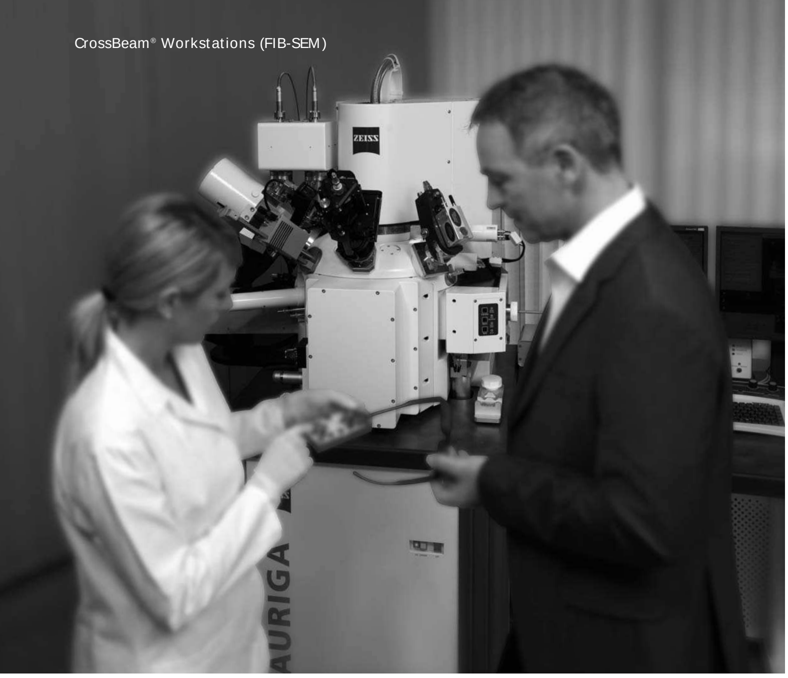


AURIGA® Series
Information Beyond Resolution

ZEISS

We make it visible.

Carl Zeiss Microscopy
Electron and Ion Beam Microscopes

More than 160 years of experience in optics has laid the foundation for pioneering light, electron and ion beam microscopes from Carl Zeiss. Superior integration of imaging and analytical capabilities provides information beyond resolution, unlocking the best kept secrets of your sample.

With a broad technology portfolio Carl Zeiss provides instruments both tailored to your requirements and adaptable to your evolving needs. With our highly versatile application solutions we endeavor to be your partner of choice.

Regional demo centers provide you with access to our applications expertise developed in collaboration with world-class partners in industry and academia. Global customer support is provided by the Carl Zeiss Group together with an extensive network of authorized dealers.

AURIGA® Series
Information Beyond Resolution

Unique Imaging
- Imaging of non-conductive specimens using all standard detectors with local charge compensation
- Simultaneous detection of topographical and compositional information with a unique detector scheme including EsB®-technology
- Investigation of magnetic samples with GEMINI® objective lens design

Advanced Analytics
- Analysis of non-conducting materials with local charge compensation
- Multi-purpose chamber with 15 accessory ports
- Optimum chamber geometry for the simultaneous integration of EDS, EBSD, STEM, WDS, SIMS etc.

Precise Processing
- Innovative FIB technology with best-in-class resolution (< 2.5 nm)
- High resolution live FE-SEM monitoring of the entire preparation process
- Advanced gas processing technology for ion and e-beam assisted etching and deposition

Future Assured
- Expandable platform concept based on GEMINI® FE-SEM technology
- Modular building blocks for value-adding functionality

