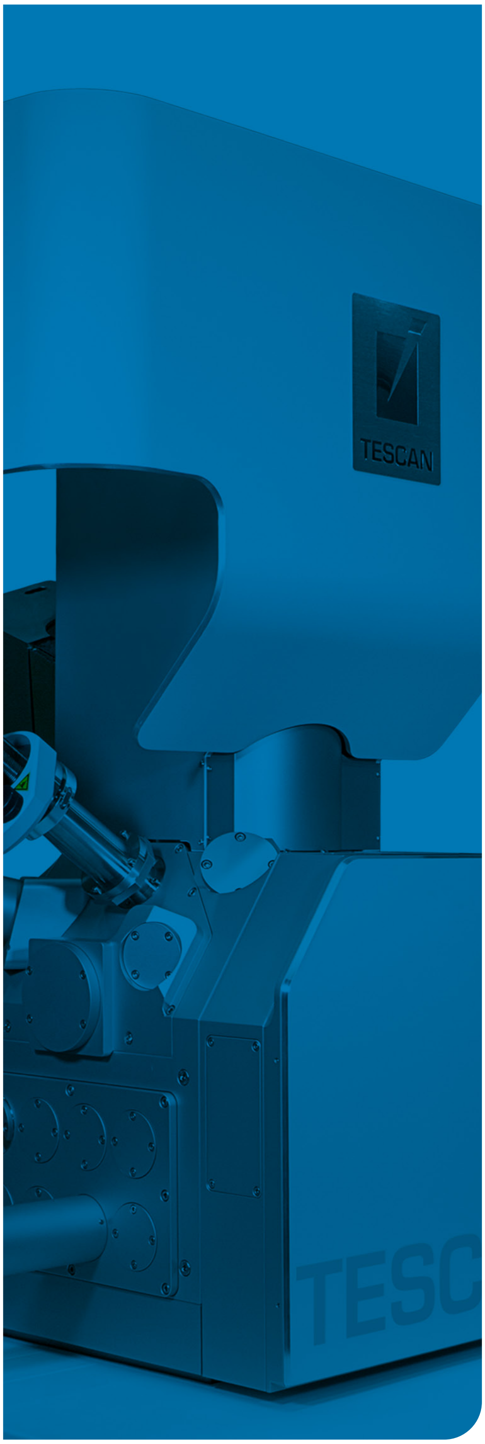
TESCAN MAGNA

UHR SEM with TriLens™ immersion optics for characterization of nanomaterials



TRIGLAV™ ELECTRON COLUMN

0.9 nm at 1 keV — LOW-KV RESOLUTION

SELECTIVE SIGNAL COLLECTION

UHR SEM

0.6 nm at 15 keV — RESOLUTION

UNIVAC

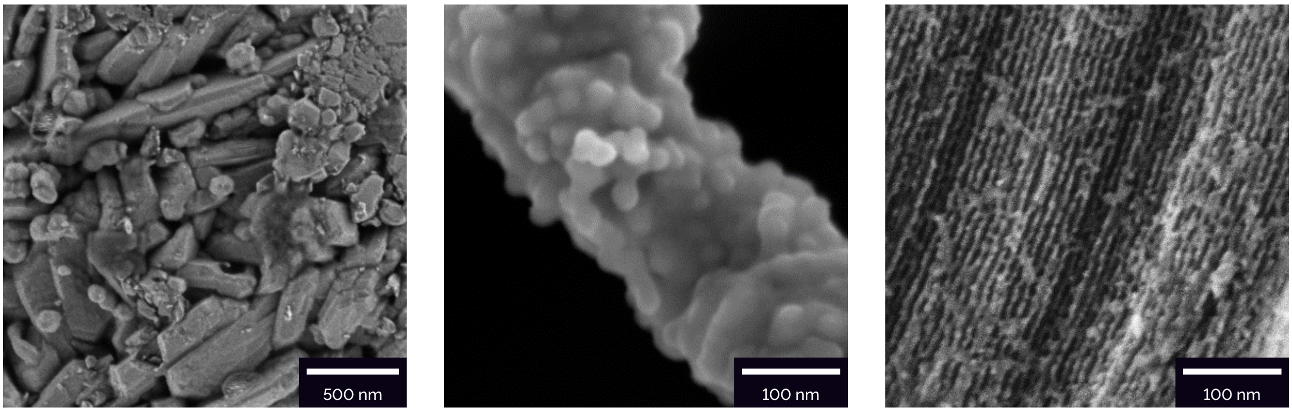
UHR SEM with TriLens™ immersion optics for characterization of nanomaterials

