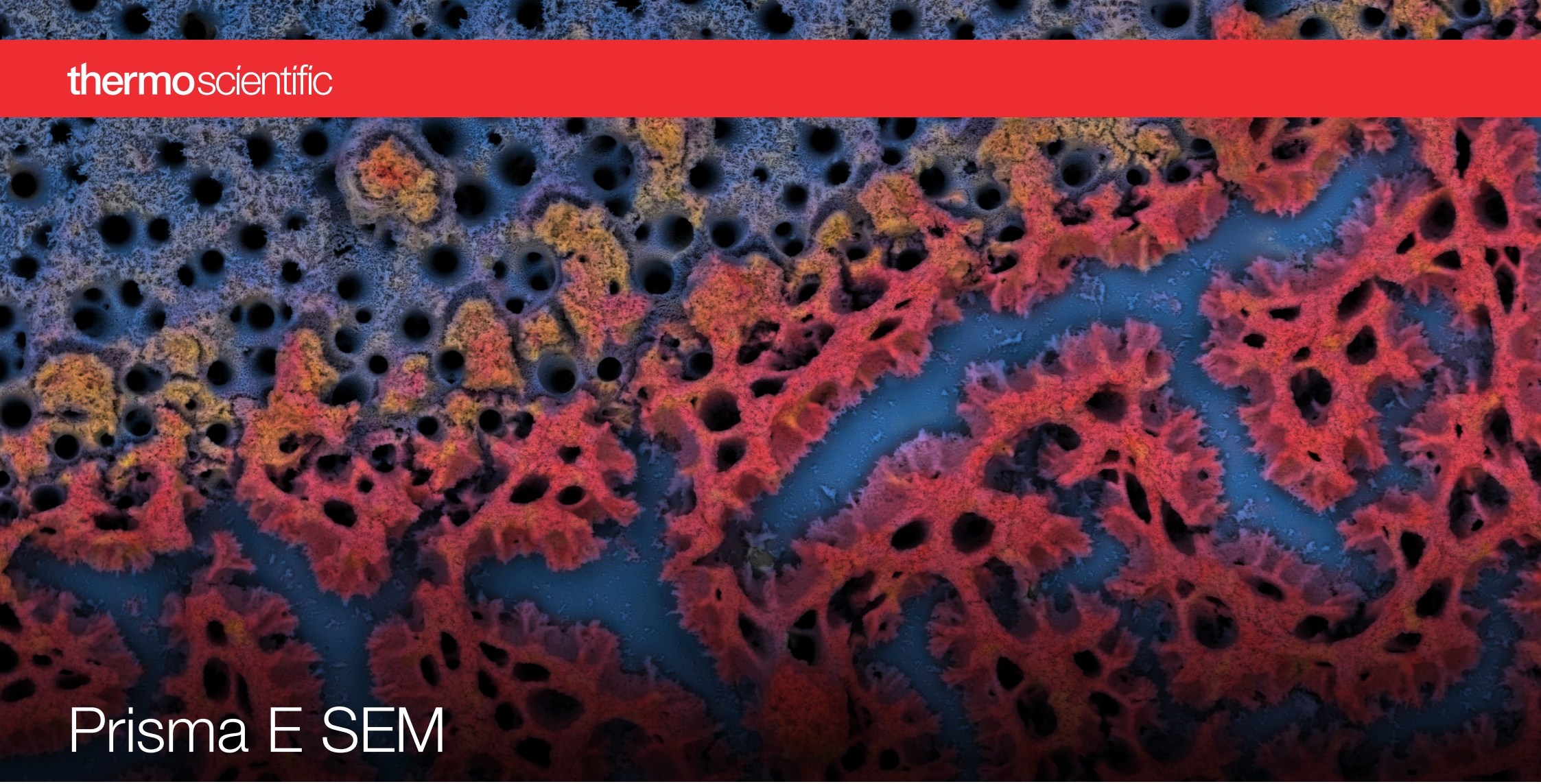
thermoscientific



Prisma E SEM

Flexible and easy to use SEM for the widest range of samples, ideal for multi-user laboratories

ThermoFisher SCIENTIFIC

Scanning Electron Microscopy is indispensable when microscale material insight is required. SEM is not only capable of creating excellent surface topography images, it also provides materials contrast and access to crystallography and elemental composition.

Building on more than 60 years of electron microscopy developments, including the first computer controlled and environmental SEMs, Thermo Fisher Scientific has continued to advance the capabilities of SEM with the release of ColorSEM Technology. Now, for the first time, scanning electron microscopes can produce images with live, meaningful colors. All these technologies come together in the Prisma E SEM – the most complete SEM available.