SEM
Scanning Electron Microscopes

FE-SEM
Field Emission - Scanning Electron Microscopes

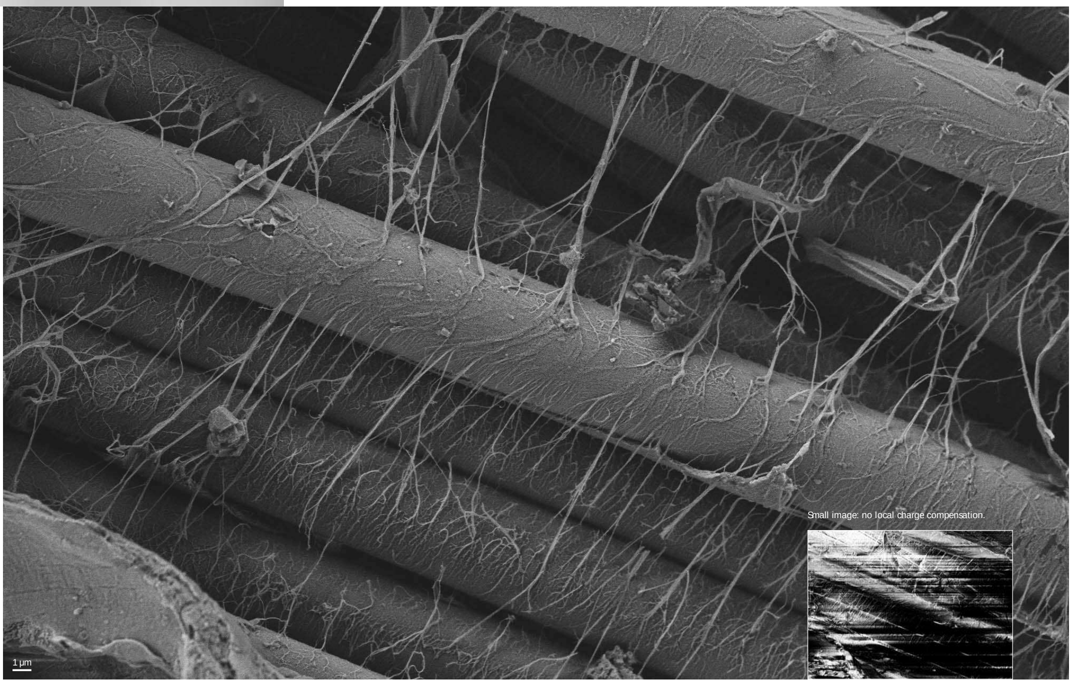
HIM
Helium Ion Microscopes

CrossBeam®
CrossBeam® Workstations (FIB-SEM)

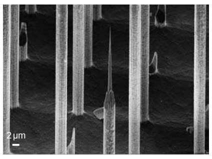
TEM
Transmission Electron Microscopes

Applications in Materials Analysis
Information Beyond Resolution

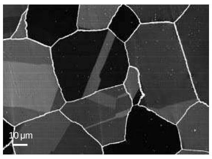
- 3D imaging and analysis of non-conducting materials with local charge compensation
- Patterning of complex nanostructures and high resolution ion imaging based on innovative FIB technology
- Simultaneous detection of topographical and compositional information with unique GEMINI® detector scheme
- Maximum information out of the sample with a system designed for advanced analytics: 3D EBSD, EDS, WDS, SIMS etc.



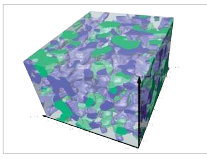
Chamber SE image of an uncoated fibre adhesive (used in modern shipbuilding) taken at 5 kV with local charge compensation.



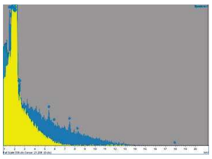
Annular milling: Nanometer-scale structuring by direct ion beam writing, e.g. for atom probe tips. The image shows a very sharp Si tip (radius < 20 nm) trimmed from Si posts which were fabricated by reactive ion etching.



Secondary ion detector: Visualisation of the intergranular corrosion in a Ni based superalloy by detection of secondary ions. The image was taken using a FIB current of 3 nA.



3D anode reconstruction of a solid oxide fuel cell illustrating the distribution of the different phases. The pores are in blue, Ni in green and the YSZ phase is translucent. Courtesy of J. Wilson, Northwestern University, USA.



