TESCAN

TESCAN CLARA

Field-free analytical UHR SEM for materials characterization at the nanoscale

BrightBeam™ electron column

1.2 nm at 1 keV — Low-kV resolution

Selective signal collection

Field-free UHR SEM

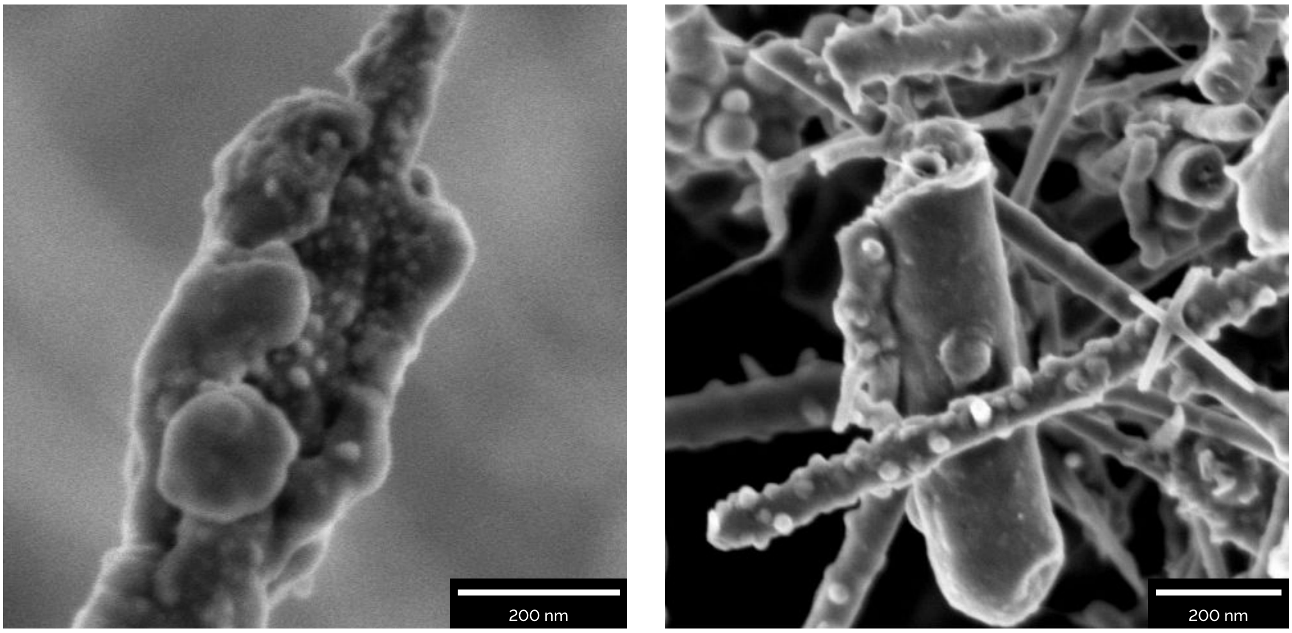
0.9 nm at 15 keV — Resolution

Variable Pressure (MultiVac)

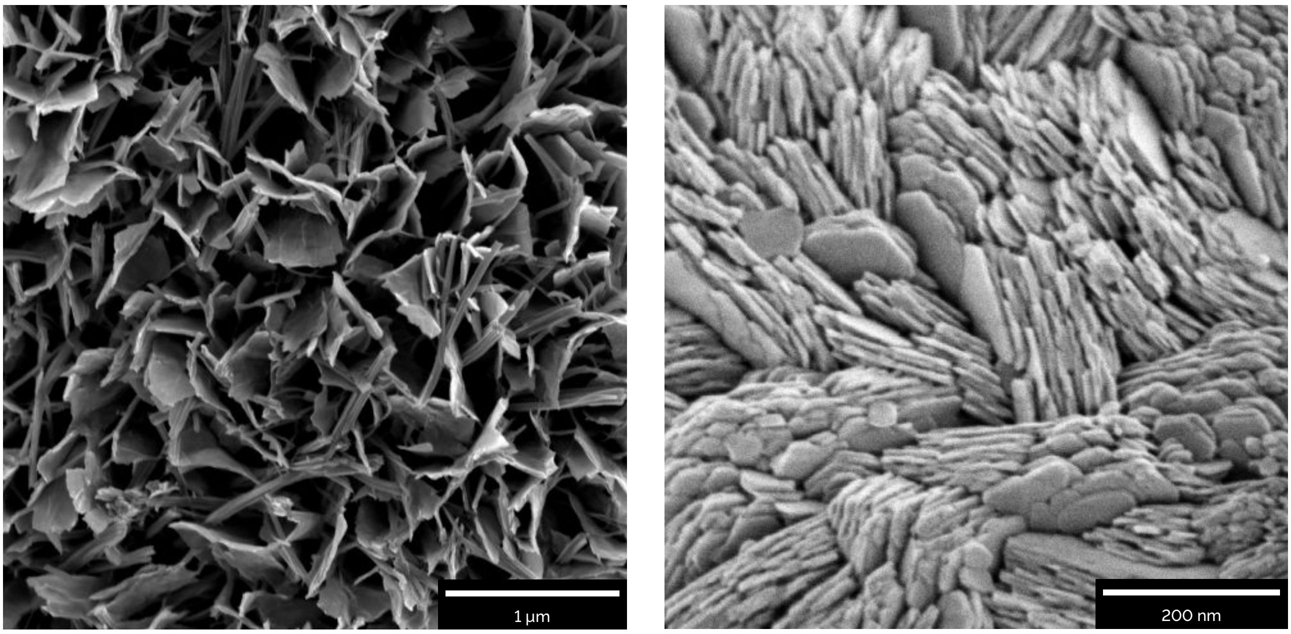
Key features

UHR Field-free characterization of materials at low beam energies for maximum topography

The BrightBeam™ SEM column delivers field-free ultra-high resolution imaging which guarantees maximum universality in sample analysis and allows ultra-high resolution imaging of samples at low landing voltages. The combination of the BrightBeam™ column design and the detection system results in excellent imaging performance, which is ideal for imaging all types of samples without charging artifact.



