nanores
lab

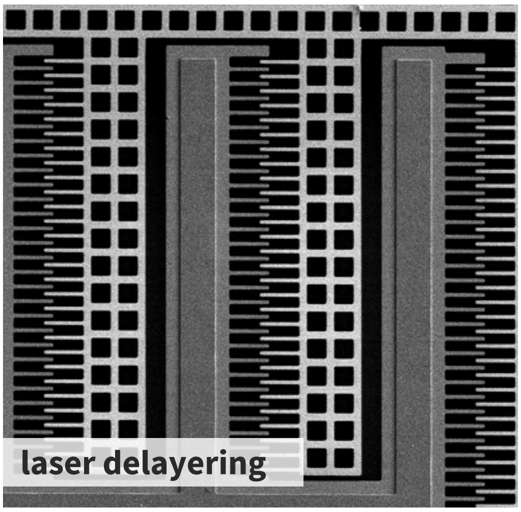
SEMICONDUCTORS
TESTING

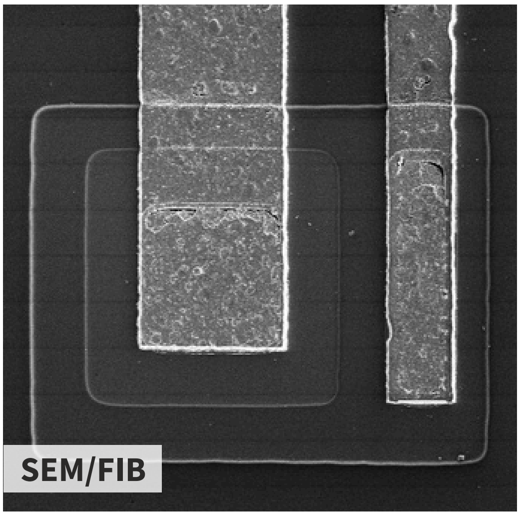
ABOUT:

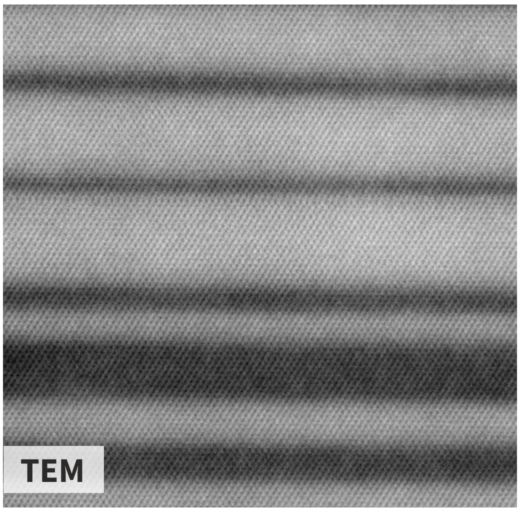
SEMICONDUCTORS TESTING

Semiconductor industry continues to develop and the state-of-the-art semiconductor devices are not only getting smaller than their precursors, but also more complex. As a result, they require more sophisticated tools needed for development, prototyping, identification and control of defects, as well as making precise and high-resolution microscopic observations.

Scanning electron microscopy (SEM) in combination with focused ion beam (FIB) is a perfect technique that offers high-precision analytical capabilities.

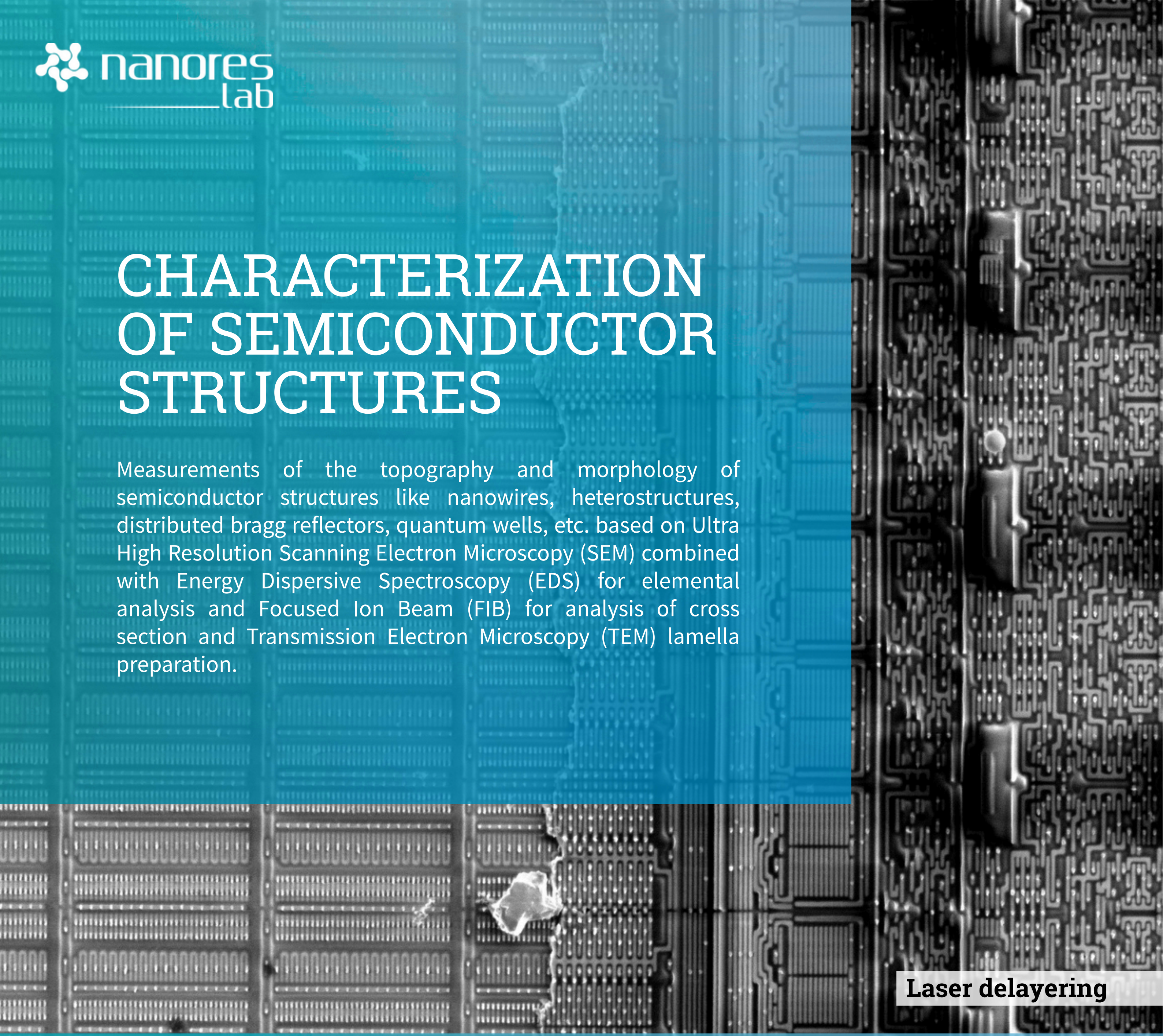

laser delayering


SEM/FIB

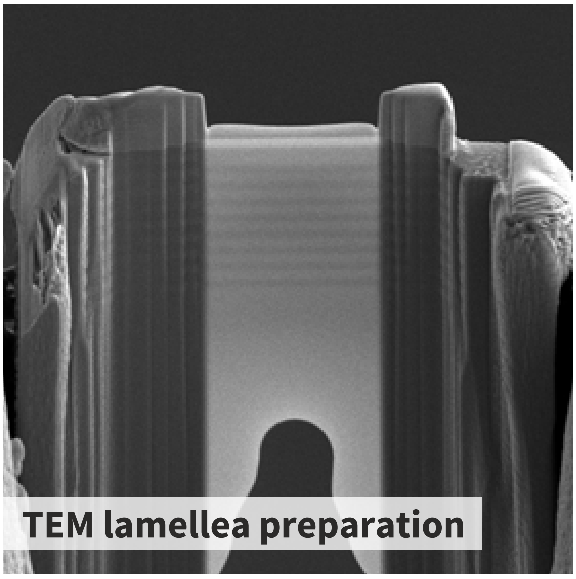

TEM

CHARACTERIZATION OF SEMICONDUCTOR STRUCTURES

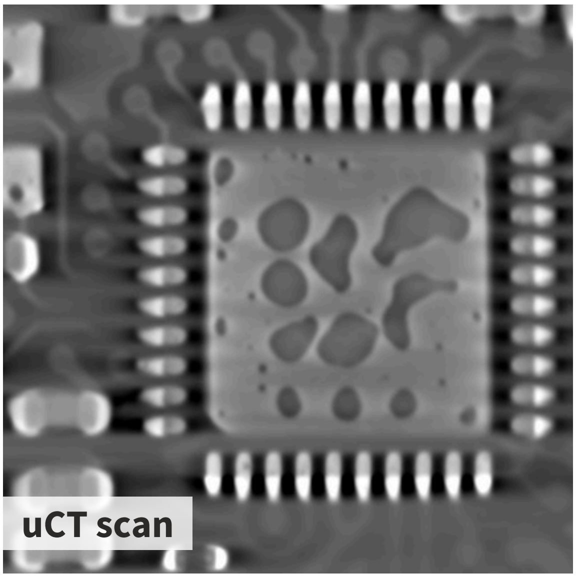
Measurements of the topography and morphology of semiconductor structures like nanowires, heterostructures, distributed bragg reflectors, quantum wells, etc. based on Ultra High Resolution Scanning Electron Microscopy (SEM) combined with Energy Dispersive Spectroscopy (EDS) for elemental analysis and Focused Ion Beam (FIB) for analysis of cross section and Transmission Electron Microscopy (TEM) lamella preparation.



