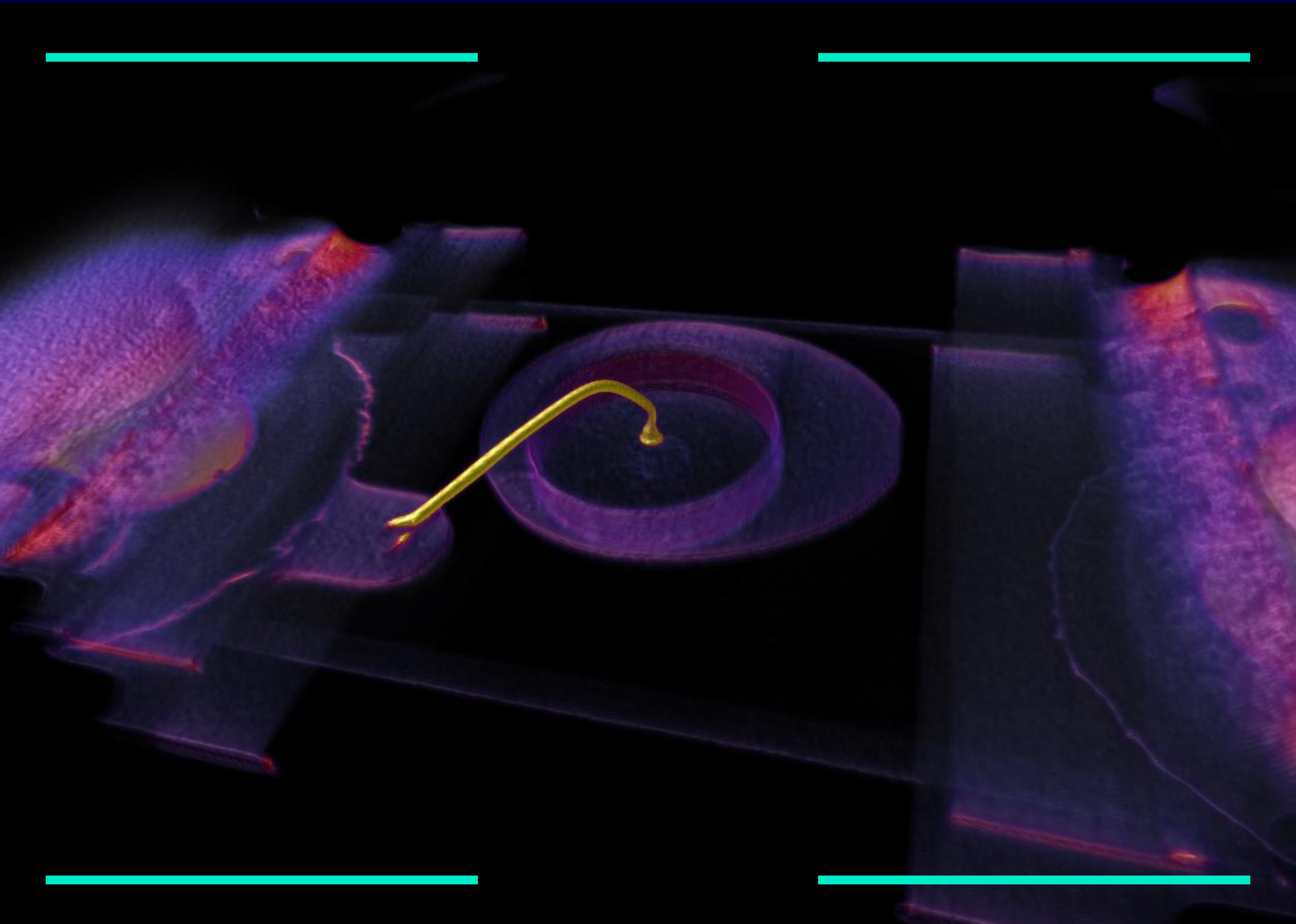
Inspired by Knowledge

Importance of combining X-Ray Tomography, SAM and Cross section techniques for electronic components inspections

CSAM - TEST COMBINATION



Test Combination

It is uncommon to run routinely multiple diagnostic tests during electronic components testing.However, when the origin of the anomalies is uncertain, a variety of complementary testingincreases the accuracy of the diagnosis and provides greater confidence in identifying theproblem.

When performing failure analysis, the first objective is to determine the most convenient testflow to try to define the root cause of the problem, depending on the type and mode of failure,device, packaging, etc. There there are three main tests for anomalies detection and studywhen it comes to electronic components: X-Ray Tomography, Scanning Acoustic Microscopy,and Cross Section.