TESCAN MAGNA is a powerful analytical tool for ultimate surface characterization of nanomaterials. TESCAN MAGNA features the Triglav™ SEM column for excellent ultra-high-resolution imaging performance, especially for low electron beam energies. It also includes a unique in-beam detection system with energy filtered and angular differentiated electron acquisition to allow selective backscattered electron imaging contrast methods. In addition, TESCAN MAGNA operates with a Schottky field electron source, capable of generating high electron beam currents up to 400 nA, to provide optimum conditions for microanalysis applications that require long acquisition times. TESCAN Essence™ graphical user interface, which features a user-friendly, customizable layout and dedicated software modules, is designed to deliver an intuitive operator experience for this state of the art UHR SEM solution.

These features work together to make TESCAN MAGNA a turn-key solution for characterization of next-generation materials such as catalyst structures, nanotubes, nanoparticles and prefabricated nanoscale structures.

Ultra-high resolution and high-contrast imaging of next-gen materials

The Triglav™ immersion lens electron column features our proprietary TriLens™ triple objective lens design. The immersion field between pole piece and sample benefits both imaging resolution and contrast at low electron beam energies to provide that extra performance boost for certain samples such as catalysts, nanotubes and non-magnetic nanoparticles. That additional electron beam demagnification also benefits applications that require the highest electron beam energies (30 keV), like scanning transmission electron imaging (STEM). TriLens™ also features an analytical mode which delivers field-free imaging. Analytical mode is recommended for imaging magnetic samples and analytical applications such as EDS or EBSD. In-Flight Beam Tracing™ maintains the smallest possible electron beam at the higher beam currents needed for high-throughput microanalysis applications.

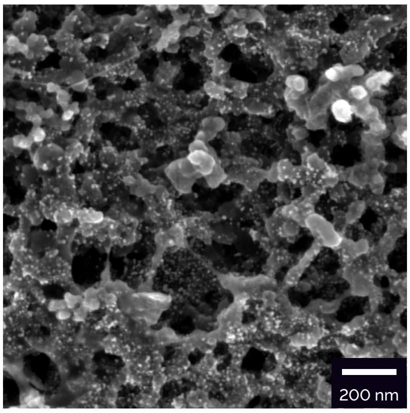


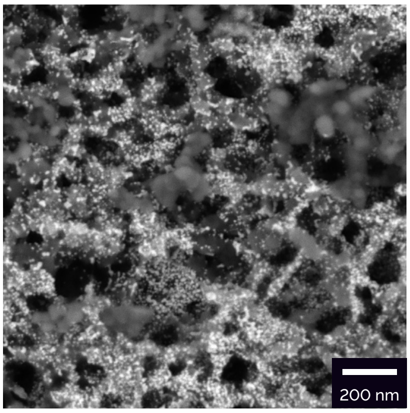
▲ (left) Agglomerate of lithium rich powder, (center) Iron oxide nano-rods (right) Detail of mesoporous sillica (uncoated specimen)

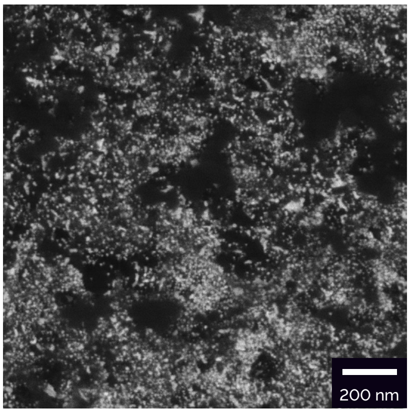
Unique TriBE™ and TriSE™ In-Beam detection for advanced nano characterization

Materials scientists need to not only generate appealing images, but also produce images that highlight all of details that their sample may be concealing. TESCAN's own TriBE™ and TriSE™ In-Beam detection methods allow differentiated SE and BSE contrast methods that improve visibility to nanoscale details for materials characterization.