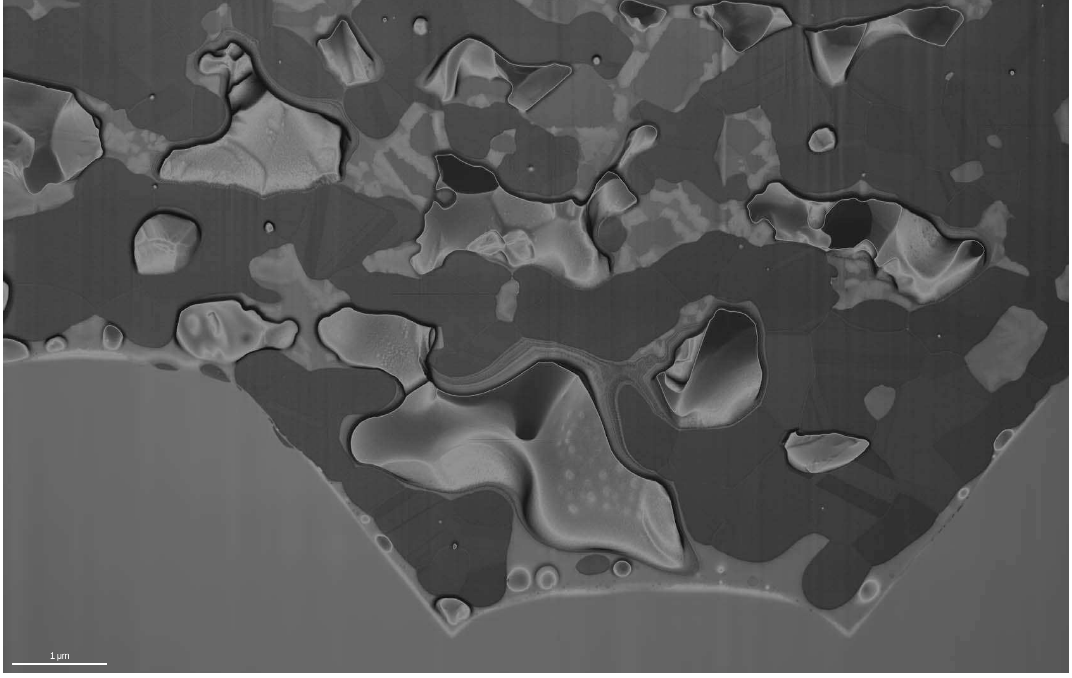
Local charge compensation produces a significant increase in the analytical data. EDS spectra of a ZrO_2 sample taken at 15 kV with (blue) and without (yellow) local charge compensation. All emission lines above approx. 6 kV are only accessible with local charge compensation.

3D EBSD data cube of an electrodeposited Ni film providing microstructural information such as grain orientation. Dimensions: 10 µm x 4 µm x 5 µm.

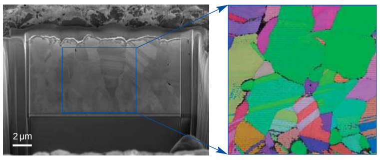
Applications in Materials Analysis
Information Beyond Resolution

Semiconductor Technology

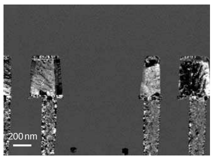
- 3D surface sensitive imaging with fast FIB cross section milling and low voltage high resolution optics design
- Perfect sample characterization using integrated and optional analysis technology such as STEM or EBSD
- Creation of complex nanopatterns with advanced focused ion beam and gas processing instrumentation
- Full workflow control and throughput enhancement in TEM sample preparation by high resolution live imaging and software-based process automation



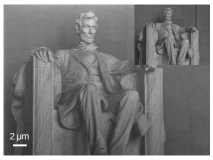
Cross section through the front contact of a Si wafer-based solar cell. The image was taken with in-lens SE detector at 2 kV. Courtesy of Dr. F. Machalett, ersol Solar Energy AG, Erfurt, Germany.



