TESCAN
PERFORMANCE IN NANOSPACE

TESCAN FERA3 - The world's first fully integrated Xe plasma FIB-SEM

The world's first fully integrated Xe plasma source focused ion beam (FIB) with scanning electron microscopy (SEM) enables extremely high ion currents up to 2 µA which results in increased milling speeds that can be up to 50 times faster compared to conventional Ga source FIBs. This makes FERA3 the ideal instrument for accomplishing large volume milling tasks that were once either time-consuming or practically impossible.

The focused ion beam scanning electron microscopes (FIB-SEMs) open up a world of new capabilities enabling applications which would otherwise not be possible to achieve with either standalone systems. The configuration in the FIB-SEM systems is such that the electron and ion beam focal points coincide, which results in the optimisation of many applications. This feature enables simultaneous SEM imaging during FIB milling tasks - a significant leap in terms of performance and throughput in all those FIB operations which demand extremely high level of precision. FERA3 features high-performance electronics for faster image acquisition, ultra-fast scanning system along with compensation of static and dynamic image aberrations and built-in scripting for user-defined applications.

Key features of the Xenon plasma FIB

- Extremely powerful Xe plasma ion source FIB column for achieving the most challenging large-scale milling tasks in unbeatably short time-frames
- Versatile ion beam current range:
  - high currents for cross-sectioning in TSVs, BGAs and MEMS
  - medium currents for large-area surface polishing, large-volume FIB tomography
  - low currents for TEM lamella polishing, delayering, TOF-SIMS
  - ultra-low currents for very fine polishing, nanopatterning, ion imaging
- Large-mass xenon ions for ultra-high sputtering yields without the need for gas-assisted enhancement
- Large-scale 3D microstructural analysis
- Significant reduction in surface amorphisation and ion implantation compared to Ga LMIS FIBs
- No intermetallic compounds formed during FIB milling

Modern electron optics

- The unique Wide Field Optics™ design with a proprietary Intermediate Lens (IML) offers a variety of working and display modes with enhanced field of view or depth of focus
- Real time In-Flight Beam Tracing™ for performance and beam optimization. Also includes direct and continual control of beam parameters.
- Fully automated electron optics set-up and alignment
- Rapid imaging with rates up to 20 ns
- Unique live stereoscopic imaging using the advanced 3D Beam Technology opens up the micro and nano-world for an amazing 3D experience and 3D navigation

Analytical Potential

- All the chamber models provide superior specimen handling using a full 5-axis motorized compucentric stage and ideal geometry for microanalysis
- Robust stages in XM and GM chambers can accommodate large samples
- Extended XM/GM chambers can accommodate larger samples such as wafers up to 12" for their analysis.
- Numerous interface ports with optimised analytical geometry for microanalysis as well as for attaching many other detectors
- First-class YAG scintillator-based detectors
- Wide range of optional detectors and accessories
- Fast vacuum system
- Investigation of non-conductive samples in the variable pressure mode.
- Integrated active vibration isolation ensures effective reduction of ambient vibrations
- Observation of magnetic samples
- Undistorted EBSD pattern

Beam Deceleration Technology (BDT)

Beam deceleration technology (BDT) is intended for the highest resolution at low electron beam energies. BDT includes a system for negative voltage biasing of the sample stage and an In-beam detector that works either as SE detector in the beam deceleration mode (BDM) or BSE detector in the standard mode.
In the BDM, the energy of the electrons in the beam is decreased before they impact the surface of the specimen by means of a negative bias voltage which is applied to the sample stage. Ultra-low landing energies down to 50 eV (or 0 eV in manual control) are achievable. BDM enhances the performance of the electron column by reducing optical aberrations, thus allowing small spot sizes and high-resolution imaging at low energies. Low electron energies are advantageous for reducing charging effects in non-conductive samples and beam-sensitive specimens. BDM is especially suited for imaging biological specimens in their uncoated state at ultra-low beam energies without damaging the samples.

LE-BSE detectors: the ideal detector for FIB-SEM tomography

In FIB-SEM tomography, thin layers (typically few tens of nanometres thick) are sliced sequentially using the FIB followed by SEM-imaging. The BSE signal is used for image acquisition of each layer because it provides material contrast. At high energies, the BSE interaction volume is too large and is not suited for imaging such thin layers. Therefore, in order to achieve high-resolution FIB tomography the ability of imaging at low beam energies is essential. TESCAN has designed highly sensitive BSE detectors optimised for low energies specifically for this purpose.

LE-BSE detector with integrated shutter

This detector features a specially prepared silicate scintillator which significantly increases the sensitivity of the detector in the low energy regime. The detector is capable of operating in the whole range of energies of the electron column, i.e. from 30 keV down to 200 eV. The Low Energy BSE shutter avoids contamination of the scintillator crystal and guarantees the detector performance over the long term. Features such as high-speed retractability and the ability to operate for a large number of cycles make the shutter especially suitable for FIB-SEM tomography.

In-Beam LE-BSE detector

The In-Beam LE-BSE detector enables the capture of BSE images at low energies and very short working distances. This detector is well suited for FIB-SEM tomography applications as it is protected from material deposition produced during FIB milling. The detection limit of this in-beam version is 500 eV.