TriBE™ triple BSE detection is valuable for both energy and angular backscattered electron contrast selection, providing a means to enhance contrast on the morphological and compositional attributes of your sample. The Mid-Angle BSE and In-Beam f-BSE detectors, located inside the column, acquire medium-angle and axial backscattered electrons, while the chamber-mounted BSE detector acquires wide-angle electrons. Energy-filtering of the backscattered electron signal provides an innovative energy selective contrast methodology for obtaining contrast created by the BSEs with smallest energy loss, from a very shallow region on the samples surface. TriSE™ triple SE detection selectively acquires secondary electrons for the three operating modes. The In-Beam SE detector is preferred for acquisition of electrons at very short working distances. Secondary electron acquisition with the In-Beam SE detector is further optimized when beam deceleration is applied to enhance low keV imaging resolution and contrast from specific sample types. Finally, the Everhart-Thornley in-chamber SE detector is used to maximize topography visible from the sample surface.







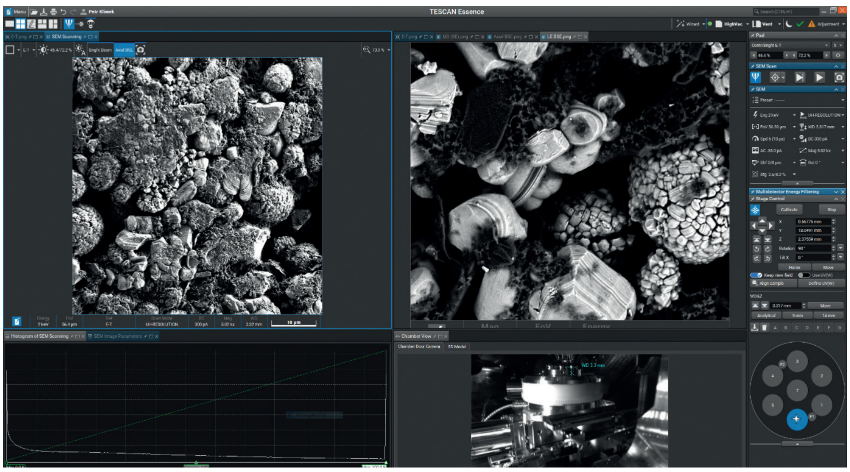
▲ (left) SE image of carbon catalyst with platinum nanoparticles imaged with in-column SE detector; (middle) BSE image of carbon catalyst with platinum nanoparticles imaged with in-column Mid-Angle BSE detector; (right) BSE image of carbon catalyst with platinum nanoparticles imaged with in-column BSE detector

Optimal imaging and analytical conditions guaranteed by TESCAN In-Flight Beam Tracing™

TESCAN MAGNA features adaptive spot shape optimization through In-Flight Beam Tracing™, which delivers enhanced resolution at high electron beam currents, up to 400 nA. This capability is beneficial for analytical techniques such as EDX, WDS, and EBSD that may require high currents to keep acquisition times within reason, without sacrificing spatial resolution of compositional and textural heterogeneity.

TESCAN Essence™ User Interface

Essence™ is TESCAN's graphical user interface, featuring a layout manager that gives fast and easy access to all TESCAN MAGNA main functions. This modern, user-friendly interface can be customized to streamline specific application workflows as well as the lay-out preferences of novice, routine and expert users. A collection of software modules, wizards and recipes all contribute to enhanced productivity and throughput in the lab.