This document reports the importance of X-Ray Tomography, Scanning Acoustic Microscopy (SAM), and Cross Section techniques, and the advantages of their combined use for accurate testing.

X-Ray Tomography

X-Ray Tomography allows us to know the internal structure of the electronic components with great precision, and it is an essential tool when carrying out a non-destructive analysis. The purpose of a Radiographic Inspection or 3D Tomography is to detect defects that are not otherwise visible: improper positioning of parts, broken elements, inhomogeneities in materials, foreign objects...

One of its drawbacks is its inability to detect the presence of air-gap defects within plastic encapsulated devices. Therefore, certain flaws would remain unnoticeable.

ALTER radiation equipment allows using a dynamic radiographic inspection technique, with a possibility to manipulate the sample to display different live views on a monitor, both in 2D and 3D. 2D X-ray inspection is one of the oldest and more consolidated methods for non-destructive internal inspection of not only EEE parts but also raw materials.

As it is illustrated in Figure 1, which compares X-ray inspection with CSAM microscopy, one of the main advantages of this technique relies on the capability to pass through thick objects and to detect sub-millimetric vertical features by recording top-down views of the samples.

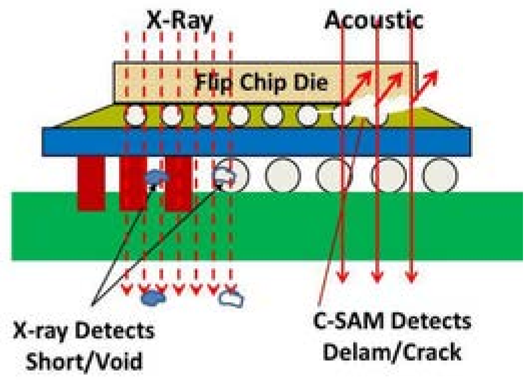


Figure 1. X-ray vs Acoustic Microscopy reprinted from "ECS Transactions, 33 (4) 47-57 (2010)"

However, such planar views do not provide enough information about internal structure of complex 3D assemblies and 3D reconstruction techniques are becoming a useful tool for the comprehensive inspection of such systems (Figure 2).

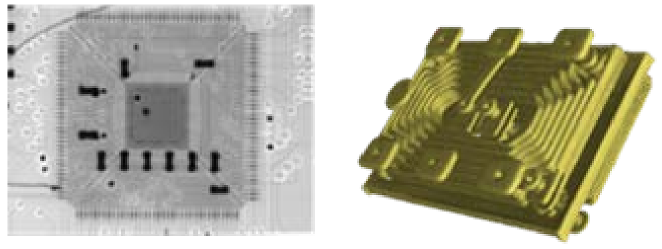


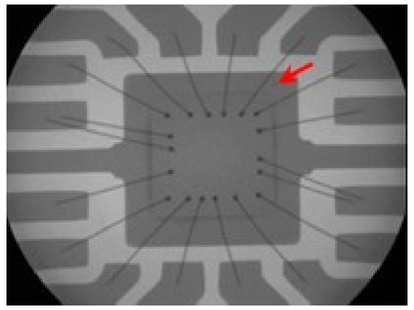
Figure 2. 2D (left) and 3D (right) X-ray non verification

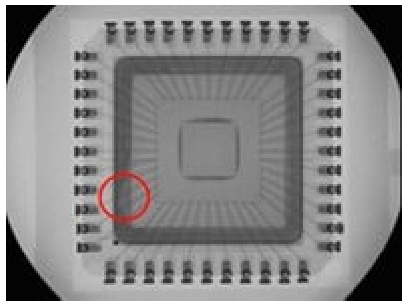
X-Ray Tomography capabilities:

- Accurate, fast, and repeatable inspection for EEE parts, RF harness, and PCB assemblies.
- High-power, a high-resolution inspection of minimal features.
- 2D X-Ray Inspection.
- 3D X-Ray inspection.: Computed Tomography (CT) with an in-depth 3D examination of inspection items via virtual cross-sections and layers. Dimensions and angles measurement.
- Multi-Area Void Calculation.
- Extended BGA inspection: BGA ball broke pad connection in CT, BGA head on a pillow, misaligned balls and pads, BGA with voids in 3D review, ...

Test Case: Device flaws detected by X-Ray radiographic inspection

The sample to be inspected is placed between the source of radiation and the detecting device which collects the radiation not absorbed by the sample. The amount of radiation reaching each area depends on the density and thickness of the materials, therefore the obtained image is of varying density.