Image Processing	☑
Histogram	☑
Analysis & Measurement	☑
Object Area	☑
Hardness	☑
Tolerance	☑
Multi-Image Calibrator	☑
Switch-Off Timer	☑
3D Scanning	☑
X-Positioner	☑
Live Video	☑
DrawBeam Advanced	☑
Easy SEM™	☑
Particles Basic	☐
Particles Advanced	☐
Image Snapper	☐
3D Tomography	☐
3D Tomography Advanced	☐
Sample Observer	☐
3D Metrology (MeX) *	☐
TESCAN TRACE GSR	☐
System Examiner	☐
Cell Counter	☐
AutoSlicer	☐
SYNOPSYS Avalon™	☐
Coral	☐

☑ standard, ☐ option,
* third-party dedicated software by Alicona Imaging GmbH

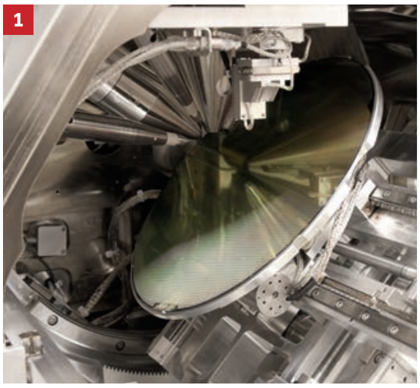


Fig. 1: An 8" wafer tilted to align with the FIB-axis.

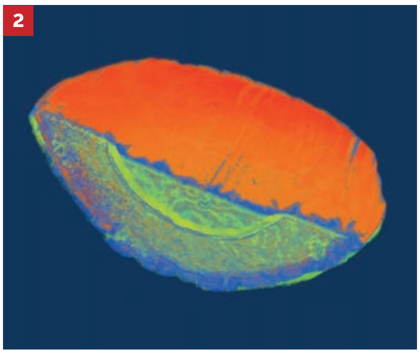


Fig. 2: 3D BSE reconstruction of a solder ball. A volume of 100 µm × 100 µm × 100 µm was milled in just 7 hours at 100 nA.

Software Tools

DrawBeam
is a powerful software for advanced patterning in FIB-SEM lithographic applications such as deposition of protective masks for cross-sectioning or lamellae preparation, electron beam lithography (EBL), focused ion beam induced deposition (FIBID), etc. DrawBeam enables multi-layer tasks with different processing mode settings (etching/deposition) independently for each layer. DrawBeam contains a built-in material database, performs slope correction in order to prevent redeposition artifacts, provides precise endpoint detection and, makes live imaging during milling possible, all features that optimise FIB milling tasks.

3D Tomography
is a dedicated software for performing FIB-SEM tomography and subsequent 3D reconstructions from the collected data. Different visualisation methods are available and data post-processing is also possible.

AutoSlicer
enables automation of FIB-SEM operations such as serial cross-sectioning and the preparation of lamellae or other objects defined at multiple locations. Overnight and unattended operations can be set.

Plasma FIB-SEM configurations

FERA3 can be equipped with a gas injection system (GIS) which is an essential component for almost all FIB applications as it delivers the gas chemistry needed for depositing Pt protective layers for cross-sectioning and lamellae preparation, Pt, W and SiO_2 depositions for circuit edit, XeF_2 for enhanced milling rates in Si, and, allows for gas-assisted delayering. FERA3 can also be equipped with nanomanipulators, and a wide variety of detectors to comply with the most diverse range of applications in all fields of research in both science and industry. In addition, FERA3 can be configured with different chamber sizes for accommodating small, large or extra-large specimens according to the specific requirements for sample analysis.

XM/GM chambers
The XM/GM chambers are equipped with a compucentric fully motorised specimen stage, and, their optimised geometry allows multiple detectors to be installed. The chambers can be configured to operate either high vacuum (XMH/GMH), or, in the variable pressure (XMU/GMU) modes - a feature that extends their operations to low vacuum. The XMH/GMH chambers allow imaging of conductive specimens under high-vacuum conditions while the XMU/GMU chambers enable imaging of uncoated non-conductive samples under low-vacuum conditions.

Extended XM and GM chambers
The volume capabilities of the standard XM and GM chambers can be further extended by means of special front-mounted chamber frames. Larger analytical chambers mean a wider range of applications in science and technology. For instance, such extended chambers is a specific solution for the semiconductor industry and fabs enabling the inspection of large wafers. The extended XM chamber with a modified Y-axis and an extension frame allows the FERA3 system to perform SEM inspection as well as FIB micromachining at any location of both 6" and 8" wafers. In addition to that, the extended GM chamber also enables SEM inspection of 12" wafers.

Detectors	XMH GMH	XMU GMU
SE Detector	☑	☑
Retractable BSE Detector (motor.)	☑	☑
In-Beam BSE Detector	☑	☑
In-Beam SE Detector	☐	☐
In-Beam LE-BSE Detector	☐	☐
LE-BSE Detector with shutter (motor.)	☐	☐
Beam Deceleration Technology[1]	☐	☐
LVSTD Detector	⊘	☐
Secondary Ion TESCAN Detector	☐	☐
STEM Detector	☐	☐
HADF R-STEM Detector (motor.)	☐	☐
CL Detector (motor.)	☐	☐
Rainbow CL Detector (motor.)	☐	☐
EBIC	☐	☐
EDX[2, 3]	☐	☐
WDX[2]	☐	☐
EBSD[2]	☐	☐
TOF-SIMS[2]	⊘/☐	⊘/☐
WiTec Raman (RISE)	⊘/☐	⊘/☐

[1]A package containing BDT and decontaminator is also available
[2]Fully integrated third party products
[3]EDX detectors must be equipped with shutter

Other Options*	XMH GMH	XMU GMU
pA Meter	☑	☑
Touch Alarm	☑	☑
IR TV Camera	☑	☑
Peltier Cooling Stage	☐	☐
Beam Blanker for SEM column	☐	☐
Load Lock**	☐	☐
Control Panel	☐	☐
Optical Stage Navigation***	☐	☐
Nanomanipulators	☐	☐
Gas Injection System (5 precursors)	☐	☐
MonoGIS	☐	☐
Decontaminator/ plasma cleaner	☐	☐
Flood gun	☐	☐
Rocking Stage****	⊘/☐	⊘/☐
EDX piezo shutter	☐	☐
Active vibration isolation	☑	☑

*Possible combinations of optional detectors and other accessories must be discussed
**Manual and motorised options available
***Not available for the extended chambers
****Automated sample loading possible with Load Lock (motorized) only

☑ standard, ☐ option, ⊘ not available

Common applications

The Xe plasma FIB-SEM FERA3 system is the ideal solution for large-scale milling applications. FERA3 features the i-FIB column; a powerful ECR-generated Xe plasma ion source capable of achieving high ion beam currents up to 2 µA which is suited for challenging applications that require the sputtering of large volumes of material while maintaining high productivity and high throughput. The Xe plasma FIB can perform milling tasks up to 50 times faster than any conventional Ga ion source FIB. Xe ions being much heavier than Ga ions facilitate the sputtering of much more material in shorter time-frames at any given current. This makes the Xe plasma FIB ideal for large-scale milling tasks (> 10^6 µm^3). FERA3 overcomes the volume limitation of Ga ion source FIBs, thus extending the range of FIB-SEM applications.