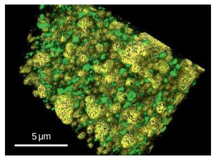
Layer stack and morphology of a CdTe based thin film solar cell. The images show a cross section taken with in-lens SE detector at 2 kV (left) and a 2D EBSD map of the CdTe absorber film (right). Courtesy of Prof. W. Jaegermann, TU Darmstadt, Germany.



High-angle annular orientation dark field (HAAoDF) STEM image of a semiconductor device showing Cu metal lines and W plugs with grain orientation contrast. Imaged at 30 kV.



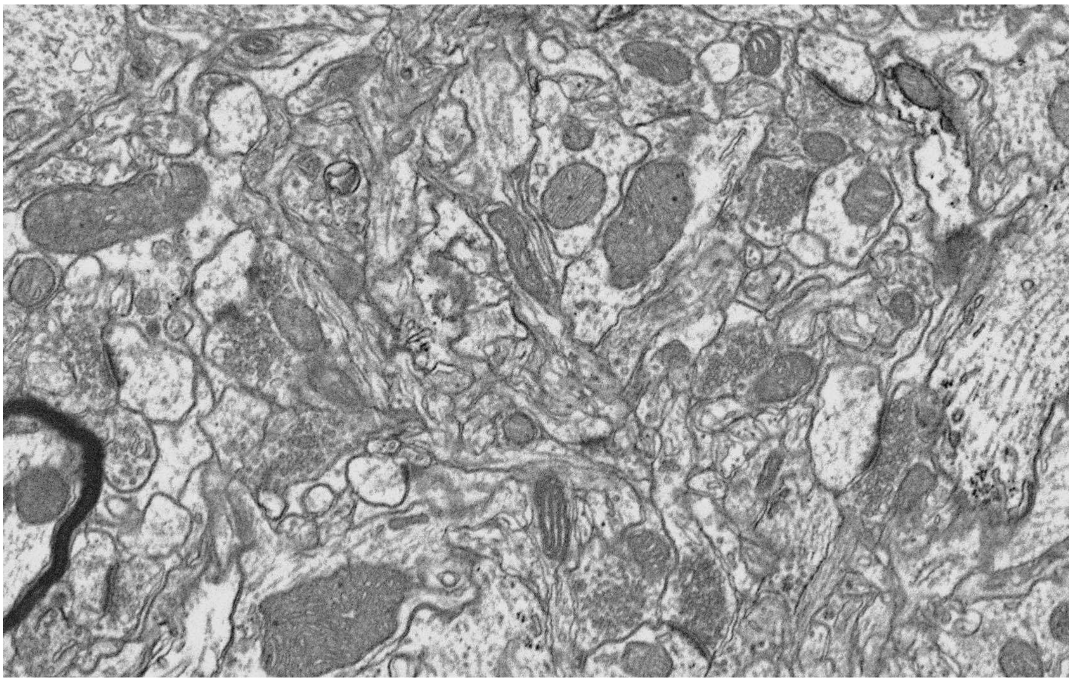
3D nanopatterning based on greyscale bitmap image. Example shows a "NanoLincoln" (large image) and the original photograph of the Lincoln Memorial (inset).



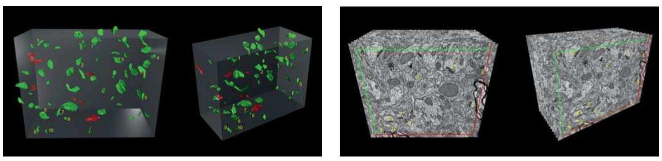
Quantitative three-dimensional EDS map of Ag(SnO_2, In_2O_3), a lead-free solder alloy. This 3D reconstruction was calculated from 117 individual EDS elemental maps recorded automatically over 14 hours. Yellow: tin, green: indium, blue: oxygen.