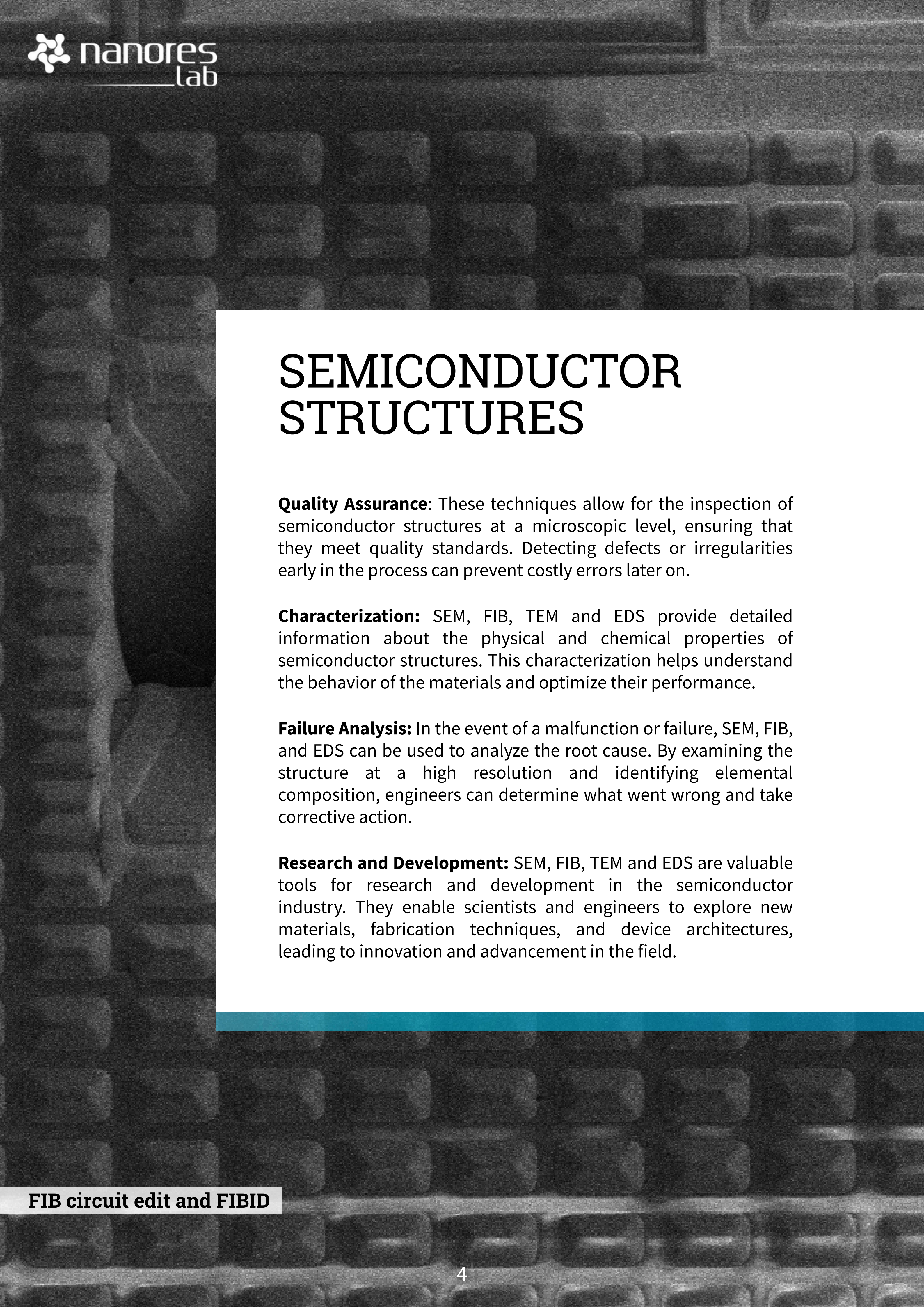
Laser delayering



TEM lamellea preparation



uCT scan



FIB circuit edit and FIBID

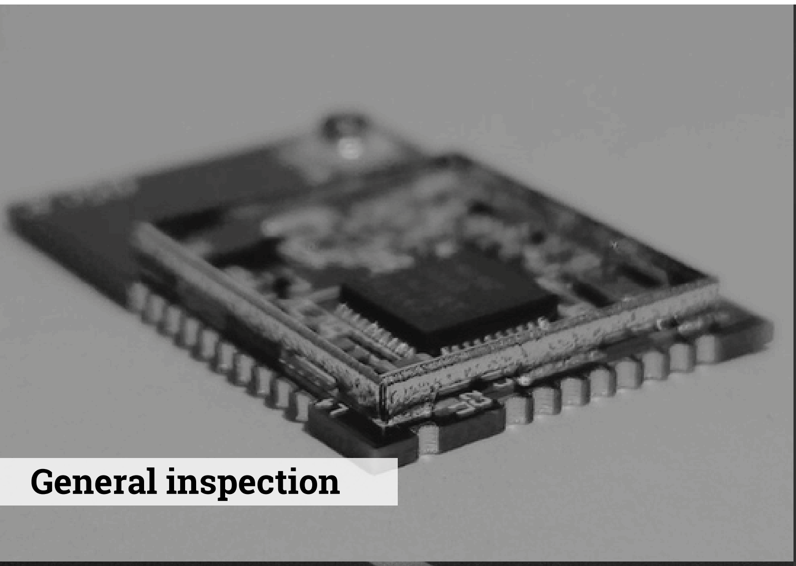
SEMICONDUCTOR STRUCTURES

Quality Assurance: These techniques allow for the inspection of semiconductor structures at a microscopic level, ensuring that they meet quality standards. Detecting defects or irregularities early in the process can prevent costly errors later on.

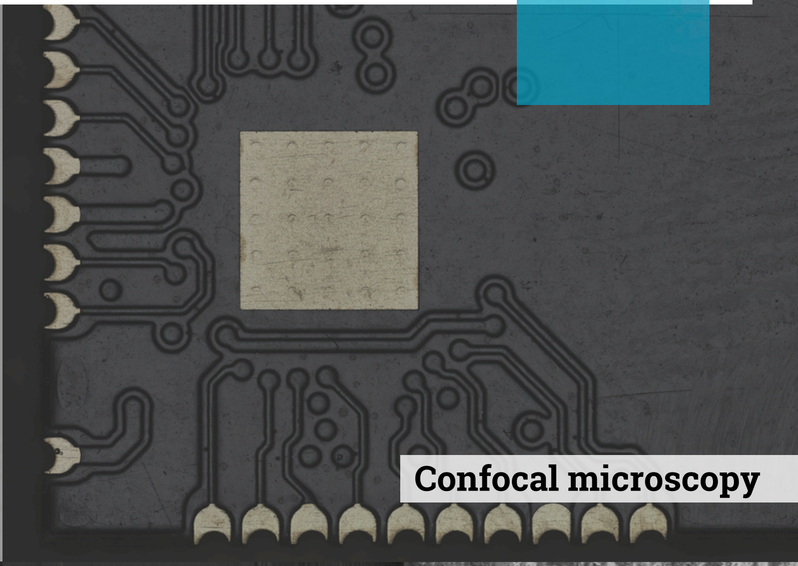
Characterization: SEM, FIB, TEM and EDS provide detailed information about the physical and chemical properties of semiconductor structures. This characterization helps understand the behavior of the materials and optimize their performance.