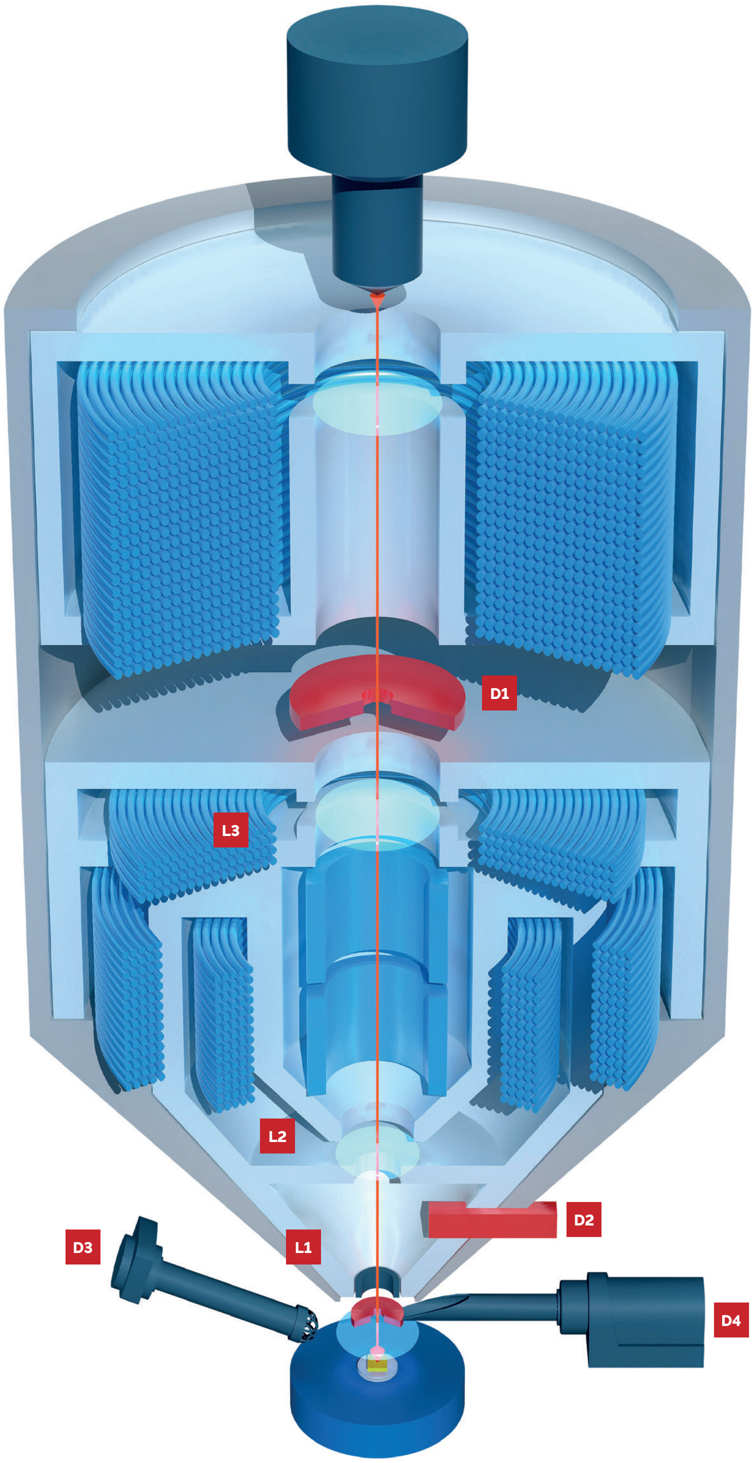


▲ New TESCAN Essence™ SW interface – customizable layout

Ultimate resolution and enhanced detection capabilities for sample characterization