On the cover: Electroplated bimetallic metal foams used as catalysts for the electrochemical reduction of CO_2.
Images courtesy of Prof. Dr. Peter Broekmann, Department of Chemistry and Biochemistry, University of Bern.

Introduction

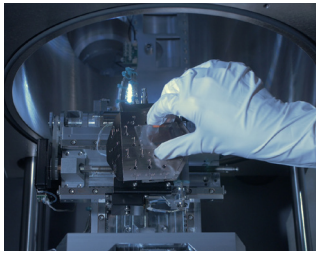
The Thermo Scientific™ Prisma™ E SEM is a highly flexible scanning electron microscope (SEM) capable of remarkable all-around performance under a variety of conditions. With its low vacuum and environmental SEM (ESEM) modes, it is fully equipped to analyze charging, outgassing or otherwise difficult samples.

Highlights

- Easy and quick sample loading for multiple and/or heavy samples
- Simplified sample navigation with the Thermo Scientific™ Nav-Cam™ Camera and navigation montage
- Ease of use thanks to User Guidance and an Undo function
- Excellent image quality with advanced scanning modes and beam deceleration
- Intuitive elemental analysis with Thermo Scientific™ ColorSEM™ Technology
- Compatible with a wide range of samples thanks to dedicated vacuum modes
- Ability to image materials in their natural state with the unique environmental mode
- Easily controlled dynamic experiments with integrated heating/cooling stages
- Wide selection of detectors and accessories including scanning transmission electron microscopy (STEM), cathodoluminescence, scripting, as well as image tiling and stitching

Prisma E SEM workflow

Sample loading



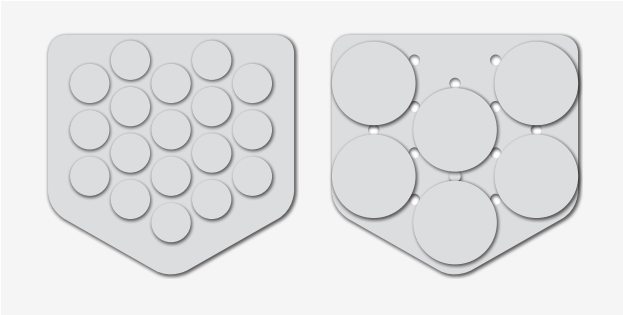
The Prisma E SEM provides extensive sample flexibility; it not only accommodates multiple samples weighing up to a total of 5 kg, but it can fit large samples due to its interior chamber width of 340 mm.

Dedicated to analyzing the widest possible range of samples, the Prisma E SEM offers easy sample loading through the door, and a pumping system that allows the microscope to be turned on quickly, reaching a high vacuum level (pressure below 6 × 10^{-4} Pa) in less than 3.5 minutes.