X-ray Tomography is widely used in:

- Aerospace industries. ESCC 20900 – ASTM E1742 – ...
- Military defense. MIL-STD-883, TM 2012 – MIL-STD-750, TM 2076 – MIL-STD-202, TM 209 – ...
- Manufacturing industries.
- Automotive industries.
- Transport industries.

Scanning Acoustic Microscope (SAM)

Scanning Acoustic Microscopy (SAM) is a very reliable non-destructive technique for thedetection of air-gap anomalies of electronic components: Plastic encapsulated I, FlipChip systems (CGA, FCBGA, PBGA, FPBGA...), Bonded Wafers, Printed Circuit BoardsCapacitors, MEMS... allowing the identification of defects such as delamination, voids,and cracks within the internal structure.

Since these kinds of anomalies may lead to other defects, this technique is crucial in preventing more serious failures.However, once a defect is detected, it is not easy to know what is going on underneath it. This is the case of voids andcracks, that when being close to a thread, it is difficult to be sure whether they are intersecting it or not.

The working principle of SAM is based on the reflection that acoustic waves experience at the interface betweendifferent media and density irregularities.

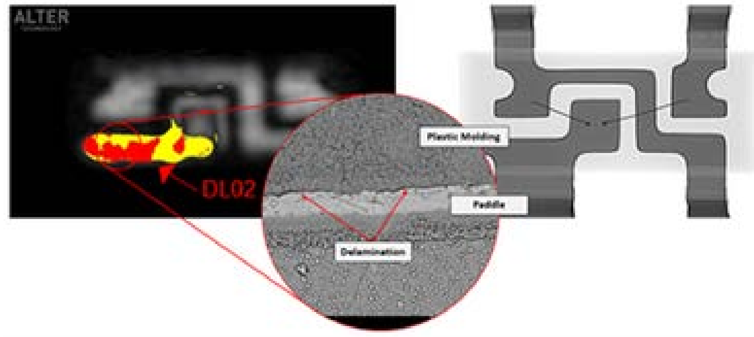
Working process of SAM in EEE parts

Scanning acoustic microscopy (SAM), also denominated acoustic micro imaging (AMI) and scanning acoustic tomography (SAT), is a consolidated and recognized tool for non-destructive quality control, inspection and failure analysis in microelectronics components and materials, which is routinely used for the inspection of plastic encapsulated integrated circuits amongst other systems.

SAM techniques analyze the intensity and phase of both the reflected and transmitted waves to create visual images reflecting the variations in the acoustic impedance of the specimen, thereby disclosing internal flaws and defects such as delamination and voids.

During this non-destructive test, an ultrasound acoustic wave is generated by a piezoelectric transducer that converts electrical signals into acoustic signals and viceversa (detection stage). The acoustic waves are focalized, by means of a set of acoustic lenses, inside the specimen for the internal inspection of the system.

Test Case: The importance of the SAM for delamination detection



The picture shows a case where delamination was detected during SAM inspection; this anomaly extends a huge area from one edge of the paddle to the die, covering almost the entire length. As you can see in the X-Ray image, there is no evidence of delamination since this technique is not sensitive to this kind of defect.

However, the presence of this air-gap anomaly was confirmed after performing a cross-section.

Scanning Acoustic Microscope (SAM) is widely used in:

- Space
- Defense and Aerospace
- Automotive
- Power and Energy
- Materials analysis: ceramics and composites

Cross Section

Cross section preparation is a very powerful way of examining the internal disposition of soldered connections, as well as analyzing potential failure mechanisms.

Microsection inspection is performed on an assembled through hole device as a part of a failure analysis. Cross-section through the plane of interest can provide helpfully information about solder defects, PCB inner layers and internal construction. As a part of a failure analysis, the plane of interest must be selected taking into account PCB characteristic, observed failure and previous test results.

By performing Cross Section, it is possible to mechanically expose a plane of interest in an electronic component by sawing, grinding, polishing, and staining the specimen. This technique is at its most useful when the location of the inspected part is known, providing a high-resolution imaging useful for evaluating various materials for surface fractures, flaws, contaminants, morphology of the intermetallic compound, etc.