▲ Au nanoparticles on cotton nanofiber imaged at 500 eV with Axial (SE) detector (left);
Carbon nanotubes captured at 1 keV with Axial (SE) detector (right)

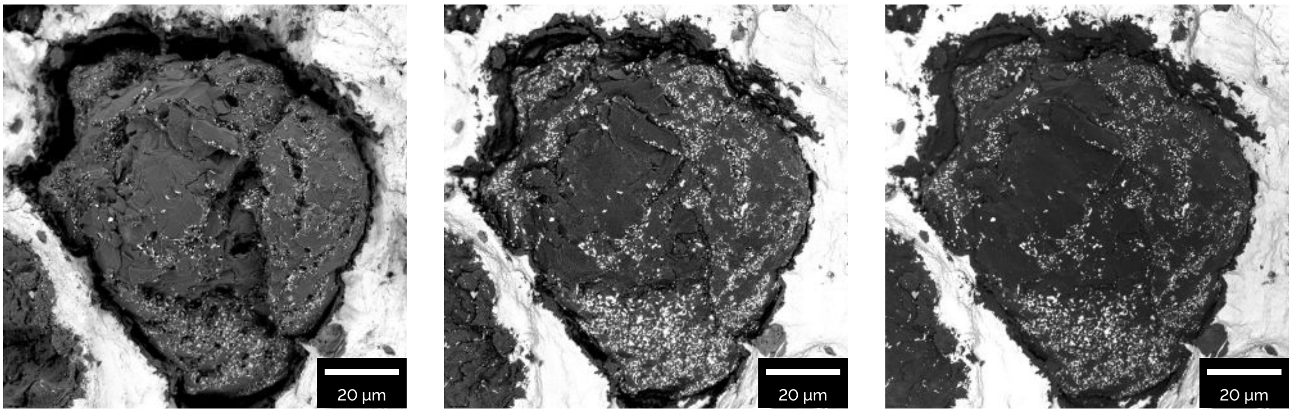


▲ Ceramic nanoflakes imaged at 2 keV with Axial (SE) detector (left);
Ni Rich Li powder imaged at 500 eV with Axial (SE) detector in BDM mode (right)

Unique in-column BSE detector designs allow filtering of signal based on energy and take off angle

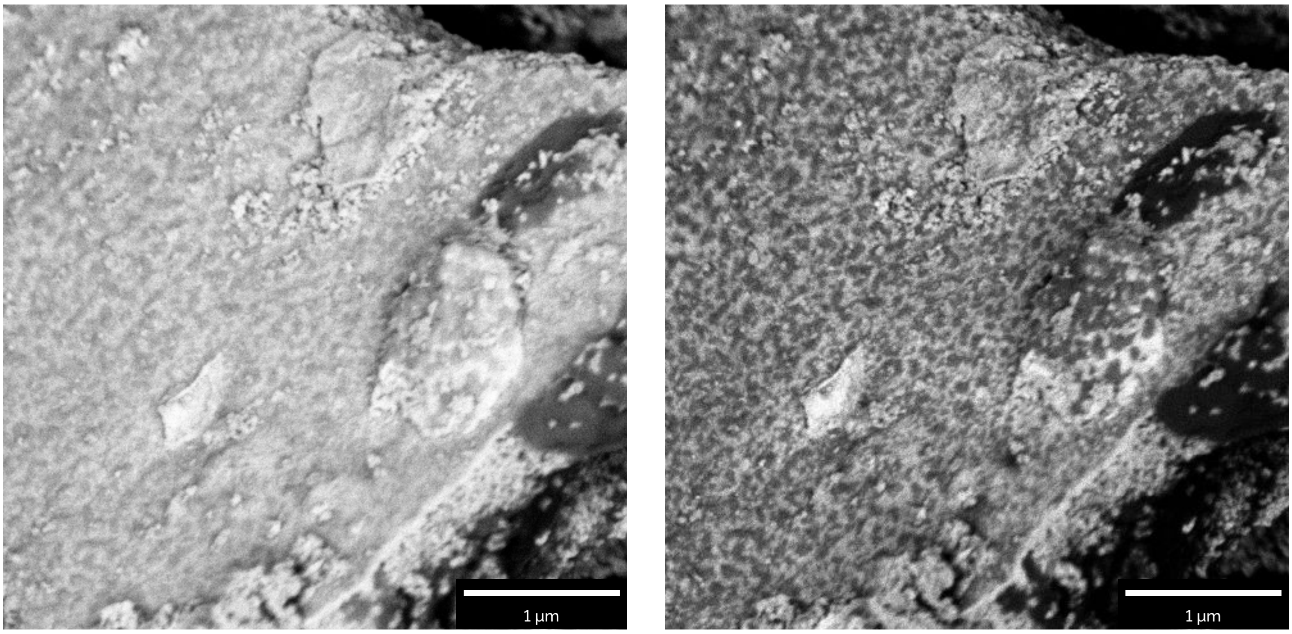
Uniquely designed positions of the in-column BSE detectors allow simultaneous acquisition of BSE signal emitted from the sample at different take-off angles. The Axial BSE detector collects narrow-angle backscattered electrons while the in-column Multidetector (BSE) collects mid-angle backscattered electrons. These two signals differ in contrast information. In the Axial BSE detector maximum material contrast is visible, while suppressing sometimes unwanted brightness artifacts caused by topography of the sample. In contrast, the Multidetector (BSE) collects mid-angle backscatterered electrons, generating images that exhibit both material contrast and topographic contrasts to highlight surface contours. The Multidetector includes an energy filtering grid, so SE signal and BSE signal can be energy filtered in order to enhance BSE contrast of the surface features on the sample.