Failure Analysis in Advanced Packaging

The Xe plasma FIB delivers the power and speed essential for performing high-throughput failure analysis of TSVs, BGAs and wire bonding. FERA3 allows for pinpointing failure sites and their subsequent local inspection and characterisation. Large cross-sectioning make it possible to find and examine voids, delamination, cracks, and other defects present in TSVs. Furthermore, EDX and EBSD mapping analyses can be implemented to study the microstructure and different grain size distributions in TSVs as well as bondability and metallisation studies in wire bonding. In addition, solder balls of hundreds of microns in diameter can be effortlessly cross-sectioned or analysed by means of 3D reconstructions (3D EDX, 3D EBSD) thus revealing voids, brittle fractures, die cracking or dendritic structures. And all of this, is done in unbeatably short time frames.

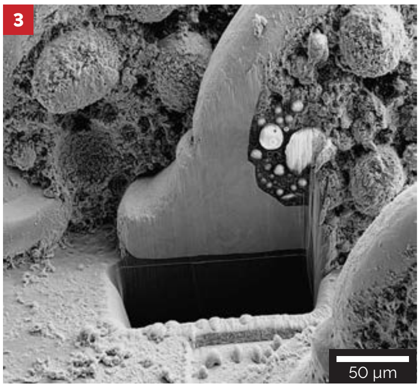
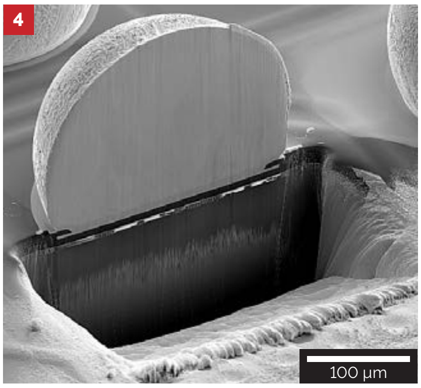


Fig. 3: A cross-section underneath a bonded ball. A volume of 160 µm × 70 µm, 113 µm depth was milled in 10 minutes at 300 nA. The polishing of the cross-section area was performed in 50 minutes at 30 nA.



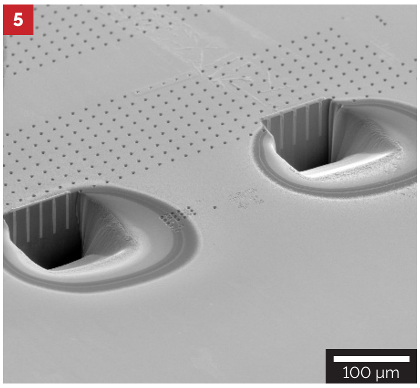


Fig. 4: A cross-section of a solder bump of 270 µm diameter. The rough milling of a volume of 340 µm × 180 µm, depth 130 µm was completed in 1 hour at an ion beam current of 2 µA. The total preparation time including final polishing with the rocking stage was 4 hours and 35 minutes.

Fig. 5: Preparing cross-sections in TSVs. The rough milling of a volume of 118 µm × 83 µm, depth 100 µm, was performed in 11 minutes at ion beam current 2 µA. The total preparation time including protective metal depositions and fine polishing with the rocking stage was 2 hours and 16 minutes (each trench).

Failure Analysis of Integrated Circuits

The latest integrated circuits are based on 14 nm technology nodes and smaller node technologies are already under development. Such integrated circuits are multilayer structures based on FinFET technology. Failure analysis of such devices requires planar delayering and electrical nanoprobing. Gas-assisted Xe plasma etching has proven to be an effective technique for accomplishing perpendicular delayering in state-of-the-art technology nodes.

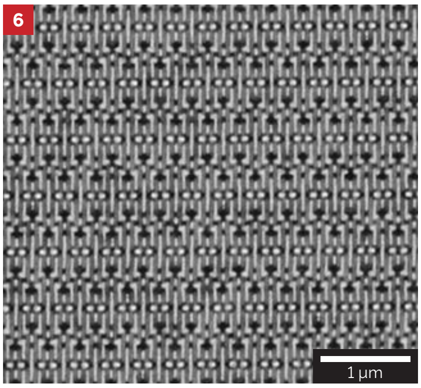


Fig. 6: Gas-assisted perpendicular delayering process in state-of-the-art technology nodes.

Material Sciences

Plasma FIB enables ultra-fast milling rates and damage-free sample modification, i.e. without delamination, smearing, grain modification or other damage which is commonly introduced when using other sectioning techniques such as microtomes or mechanical polishing. In terms of material characterisation and microanalysis, xenon in contrast to gallium is an inert gas and non-electrically active. It therefore does not form intermetallic compounds that might modify the original physical properties (electrical, magnetic) of the sample or, interfere with elemental analyses.

Life Sciences

The integration of the Xe plasma FIB in the SEM extends the role of electron and ion microscopy in life sciences. FIB cross-sectioning and FIB-SEM tomography of whole biological samples have become feasible only thanks to plasma FIB. Such sample analyses reveal localised morphological and structural information that cannot be obtained by other conventional imaging techniques.