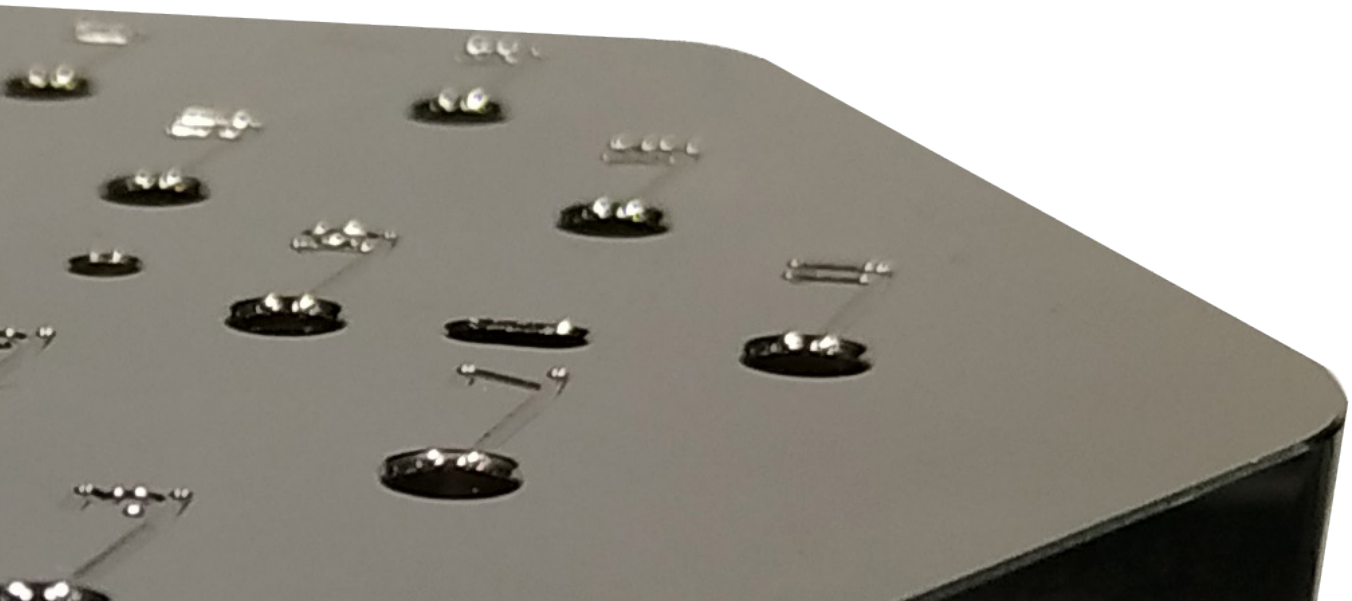
Standard multi-sample SEM holder

The Prisma E specimen chamber accepts a maximum sample diameter >200 mm on a multi-sample stub holder, which allows up to 18 samples to be loaded on 12 mm stubs, or up to 6 samples on 25 mm stubs.

- All stub positions are marked for easy navigation
- A stub can be mounted without any tools

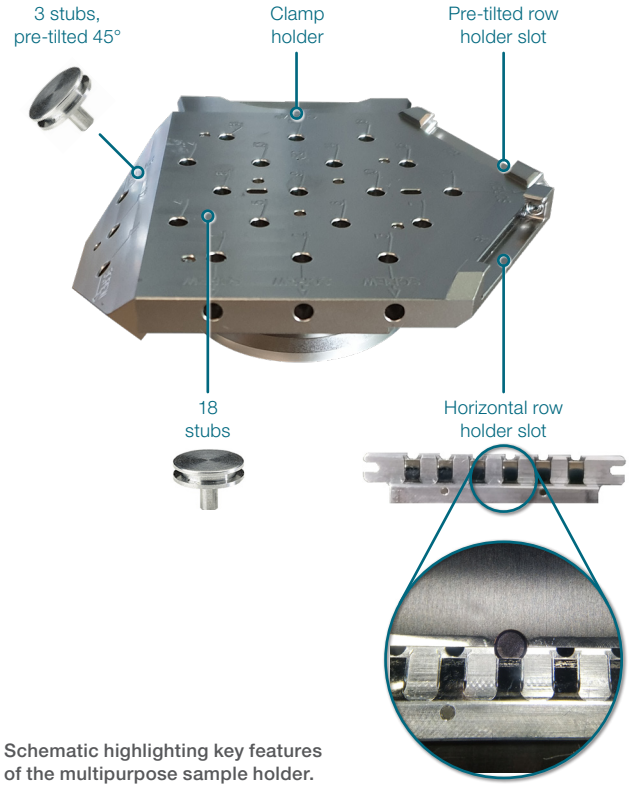


Multi-sample stub holder with 18- and 6 stubs configurations.



Multipurpose sample holder*

The multipurpose sample holder provides a fast way to fit a range of different sample types with no need for additional special preparation.



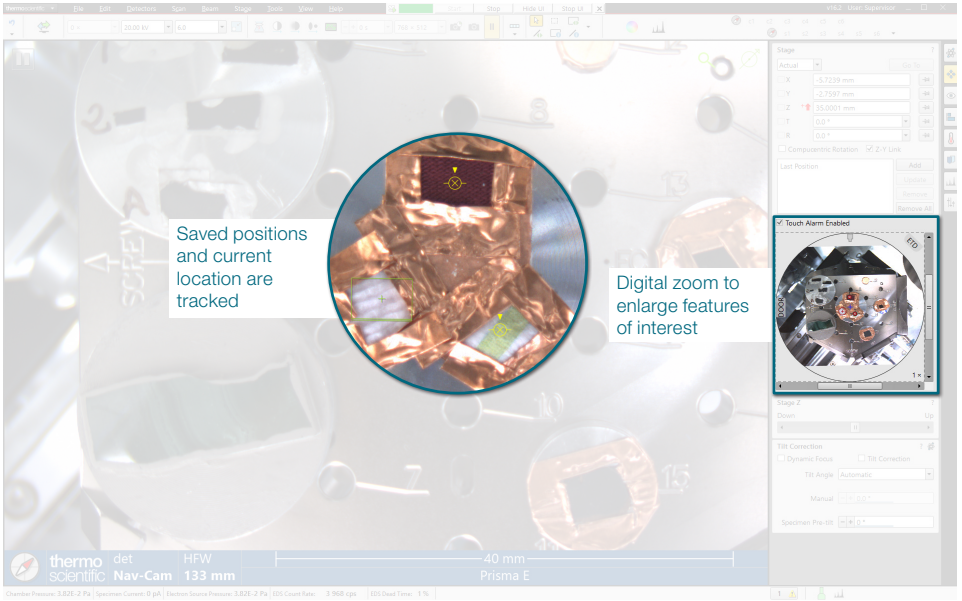
Schematic highlighting key features of the multipurpose sample holder.