Applications in Life Sciences
Information Beyond Resolution

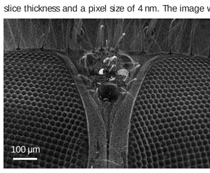
- Full sample information with large area / large volume milling and high resolution imaging
- Vivid high depth of focus imaging of biological samples with no additional preparation using the local charge compensation method
- Unsurpassed depth resolution in tomography applications with highly sophisticated milling control
- Access to accurate structural information with 3D reconstruction



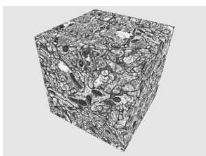
3D mapping of mouse brain with high z-resolution by serial FIB slicing and SEM imaging. The exemplary cross section is one of a large image stack with 20 nm slice thickness and a pixel size of 4 nm. The image was taken with the EsB® detector at 2 kV.



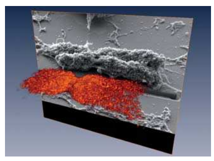
Counting synapses using FIB/SEM microscopy: A true revolution for ultrastructural volume reconstruction.



Detail image of uncoated fly in the eye region. Imaged at 3.4 kV with local charge compensation and in-lens SE detector.



3D view of a 5 x 5 x 5 µm section of a drosophila larval brain at 5 nm isotropic resolution. A complete wiring diagram of the brain can be constructed when one images its entire volume. Sub 10 nm resolution along z-axis is crucial for neuronal wiring diagram reconstruction. Courtesy of C. Shan Xu, Janelia Farm Research Campus, HHMI, USA.



3D reconstruction of chromosomes based on real-time movie. The individual frames were acquired with in-lens SE detector at 2 kV. Courtesy of Prof. G. Wanner, Munich, Germany.

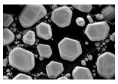
Image shows AURIGA® with a 4" stage.

AURIGA® Series
Custom-Tailored and Future Assured

- Based on a fully modular concept, the AURIGA® CrossBeam® workstations can be tailored to the individual customer's applications – today and in the future.
- Starting with a high-performance FE-SEM platform, the system can be upgraded with a wide variety of hardware and software options, such as FIB, GIS, local charge compensation system and different detectors.

FE-SEM Platform

1 GEMINI® FE-SEM column
with in-lens SE detector for high resolution and contrast imaging

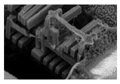


2 AURIGA® vacuum chamber
with 15 free accessory ports

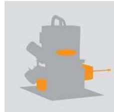
CrossBeam® Components

3 FIB column
for fast and precise sample modification
- Canion column for multi-purpose applications
- Cobra column with best-in-class FIB resolution

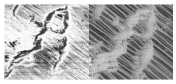
4 Gas injection system
for a wide range of versatile gas processes
- Single GIS
- Multi GIS with up to 5 precursor materials



Options



5 Local charge compensation and in-situ sample cleaning
- Multi GIS integrated or
- Charge compensator



6 In-lens EsB® detector
for the highest material contrast

7 Airlock
for fast and convenient sample transfer
- 80 mm or
- 100 mm maximum specimen size

Further Options
Ion detector, STEM, 4QBSD, EDS, EBSD, WDS, SIMS etc.

AURIGA® & AURIGA® 60
Flexibility Taken to Extreme

1 Focused Ion Beam – the essential CrossBeam® component
2 WDS for highest sensitivity chemical analysis
3 Electron flood gun for charge control during ion beam preparation
4 Charge compensation for charge control in SEM imaging and analysis
5 EDX for fastest chemical analysis
6 STEM detector for TEM like imaging and quality control
7 EBSD for crystallographic mapping
8 Multichannel GIS for maximum precursor flexibility on a single flange
9 Single needle GIS for high angle sample access
10 Manipulators for sample modification and probing
11 4QBSD detector for high efficiency and angle selective material characterization
12 EsB® detector for finest z resolution without topographic artefacts in FIB nanotomography
13 Cathodoluminescence detection for optical material characterization
14 Cryo stage and transfer for access to frozen or beam sensitive material
15 Airlock solution (80 mm) for fast and efficient sample transfer
16 Airlock solution (200 mm) for fast and efficient sample transfer

CrossBeam® Workstations (FIB-SEM)
AURIGA® & AURIGA® 60

Modern materials research is characterized by a great complexity of tasks. Chemical composition, crystallographic orientation, complete morphology, and electrical attributes are only some of the questions scientists and engineers seek answers to. Their success depends on a detailed insight into topography and structure of the samples examined. On the other hand, in developing novel materials specimens often have to be extremely precisely processed.

