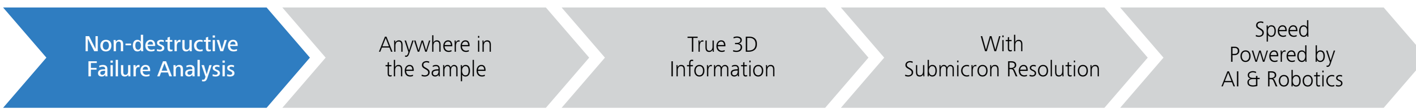
1 Non-destructive X-ray Imaging for Failure Analysis

Before You Do Anything to Disturb Your Sample, Take a Close Look Inside

Advances in semiconductor packaging technology are enabling improved device performance but are also presenting more challenging problems for failure analysts. In this series of Technical Briefs, we explore the critical role of high-resolution 3D X-ray imaging to visualize buried defects and key structures within intact samples in a non-destructive manner.



As transistor scaling described by Moore's Law slows, novel packaging approaches have emerged to continue driving device performance. Stacked die in 2.5D and 3D configurations, chiplets and heterogeneous integration approaches, and denser and smaller interconnects have all contributed to the increasing role that packaging technology plays in next-generation semiconductor products.

X-ray Microscopy Streamlines the FA Workflow

With the increasing complexity comes greater cost of failures and more challenging failure analysis (FA) tasks. Whether associated with process/package development, quality assurance, or field returns, the FA engineer must provide definitive proof of what (and who) is responsible for the failure.

Non-destructive 3D X-ray microscopy (XRM) has a critical role to play in the ecosystem of FA techniques. Typically following fault isolation, X-ray imaging provides a crucial high-resolution look inside the part prior to any further investigation, including destructive physical analysis. Due to the increasing complexity of modern semiconductor packages, 2D X-ray images are often insufficient for visualizing defects in the failure region, a topic which will be detailed in the third Tech Brief in this series.

Before physically cutting open the sample and risking disturbing the region of interest, use XRM to:

- Determine the likely nature of the defect (crack, void, short, non-wet, etc.)
- Gain a sense of the size of the defect
- Understand how prevalent the defects or features are in the sample
- Better determine where and at what orientation to cut a physical cross section, significantly enhancing efficiency of the subsequent FIB cut if required
- Assess which additional FA techniques might be required

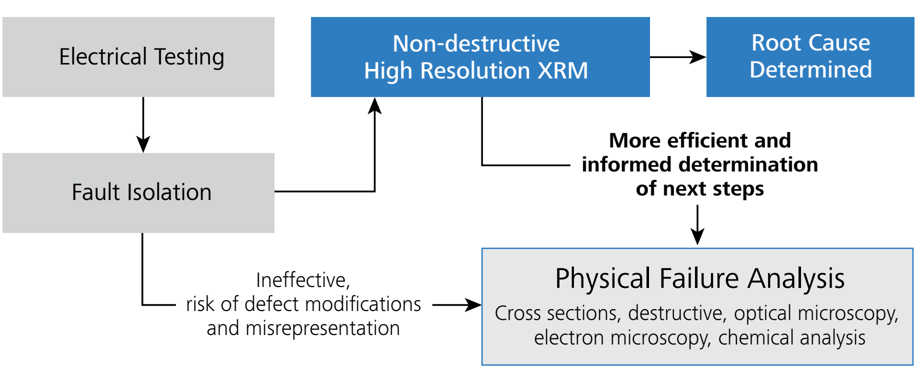


Figure 1 *XRM is performed following fault isolation but prior to physical and destructive failure analysis. Visualizing structures in 3D with XRM helps to accelerate downstream processes or can even determine failure root cause.*

The approach of bypassing X-ray and instead going straight from fault isolation to physical cross sections carries the potential for major risks and time delays.

A single cross-section preparation and imaging workflow can consume a full working day, leading to several-day turnaround times when multiple learning cycles are needed on different samples or different cross-section locations. When the financial impact due to production delays, launch delays, or yield loss can quickly run into millions of dollars, such slow learning cycles are crippling.