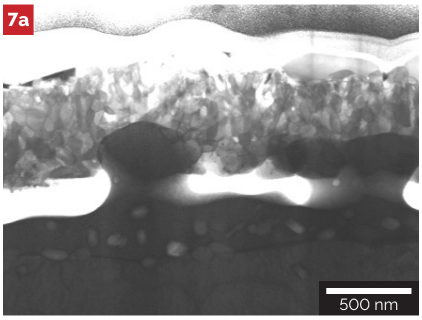
Enhance your SEM analysis of TEM lamellae with the **HADF R-STEM detector**

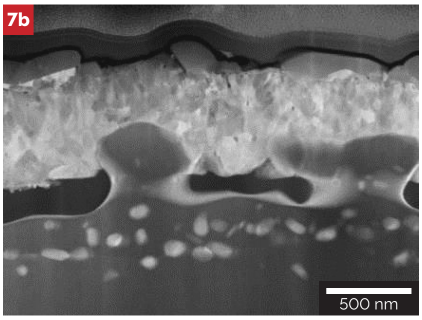
The High Angle Dark Field Retractable STEM Detector (HADF R-STEM) combines the principles of TEM with that of SEM allowing every TESCAN SEM and FIB-SEM system to be turned into a (low energy) STEM platform. With the HADF R-STEM detector, you can enhance FIB-SEM analysis (SE, BSE, EDX, EBSD, SI, and TOF-SIMS) of your thinly-sliced samples by acquiring the unique information carried by transmitted electrons.
This detector represents a concrete and efficient solution for those research facilities that have no TEM infrastructure but nonetheless have the same needs for sample analysis. The HADF R-STEM detector is undoubtedly a valuable tool for those laboratories involved in cutting-edge research in life sciences, materials sciences and the semiconductor industry.

- **Observation of multiple samples** without breaking the chamber vacuum
- **Simultaneous acquisition of bright field (BF), dark field (DF) and high angle dark field (HADF) signals** which provide valuable information such as Bragg-diffraction orientation contrast and material contrast
- **Lifting up and down of the sample relative to the detector** in order to reach the best imaging conditions
- **Tilting of the sample independently of the detector**
- **Improved geometry of the sample holders for EDX analysis**

- Two different sample holders:
  1) Multiple sample holder: for up to 8 standard TEM grids
  2) TEM lamella holder: a system of exchangeable single grid holders optimised for easy grid manipulation, handling and lift-out

This new detector has been designed to complement a broad range of SEM applications in diverse fields of science and industry enabling for instance, the investigation of the ultrastructure of biological samples, rigorous failure analysis of integrated circuits in the semiconductor industry, or the characterisation and research in material engineering.





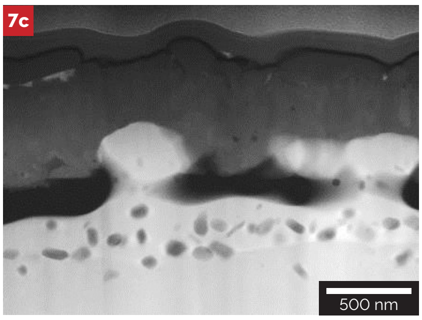


Fig. 7: A thin lamella to study corrosion growth through Cr plating on steel. The images correspond with different HADF R-STEM signals: **(a)** Bright Field, **(b)** Dark Field, **(c)** High Angle Dark Field.

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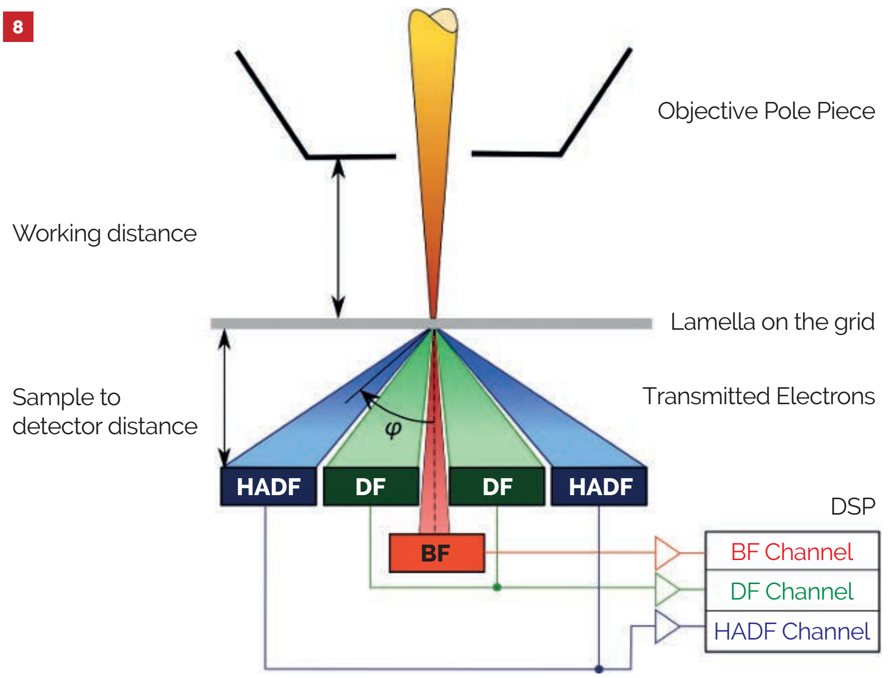


Fig. 8: Schematic drawing of the new HADF R-STEM detector with HADF imaging mode; φ is the scattering angle.

DrawBeam and AutoSlicer are powerful and user-friendly software for the preparation of high-quality lamellae with high throughput

Prepare top-quality surfaces for failure analysis with the **Rocking Stage**

FIB cross-sectioning and the preparation of thin lamellae for TEM analysis are two of the most common applications of FIB-SEM systems. Cross-sectioning is a valuable SEM technique for unveiling defects or structures not visible from the surface as they are often buried under surface layers of the sample while thin lamellae allow the analysis of samples using the information given by transmitted electrons.