Angular filtering



▲ Austempered ductile cast iron captured with: chamber LE RBSE (BSE) - wide angle BSE (left); In-column Multidetector (BSE) - mid-angle BSE (middle); In-column Axial (BSE) - Narrow angle BSE (right).

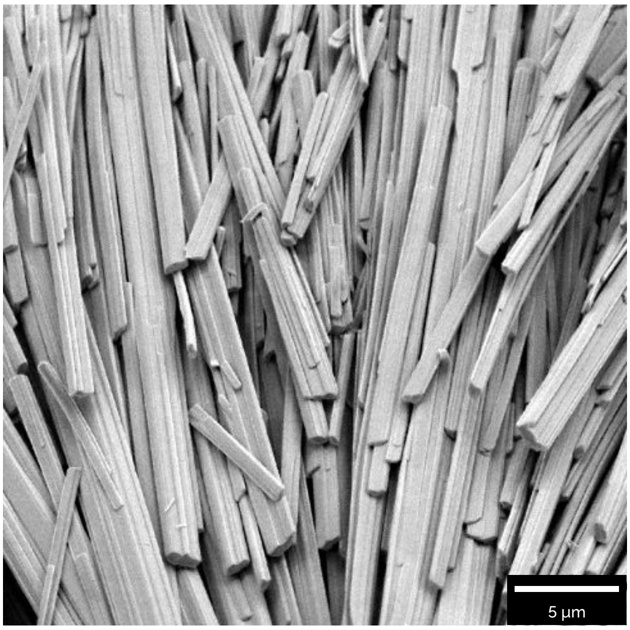
Energy filtering



▲ Sintered ceramic powder imaged with: Multidetector (BSE) at 4 keV - filtering energy set on 50 eV bias (left); Multidetector (BSE) at 4 keV - filtering energy set on 3500 eV bias (right)

MultiVac mode for the finest topographic characterization of nanomaterials in low vacuum

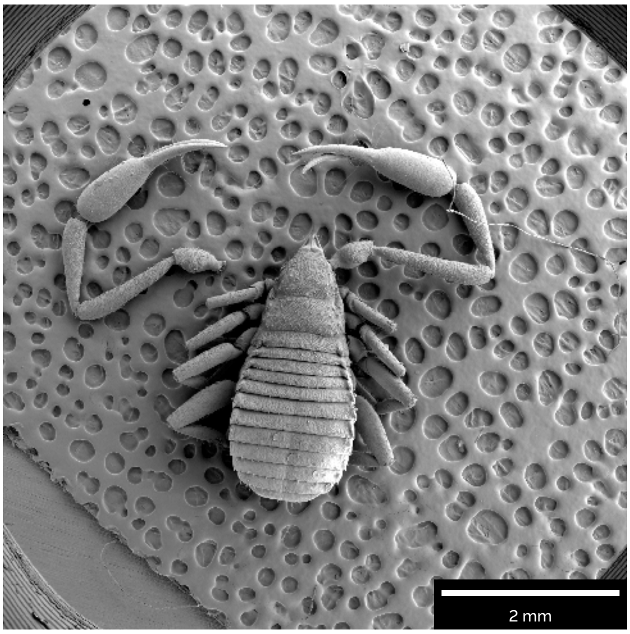
TESCAN MultiVac supports imaging of insulating samples by enabling low vacuum and extended variable pressure on TESCAN SEMs. MultiVac operates in both N_2 and H_2O atmospheres, and MultiVac's extended variable pressure (up to 500 Pa) mode allows controlled fine-tuning of vacuum to achieve the best charge compensation for any insulating sample. MultiVac also includes a gaseous secondary electron detector (GSD) which, when used in H_2O atmosphere, enables characterization of beam sensitive and extremely charging nanomaterials in big detail at low keV and low beam currents.



▶ Erythrite ($Co_3(AsO_4)_2 \cdot 8H_2O$), a secondary hydrated cobalt arsenate mineral, captured at 3 keV in MultiVac using GSD detector

Intuitive and precise live SEM navigation on the sample at low magnification

Unique Wide Field Optics™ includes the proprietary dual objective lens configuration that enables an undistorted large field-of-view and a variety of imaging modes. Switching between modes is fast and easy and high to low magnification images are only one click away.

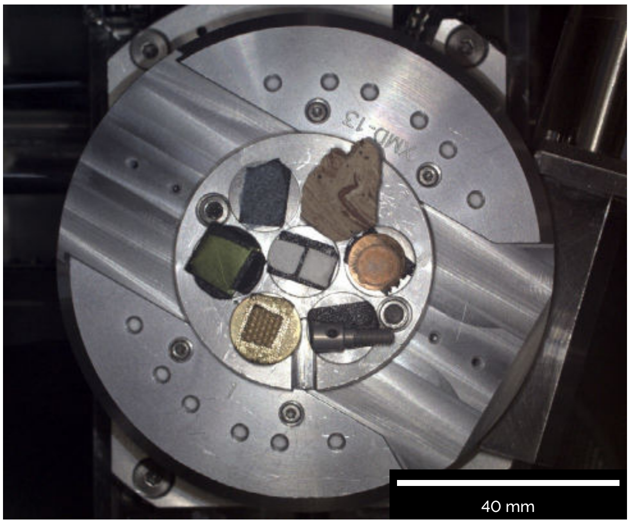


▶ 7 mm field of view at working distance 6 mm.

Optical Navigation and Correlation camera (ONCam) for immediate navigation to the features of interest according to their true color, appearance or marks that cannot be seen with SEM contrast methods alone

TESCAN's Optical Navigation and Correlation Camera (ONCam) provides intuitive, image-based sample navigation from within TESCAN's Essence™ software environment. ONCam is a 14 MP camera mounted directly to the chamber to provide a photo-realistic image of all samples on the specimen stage at any time. ONCam navigation is also increase efficiency when analyzing samples at highest magnification and short working distances where ONCam provides always field of view over 120 × 120 mm^2.