Failure Analysis: In the event of a malfunction or failure, SEM, FIB, and EDS can be used to analyze the root cause. By examining the structure at a high resolution and identifying elemental composition, engineers can determine what went wrong and take corrective action.

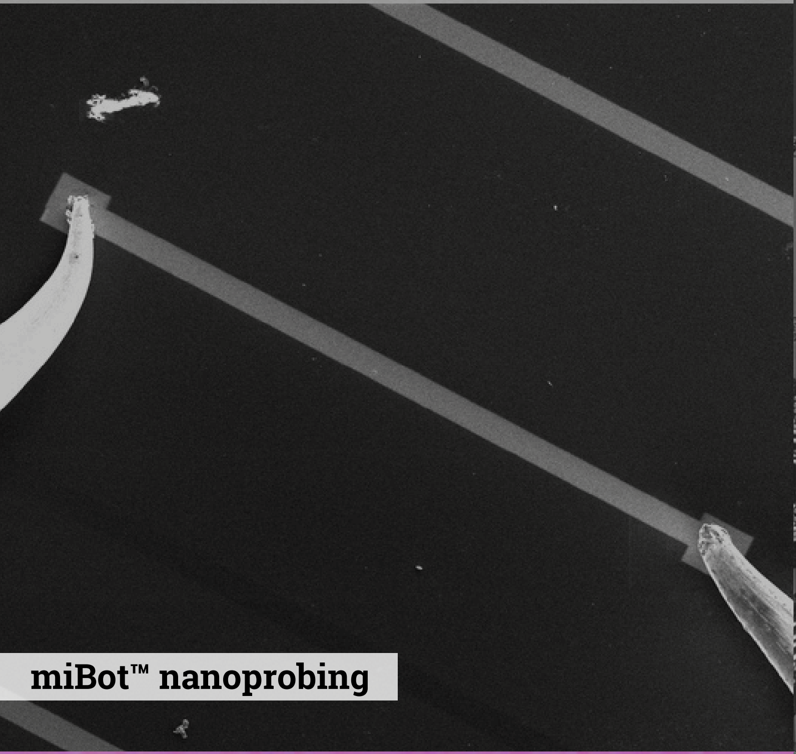
Research and Development: SEM, FIB, TEM and EDS are valuable tools for research and development in the semiconductor industry. They enable scientists and engineers to explore new materials, fabrication techniques, and device architectures, leading to innovation and advancement in the field.



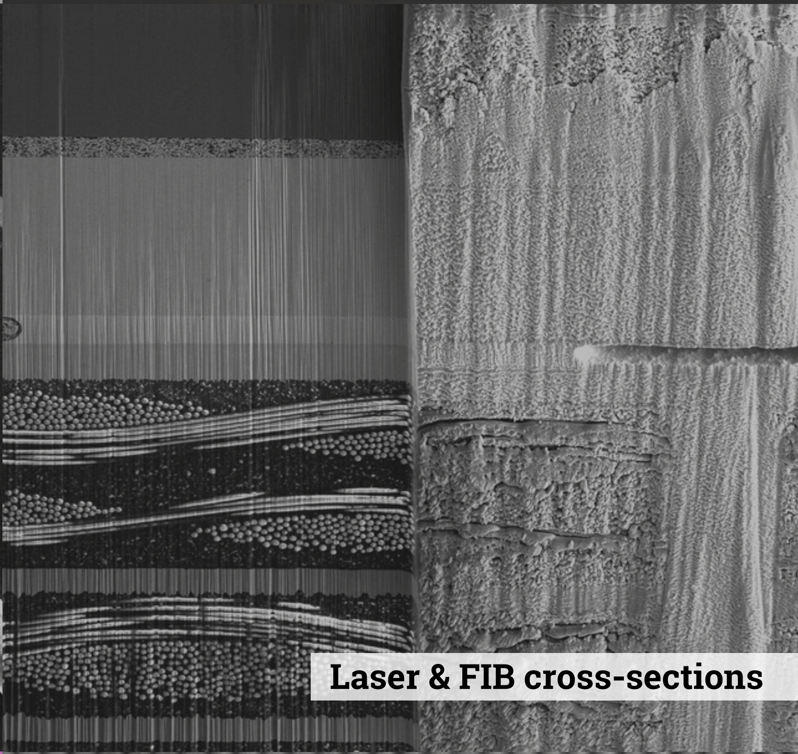
General inspection



Confocal microscopy

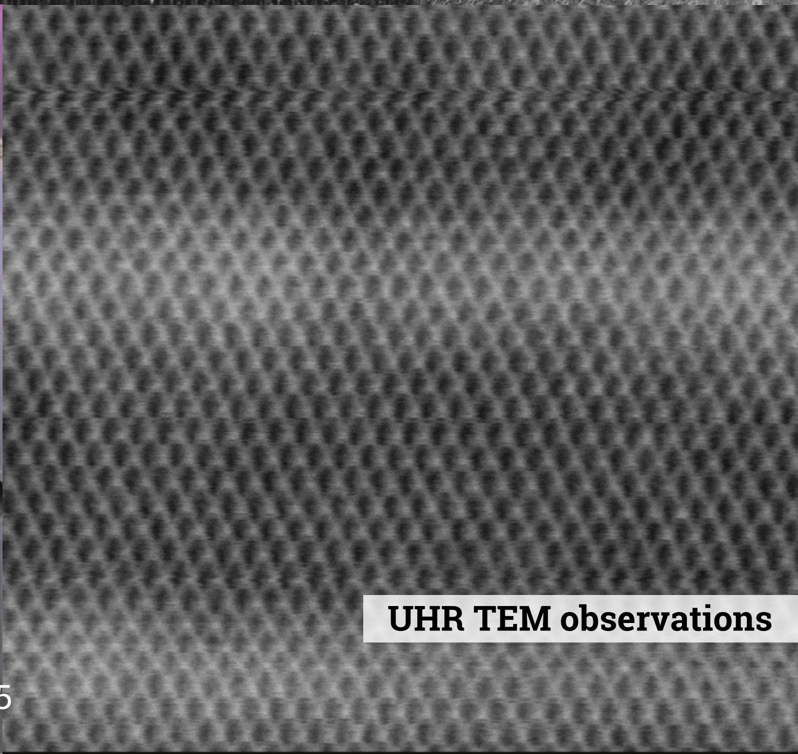


miBot™ nanoprobing



Laser & FIB cross-sections

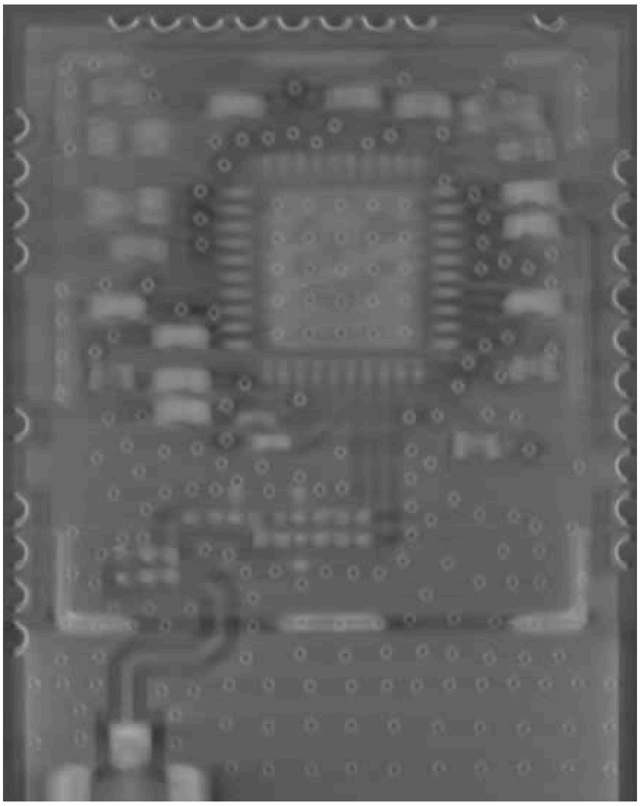
EDS



UHR TEM observations

ICS TESTING - CT SCAN

Using Computerized Tomography (CT) scans to examine integrated circuits (ICs) is important for several reasons, particularly in the context of quality control, failure analysis, and research and development of advanced electronics. CT scans are a powerful tool for examining integrated circuits, offering a non-destructive means to gain detailed internal insights. This technology enhances accuracy, efficiency, and reliability in the analysis and production of ICs, ultimately contributing to higher quality and performance in electronic devices.