The microelectronic and semiconductor industries require high-quality surfaces and rely on cross-sections and lamellae for successful failure analysis. The surface of the cross-section or of lamellae need to be really smooth and artifact-free. Otherwise, the task of finding or identifying possible failures is very difficult as they can easily hide among surface defects.
Curtaining effects are unwanted surface artifacts that appear on cross-sections or lamellae prepared with FIB, a defect that is more common when milling at high ion currents. Curtaining can arise due to the topography of the sample, its composition, or the characteristic grain and crystal orientation in the sample. Beam tail effects can also lead to curtaining.
In reality, making a defect-free surface is an elaborate and difficult task using the FIB-SEM alone and additional procedures to avoid curtaining are required. One of these techniques is the use of the Rocking Stage which has proven to be effective not only against curtaining but also for the optimisation of cross-sectioning tasks

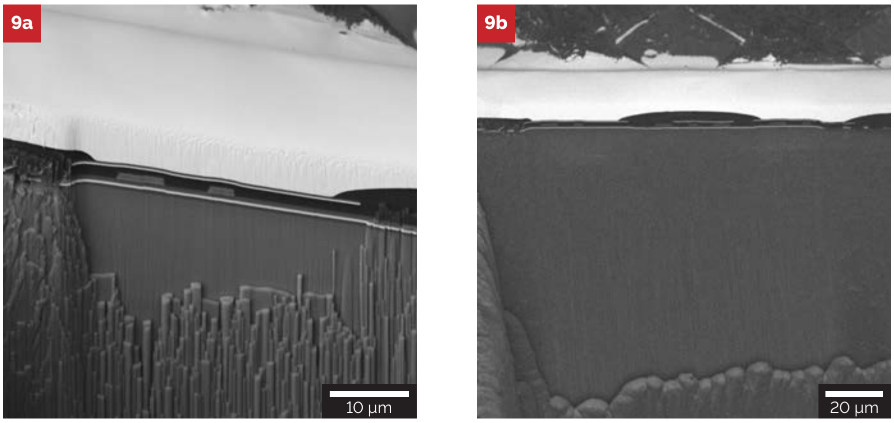
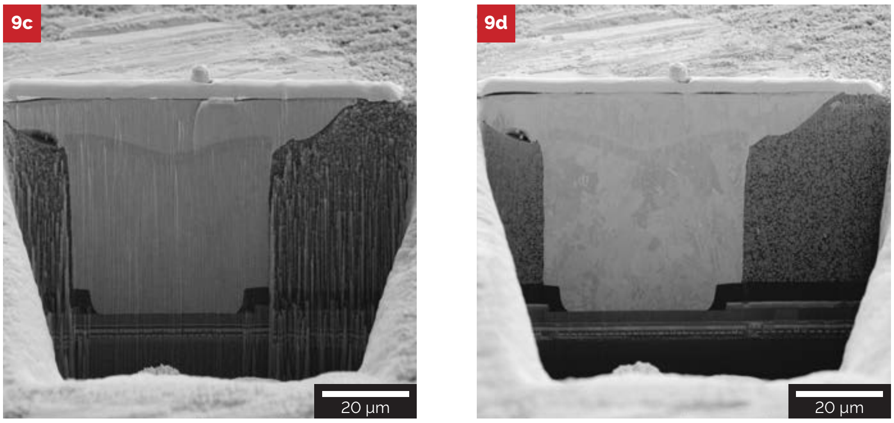


Fig. 9: (a and c) Curtaining can appear when milling at high ion beam currents. **(b and d)** Tilt-polishing with the Rocking Stage is an effective technique to get rid of the curtaining which results in smooth surfaces suited to perform failure analysis**.**



■ Milling in different directions: Rocking Stage

It has been proven that tilting the sample (up to a maximum of ±10°) during milling is an effective strategy for reducing curtaining effects when preparing cross-sections. Milling in different directions is possible with a conventional 5-axis eucentric stage for which the sample has to be rotated by 90° followed by the respective tilting angle. The disadvantage of this procedure is that the cross-section cannot be imaged with the SEM column as the electron beam axis is parallel to the cross-section.
TESCAN Rocking Stage enables FIB milling in different directions by tilting the sample about an axis perpendicular to the cross-sectioned surface. The great advantage of this procedure is that the entire milling process can be monitored in real time with SEM imaging.

■ Benefits of the Rocking Stage include:

- Real time SEM imaging during the entire milling process for absolute control and monitoring of quality
- Reliable end-point detection
- Full integration with DrawBeam
- Multi-direction surface milling to prevent curtaining
- Piezo-drives for precise stage movements

TOF-SIMS for superior compositional analysis of ultra-thin layers and nanoscale sample features

Time-of-flight secondary ion mass spectrometry (TOF-SIMS) is a highly sensitive analytical technique that provides chemical characterisation of the surfaces of materials. This is achieved by using a focused ion beam typically at energies of 10-30 keV, which impinges on the surface of the sample releasing secondary ions (SI), ion clusters, and molecules from the uppermost atomic layers of the specimen. Signals of which are then collected and analysed.

With TOF-SIMS, smaller means better

The interaction volume generated by ions is of the order of a few nanometres which is much smaller than the one generated by an electron beam - typically of the order of a few microns. As a result, TOF-SIMS can achieve better lateral and depth resolution compared to other common chemical analytical SEM techniques such as EDX. TOF-SIMS provides characterisation of the surface of materials via mass spectra, depth profiles and elemental/molecular maps. Mass spectra allow identification and quantification of elements, and molecular species present in the surface layers of the sample, as well as the distinction of isotopes and species with similar nominal mass. Depth profiling – an advantage of this technique - is used to detect trace elements of dopants and other impurities at different depth ranges. All the elements in the periodic table can be detected including light elements such as hydrogen, beryllium, boron and lithium at very low concentrations of a few ppm. In addition, 3D chemical characterisation with high mass resolution and high spatial resolution imaging is also possible.