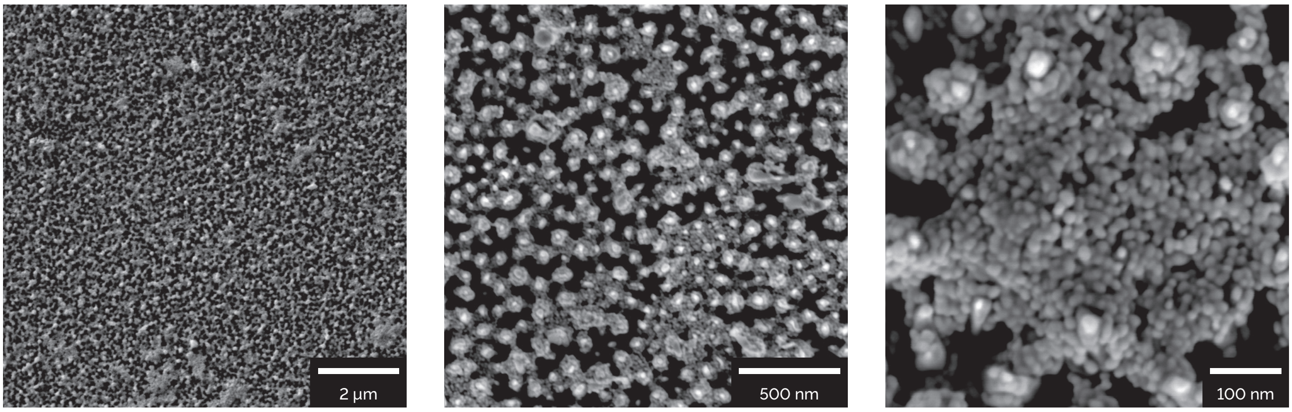
The Triglav™ SEM column features TriLens™, a three-lens compound objective system that enables both an ultra-high-resolution (UHR) immersion imaging mode and a high-throughput analytical mode. The UHR mode can be combined in a unique way with a crossover-free configuration, resulting in reduced aberrations for a significant improvement in beam performance at low beam energies. Moreover, immersion optics technology remains the best choice for STEM and microanalysis, delivering an unprecedented 0.5 nm optical resolution at 30 keV electron beam energy.

Microanalysis (i.e. EDS, EBSD) is performed in the field-free analytical mode. Field-free analytical mode is ideal for morphological characterization of magnetic samples. This analytical mode also provides a large field-of-view for fast, smooth and easy navigation across the sample surface.



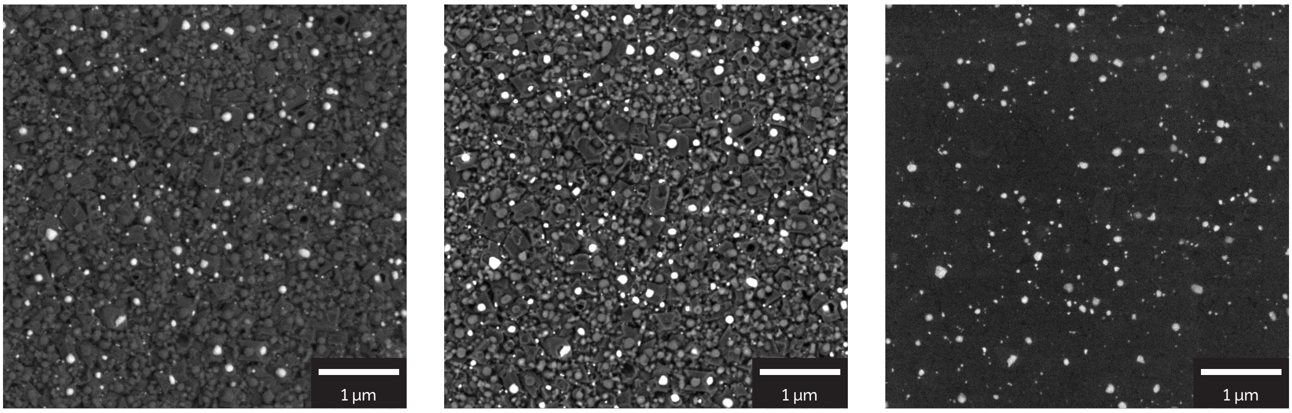
- **L1** UH-resolution lens
- **L2** Analytical lens
- **L3** Third objective lens
- **D1** In-Beam f-BSE detector
- **D2** In-Beam SE / Mid-Angle BSE detector
- **D3** SE detector
- **D4** R-BSE detector