To address these demands, the AURIGA® CrossBeam® workstation series has been designed to accommodate an optimum number of accessories/detectors only depending on the size of the vacuum chamber.

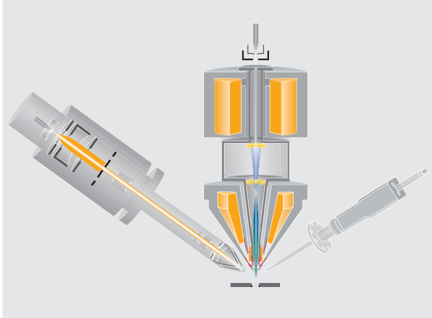
Due to a large 6" stage vacuum chamber, the AURIGA® 60 essentially broadens the application spectrum of the Carl Zeiss CrossBeam® technology. Up to 23 analytical or other accessories for diverse chemical or physical experiments can be mounted on the chamber, e.g. different detectors or a cryogenic transfer unit.

Thanks to a modular setup the system is capable of being simply and flexibly upgraded. So, one can start with a stand-alone FE-SEM platform that can be upgraded stepwise to a fully equipped CrossBeam® workstation.

The highly versatile and flexible functionality of AURIGA® 60 enables new perspectives in 3D-imaging leading to fascinating insights into the building blocks of life or novel materials for future technological applications.

CrossBeam® Concept

Fast and precise sample modification
The ever increasing requirements on sample throughput and precision of milled objects are met by integrating the most innovative focused ion beam technology. High brightness liquid metal ion sources combined with state-of-the-art electrostatic lens design deliver an excellent imaging resolution combined with high current ion beam densities and up to 50 nA total beam current.
Deposition of conducting or non-conducting materials, as well as enhanced and selective etching, can be performed with either the electron or ion beam when combined with the highly flexible gas injection technology.
Instrument usage can be optimized by the "on-board" automation tool set that is easily adapted to specific customer requirements using straightforward setup wizards and an intuitive scripting language.

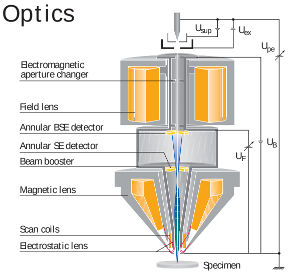


Key components of the AURIGA® CrossBeam®:
GEMINI® electron optical column (center), focused ion beam (left) and gas injection system (right).

High resolution process control
High resolution live electron imaging for excellent site specific control of the milling process is based on an advanced optical design that provides a practically magnetic field-free sample environment. Consequently, a change in the settings of the electron optical system will not interfere at all with the FIB processing; even more importantly there will be no compromises in terms of SEM resolution or ease-of-use of operation while monitoring and controlling the ion beam processing in real time.

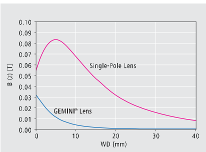
Flexible imaging
Topographical and compositional sample information are conveyed simultaneously by high resolution scanning electron imaging of secondary and backscattered electrons.
Structural and material information on crystalline samples or oxidation layers can be obtained when operating in FIB imaging mode and detecting secondary ions generated during ion beam scanning of the specimen.

GEMINI® Electron Optics

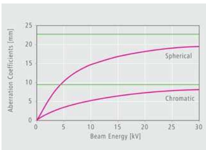


Schematic view of the GEMINI® column. With its minimum mechanical degrees of freedom, the system is designed for maximum ease of use.