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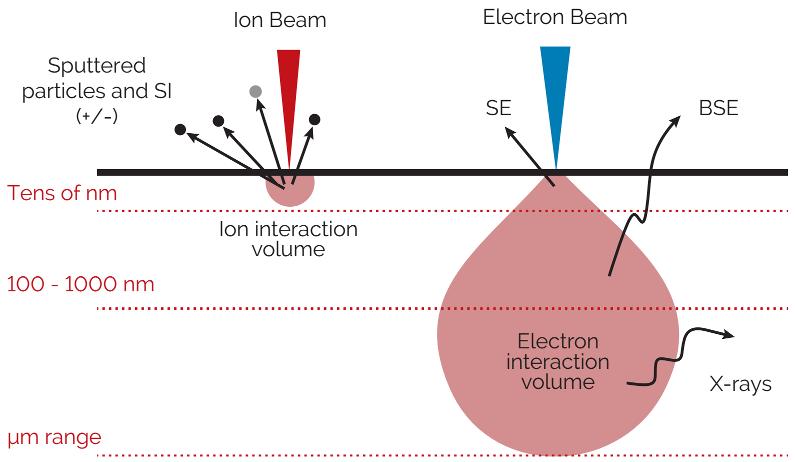

Fig. 10: Interaction volume generated by ion/electron beams.

Time-of-Flight

TOF-SIMS analysers are based on the principle that for a given ion energy, the velocity of each ion is mass-dependent. Secondary ions extracted from the surface of the specimen are directed into a drift tube in which the ions are sorted according to their m/q ratio, and the time-of-flight is measured, i.e. the length of time necessary for the SI to move from the ion source to the detector. Ions with the same mass will have the same kinetic energy and thus lighter ions will have shorter time-of-flight than heavier ones. Accurate measurement of the time-of-flight determines the mass of each of the secondary ions or molecules revealing the elemental composition of the sample surface.

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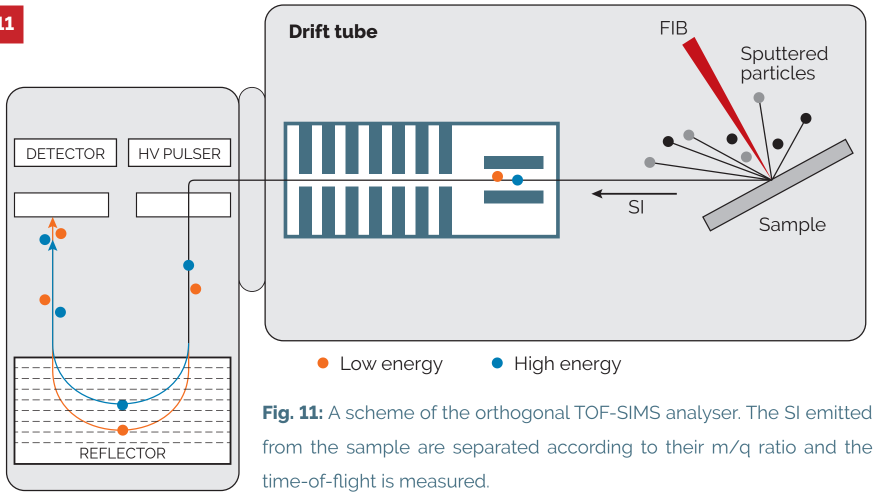
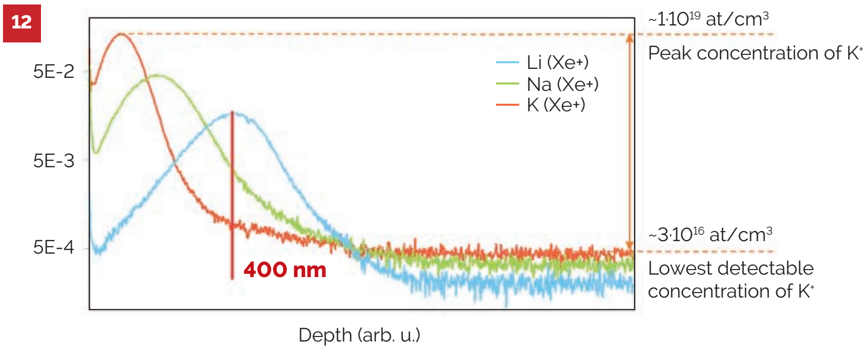


Fig. 11: A scheme of the orthogonal TOF-SIMS analyser. The SI emitted from the sample are separated according to their m/q ratio and the time-of-flight is measured.

A non-destructive analytical technique

TOF-SIMS uses a low-current primary ion beam to impinge on the surface of the sample in order to generate secondary species. This technique minimises damage and preserves the chemical structure of the sample. TOF-SIMS is a suitable technique for molecular characterisation of sensitive organic specimens or tissue that cannot be analysed with spectral techniques such as EDX.



An orthogonal TOF-SIMS analyser can be fully integrated into any TESCAN FIB-SEM system. This combination represents a novel and cost-effective solution for enhanced sample surface analyses.

Fig. 12: The detection limits for Li, Na and K is less than 1×10^{17} atoms/cm³ which is 2 ppm atomic obtained without any additional method for yield enhancement.