Unique TriSE™ detection



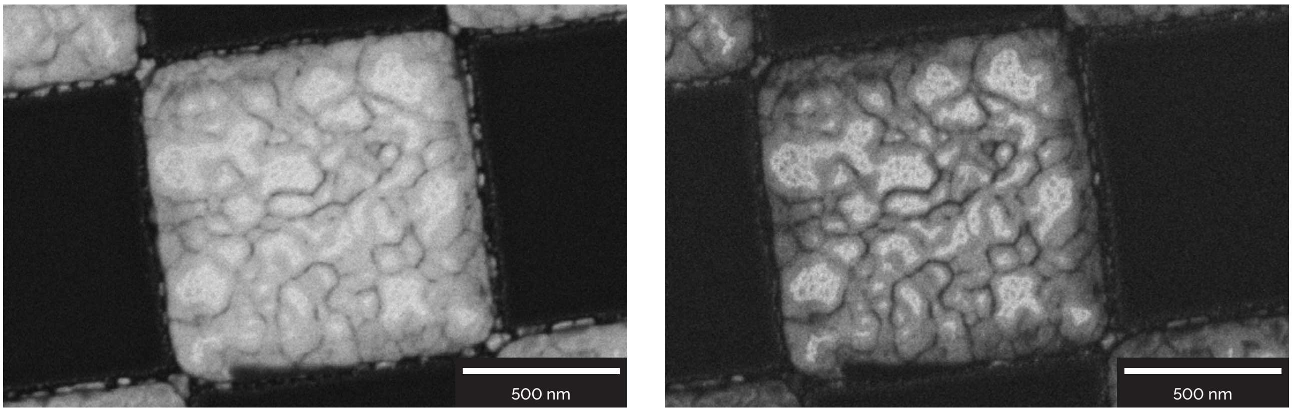
▲ Black silicon with gold nanoparticles: (left) overview image - in-chamber SE, (center) In-Beam SE, (right) In-Beam SE (BDM).

Unique TriBE™ detection



▲ Images acquired simultaneously, Ni particles on C, 2 keV: (left) in-chamber BSE (wide-angle BSE), (center) Mid-Angle BSE, (right) In-Beam BSE.

In column BSE's selective energy filtering

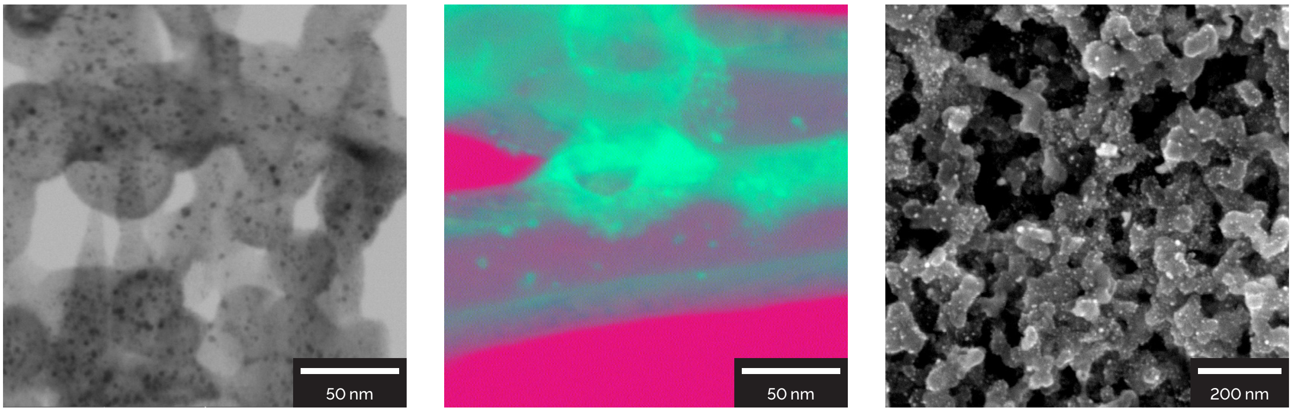


▲ (Left) BSE image of Au grains on Si imaged at 4 keV with in-column BSE detector (energy filter off);
(right) low loss BSE image of Au grains on Si imaged at 4 keV with in-column BSE detector (energy filter on 3900 eV).