Superb imaging and analysis
Imaging of modern compound materials requires an electron optical system capable of delivering high resolution images with excellent contrast even at very low beam energies. The advanced optical system design of the GEMINI® meets this requirement with its unique beam booster approach, providing decreasing lens aberration coefficients with decreasing beam energy.
Imaging of magnetic materials, such as ferromagnetic steel or rare earths, can be easily achieved with an objective lens designed for minimum magnetic field at the sample.
High voltage material characterization by EDS, EBSD or other advanced techniques is based on a system designed for analytics.
With its short analytical working distance of down to 5 mm and an optics design that provides optimised beam current conditions and hence signal to noise ratios, the system is ideally suited for any kind of material investigation.



Magnetic field leakage of the GEMINI® lens compared to a traditional single pole lens design. A minimum magnetic field is required for the high resolution investigation of magnetic materials and undistorted ion beam operation.

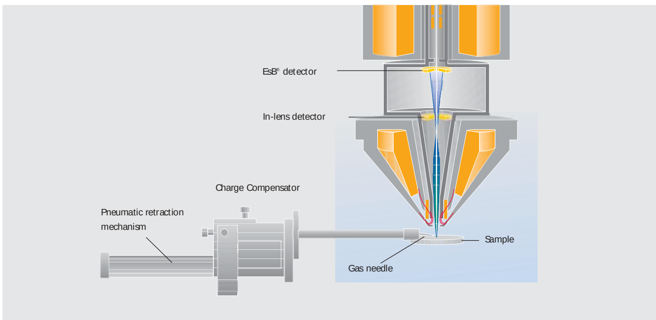


The beam booster advantage: decreasing lens aberrations with decreasing beam voltage for high resolution imaging at very low landing energies.

Ease of use by design
Being able to easily adjust parameters such as the beam voltage and field of view is of key importance in optimizing an instrument for maximum resolution and contrast imaging. Faster time to result can be achieved with an optical system design providing truly continuous adjustment of magnificati-on, no tedious re-alignments after a change in beam energy, and a system control that automatically provides optimized values for beam aperture selection.

Instant topography and composition
Topographical and compositional information is obtained simultaneously thanks to the unique detector architecture that allows parallel detection of secondary and back-scattered electrons. Two secondary electron detectors – chamber mounted and in-lens – guarantee maximum topography information for samples of various heights and shapes.
The optional EsB® detector provides highest material contrast with energy-filtered detection of backscattered electrons.

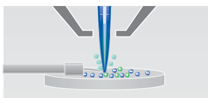
Local Charge Compensation
Unique Technology



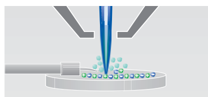
Fast change between local charge compensation and high vacuum operation is guaranteed by a simple pneumatic retraction mechanism for the gas injection system.

Imaging and analysis of charging samples
The local charge compensator is essential to ensure maximum information gain for insulating materials. This system enables convenient SEM imaging across the entire range of acceleration voltages, better milling results by suppressing FIB-deflections, superior high kV analytics, such as EDS or EBSD, with no information loss, as well as the use of all standard detectors.

The design of the local charge compensation system is based on a gas which is locally injected into the area of interest and ionized by collisions with charged particles. This ionisation results in the desired removal of specimen charging and can also be used for in-situ sample cleaning.



The sample surface is charged up by electron irradiation. The gas flow is turned on and the gas molecules (light green) form a local gas cloud above the sample surface.

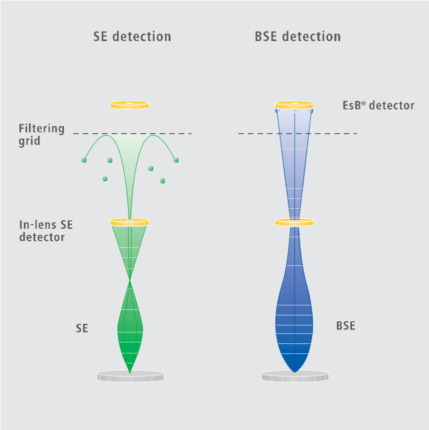


SE and BSE emitted from the sample surface ionize the gas molecules. The sample surface is neutralized when the resulting positive ions (darkgreen) hit the sample. Full imaging and analytical capabilities are thus enabled.