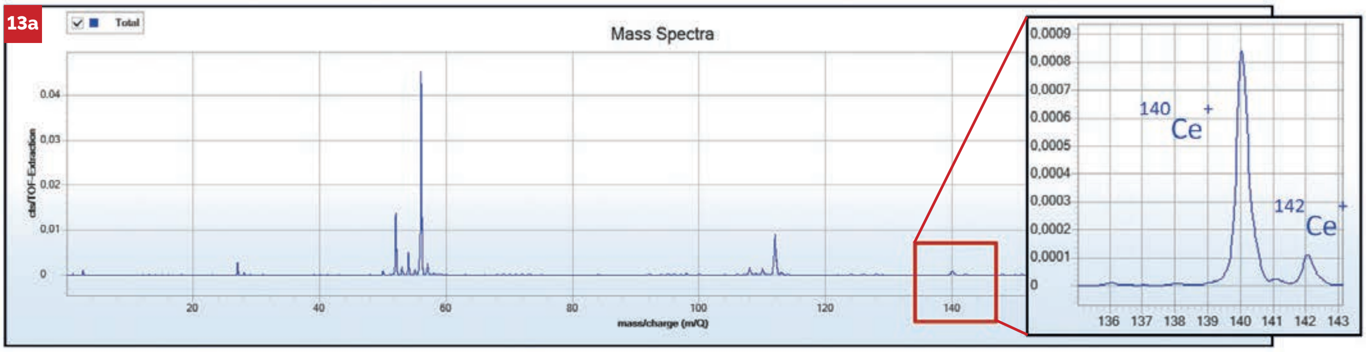
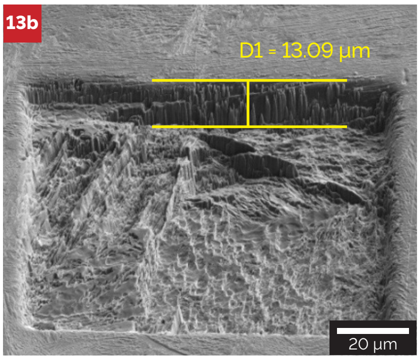
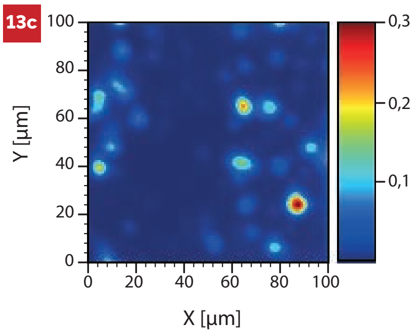
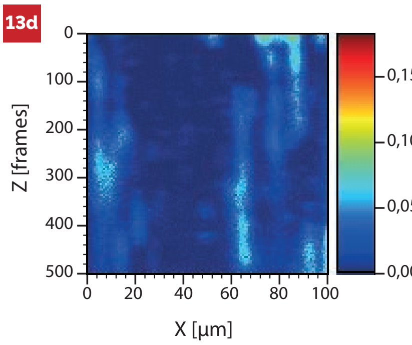


Fig. 13: A steel sample with traces of different isotopes of cerium with different relative abundances. The sample was analysed with FERA3 equipped with a TOF-SIMS analyser. **(a)** TOF-SIMS spectrum showing the presence of two Ce isotopes in the sample (inset). **(b)** The crater in the sample after analysis, and distributions maps from the top **(c)**, and the side **(d)** of the sample showing the presence of Ce in the sample. Sample courtesy of Prof. Jaromír Drápala (Technical University of Ostrava, Faculty of Metallurgy and Materials Engineering).







Applications

TOF-SIMS is the ideal characterisation technique for those fields of science and technology where the composition of surfaces, thin films or layers plays an essential role in performance. This is the case for nanomaterials, magnetic media, 3D IC packaging in semiconductors, corrosion studies, display technology, biomaterials, polymer surface modification, etc. TOF-SIMS also provides a powerful analytical technique for the battery manufacturing industry and research groups or industries involved in nuclear research.

The main benefits of the integration of TOF-SIMS into FIB-SEM are:

- Identification and quantification of ions, molecular species and isotopes
- High mass resolution to distinguish species of similar nominal mass
- In-situ chemical composition analysis of the sample
- Surface analysis of insulating and conductive specimens
- No additional ionisation source necessary
- Non-destructive analysis
- Trace elemental analysis
- 3D chemical mapping and depth profiling
- Post-data acquisition analysis

The integration of TOF-SIMS analysis with a Xe ion source brings additional advantages over conventional Ga ion sources including:

- Improved secondary ion yields especially of high mass molecules and fragments
- Excellent detection limits of less than 2 ppm with Xe ion sources which in the case of light elements such as Li, Na and K is less than 1×10^{17} atoms/cm³
- No interference in the spectrum arising from primary gallium (Ga^+ features interfere with peaks of other elements such as Ce, Ge and Ga itself)
- In addition, the lateral resolution achieved with a Xe ion source is less than 100 nm

Chamber	XM	GM
Internal size	290 mm (W) × 340 mm (D)	340 mm (W) × 315 mm (D)
Door	290 mm (W) × 322 mm (H)	340 mm (W) × 320 mm (H)
Maximum Specimen Height (in mm)	100 (with rotation stage) 141 (without rotation stage)	100 (with rotation stage) 141 (without rotation stage)
Number of ports	12+	20+
Chamber suspension	Integrated active vibration isolation system	Integrated active vibration isolation system

Specimen Stage	XM	GM
Type	Compucentric fully motorised	Compucentric fully motorised
Movements (in mm)	X = 130 (-50 to +80) Y = 130 (-65 to +65) Z = 100	X = 130 (-65 to +65) Y = 130 (-65 to +65) Z =100
Rotation	360° continuous	360° continuous
Tilt	-30° to +90°	-60° to +90°

