

NEW

High-resolution Xe Plasma FIB
Resolution < 15 nm at 30 keV

XEIA3



XEIA3 - Extraordinary ultra-high resolution imaging and extremely fast micromachining

TESCAN XEIA3 is an ultra-high resolution (UHR) SEM/Xe plasma FIB platform for top-end applications in the semiconductor industry including physical failure analysis and fault isolation of microelectronic packaging devices, IC deprocessing and *in-situ* electrical nanoprobing of sub-20 nm process nodes as well as all those challenging applications in which power and precision in micro- and nano-machining is crucial and the only way to success.

Key features:

- **Slash time-to-result in all your FIB applications** while maintaining high precision during etching. The i-FIB Xe plasma FIB column is capable of generating high FIB currents of up to 2 μ A with optimised beam thus assuring minimum possible spot size over the entire ion current range. The optional high resolution i-FIB delivers smaller beam spots suited for challenging tasks that require ultimate precision.
- **Versatility that extends your possibilities in FIB analysis and microengineering.** The Xe plasma FIB offers a large ion beam current range enabling a wide range of applications in one single machine: large currents enable fast milling rates for large-volume bulk material removal, medium currents for large-volume FIB-tomography, low currents for TEM lamella polishing and delayering, and ultra-low currents for damage-free polishing and nanopatterning.
- **Preserving the properties of samples after milling** is one of the many advantages of Xe plasma FIB. The inert nature of Xe ions prevents them of forming intermetallic compounds with atoms of the milled sample that could result in changes in the physical properties of the specimen.
- **No more volume limitations in FIB-SEM tomography.** The Xe plasma FIB enables fast material removal thus reducing time-to-data. Obtain 3D EDS and 3D EBSD sample reconstructions with the 3D Tomography Advanced SW module for data rendering and different data visualisation.
- **Different imaging and displaying modes** that help you find, explore and resolve the features of your interest and make navigation across the sample easier than ever. The TriLens™ objective system is a unique combination of three objective lenses and a crossover-free mode that results in a variety of imaging and working modes including UHR mode at low beam energies and field-free mode for imaging magnetic samples.
- **Resolve nano-sized features of your materials** at low and ultra-beam beam energies thanks to the excellent performance of the Triglav™ SEM column technology and robust in-beam detection which delivers maximum topographic and material contrast.
- **Quickly obtain meaningful information of your sample** thanks to multiple electron signals that can be simultaneously acquired with the robust multi-detector system comprised of TriSE™, three SE detectors for capturing the finest surface details and, TriBE™, three BSE detectors for angle-selective BSE collection. Together, they deliver maximum surface sensitivity with excellent material contrast.
- **Enhancement of detection limits in TOF-SIMS analysis** and no interference in the elemental spectrum (as opposed to Ga FIBs in which Ga+ peaks can interfere with the detection of other elements, such as Ce, Ge and Ga itself).
- **Fast microanalysis without sacrificing spatial resolution.** The Triglav™ SEM column features a new Schottky FE gun that enables beam currents up to 400 nA and rapid beam energy changes. The In-Flight Beam Tracing™ is a continual aperture optimisation that guarantees the minimal spots sizes over the entire electron current range.
- **Large wafer analysis** is possible thanks to optimal 60° objective geometry design and a large chamber that allows both SEM and FIB analysis of 6" and 8" wafers at any location.
- **Complex applications easier than ever.** A wide range of SW modules make all your FIB-SEM applications easy and smooth experiences for any thus boosting productivity and contributing to increase throughput in your lab.





Resolve nano-sized structures for ultimate sample characterisation

The TESCAN Triglav™ UHR SEM column excels in the entire beam energy range; however, it is the ultimate resolution and outstanding low-kV performance what truly makes this column suitable for today's needs in root-cause failure analysis and nanocharacterisation. Samples can be imaged at low beam energies not only to prevent electron beam-induced damage but also to resolve nano-sized structures in semiconductor devices and nanomaterials. Triglav™ features TriLens™, a three-lens compound objective which enables multiple imaging modes including the Analytical mode for imaging magnetic samples, and Overview mode for large field of view and easy navigation across samples. The immersion optics can be combined with a crossover-free mode; a unique combination that reduces beam energy spread and further improves resolution and beam performance at low beam energies. The Triglav™ column is also equipped with the EquiPower™ technology which guarantees SEM column stability – an essential feature for time-consuming applications such as FIB-SEM tomography.