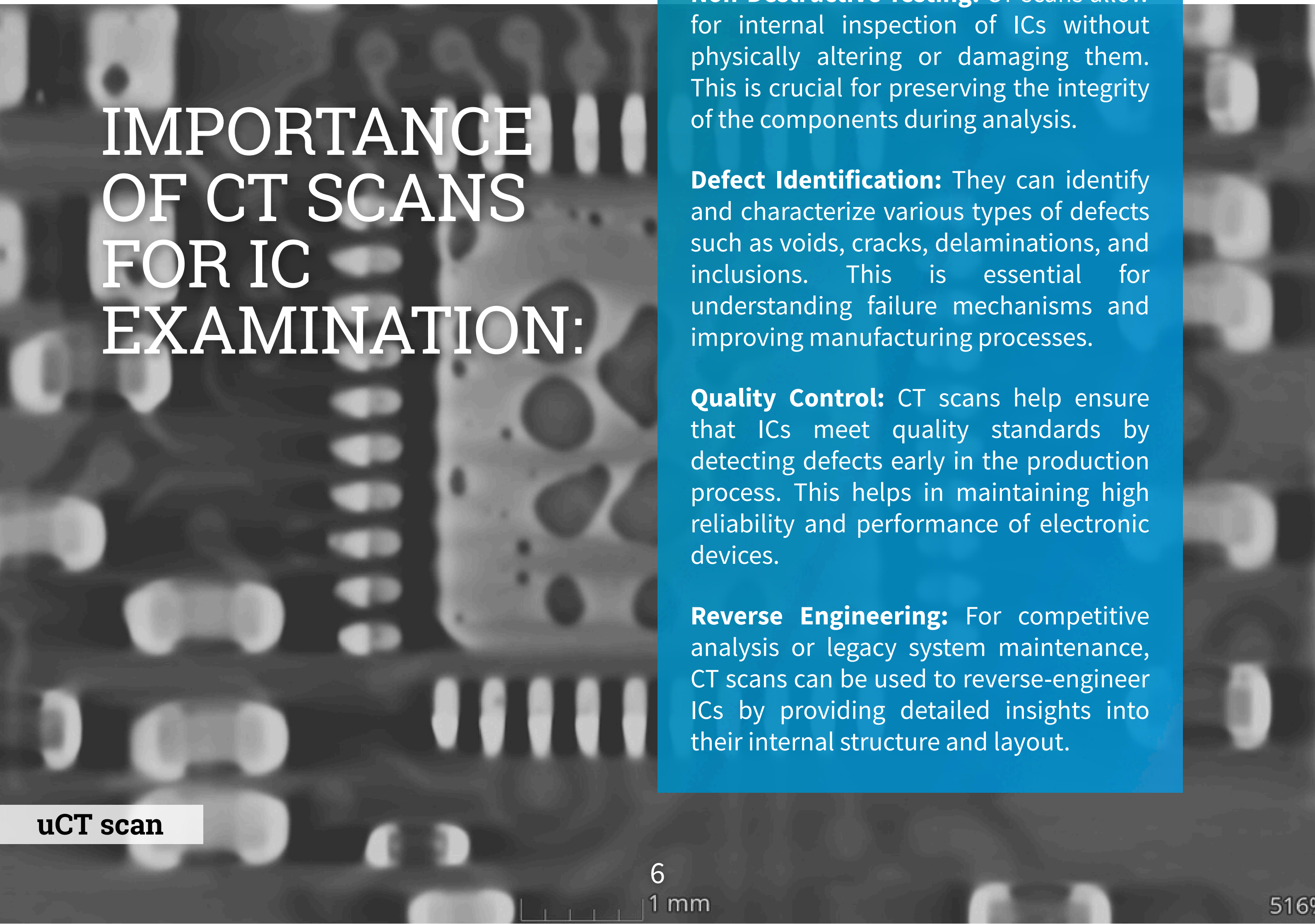
IMPORTANCE OF CT SCANS FOR IC EXAMINATION:

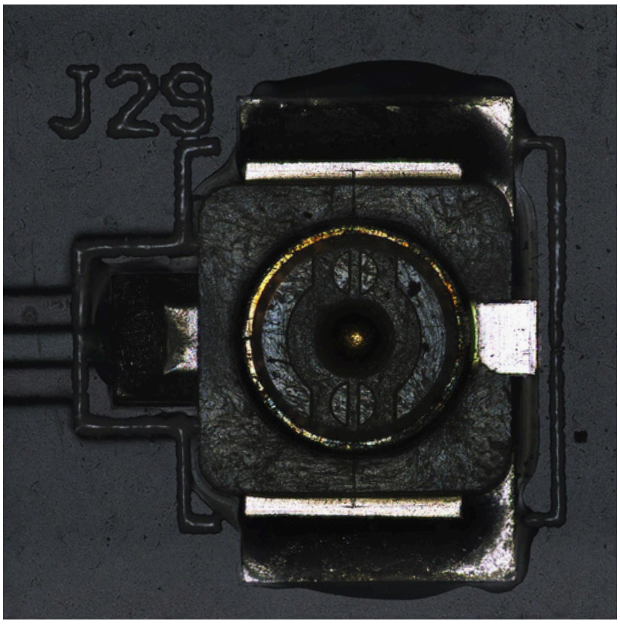
Non-Destructive Testing: CT scans allow for internal inspection of ICs without physically altering or damaging them. This is crucial for preserving the integrity of the components during analysis.

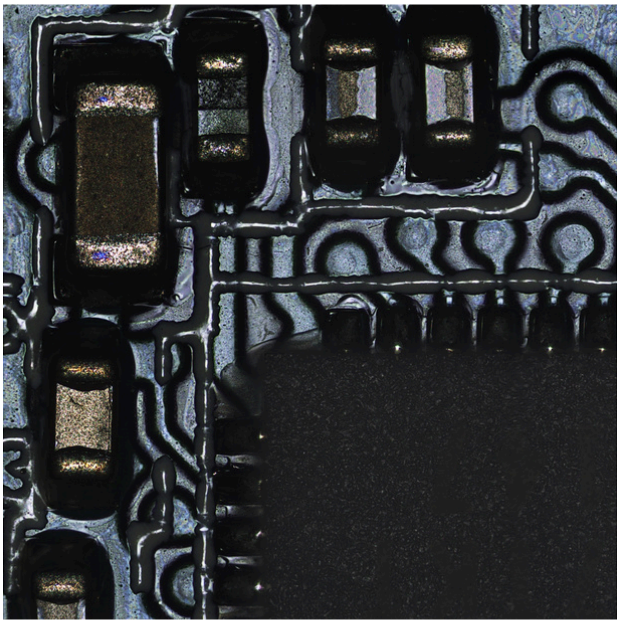
Defect Identification: They can identify and characterize various types of defects such as voids, cracks, delaminations, and inclusions. This is essential for understanding failure mechanisms and improving manufacturing processes.