Test case: Constructional analysis in cross-section technique

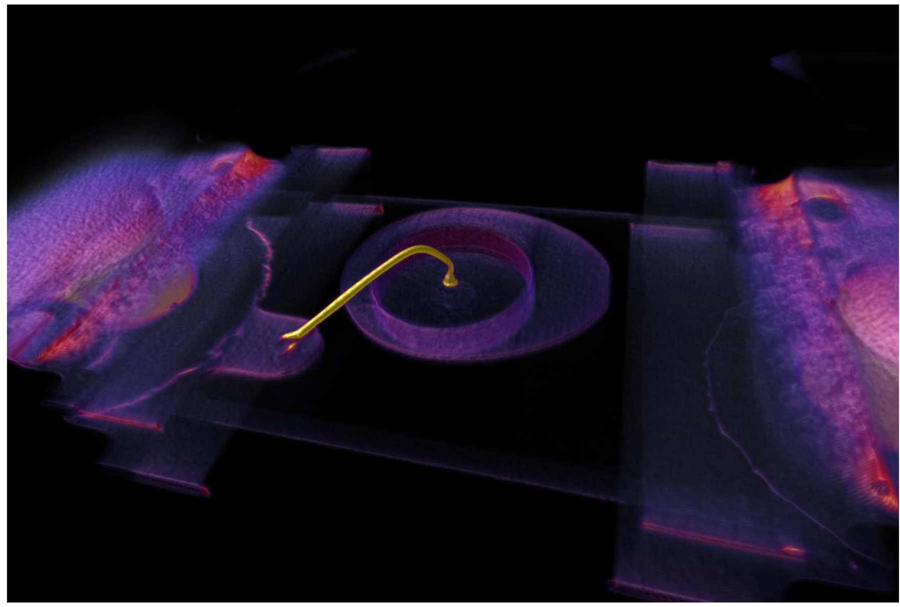
The FP device is potted in epoxy resin. After curing, the sample is sequentially grinded up to reach the plane of interest. Then, the specimen is subjected to several polishing steps to achieve a high-quality surface to be analyzed by a metallographic microscopy. Cross-section analysis, as a part of the constructional analysis, allows us to obtain information about the state of Die attaching, IC bonding, IC encapsulation and the whole internal structure.

Test combination: X-Ray Tomography,Scanning Acoustic Microscopy (SAM) and Cross Section techniques

Simulation studies are performed to examine the performance of the combination method.

Knowing the strengths and weaknesses of these techniques, it is clear how advantageous it is to combine all of them.X-Ray Tomography allows knowing the internal structure of the component, which is crucial for both SAM and Cross Section.

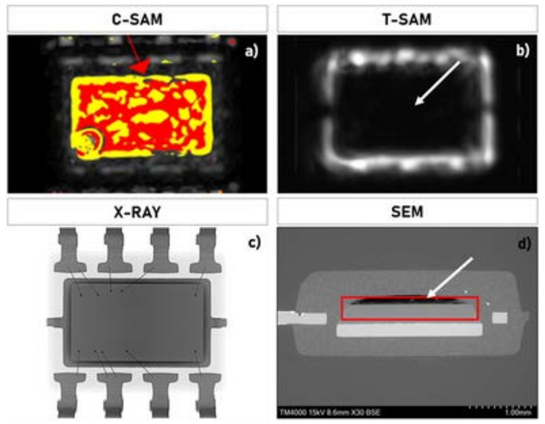
SAM allows detecting the presence of anomalies in a non-destructive way, allowing to perform Cross Section with accuracy to assess what SAM and X-Ray previously predicted.



Tomography, SAM and Microsection Images

In this particular case, which is illustrative of all theabove, it can be seen how the test flow, first of all,includes an X-ray test, which is not only beneficial forfinding possible faults but is also essential for carryingout an accurate SAM inspection.

X-rays reveal the internal structure of the component,and in this case, apparently do not raise suspicionsabout any possible defects. However, the SAMinspection, reveals the presence of a large cavity(delamination) on the surface of the die. This type ofdefect, which endangers not only the die but also thewires, implies the batch must be immediately rejected.



The reason why this anomaly was not detected by X-rays is due to the specific characteristic of the technique, wherebythe plastic is transparent to this kind of analysis. For this reason, the SAM is essential in detecting defects in the plastic,which may go undetected by X-rays.

Once the SAM inspection is completed, micro-sectioning can begin, which allows destructive cutting and corroborationof the presence of the faults detected by X-Ray and SAM. Here again, the "Dream Team" concept comes into play, asboth X-Ray and SAM are indispensable for determining the sectioning plane. This again shows how the techniquesfeedback on each other and are necessary to perform a quality inspection.