Furthermore, ONCam is equipped with four independent LED segments that use ONCam's advanced minimum intensity stacking algorithm to eliminate reflections in the optical navigation image. Full integration of ONCam within the Essence™ interface allows users to perform quick "click and move" navigation to the region of interest using the ONCam image and provides correlative functionality via direct overlay of the SEM image on the ONCam capture, with adjustable transparency.



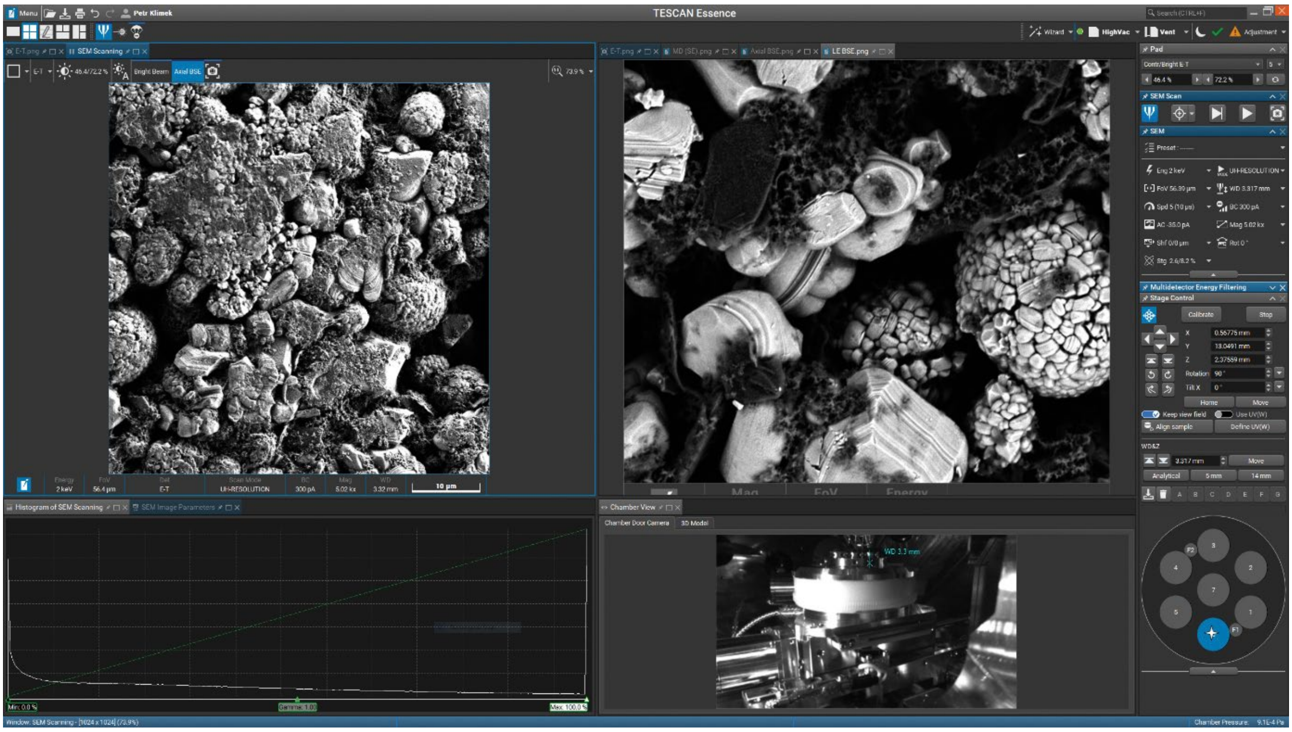
◄ Photo-realistic image of a ceramic foam captured with Optical Navigation and Correlation camera (ONCam)

Fast setup of electron beam – optimal imaging and analytical conditions guaranteed

EquiPower™ lens technologies assure constant thermal power dissipation for excellent stability in time-consuming microanalysis. These technologies, in combination with real-time beam optimization, enable TESCAN CLARA to obtain high resolution images and analytical (EDS/EBSD) data at all beam currents.

Intuitive Essence™ software modular platform designed for effortless operation regardless of the user's skill level

TESCAN Essence™ software platform makes microscope control easier than ever. A simplified and user oriented SW environment maximizes productivity of the SEM. Operators can easily access all functionalities via simple search functions or drag and drop the function at a display. Also, operators of all skill levels can easily change the SEM set-up to a previous condition or navigate to previous areas. An advanced live-3D collision model prevents hazardous movements during sample movements.



