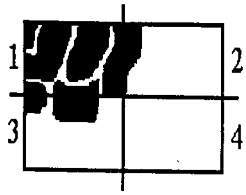
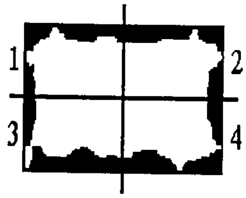
C-DIA

Quantification
and
MIL-STD-883C
Method 2030
Die Attach Evaluation

Delamination/Void	Criteria	Statistic
	Reject: Single void larger than 15% of total intended contact area.	A
	Reject: Corner void larger than 10% of total intended contact area.	B
	Reject: Quadrant more than 70% disbonded.	C
	Reject: Total voids in excess of 50% of total intended contact area.	D

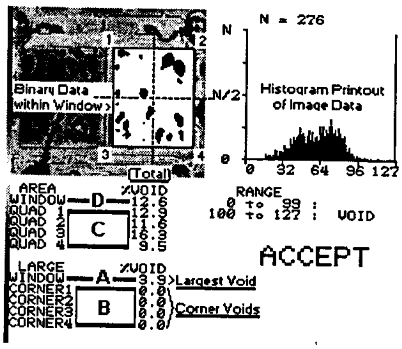


Figure 1

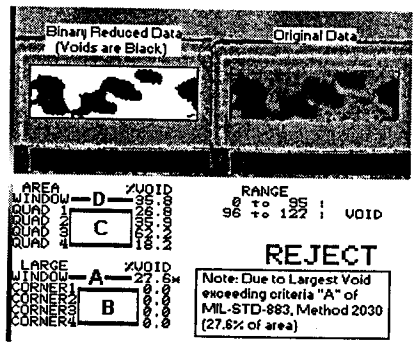


Figure 2

Quantitative analysis is performed on the SLAM™ and C-SAM™ acoustic microscopes using the C-DIA (Computer Digital Image Analysis) feature. During any quantitative analysis a window is placed around the region to be analyzed and the 256 level color scale is reduced to contain binary information (two levels). This results in a percentage of the pixel values being placed in the "bonded" region and the remaining pixels in the "disbonded" region.

The acoustic micrograph that coincides with the quantized result displays the thresholded (two level) information in the upper left corner. The grey level histogram or the actual grey level image (analyst's choice) is displayed to its right (figure 1 & 2).

If the histogram is displayed (figure 1) the graph represents the pixel frequency distribution for the 128 intensity levels within the windowed area. The histogram statistics, including the percent bond (range # to #) and the percent void (range # to #) are displayed in the lower right section.

Any interface can be quantized. The ones most typically analyzed are the die attach or substrate attach. Additionally, customized algorithms, developed exclusively by Sonoscan, can be implemented to automatically calculate the percentage bond/disbond within the specified area.

If MIL-STD-883C, Method 2030 is applied, eight separate calculations are performed. The predetermined Accept/Reject criteria has been outlined above.

What results is a calculated value that is classified according to the standard. If the percentage of attach meets the criteria it is considered "Accepted" and labeled so, if not it will be labeled "Rejected". The cause(s) for rejection are noted by an asterisk on the quantized C-DIA image.

Image Interpretation

The images below show each of the TO packages imaged through the top (plastic) side. The top two images show the top side of the lead frame and post leads. Red regions are disbonds. The bottom two images show a deeper level where the heat sink and die are bonded with the molding compound. Red regions are disbonds. Due to device geometry and design, part of the die surface is obscured.