*Depending on the WD and the size of the sample

Technical specification

Electron Optics

Electron gun	High brightness Schottky emitter
Resolution	
In high-vacuum mode SE	1.2 nm at 30 keV, 2.5 nm at 3 keV
In high-vacuum mode In-Beam SE	1.0 nm at 30 keV
In high-vacuum BDM (Beam Deceleration Mode)	1.8 nm at 3 keV, 3.5 nm at 200 eV
In-Beam BSE	2 nm at 15 keV
STEM Detector	0.9 nm at 30 keV
In low-vacuum mode LVSTD	1.5 nm at 30 keV
Electron optics working modes	
High-vacuum mode	Resolution, Depth, Field, Wide Field, Channelling
Low-vacuum mode	Resolution, Depth
Magnification	Continuous from 1 × to 1,000,000 ×
Field of view	6.0 mm at $WD_{analytical}$ 9 mm 17 mm at WD 30 mm
Accelerating voltage	200 eV to 30 keV / down to 50 eV with BDT option
Probe current	2 pA to 200 nA

Ion Optics

Ion column	HR i-FIB	i-FIB
Ion Gun	ECR-generated Xe plasma ion source	
Accelerating Voltage	3 keV to 30 keV	
Probe Current	**1 pA to 1 μA**	**1 pA to 2 μA**
Resolution	**< 15 nm**	**< 25 nm**
Magnification	Minimum 150 × at coincidence point and 10 kV (corresponding to 1 mm field of view), maximum 1,000,000 ×	
SEM-FIB coincidence at	WD 9 mm for SEM – WD 12 mm for FIB	
SEM-FIB angle	55°	

Vacuum System

System pressure:	
Chamber – High-vacuum mode	$< 9 \times 10^{-3}$ Pa*
Chamber – Low-vacuum mode	7–500 Pa**
Electron Gun	$< 3 \times 10^{-7}$ Pa
FIB Gun	$< 5 \times 10^{-4}$ Pa

*pressure $< 5 \times 10^{-4}$ Pa can be displayed with an optional WRG vacuum gauge (on request)
** with a low vacuum aperture inserted

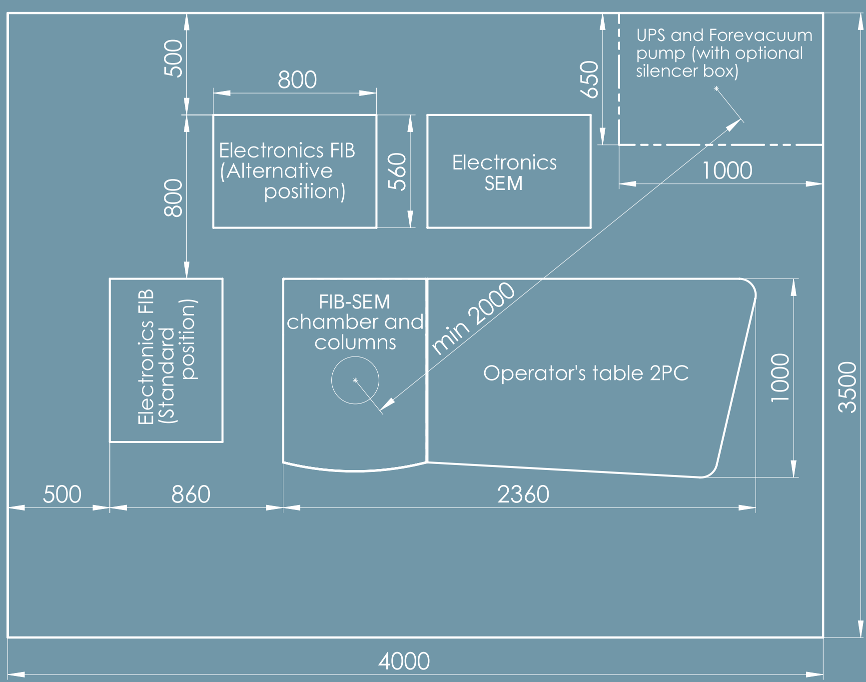
System Control

System control	All system functions are PC-controlled using trackball, mouse and keyboard via the program FeraTC under the Windows™ platform.
Scanning speed	From 20 ns to 10 ms per pixel adjustable in steps or continuously
Scanning features	Focus Window, Dynamic focus, Point & Line scan, Image rotation, Image shift, Tilt compensation, 3D Beam, Live Stereoscopic Imaging, Other scanning shapes available through DrawBeam Software
Image size	16,384 × 16,384 pixels, adjustable separately for live image (in 3 steps) and for stored images (11steps), selectable square or 4:3 or 2:1 rectangle. TSLI is available as an additional image format for effective handling of gigapixel images (panorama images).
Automatic procedures	In-Flight Beam Tracing™ beam optimization, Spot Size and Beam Current Continual, WD (focus) & Stigmator, Scanning Speed (according to Signal- Noise Ratio), Gun Heating, Gun Centering, Column Centering, Compensation for kV, Contrast & Brightness, Vacuum Control, Look Up Table, Auto-diagnostics, Setup of FIB-SEM intersection point, Automated FIB emission start
Remote control	Via TCP/ IP, open protocol

Requirements

Installation requirements	Power 230 V/50 Hz or 120 V/60 Hz, 2300 VA No water cooling Compressed dry nitrogen for venting: 150 – 500 kPa Compressed air: 600 – 800 kPa Compressed xenon for plasma source: 300 kPa	
Environmental requirements	Environment Temperature:	17 – 24 °C with stability better than 2°C with a rate of change 1°C/hour (0.017°C/min)
	Relative humidity:	< 65 %
	Acoustic noise:	< 60 dBC
	Active vibration isolation:	< 10 µm/s below 30 Hz < 20 µm/s above 30 Hz
	Background magnetic field:	synchronous < 300 nT asynchronous < 100 nT
	Room for installation:	3.5 m x 4 m minimum minimum door width 1 m
	Altitude:	max. 3000 m above sea level

Footprint of the microscope FERA3 XM/GM
(all dimensions in mm)



TESCAN ORSAY HOLDING, a. s.
Libušina tř. 21
623 00 Brno - Kohoutovice
Czech Republic
(phone) +420 530 353 411
(email) sales@tescan.cz
(email) marketing@tescan.cz