TESCAN BrightBeam™ SEM column technology

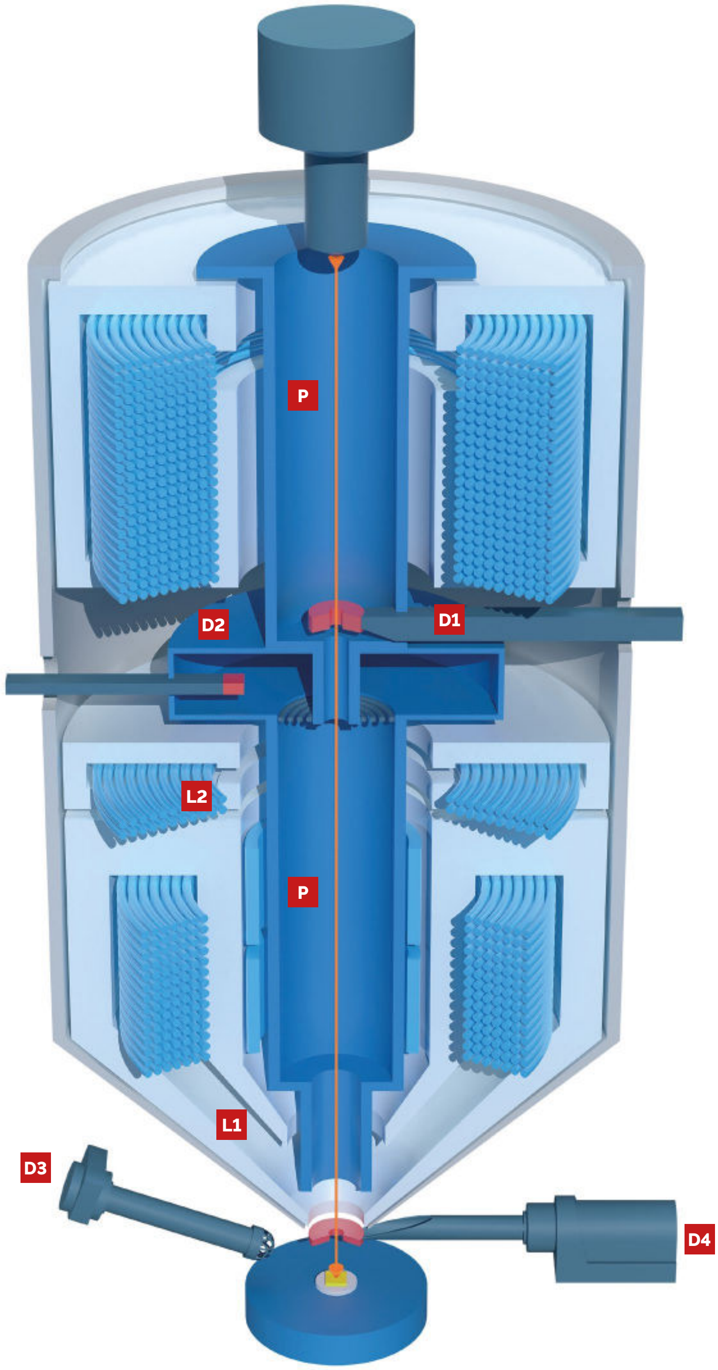
The electron optics in the new TESCAN BrightBeam™ SEM column is based on a combined electrostatic-magnetic objective. A potential tube through the whole column keeps electrons at an energy that is higher than the electron beam landing energy and as a result, electrostatic interactions within the beam are reduced. In addition, this significantly reduces optical aberrations especially at low beam energies.

Lastly, the potential tube makes the electron beam less susceptible to environmental (stray) magnetic fields. These features result in excellent quality imaging at low electron-beam energies down to 50 eV, without relying on sample bias beam deceleration.

A dual objective lens configuration with two-stage scanner offers an extremely wide field-of-view, making live navigation across the sample easy and comfortable and locating the region of interest straightforward.

The TESCAN CLARA is fitted with a robust multidetector system that allows selective electron collection according to their take-off angle and energy resulting in maximum topographic and compositional information from the sample.

Furthermore, both the E-T detector (Everhart-Thornley), which provides topographical contrast without edge effects, and the Multidetector with energy-filtering capabilities can be used for suppressing charging artifacts. The detection system is optimized to maximize signal collection in the entire beam energy range.