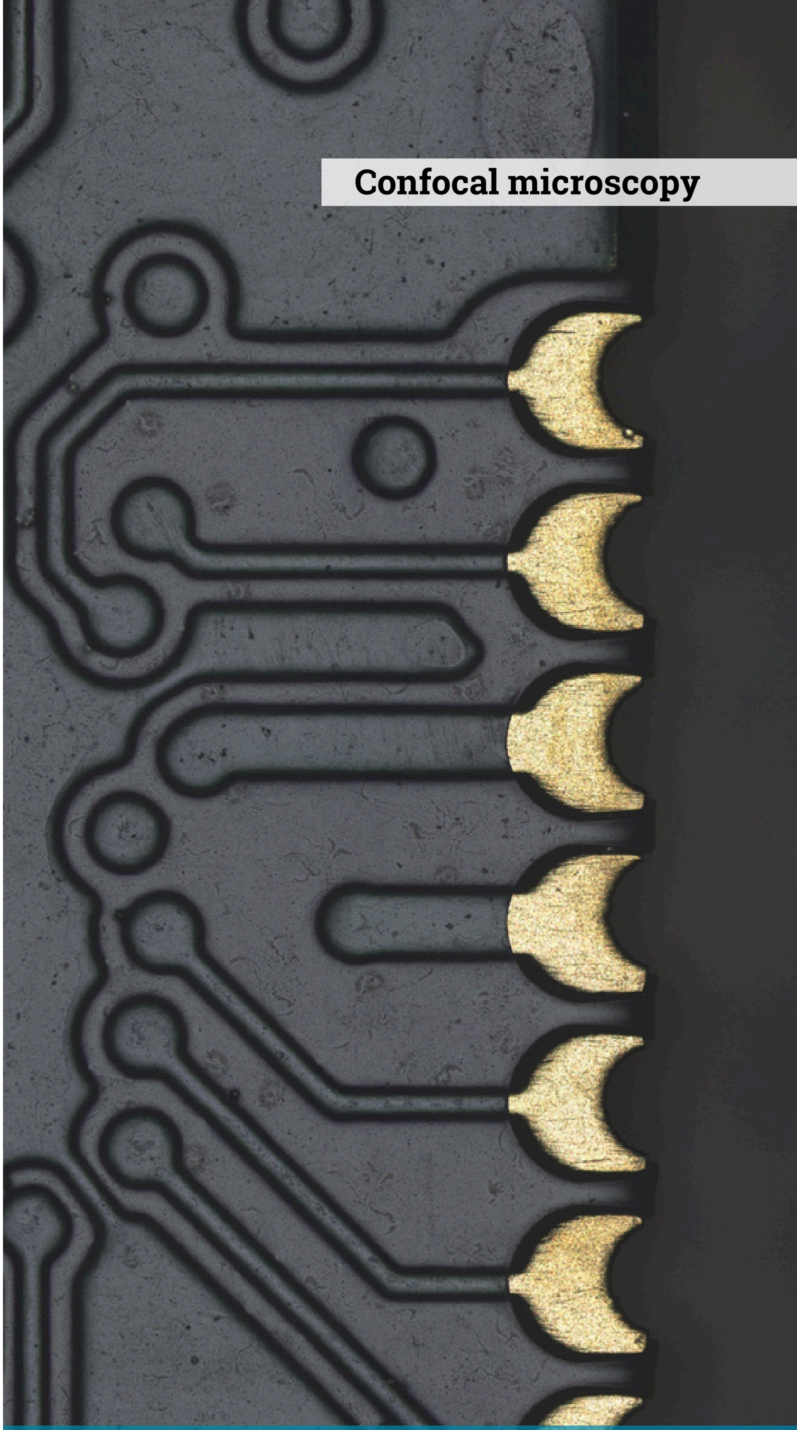
Quality Control: CT scans help ensure that ICs meet quality standards by detecting defects early in the production process. This helps in maintaining high reliability and performance of electronic devices.

Reverse Engineering: For competitive analysis or legacy system maintenance, CT scans can be used to reverse-engineer ICs by providing detailed insights into their internal structure and layout.





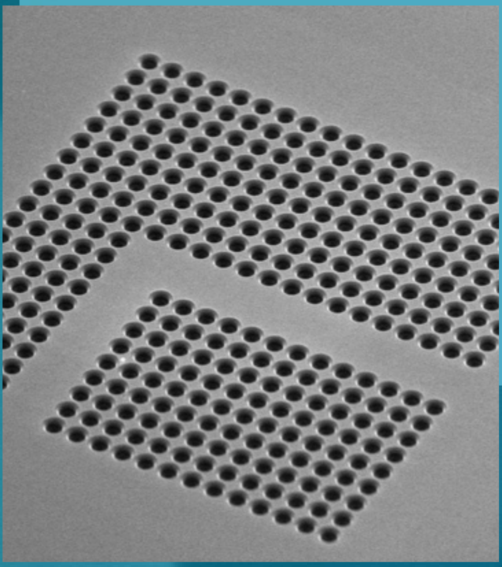




CONFOCAL MICROSCOPY IN IC TESTING:

Using confocal microscopy in the testing of integrated circuits (ICs) provides high-resolution imaging capabilities, precise depth profiling, and enhanced contrast, which are crucial for detailed inspection and analysis of ICs. Confocal microscopy is an invaluable tool in the testing and analysis of integrated circuits due to its ability to provide high-resolution images.

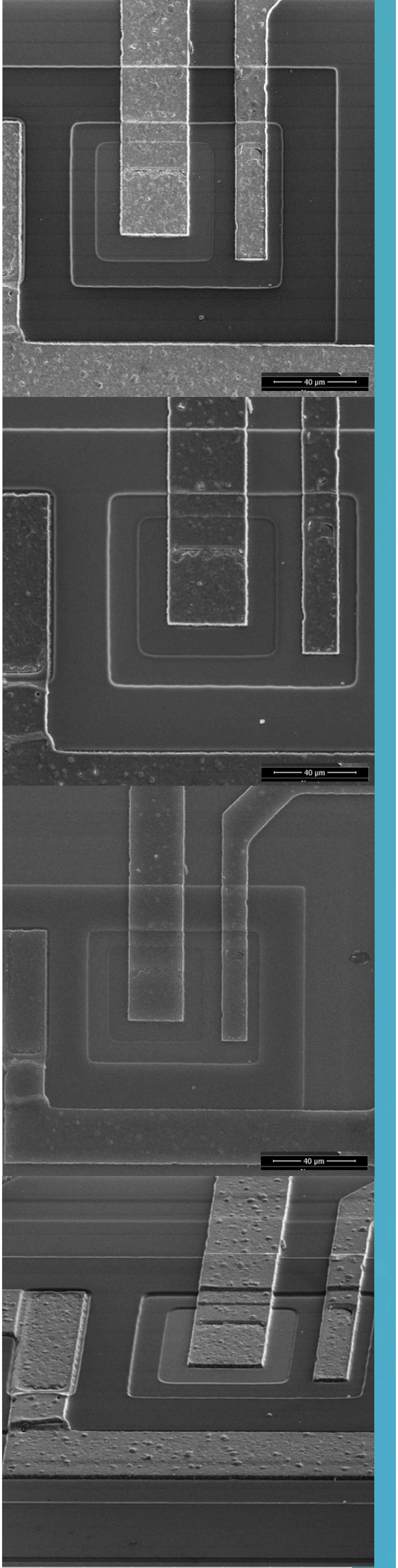
ICS TESTING - SEM IMAGING



SEM microscopy offers unparalleled advantages for the testing and analysis of integrated circuits, providing high-resolution imaging, versatile signal detection, and detailed failure analysis capabilities. Its ability to deliver detailed surface and subsurface information, combined with non-destructive testing, makes SEM an essential tool in ensuring the quality, reliability, and performance of modern ICs.

USING SCANNING ELECTRON MICROSCOPY (SEM) FOR INTEGRATED CIRCUITS (ICS) TESTING OFFERS SEVERAL SIGNIFICANT ADVANTAGES, MAKING IT AN INVALUABLE TOOL IN THE SEMICONDUCTOR INDUSTRY:

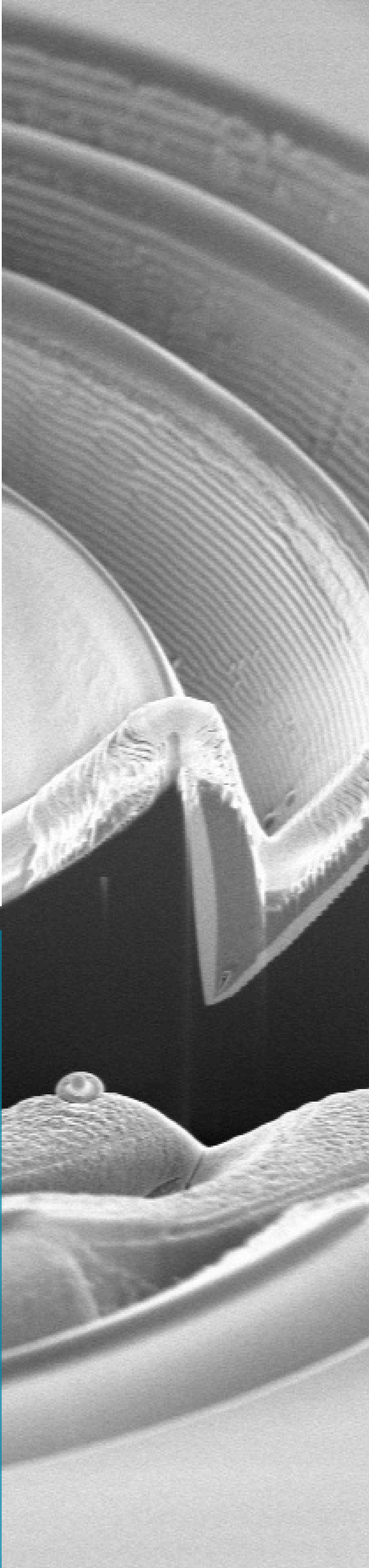
- SEM provides extremely high-resolution images, typically down to the nanometer scale. This allows for the detailed examination of surface features and fine structures within ICs, which is crucial for identifying defects and ensuring quality.
- With modern ICs having features as small as a few nanometers, SEM’s ability to visualize these tiny features is essential for accurate inspection and analysis.
- Secondary Electrons (SE): These provide detailed topographical information, which is essential for examining the surface structure and identifying physical defects such as cracks, voids, and contamination.
- Backscattered Electrons (BSE): These provide compositional contrast, which is useful for identifying different materials and layers within the IC. This can help in detecting issues like incorrect material deposition or diffusion.
- When combined with EDS, SEM can provide elemental composition analysis. This is valuable for verifying the material composition of various parts of the IC and identifying contamination or impurities.
- SEM is critical for failure analysis, enabling the detailed examination of defects that may cause IC failure. This includes identifying issues such as electromigration, stress voiding, and contamination.
- By providing detailed images and compositional data, SEM helps engineers trace the root causes of failures, allowing for targeted improvements in design and manufacturing processes.