Increase your insight and find the right answers

The Triglav™ column features an advanced multi-detector system designed for taking the most of the SE and BSE signals thus delivering outstanding surface sensitivity and ultimate image contrast. Each of the detectors is optimised to detect SE/BSE in concrete working regimes which carry valuable information that complements each other for maximum quality in topographical and compositional surface analysis.

TESCAN Xe Plasma FIB: power and precision combined at last!

Xe plasma FIB has positioned as a powerful microanalytical technique that has completely changed the landscape and scope of FIB applications in science but also and mainly industry. What makes Xe plasma special is that it is possible to achieve very high ion beam currents that can be up to 2 μA without compromising beam quality, a feature which makes the TESCAN XEIA3 a suitable technique for large-volume milling tasks and the ideal choice to increase throughput and productivity in your lab. The time for processing or preparing samples with Xe plasma FIB can be up to 50 times faster compared to conventional Ga source FIBs. In terms of precision, TESCAN offers an optional high-resolution Xe plasma FIB with increased brightness and improved resolution of less than 15 nm thus making it possible to perform nanoengineering tasks that require a great deal of precision and that up until recently were only achievable with Ga-source FIBs. The inert nature of Xe makes it the ideal ion specie for applications that require being Ga-free in order to not alter physical properties such as conductivity of samples – that is the case of IC delayering processes and Hall probes or atom probe tips fabrication. In addition, Xe ions cause less amorphous damage compared to Ga which is advantageous for increasing quality of the prepared TEM specimens (at 30 keV).

Benefits:

- Extensive ion beam current range gives incomparable FIB versatility
- Large FIB currents for fast milling rates without gas-assisted enhancement
- Highly-localised and well-controlled sample modification and nanoengineering
- Significant reduction in surface amorphisation and ion implantation
- No intermetallic compounds formed during milling
- Xe ions enhance detection limits in TOF-SIMS analysis

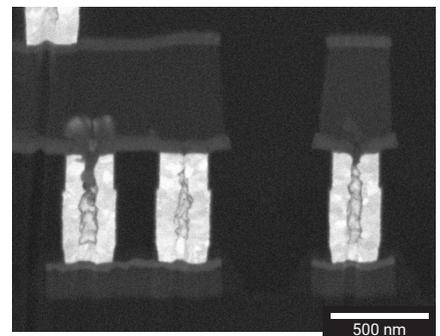


Fig: Cross-section in a IC, metal vias are clearly visible with excellent contrast.

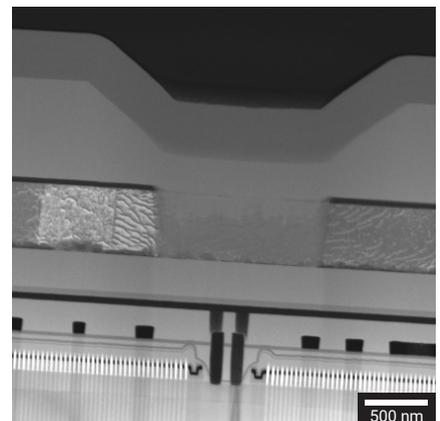


Fig: STEM BF image of a TEM specimen prepared with Xe plasma FIB.

Applications

Modern microelectronic and semiconductor devices are manufactured using different technologies that have made it possible to shrink the physical dimensions of all device's components maximising their performance and power efficiency. Root-cause failure analysis of such devices become extremely challenging and requires new and more powerful techniques to find, reach and analyse the fail at hand.

The TESCAN XEIA3 Xe plasma FIB-SEM has all that it takes to cope with the ever-increasingly demanding needs for physical failure analysis and fault isolation processes in current and near-future semiconductor devices.