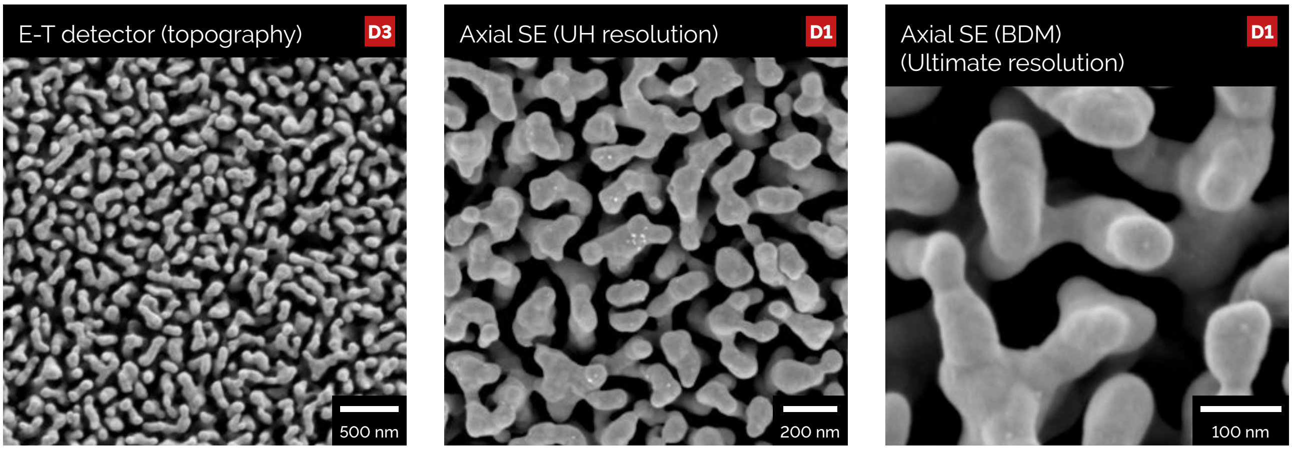


Beam Deceleration Technology
(stage bias 5 keV)*

* Optional equipment

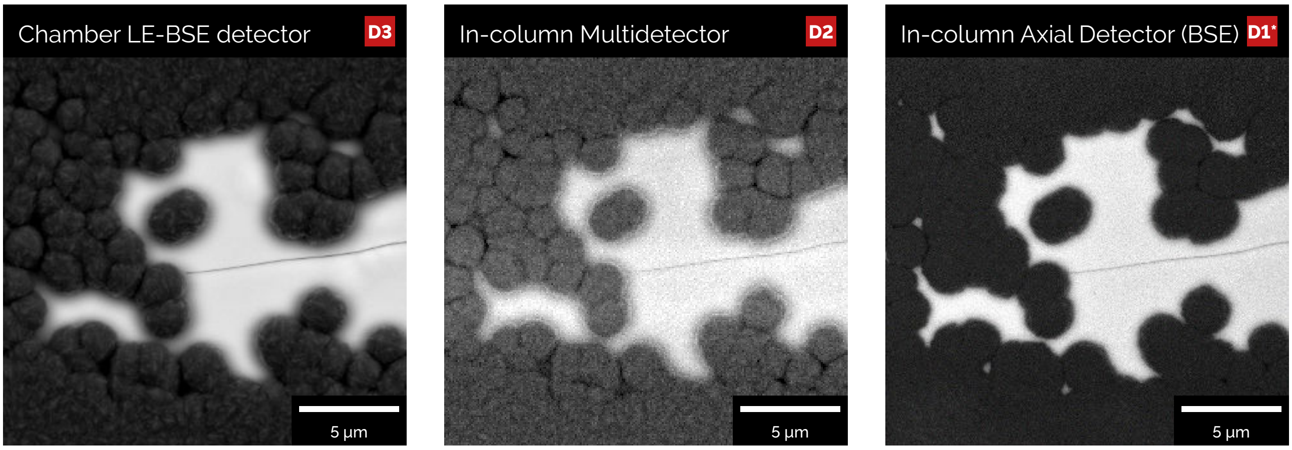
- **L1** Combined magnetic-electrostatic lens
- **L2** Second magnetic lens
- **P** Potential tube
- **D1** In-Column Axial detector
- **D2** In-Column Multidetector
- **D3** E-T detector
- **D4** R-BSE detector

SE Detection



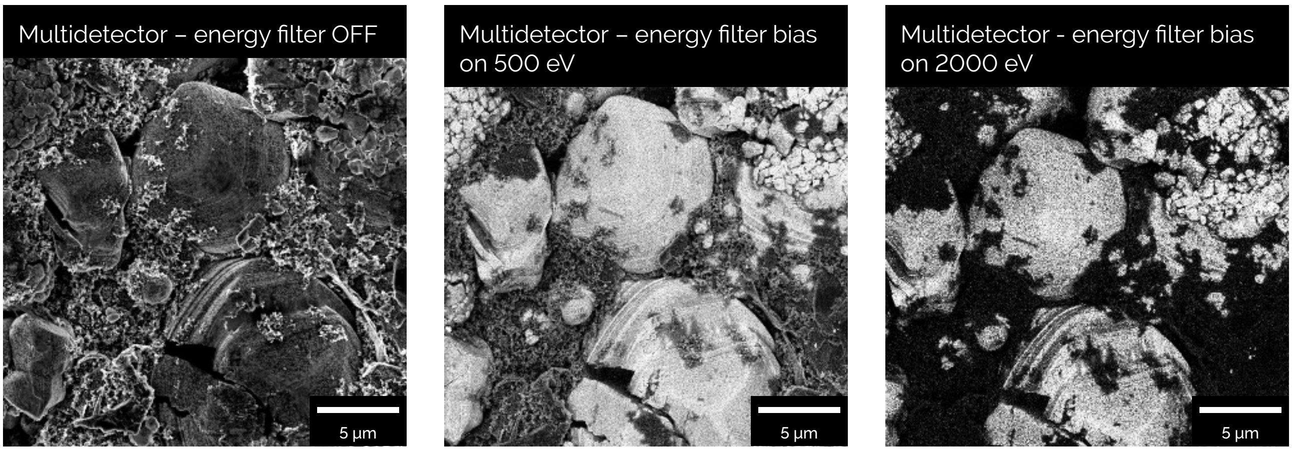
▲ Nanoporous gold imaged at 500 eV with: E-T detector (left); Axial (SE) detector (middle); Axial (SE) detector in BDM mode (right).

BSE Detection



▲ Nano diamond coating – simultaneous detection of three BSE signals, different by take-off angle.
* Axial BSE mode

Multidetector's selective energy filtering

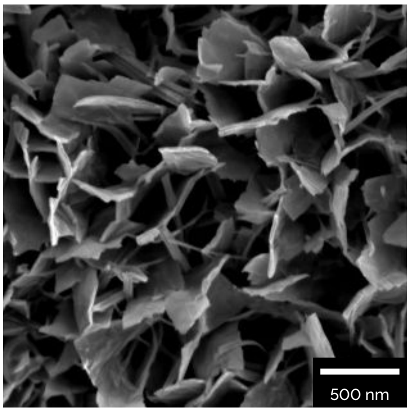


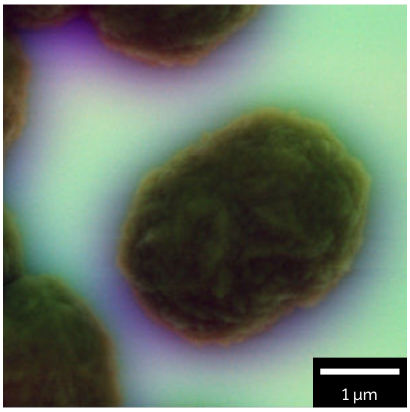
▲ Li battery cathode captured at 3 keV - continual filtering of SE and BSE signal, that enhance BSE contrast of the surface features on the sample

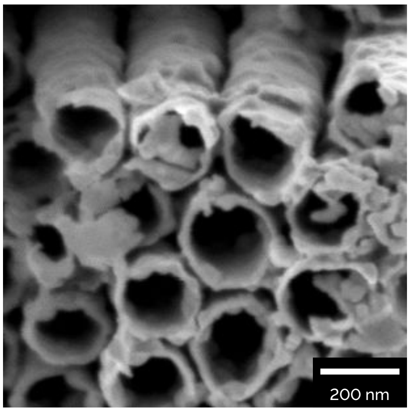
Applications – Ideal for:

Ultra High Resolution imaging of nanoparticles and agglomerates of all kinds

Processing and analysis of the materials in the form of particles is an everyday routine for many researchers in the scientific fields, research labs and quality control labs all over the world. Particles serve as a precursor material for many processes in the industry fields. Inspection with an ultra-high-resolution SEM (UHR SEM) is required to characterize ultra-fine, nanometer-scale particles. TESCAN CLARA's ability to image such nanoparticles at low beam energies reveals features that would not be visible at higher accelerating voltages.