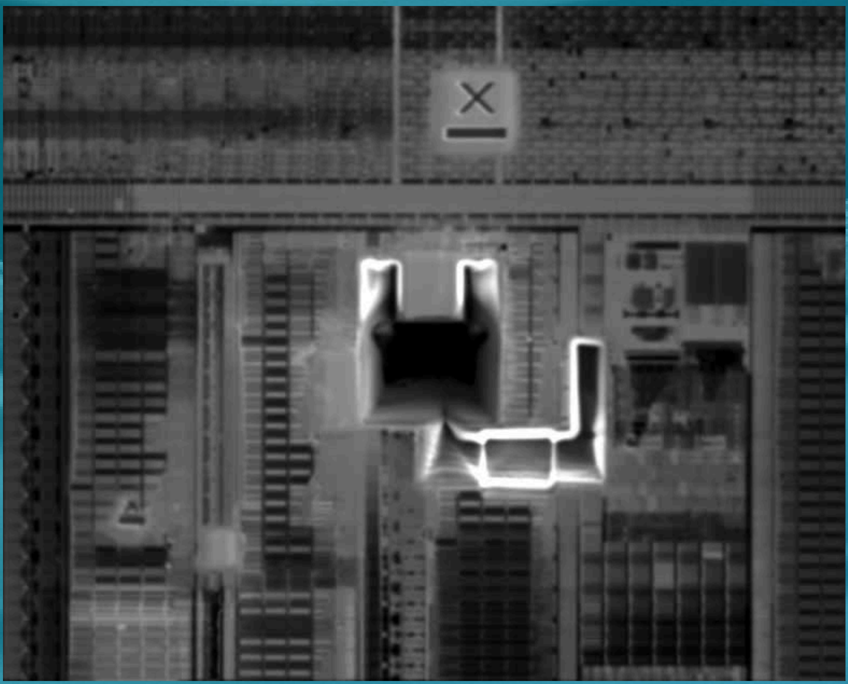


CUTTING AN IC WITH A FOCUSED ION BEAM GA-FIB AND XE-PFIB

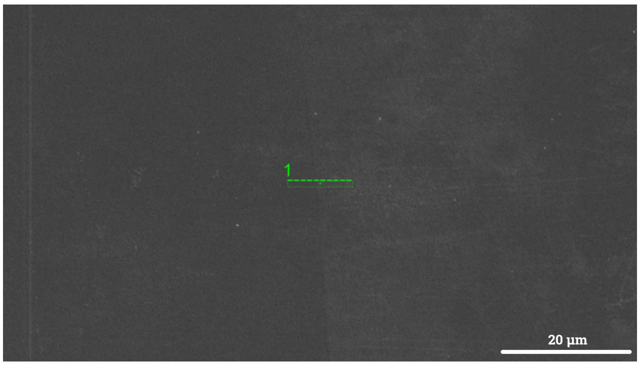
ocused Ion Beam (FIB) systems use a finely focused beam of ions to mill, cross-section, or modify materials with nanometer precision. They are indispensable in semiconductor manufacturing, failure analysis, and IC/MEMS research, where access to subsurface structures without mechanical polishing is critical. Plasma FIB (PFIB) is an evolution of this technique that replaces the conventional gallium ion source with a Xenon plasma source. This enables significantly higher ion currents and faster sputtering rates, making PFIB especially suitable for large-volume cross-sections and package-level investigations.

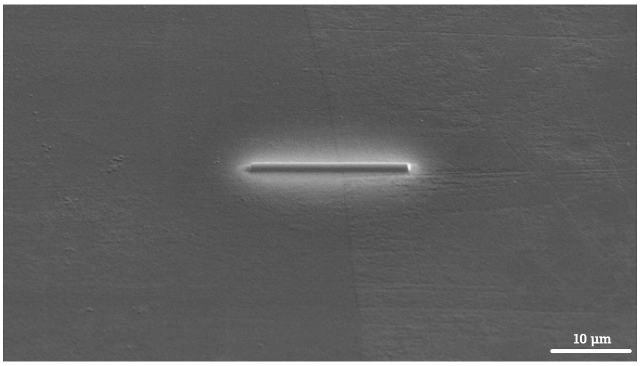
Using the method of delayering an IC Xe-PFIB is important due to its efficiency, precision, and minimal contamination. The high milling rates, combined with fine control and minimal damage, make Xe-PFIB an essential tool for detailed IC analysis.

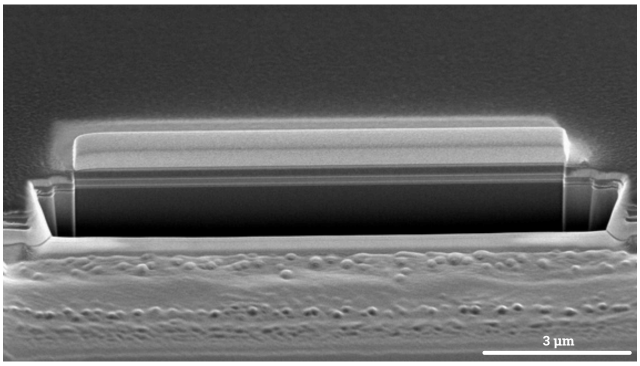


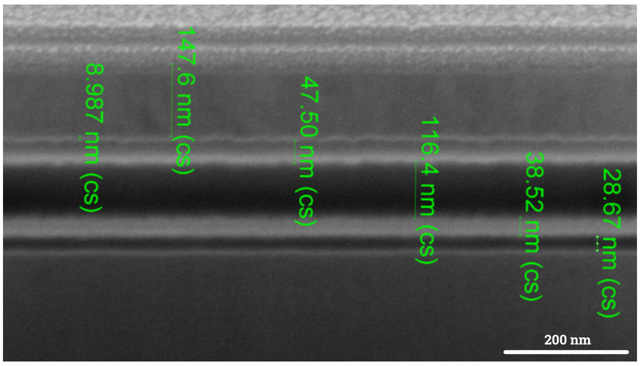


EFFICIENT MATERIAL REMOVAL FOR IC CROSS-SECTIONS AND DELAYERING:



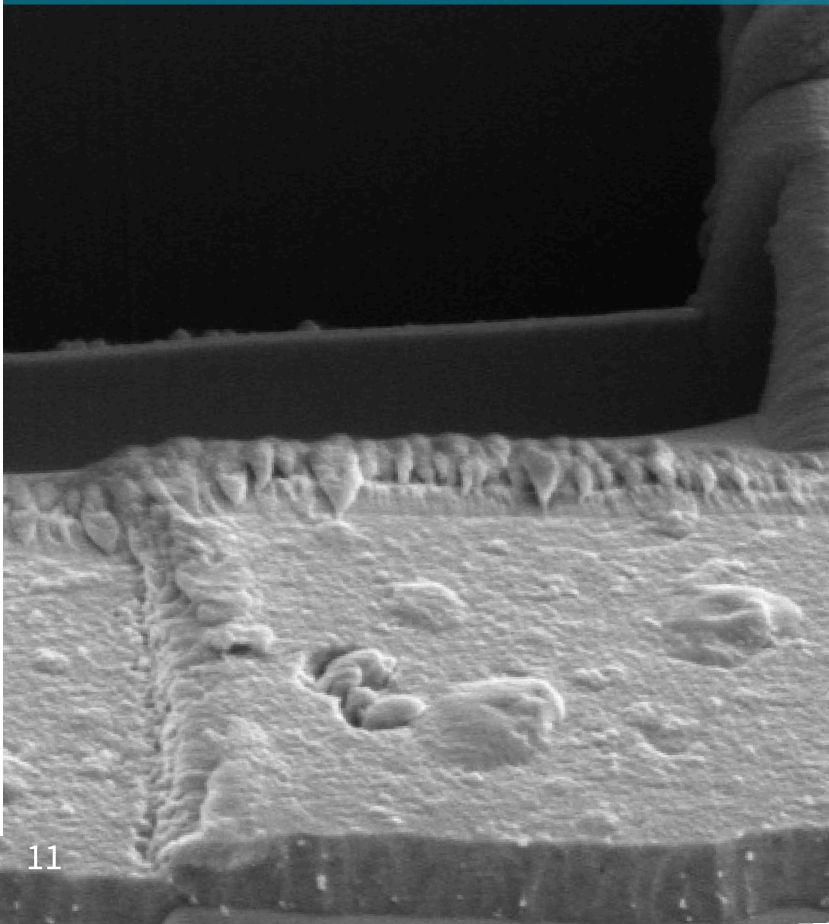






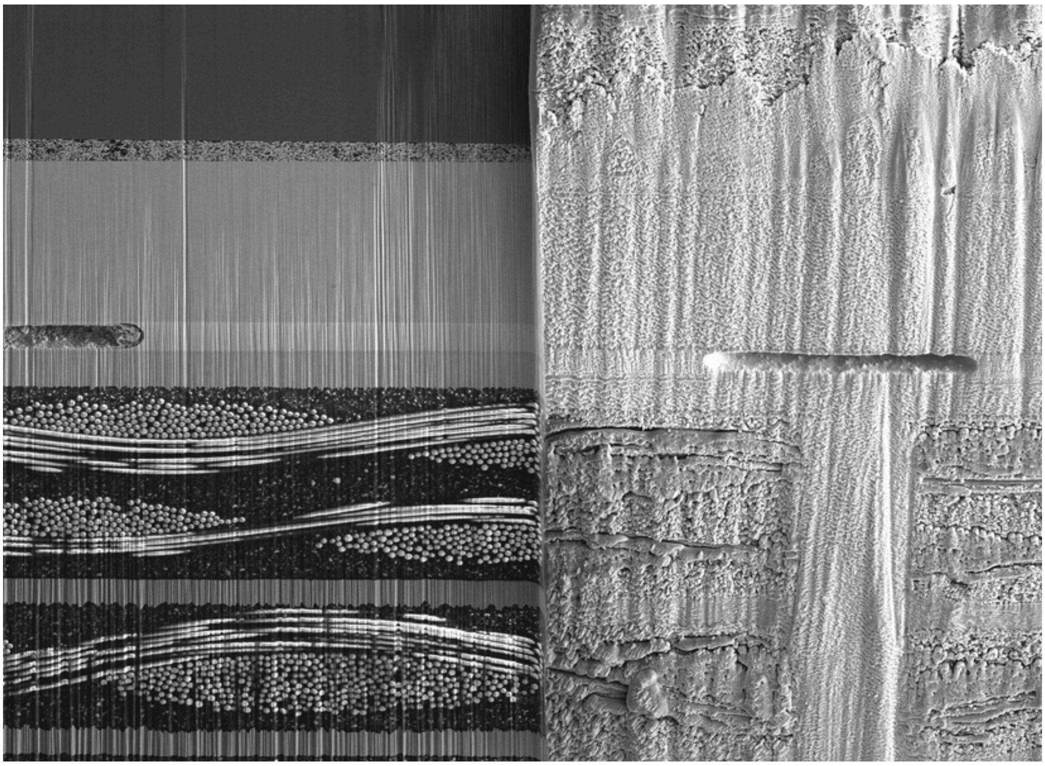
- High Throughput: Xe-PFIB can remove material much faster than traditional Ga-FIB due to the heavier xenon ions, which results in higher sputter rates. This efficiency is critical for delayering the numerous and often thick layers in modern ICs.

- Xe-PFIB enables rapid large-volume 3D reconstructions by sequentially milling and imaging device structures with high resolution. This technique reveals the full architecture of ICs, MEMS, and advanced packaging, exposing hidden defects and interfaces critical for failure analysis and R&D.



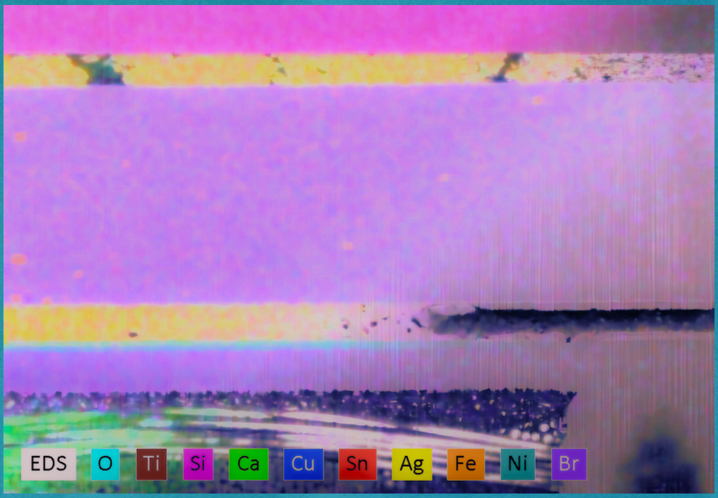
ICS TESTING WITH A FEMTOSECOND LASER FOLLOWED BY POLISHING IT WITH A FOCUSED ION BEAM (FIB)

The combined use of femtosecond laser ablation and FIB polishing for cross-sectioning ICs offers significant advantages in terms of speed, precision, and quality. This approach enables detailed and accurate analysis of ICs, facilitating failure analysis, quality control, and research and development in the semiconductor industry.



BENEFITS OF THE BOTH METHODS COMBINED:

- Rapid Bulk Removal: The femtosecond laser quickly removes large volumes of material, significantly speeding up the cross-sectioning process compared to using FIB alone.
- Precision Polishing: FIB provides the fine control needed for the final polishing steps, ensuring a high-quality cross-section suitable for detailed analysis.
- Non-Thermal Laser Ablation: The femtosecond laser minimizes thermal damage to the surrounding material, preserving the integrity of the IC features near the cross-section.s.
- Accurate Material Removal: FIB’s precise milling ensures that only the desired material is removed, maintaining the accuracy of the cross-section.
- Surface Smoothness: The combination of femtosecond laser ablation and FIB polishing produces cross-sections with smooth surfaces, free from artifacts that could obscure important features.
- Detailed Analysis: High-quality cross-sections are essential for techniques like SEM, and Energy Dispersive X-ray Spectroscopy (EDS), which require pristine surfaces for accurate imaging and analysis.



FIB CIRCUIT EDIT AND RAPID PROTOTYPING

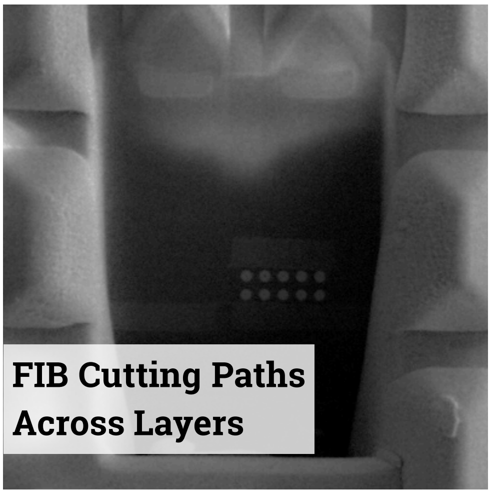
- FIB circuit edit is a set of precision techniques that allows direct modifications on functional integrated circuits. Instead of committing to costly and time-consuming mask re-spins, engineers can cut, connect, reroute, and access signals with nanometer accuracy, validating design changes in a matter of hours.

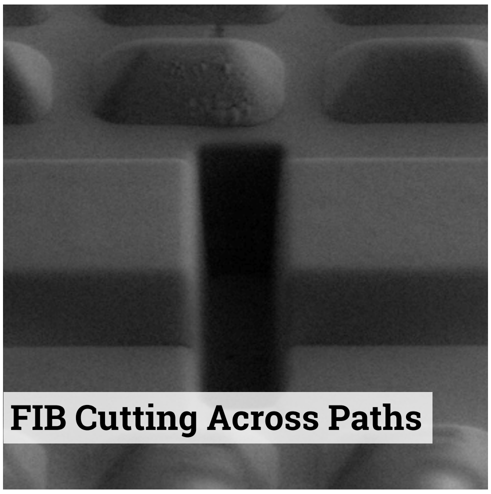
- Cutting Paths Across Layers. Precise disconnection without a costly mask respin. FIB path cutting enables selective disconnection of signals at chosen metal or semiconductor levels, with nanometer accuracy. By working directly on the finished device, design hypotheses can be validated within hours instead of weeks, avoiding the expense and delay of new mask sets.