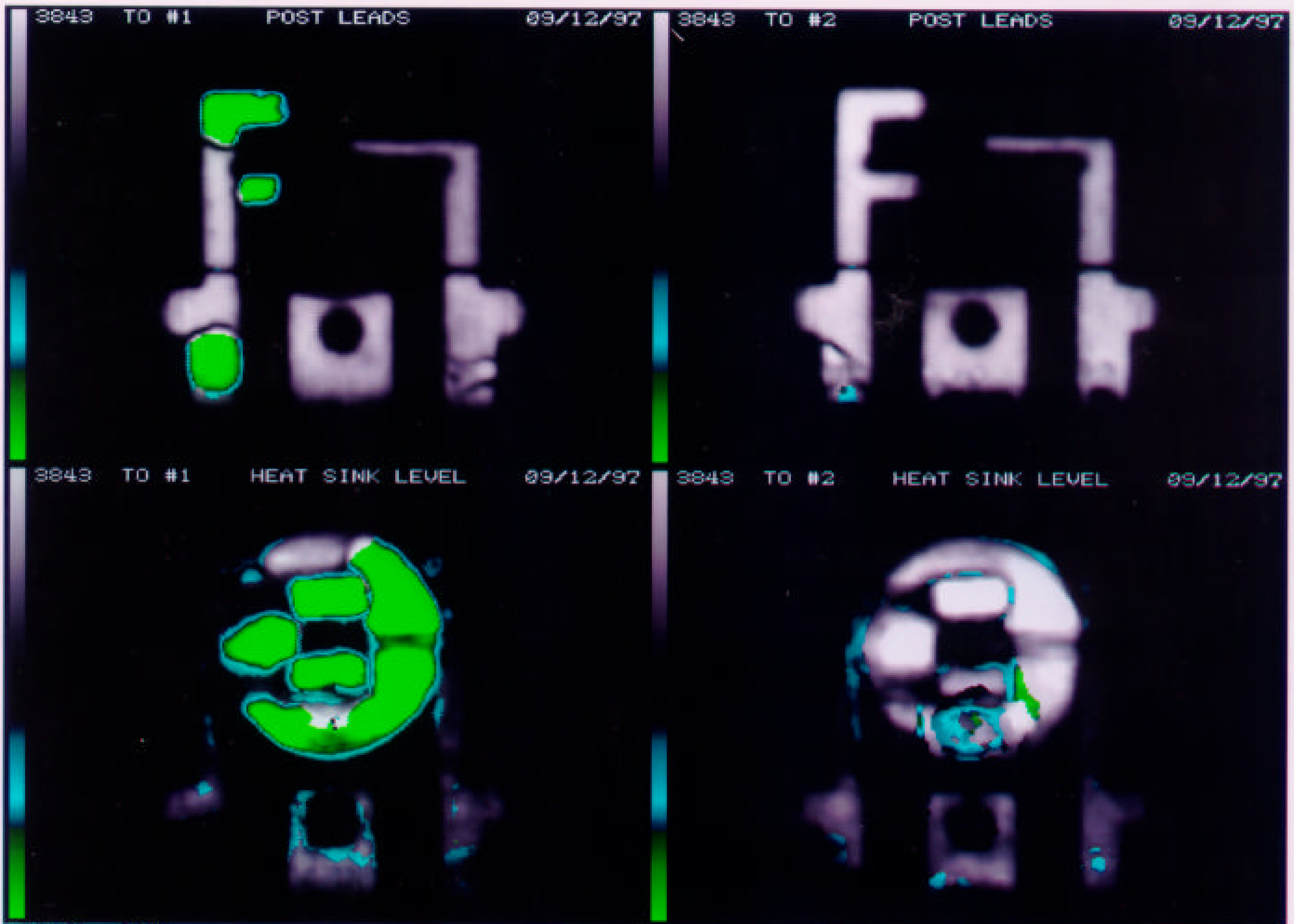


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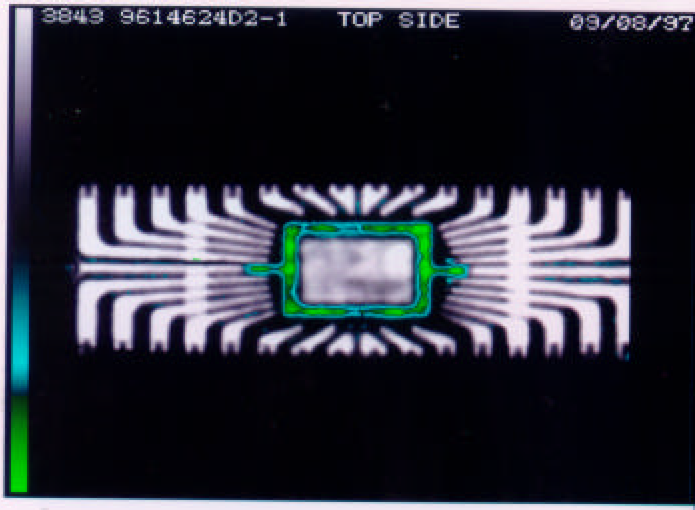
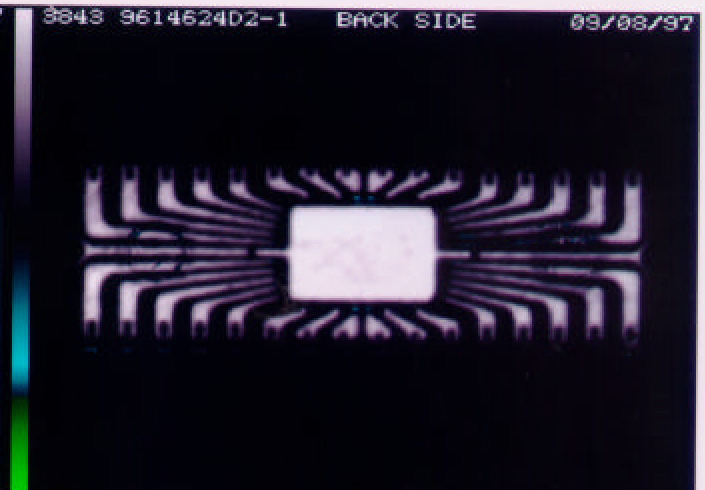
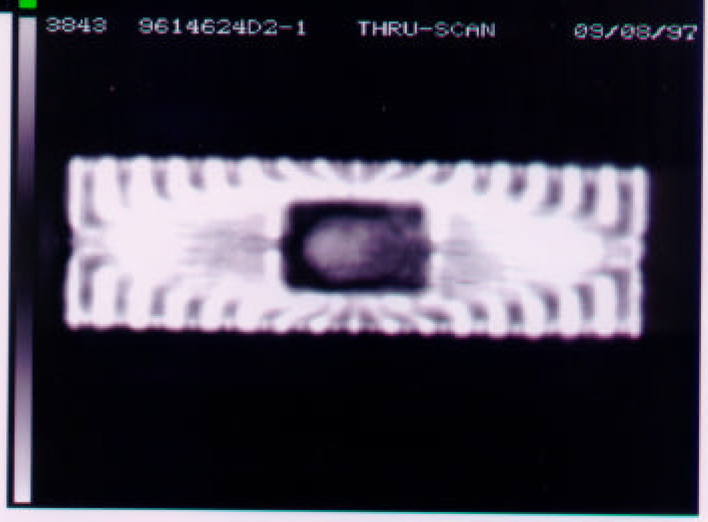
Image Interpretation

The following pictures show the DIP device imaged through the top and back sides The top side image shows the die surface, die pad surface, and lead frame surface. The back side image shows the die pad back side and lead frame. A THRU-Scan™ is also provided which shows transmission of ultrasound through the entire package thickness. Dark regions in the die area correspond to disbonds on the die pad and die attach regions.







