Acoustic Microscopy, a Tool for Evaluating Quality of Microelectronics

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JPL Quality Assurance has acquired a Sonix™ SAM (Scanning Acoustic Microscope) and is applying it to the NDE (Non Destructive Evaluation) of microelectronics, both components and encapsulated assemblies. The acoustic microscope is often used in conjunction with a x-ray microscope located in the same facility. The two provide information that is complimentary.

The SAM functions by sending pulses of extremely high frequency sound waves (10-210 megahertz) into a sample that is submerged in a fluid. Where discontinuities exist in the sample, the sound is reflected back to the transducer which functions both as the sound source and the detector. Reflections at a point are referred to as an A-scan. They are displayed as an oscilloscope trace as shown in Figure 1.

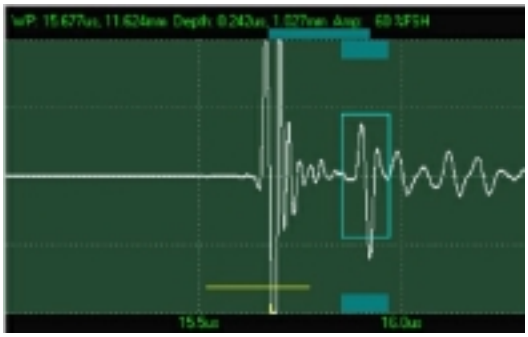

Figure 1 - A Scan

A line of these reflections taken across a sample results in a cross sectional display where large reflection intensity produces a lighter shading and weak reflections result in dark areas. Layers in the sample are clearly displayed in Figure 2.

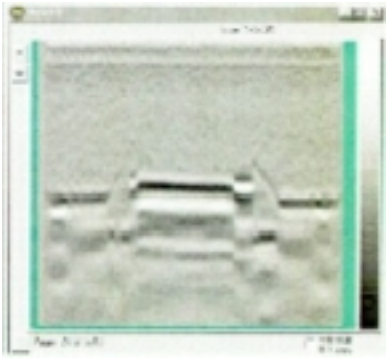

Figure 2 - B Scan

The data from multiple lines of reflections when taken together produces a planar view of the interior of a sample. Figures 3, 4 and 5 show the top surface and two interior layers of a Ball grid array package. These three pictures were produced in a single scan using a technique known as TAMI (tomagraphic acoustic microscopy inspection).

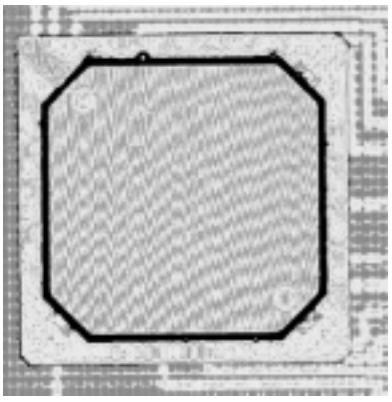

Figure 3 - Top Surface BGA.

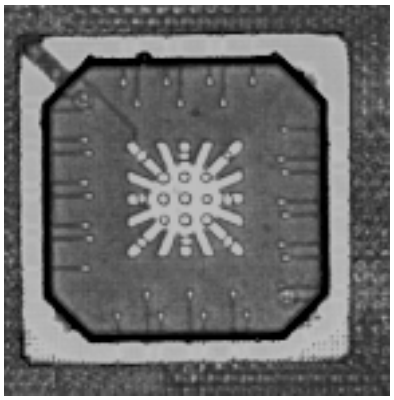

Figure 4 - Inner Layer BGA.

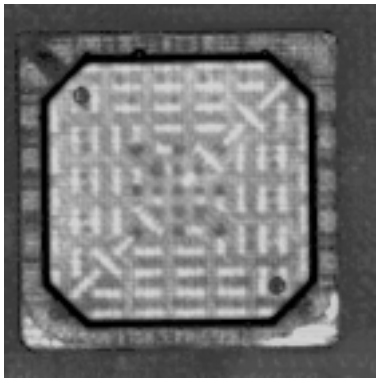

Figure 5 - Second Inner Layer BGA.

Acoustic microscopy displays delaminations as light areas against a darker background. Interpretation of areas lying below delaminations must be carefully undertaken, as most of the acoustic energy will be reflected back by the delamination so that the underlying area will appear unnaturally dark. In general, upper layers have the effect of casting a sonic shadow onto patterns contained in deeper layers.

In addition to delaminations many other defects can be revealed using SAM. These include die tilt; voids in underfill and die attach material and cracks in dies and substrates.

An example of using the acoustic microscope in conjunction with the x-ray microscope is shown in Figures 8 and 9. Both figure 8 (the x-ray image) and figure 9 (the acoustic image) show two wafers of silicon which were to be bonded together by reflowing indium squares that were deposited on facing surfaces of the wafers. The x-ray image clearly shows that the indium has not remained in place but has melted and agglomerated. The amount of actual bonding of the two wafers is somewhat in doubt. The acoustic image of the same area shows that most of the bonding occurs in the upper right quadrant which appears almost uniformly dark as a result of the acoustic energy passing freely through the indium bond.

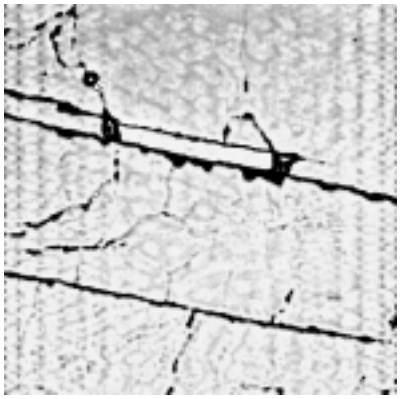

Figure 6. Rock Surface

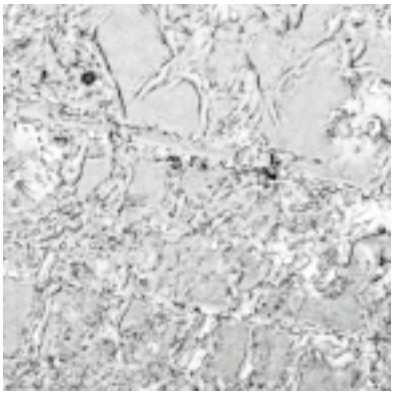

Figure 7. Rock Inner Structure.

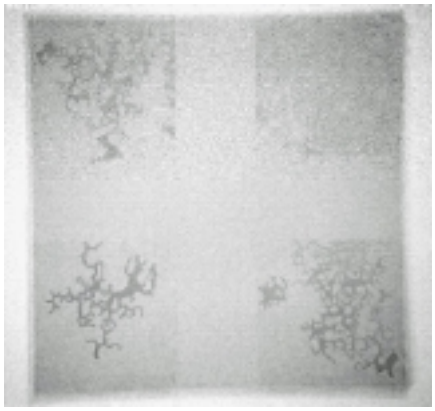

Figure 8. In bonded Si X-ray.

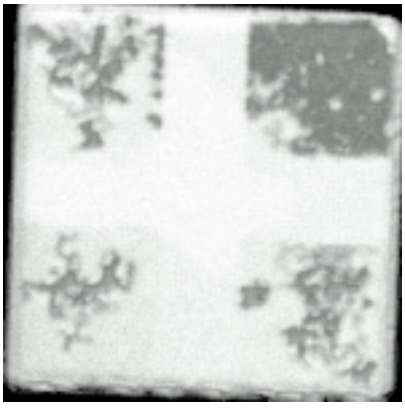

Figure 9. In bonded Si Acoustic