Applications

Precise nanometer scale studies (SEM/STEM) of material structures

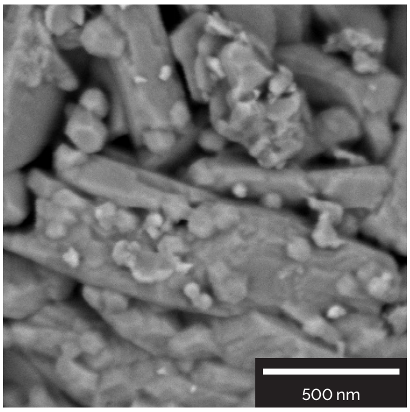
Scanning transmission electron microscopy (STEM) provides an appealing alternative to conventional scanning electron microscopy for the characterization of materials with dimensions in the lower range of the nanoscale, like nano-powders or nanowires. Some materials (nanoparticles, nanotubes or nanowires, usually with size below 100 nm) can be inspected directly when distributed on a TEM grid. Other methods, e.g. Focused Ion Beam (FIB) sample preparation, can be used first to create thin lamella, with 30 keV electron beam transparency, from the bulk material for observation using STEM. A segmented, motorized STEM detector is placed underneath the sample to collect transmitted electrons that have interacted with the sample by scattering and/or absorption. TESCAN MAGNA's STEM detector has segments for the acquisition of electrons with low to high scattering angles, referred to as bright field, dark field and high angle dark field signals respectively. STEM images are typically converted (black to white and vice-versa) to resemble conventional scanning electron microscopy image appearance.

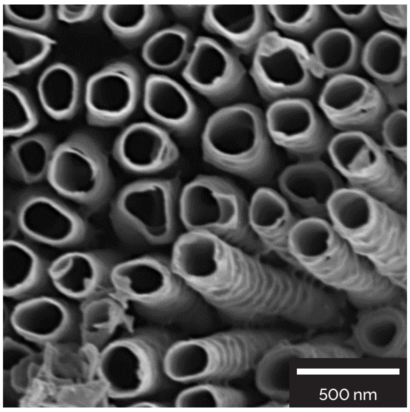


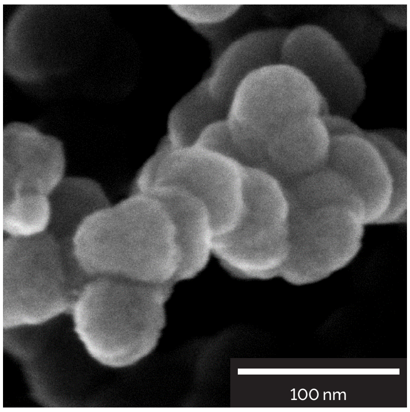
▲ (left) STEM image of a carbon catalyst (size 20–150 nm) doped with metal nanoparticles of size 1–5 nm. (center) STEM image of carbon nanotubes (size ~100 nm) with metal nanoparticles of size 1–7 nm, colored based on STEM segment. (right) Surface of a carbon catalyst (size 20–150 nm) doped with metal nanoparticles of size 1–5 nm.

Studies of nanoparticles, nanotubes and nanopores using low electron beam landing energies

For the study of nanostructures, the detection system of TESCAN MAGNA UHR-SEM provides unprecedented flexibility through the use of subtly different secondary and backscattered electron contrast methods. While MAGNA's unique BSE detection system is designed for energy and angular selective backscattered electron acquisition, its In-Beam SE detection capabilities offer flexibility for acquisition of high resolution, surface sensitive topographical information from a wide range of samples. For instance, TESCAN MAGNA's best low keV resolution (0.9 nm at 1 keV) can be achieved on certain samples by using UHR in-beam SE imaging with the optional Beam Deceleration Mode, whereby the final electron beam landing energy is reduced further by a bias that is applied to the sample surface.