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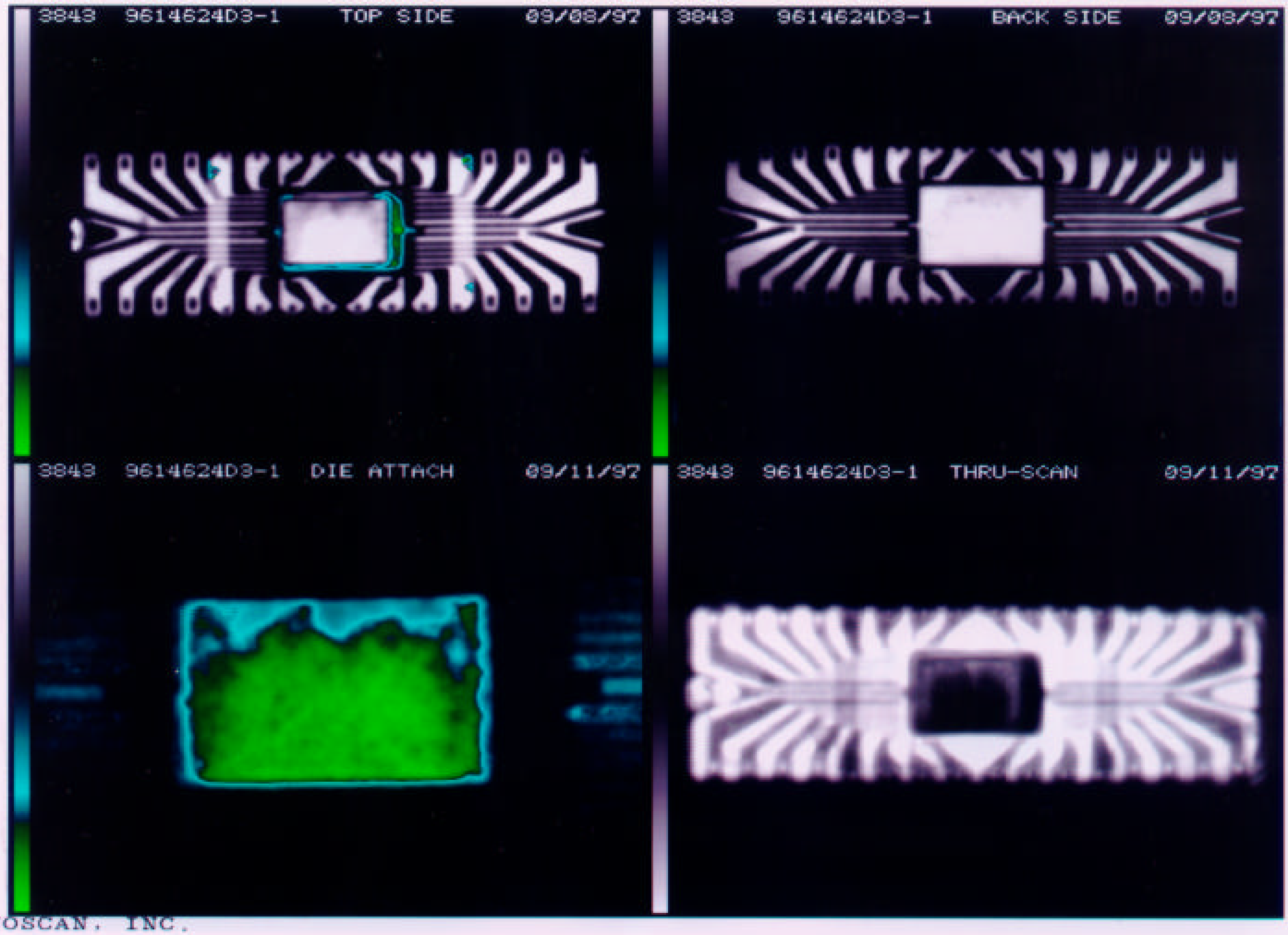