Seeing beyond

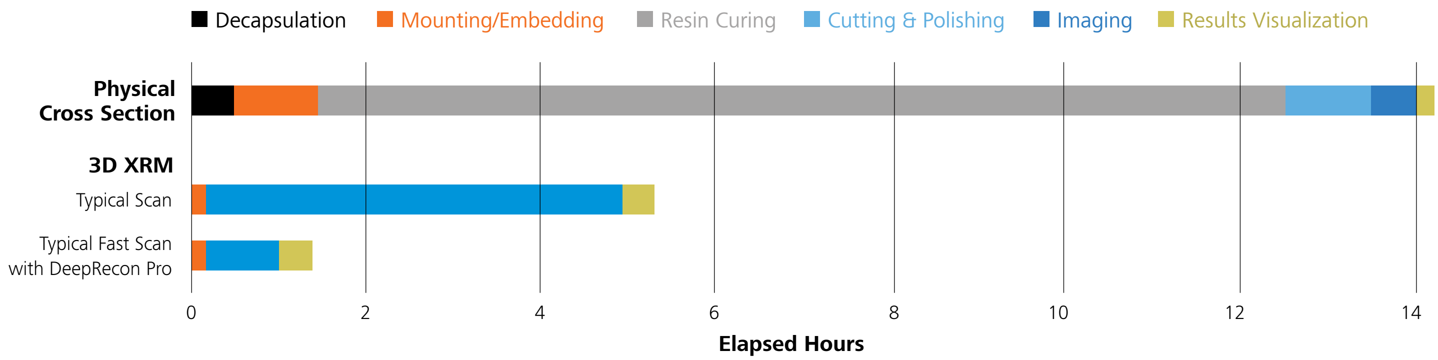


Figure 2 *Typical time-to-results comparison of physical cross section with 3D XRM.*

Reduce Uncertainty in FA

3D X-ray scanning provides data in a matter of hours and produces virtual 2D cross sections at any location or orientation the user requires. XRM scan times depend on sample characteristics, with two cases shown in Figure 2. (Tech Brief 5 in this series will show how advanced AI-powered tomography reconstruction techniques are now being used to help improve scan throughput by a factor of four.) Furthermore, by using non-destructive 3D visualization to plot a roadmap for the next steps of the FA workflow, you increase total efficiency and reduce the risk of disturbing the region of interest. You also achieve unambiguous, definitive evidence of the contained structures in their native state, avoiding the uncertainty and doubt that can arise the instant a sample is physically modified by a cutting blade or grinding/polishing machine. XRM data provides intuitive 3D results that are easily communicated to colleagues, managers, and other stakeholders.

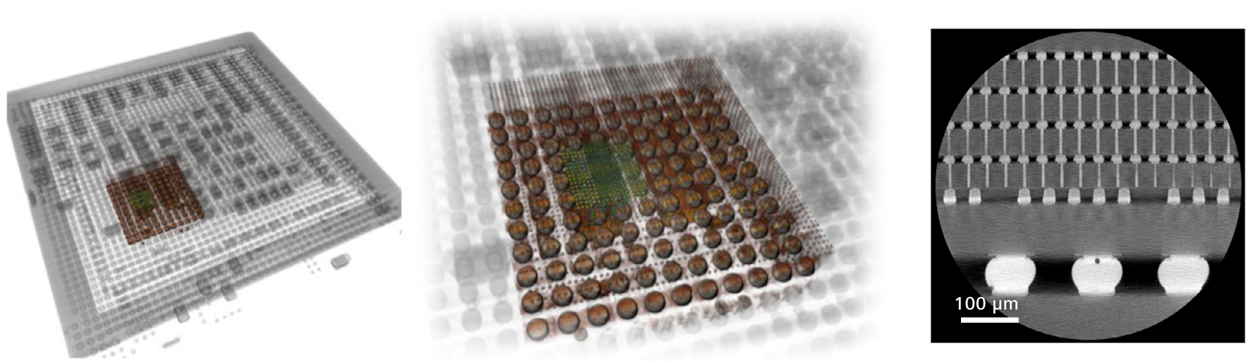


Figure 3 *2.5D interposer package imaged by Xradia 620 Versa 3D X-ray microscope at 35 µm/voxel, 11 µm /voxel and 0.72 µm/voxel, respectively.*

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