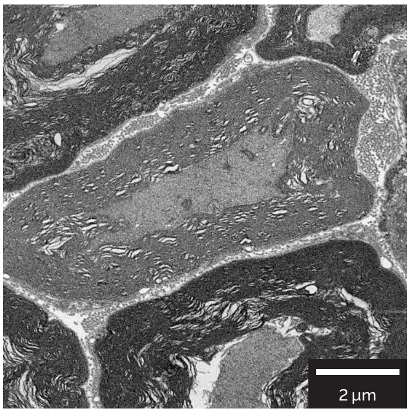


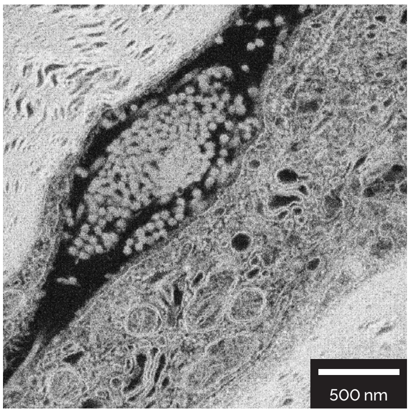
▲ (left) Agglomerate of nanoparticles: lithium-rich powder imaged with BSE in BDM mode; (center) TiO_2 nanotubes imaged with In-column SE; (right) graphite powder imaged with in-column SE in BDM mode.

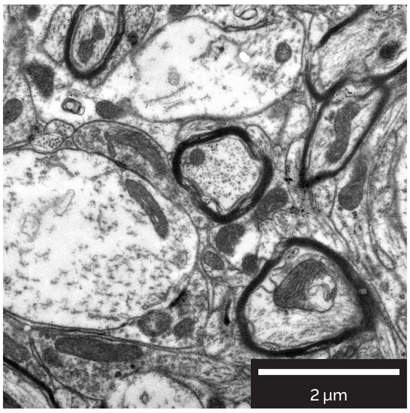
UHR imaging of delicate ultra-thin brain sections with low keV backscattered electrons

The study of brain and neural tissue is essential for the understanding of processes and mechanisms causing neurodegenerative diseases. Researchers must characterize complex neural and tissue structures to identify the subtle alterations within the neural tissue that are associated with a disease, or reaction to specific treatment. Typically, this is done using high resolution, low keV backscattered electron imaging of a thinned specimen. In addition to the in-column Mid-Angle BSE and In-Beam f-BSE detectors, TESCAN MAGNA can be equipped with a chamber mounted scintillator or solid-state backscattered electron detector to yield high contrast backscattered electron images from resin-embedded brain tissue.

STEM imaging is another method for brain tissue characterization. MAGNA's segmented, motorized STEM detector, in combination with the Image Snapper software module, is an ideal solution for automated acquisition of tiled high-resolution images that can be stitched into a single, ultra-large image mosaic. With this solution, large panoramic views—up to 42,000 pixels horizontal field of view—can be created, providing the user with information from both resolution and scale.







▲ (left) Resin-embedded brain tissue imaged with in-column BSE detector; (center) brain tissue with synapses detected by in-column BSE detector; (right) STEM (bright field) image of neural tissue, resin embedded section on the grid. The 3 × 3 tile is captured and stitched using Essence™ Image Snapper.

Technical Specifications

Electron Optics:

Electron Gun:	High brightness Schottky emitter		
Electron Optics:	Triglav™ column equipped with the three-lens compound TriLens™ objective		
Resolution:	**Standard mode:** **In-Beam SE** 0.6 nm at 15 keV 1.2 nm at 1 keV	**Beam Deceleration Mode (option):** **SE (BDM)** 0.9 nm at 1 keV	**STEM mode (option):** 0.6 nm at 30 keV
Probe Current:	up to 400 nA		

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