IC deprocessing of sub-20 nm node processes

The TESCAN XEIA3 has proven to be an effective instrument that allows controlled delayering of sub-20 nm chip nodes. Delayering is a failure analysis and fault isolation technique used in 3D IC semiconductor devices. It consists in removing top-down layer by layer of the die to reach or find a defect. The task is quite complex since the heterogeneous composition of each layer differs from each other. One of the problems commonly faced by conventional FIB or broad beam ion milling techniques is to preserve uniformity and planarity of the entire delayering process; crucial features necessary to successfully implement subsequent steps such as *in-situ* electrical nanoprobing or AFM-based analyses for fault isolation. TESCAN has developed an effective gas-assisted delayering technique which combines Xe plasma FIB with proprietary gas chemistry resulting in excellent planarity even in the most challenging top layers where the difficulty in delayering increases due to huge differences in milling rates between insulator and thick metal layers. The SE-ion-generated signal is used for precise end-point detection thus the entire process is under control and can be stopped at the desired metal or via layer for SEM inspection or electrical nanoprobing. The TESCAN XEIA3 enables smooth, site-specific and large-area window IC delayering from the top to the delicate contact via layers that combine high-k metal gates with low-k dielectric. The TESCAN Triglav™ ultra-high resolution SEM column is ideal to obtain excellent images at low beam energies during the delayering process and maximum material contrast delivered by its robust detection system with angle-selective BSE signal collection maximises topographical and material contrast at low energies down to 200 eV.

Benefits:

- **Damage-free delayering of sub-20 nm technology nodes**
- **Large-area windows > 100 μm \times 100 μm at site-specific locations with minimal damage to surroundings**
- **Proprietary gas chemistry for uniform planarity on physical layers and absence of layer intermixing**
- **Precise end-point detection**
- **Integrated probe shuttle for *in-situ* electrical fault isolation (EBIC, EBAC, RCI, current imaging)**
- **Optional AFM and C-AFM measurements techniques**
- **Keeping chip functionality as opposed to other techniques such as mechanical polishing or wet chemical etching**

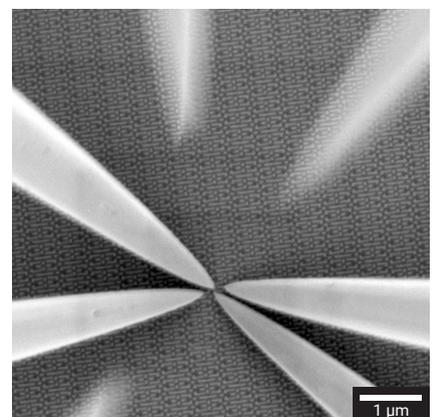
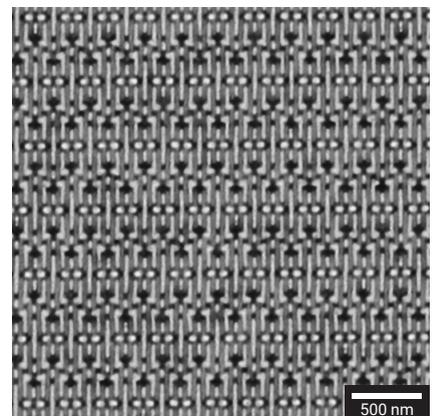
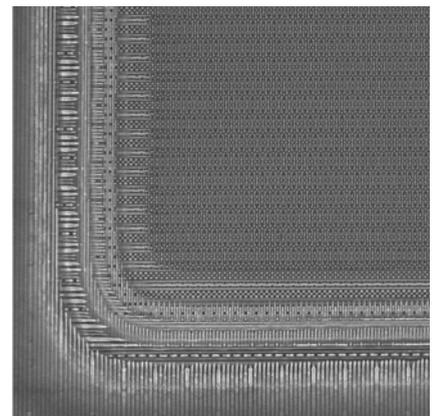
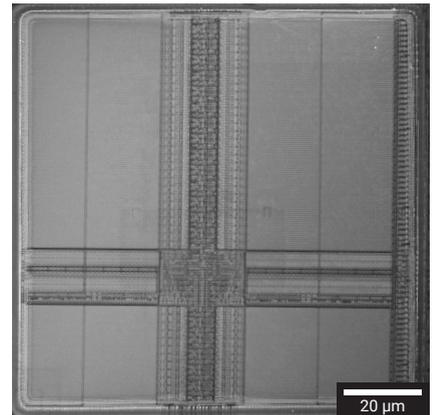


Fig: Proprietary gas chemistry guarantees uniform planarity during top-down IC deprocessing. Electrical probing can be performed *in-situ* for fault isolation.