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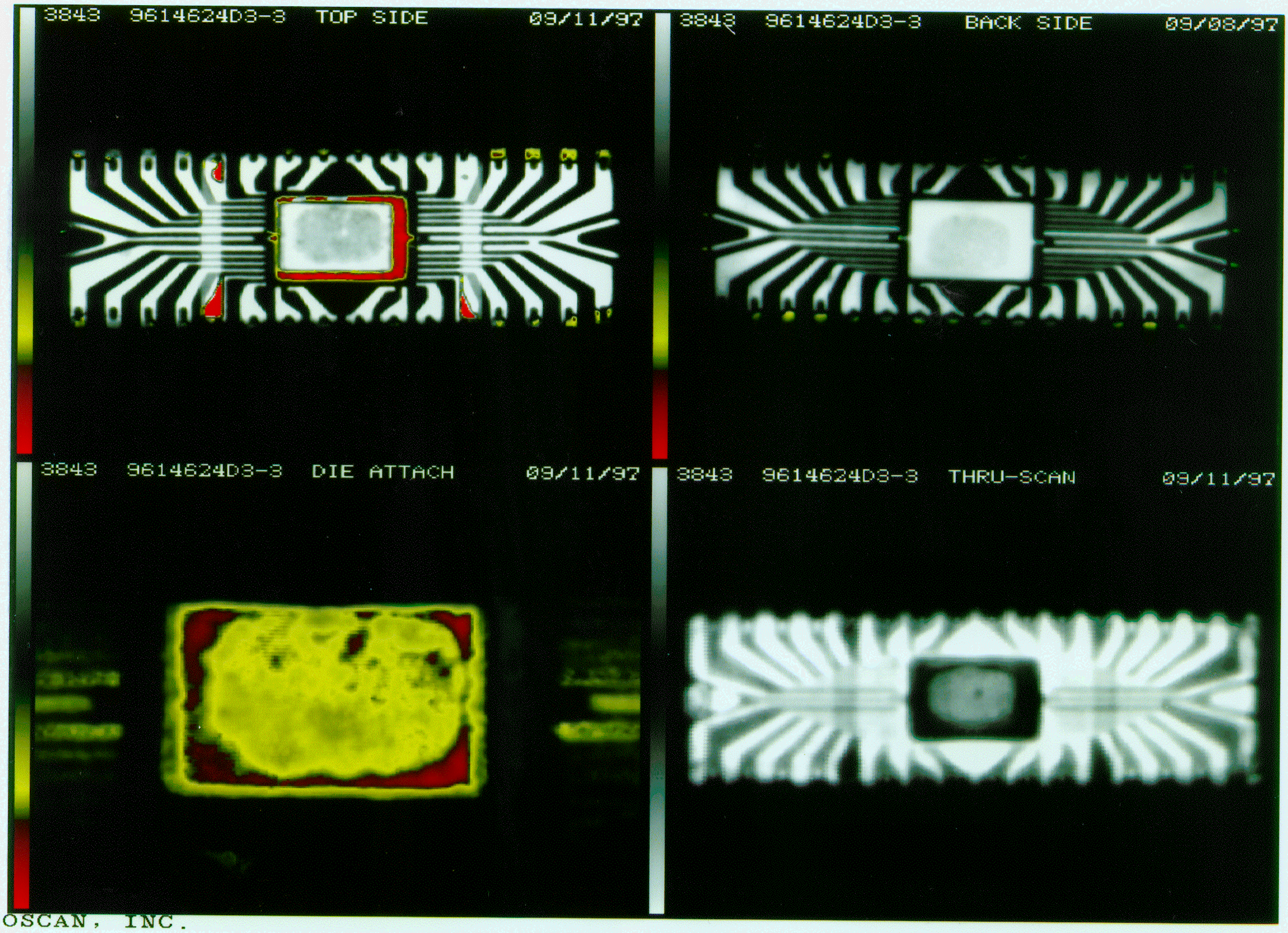