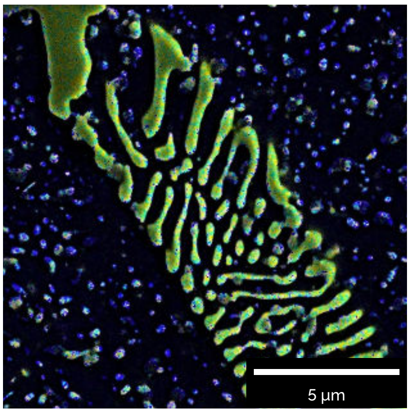


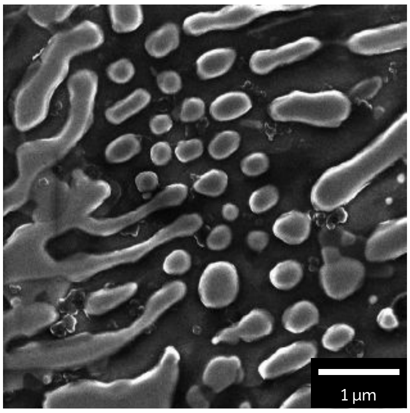


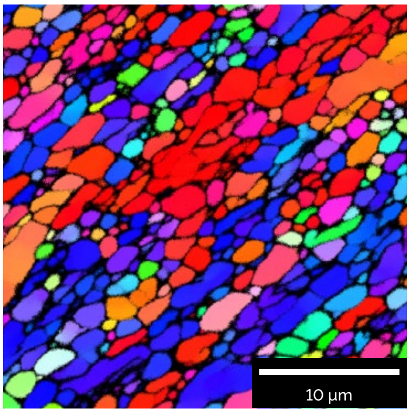
▲ Ceramic nanoflakes imaged at 2 keV with Axial (SE) detector (left);
Nano diamond coating on Si wafer imaged at 3 keV using virtual color mixing of all three in-column detectors (middle);
TiO_2 nanotubes imaged at 500 eV with Axial(SE) detector (right).

Routine study and industrial inspection of metal samples at the nanoscale

Routine sample inspections are often part of the quality control process, which is a crucial factor in the production and optimization of the production process. Therefore, the use of the SEM for material studies or sample inspections is a common practice in many companies or research facilities around the world. The CLARA BrightBeam™design makes it possible to detect multiple signals revealing specific and detailed information about the sample. Microscopes equipped with dedicated analytical detectors can be configured to analyze the material from the chemical or phase perspective. Equipped with the new BrightBeam™ column and field-free electrostatic-magnetic lens, the CLARA FESEM enables high spatial resolution EDX and EBSD analyses of any sample over a broad range of beam energies and currents.



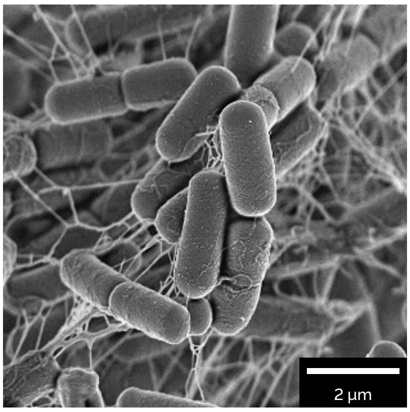


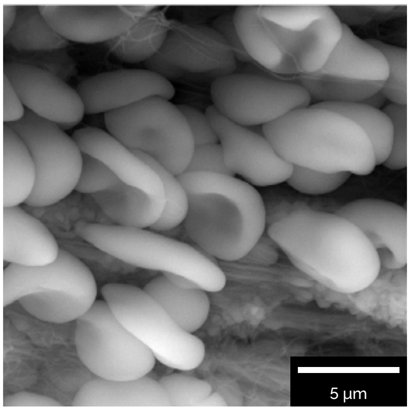


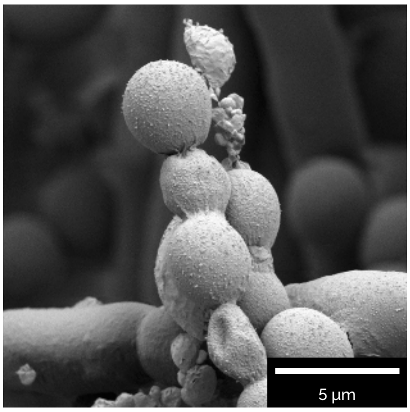
▲ EDS map of a carbides in HSS steel (left); Detail of carbides in HSS steel captured with E-T detector at 3 keV (middle); EBSD analysis of ECAP Aluminum (right).

Analysis of plants, micro-organisms and other biological specimens

Biological samples are usually beam sensitive and nonconductive. Thus, performance at low accelerating voltages is crucial. However, there is great diversity in both the types of samples and applications. Interest is paid to studies of the whole sample structure, sample morphology, distribution of the cell's structure, and chemical analysis in medical research, for example. In addition, there is great diversity in the required image resolution and magnification depending on the size of the features of interest (micron to nanoscale). Many biological samples require special treatment or the use of special methods to be successfully imaged in an SEM. Biological sample structures can be distorted or modified if imaged in a conventional high vacuum SEM, which of course is undesirable. To avoid charging, uncoated non-conductive samples can be observed in TESCAN MultiVac mode, which allows imaging samples at elevated chamber pressures in the range of hundreds of Pascals. Another approach to observing biological samples is the use of cryo techniques to rapidly freeze and image samples at cryo temperatures.