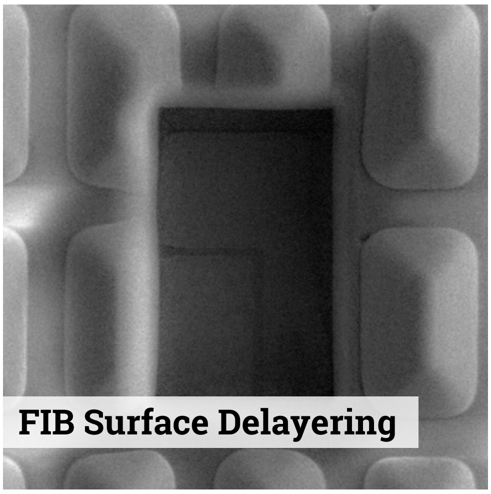
- FIBID Platinum Path Connection. Bridge, reroute, restore functionality. Through platinum deposition, FIB creates micro-bridges and new connections between nodes, even across complex topography. This provides stable conductive paths that allow engineers to reroute signals or repair open circuits with unmatched flexibility.

- Surface Delayering. Controlled access to covered device layers. FIB enables planar, layer-by-layer removal of metal and dielectric films. This method cleanly exposes specific layers, preparing sites for edits or inspection while preserving adjacent structures.

- Probe Pad Creation. Enabling electrical access where you need it. FIB can create or expose probe pads by removing dielectric layers and depositing conductive pathways to the surface, giving reliable access points for electrical probing and functional verification directly on wafer.


FIB Cutting Paths Across Layers


FIB Cutting Across Paths


FIB Surface Delayering


FIBID Platinum Path Connection

ADVANCED TEM CHARACTERIZATION OF SEMICONDUCTOR LAMELLAE

Transmission Electron Microscopy (TEM), along with Energy Dispersive Spectroscopy (EDS) and Selected Area Electron Diffraction (SAED), provides unparalleled insight into the properties of semiconductor lamellae. Our facility offers comprehensive sample preparation using both Gallium Focused Ion Beam (Ga-FIB) and Xenon Plasma Focused Ion Beam (Xe-PFIB) techniques, followed by Ultra-High Resolution Transmission Electron Microscopy (UHRTEM) analysis.

TEM ANALYSIS IN ITS FULL FORM INCLUDES:

UHRTEM allows for direct imaging of the internal structure of semiconductor materials at atomic resolution.

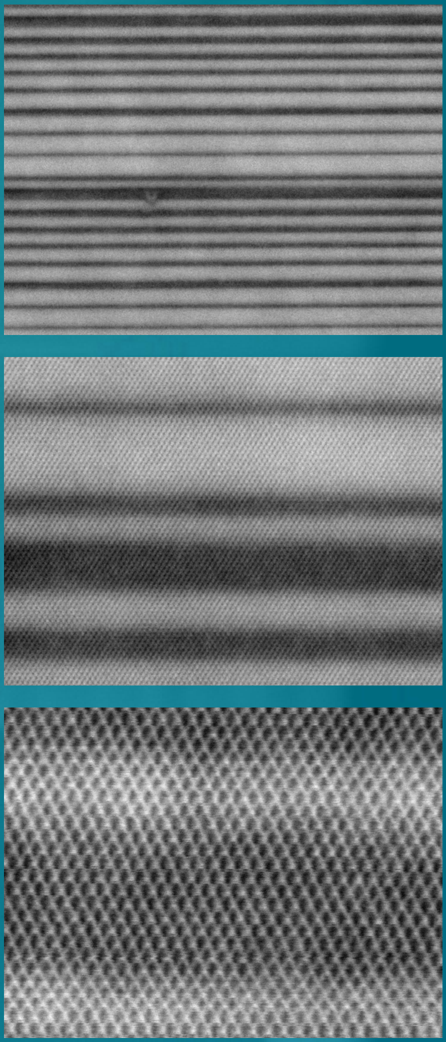
- High-resolution imaging to analyze defects, interfaces, and crystallographic orientation.
- Elemental mapping and composition analysis via EDS.
- Crystallographic phase identification using SAED.

Elemental Composition Energy Dispersive Spectroscopy (EDS) integrated with TEM enables precise elemental analysis by detecting X-ray emissions from the sample.

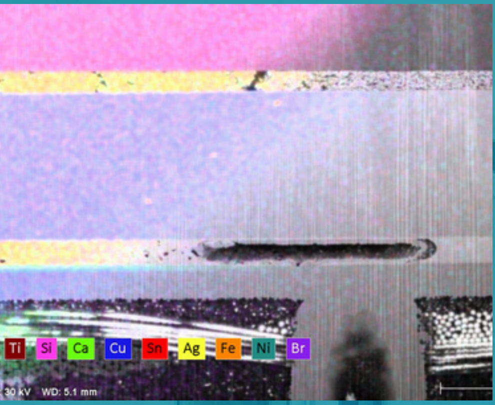
- Identifying dopant distribution in semiconductor materials.
- Detecting contamination or unintended elements.
- Understanding diffusion processes at interfaces.

Crystallographic Analysis Selected Area Electron Diffraction (SAED) is a tool for investigating the crystallographic structure of semiconductor lamellae.

- Determination of grain orientation and phase identification.
- Detection of strain and defects in crystal structures.
- Correlation between microstructure and electronic properties.

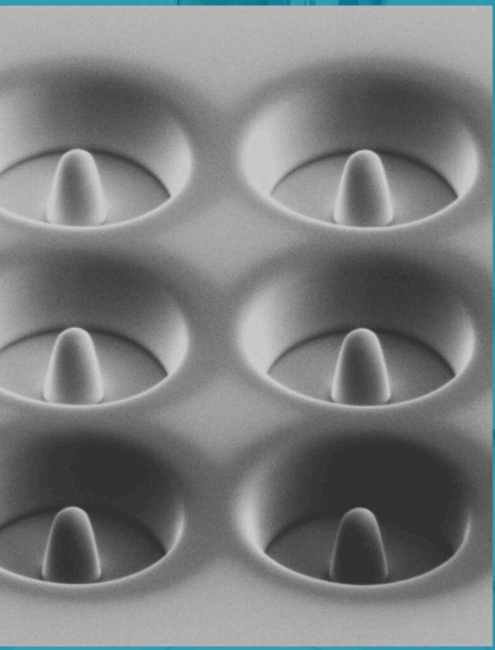


OTHER TECHNIQUES



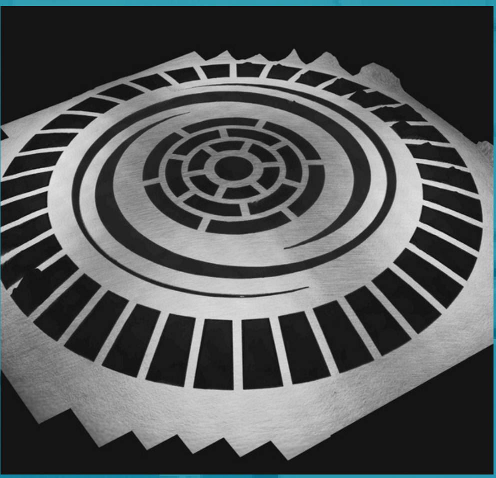
EDS ELEMENTAL ANALYSIS

The Phenom Elemental Mapping Software from Thermo Scientific provides fast and reliable information on the distribution of chemical elements within a sample.



MICRO- AND NANOCOMPONENTS PRODUCTION

The manufacture of components at the micro- and nano-scale is a subject of the increasing interest around the world, both in academia and industry. Such components require high precision, repeatability and thorough quality control already at the production stage. Using the high-class equipment, methods and experience of our experts, we are able to manufacture precise components for such industries as: electronics and photonics, optics, automatics, MEMS and many others.



FEMTOSECOND LASER WORKSTATION

The unique laser workstation constructed by our team from independent elements consists of a femtosecond laser, a five-axis head (operating, among others, in the trepanation mode) and a movable table increasing the production capacities of even very complex geometries.

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