Large-area cross-sectioning

The TESCAN XEIA3 extends the capabilities of FIB making large-scale sample analysis feasible. Cross-sectioning of areas of hundreds of microns in any direction are now tasks that can swiftly and routinely be performed. TSVs, MEMS, solder bumps, Cu pillars, bonding pads, and other large structures can be effortlessly cross-sectioned with Xe plasma FIB for the purposes of physical failure analysis. The TESCAN XEIA3 has the capabilities that guarantee the smoothest and flawless cross-sections even for the most difficult materials such as dielectrics and composite samples where the appearing of surface artefacts during FIB-milling is common.

Improving Quality in Cross-sectioning

The TESCAN Rocking Stage, a 6-axis piezo-movement stage enables milling the sample from two different directions, a well-known technique for removing curtaining while making simultaneous SEM imaging possible. The Rocking Stage is fully integrated into the SW microscope thus its implementation is easy and straightforward. In addition, TESCAN has developed and patented the TRUE X-sectioning technique, a cross-sectioning technique that has proven to be effective against Xe plasma FIB-induced artefacts even in the most challenging materials and when rocking the sample during polishing is insufficient to eliminate surface artefacts. The great advantage of this technique is that it enables polishing of cross-sections at high ion beam currents thus allowing the user to fully profit from Xe plasma FIB advantages. The TRUE X-sectioning technique improves up to 50% preparation time compared to standard milling approaches with plasma FIB thus increasing throughput and productivity in your lab.

Benefits:

- Ultra-fast large-area cross-sections preparation
- Final polishing at high currents
- Excellent surface quality even in the most difficult materials at no cost in overall preparation time
- Easy to implement and automated
- Analysis can be performed on individual cut die or on entire wafers (up to 8")

Large-volume FIB-SEM tomography

FIB-SEM tomography is a 3D sample reconstruction technique that alternates FIB-slicing with SEM imaging in serial automated way. It provides unique information on the internal structure of materials and specimens that cannot otherwise be obtained by other conventional microanalytical techniques. The TESCAN XEIA3 makes it feasible to perform large-volume 3D sample reconstructions with extreme ease and speed. The TESCAN XEIA3 can be equipped with EDS and EBSD detectors and the 3D Advanced Tomography software module which enables you to perform automated 3D EDS and 3D EBSD characterisations of whole bonding wires, solder balls, TSVs, etc. thus gaining 3D chemical maps and full crystallographic information of your samples.

Benefits:

- Unique ultra-structure information of samples
- Large-volume highly-localised sample analysis
- Ga-free contamination in sample preparation (also an advantage for TOF-SIMS)
- SW modules for data rendering and different data visualisation
- 3D EBSD for 3D chemical mapping
- 3D EBSD for volume crystallographic microanalysis

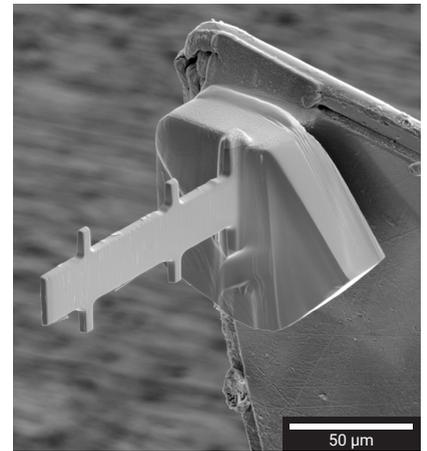


Fig: Hall probe prepared with Xe plasma FIB

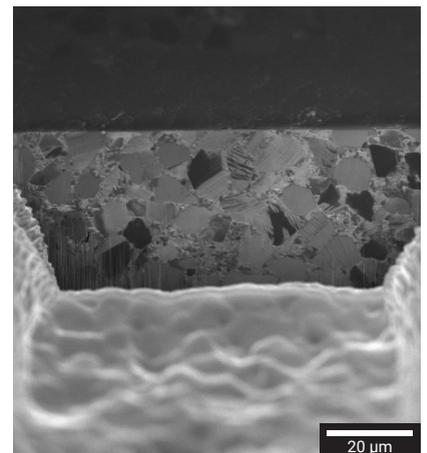


Fig: Cross-section in SiC performed with the use of a Si mask at ion current of 1 μ A.