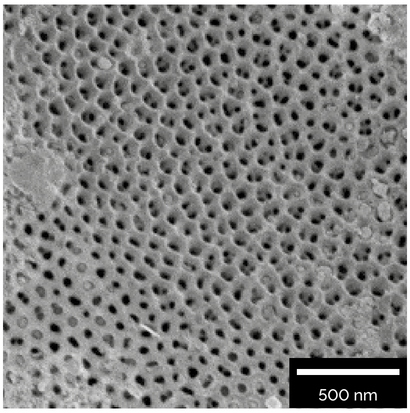


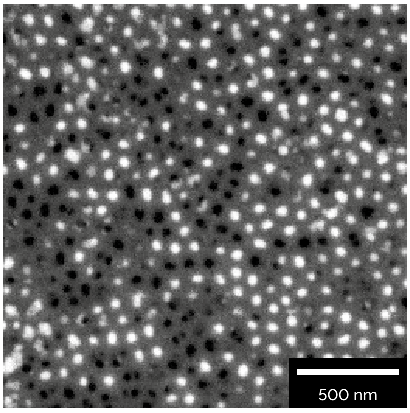


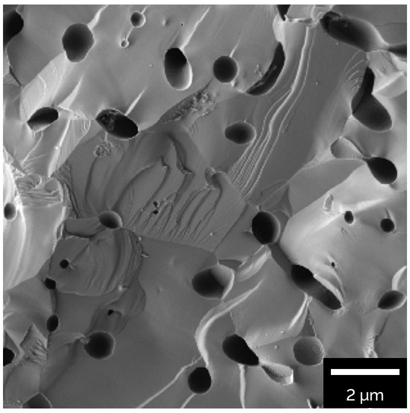
▲ Bacteria (left); Blood cells imaged in MultiVac mode (100 Pa) (middle); Fungal spores observed in Cryo conditions (right).

UHR Characterization of beam sensitive and non-conductive materials

SEM imaging of beam sensitive and non-conductive samples can be challenging. Observation of beam sensitive or non-conductive samples without damaging the samples or introducing charging artifacts requires special approaches. One solution, which reduces both beam damage and charging, is to observe the sample at low beam energies. The innovative electron optical and advanced detector technologies of the TESCAN CLARA BrightBeam™ system excel in this application. Beam energy can be tuned as needed for each sample to allow UHR imaging without sample damage and without the image or contrast distortions caused by charging.



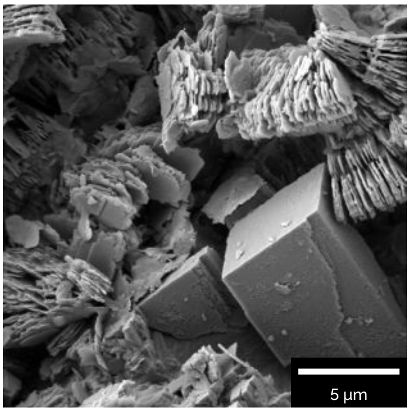


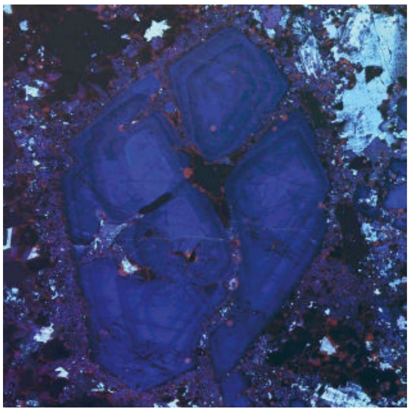
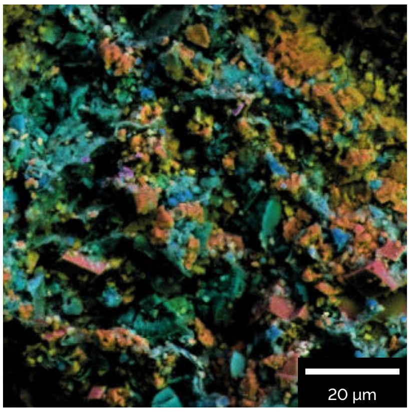


▲ Anodized Al imaged at 500 eV (left); Metal nanowires in a matrix of anodized Al imaged at 1 keV with Axial(BSE) detector (middle); Fractured surface of ceramics imaged at 2 keV with E-T detector (right).

Morphological and elemental characterization of geological samples

SEM Morphological and Chemical distribution studies are typical applications in Earth Sciences research. Both qualitative and quantitative approaches are used to provide insight into the textural and chemical relationships between mineral phases. Backscattered Electrons (BSE) give basic average atomic number contrast and are used to identify regions of interest and to navigate to acquire more detailed chemical and spatial information using correlative x-ray signals from Energy (EDS) and Wavelength (WDS) dispersive spectrometers. Cathodoluminescence (CL) - another product of the electron beam-sample interaction, is also used for investigation and navigation signal that highlights differences in trace element distribution and the structural defects of a mineral. BSE, X-ray and CL signals are used for accurate navigation and positioning as part of integrated analytical workflows using other detectors and instruments such as electron probe microprobe analysis (EPMA), optical microscopy, laser ablation (LA), Raman spectroscopy and micro-CT.



▲ Clays and carbonates filling pores in a sandstone (left); CL Image of a quartz phenocryst obtained with TESCAN CL detector (middle); EDX map of a sandstone pore filling obtained at 15 kV and 30 Pa (right).

Technical Specifications / Electron Optics:

Electron Gun:	High brightness Schottky emitter		
Electron Optics:	BrightBeam™ column with combined electrostatic-magnetic objective lens and Wide Field Optics™ technology		
Resolution:	**Standard mode:** 0.9 nm at 15 keV 1.4 nm at 1 keV	**Beam Deceleration mode:** 1.2 nm at 1 keV	**STEM:** 0.8 nm at 30 keV
Maximum Field of View:	7 mm at WD 10 mm and >50 mm at max. WD		
Probe Current:	up to 400 nA		

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