EsB® Backscattered Electron Detection
Unique Technology

Online compositional information
Acquiring data about sample composition by direct imaging provides a quick and easy way to obtain material information. The GEMINI® column features the so called Energy and Angle Selective EsB® detector that allows an almost pure compositional image to be obtained by filtering out unwanted surface information.
This compositional information is extracted by blocking secondary electrons from the EsB® detector by a negatively biased filtering grid.

Signal mixing
The possibility of adjusting the filtering strength of the EsB® detector and the simultaneous acquisition of secondary electrons by the in-lens and chamber mounted SE detectors enable optimum real-time signal mixing.



Filtering grid technology for maximum compositional contrast information.
The filtering rejects secondary electrons and only the backscattered electrons pass through to the upper EsB® detector.

AURIGA® & AURIGA® 60
Technical Data

Essential Specifications	SEM	FIB
Resolution	GEMINI® column 1.0 nm @ 15 kV 1.9 nm @ 1 kV Values measured at optimum working distance	Cobra column: < 2.5 nm @ 30 kV Canion column: < 7 nm @ 30 kV
Magnification	12 x – 1000 kx	300 x – 500 kx
Probe Current	4 pA – 20 nA (100 nA optional)	1 pA – 50 nA
Acceleration Voltage	0.1 – 30 kV	< 1.0 – 30 kV
Emitter	Schottky Field Emitter	Ga Liquid metal ion source (LMIS)
Gas Injection System	a) Multi GIS for up to 5 precursors (Pt, C, W, insulator, fluorine, further gases on request) b) Multi GIS for up to 4 precursors with integrated local charge compensation system (use of all standard detectors possible) c) Single GIS system for 1 precursor (Pt, further gases on request) d) Fully automated and pneumatic retractable gas injector for local charge compensation and in-situ sample cleaning (use of all standard detectors possible)	
Stage	6-axis super eucentric, all motorized stage Motion range X,Y = 100 mm Z = 55 mm, (50 mm = AURIGA® 60) Z´ = 10 mm, (13 mm = AURIGA® 60) Tilt = -10 – 60°, (-15 – 70° = AURIGA® 60) Rotation = 360° continuous Analytical working distance = 5 – 8.5 mm	
Airlock	80 mm / 100 mm manual airlock with specimen exchange position	
Detectors	In-lens: High efficiency annular type SE detector Chamber: Everhart-Thornley type SE detector In-lens: EsB® detector with filtering grid for BSE detection, filtering voltage 0 – 1500 V Chamber: Combined Secondary Electron Secondary Ion (SESI) detector based on scintillator photomultiplier system Solid state or scintillator type BSD detector GEMINI® multimode BF/DF STEM detector	
Chamber	330 mm (Ø), 266 mm height, (520 mm (Ø), 307 mm height = AURIGA® 60) 15 accessory ports, (23 accessory ports = AURIGA® 60) for various options including STEM, 4QBSD, EBSD, EDS, WDS, SIMS, GIS systems, local charge compensation and sample manipulation systems 2 x IR CCD-cameras included for sample viewing	
System Control	Integrated SmartSEM® user interface based on Windows® operating system, controlled by mouse, keyboard, joystick and control panel (optional) 2 x 19'' TFT monitors included	
Space Requirement	Minimum footprint: 2.3 m x 2.7 m, (2.4 m x 4.2 m x 2.3 m = AURIGA® 60) Minimum working area: 3.0 m x 4.0 m, (Recommended room size: 4.0 m x 6.0 m x 2.3 m (h) = AURIGA® 60)	

= upgrades

Global Sales and Service Network
Carl Zeiss Microscopy

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Carl Zeiss Microscopy GmbH
07745 Jena, Germany
microscopy@zeiss.com
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