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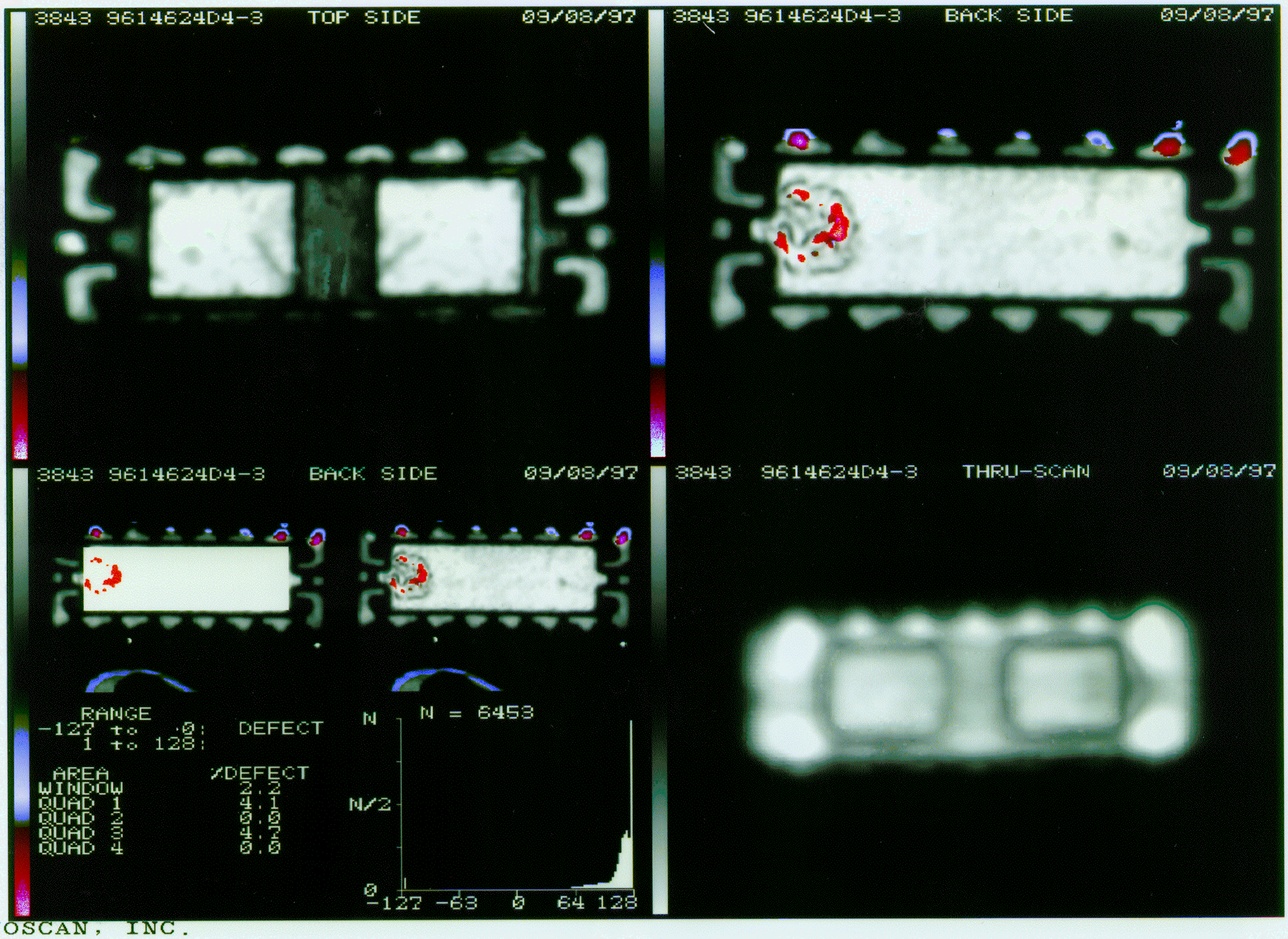
Image Interpretation

This picture shows one of the smaller SOICs imaged through the top and back sides. Disbonds appear red. A THRU-Scan™ is also provided which shows good transmission through both die. This means that all interfaces above and below the die are well bonded. An area fraction measurement of the die pad back side is provided to demonstrate how disbond percentages can be measured and displayed for any particular region on the device.



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