ALTER

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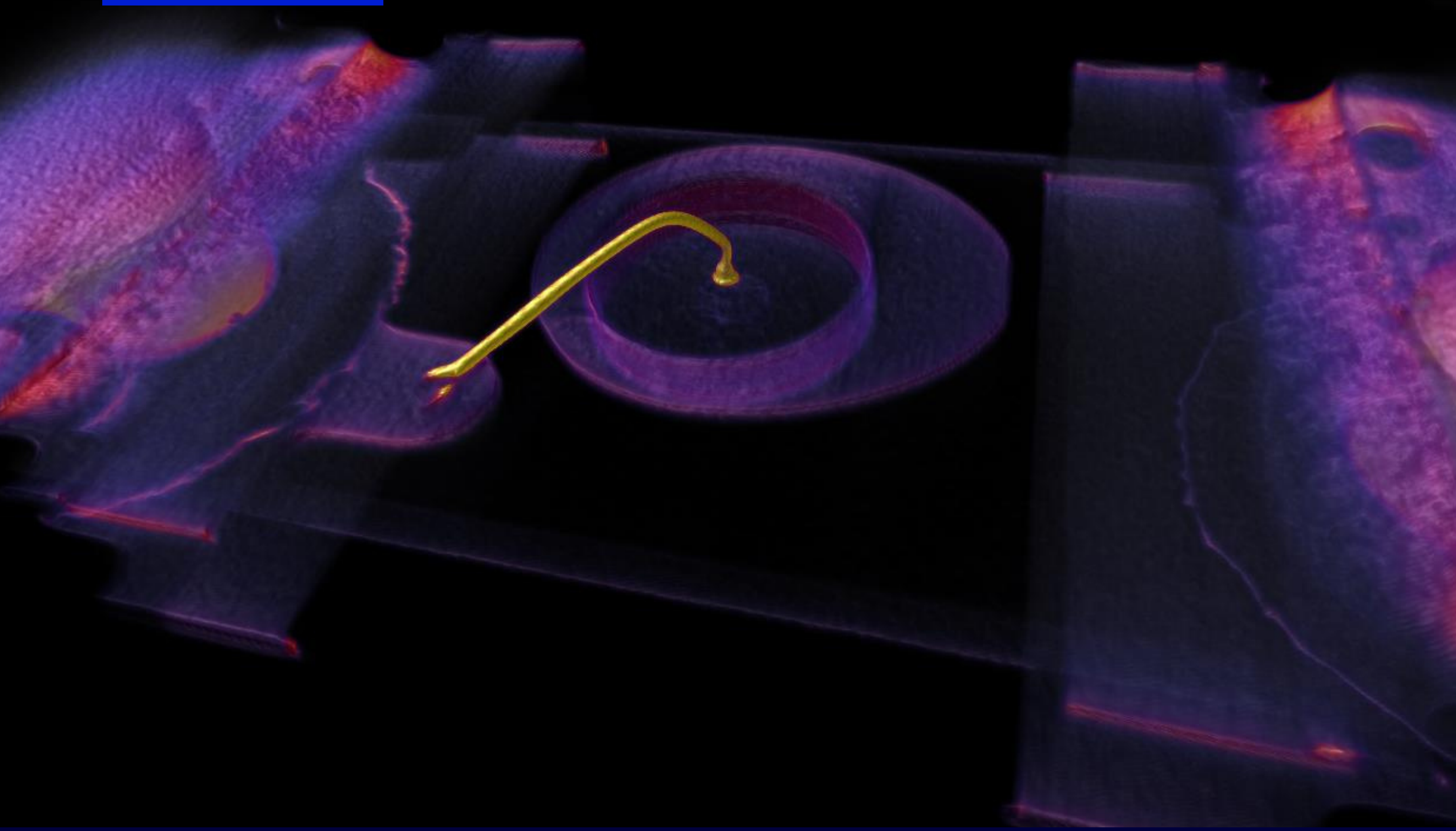

Non-destructive internal testing methods

X-Ray Tomography and Scanning Acoustic Microscopy (SAM) are non-destructive internal inspection methods that, combined with other destructive and functional tests, can be used to performa detailed analysis and study of: Plastic encapsulated IC, Flip Chip systems (CGA, FCBGA, PBGA, FPBGA...),Bonded Wafers, PCB Printed Circuit Boards, Capacitor and MEMS.

In ALTER the non-destructive inspection techniques are combined with different stress andenvironmental tests to analyse the effect on the system integrity and performance.

ALTER TECHNOLOGY

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