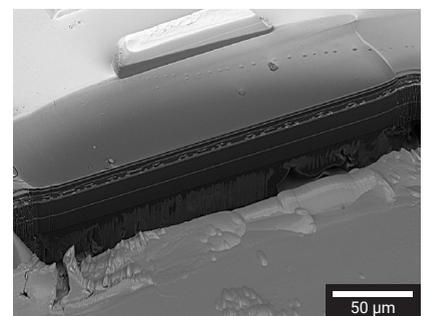


Fig: Cross-section of an OLED display. Bulk material removed ($300 \times 80 \times 50 \mu\text{m}^3$) at 1 μ A in 30 minutes followed by 20 minutes polishing at 300 nA in the Rocking stage at $\pm 5^\circ$.

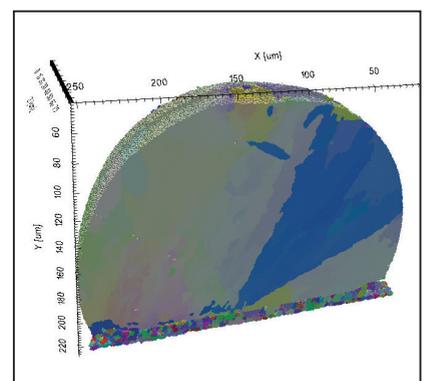


Fig: 3D EBSD reconstruction in IPF-Z mapping of a 250- μ m diameter solder ball.

Technical specifications

Electron Optics:

Electron Gun	High brightness Schottky emitter
Electron optics:	Triglav™ column equipped with Triglav™; a three-lens compound objective
Resolution	Standard mode: In-Beam SE 0.7 nm at 15 keV 1.4 nm at 1 keV / 1.0 nm at 1 keV* 1.7 nm at 500 eV / 1.2 nm at 200 eV* In-Beam LE-BSE 1.6 nm at 15 keV STEM (option) 0.7 nm at 30 keV Low Vacuum Mode: BSE 2.0 nm at 30 keV (UH-Resolution mode) LVSTD (option): 3.0 nm at 30 keV (Analysis mode)
Maximum Field of View:	4.3 mm at WD _{Analytical} 5 mm 7.5 mm at WD 30 mm
Electron beam energy:	200 eV to 30 keV / down to 50 eV with BDT option
Probe Current:	2 pA to 400 nA

Ion Optics:

Ion column:	i-FIB / High Resolution i-FIB
Ion Gun:	ECR-generated Xe ion Plasma FIB
Ion beam energy:	3 keV to 30 keV
Probe Current:	1 pA to 2 μA / 1 pA to 1 μA
Resolution:	< 25 nm at 30 keV / < 15 nm at 30 keV (at SEM-FIB coincidence point)
SEM-FIB coincidence at:	WD 5 mm for SEM - WD 12 mm for FIB
SEM-FIB angle:	55°
Detectors (standard):	SE In-Beam SE (intended for high resolution and imaging at short WD) In-Beam LE-BSE (BSE detector optimised for low energies) Mid-Angle BSE (In column detector that collects mid-angle electrons) Retractable BSE (collects wide-angle BSE) Optional analytical techniques include: HADF R-STEM, EDS, WDS, EBSD, TOF-SIMS, SITD, CL, EBIC, Raman spectroscopy integration (RISE)
Chamber GM:**	Internal dimensions: 340 mm (width) × 315 mm (depth) × 320 mm (height) Number of ports: 20+ Chambers and Column Suspension: active vibration isolation (integrated)
Specimen Stage GM	Compucentric, fully motorised XY = 130 mm (-65 mm to +65 mm), Z = 90 mm, Rotation = 360° continuous, Tilt = -60° to +90°

*With the Beam Deceleration Technology (BDT) option, ** A smaller XM chamber is also available



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