* Optional

Nav-Cam Camera*

The Nav-Cam Camera allows you to quickly traverse the whole sample holder with point-and-click navigation, letting you reach your area of interest with ease. As the camera displays a color image it's easy to differentiate between different samples, letting you take advantage of any multi-sample holder.

Fully integrated into the Prisma user interface, the Nav-Cam Camera enables you to track saved positions as well as the current imaging location. Additionally, digital zoom is available via the UI to enlarge features of interest.



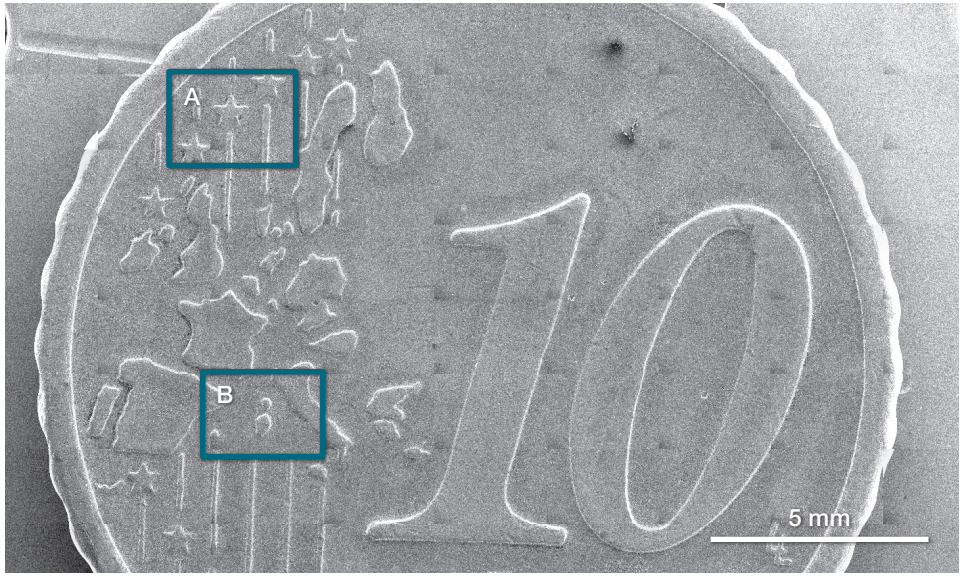
Overview of the Nav-Cam, integrated in the user interface, highlighting location tracking and digital zoom.

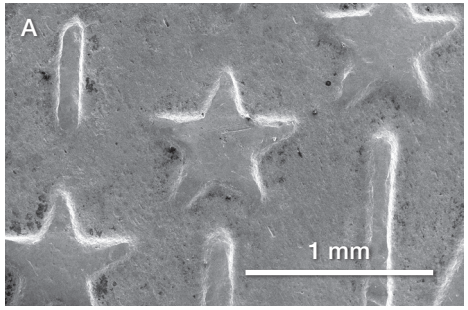
Navigation montage

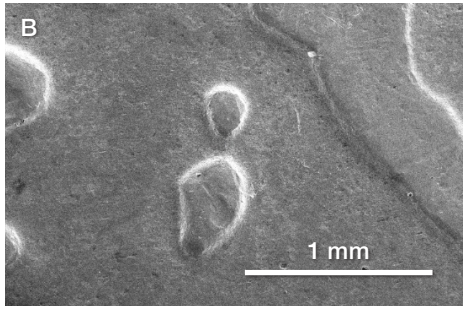
The navigation montage feature collects multiple images automatically, creating a single low-magnification image for point-and-click sample navigation. This provides;

- Quick and detailed overview of your sample
- A resulting montage with a large field of view

Thanks to the sample navigation function the user can precisely move along the acquired montage and center a feature of interest by automatically driving to its stage position.







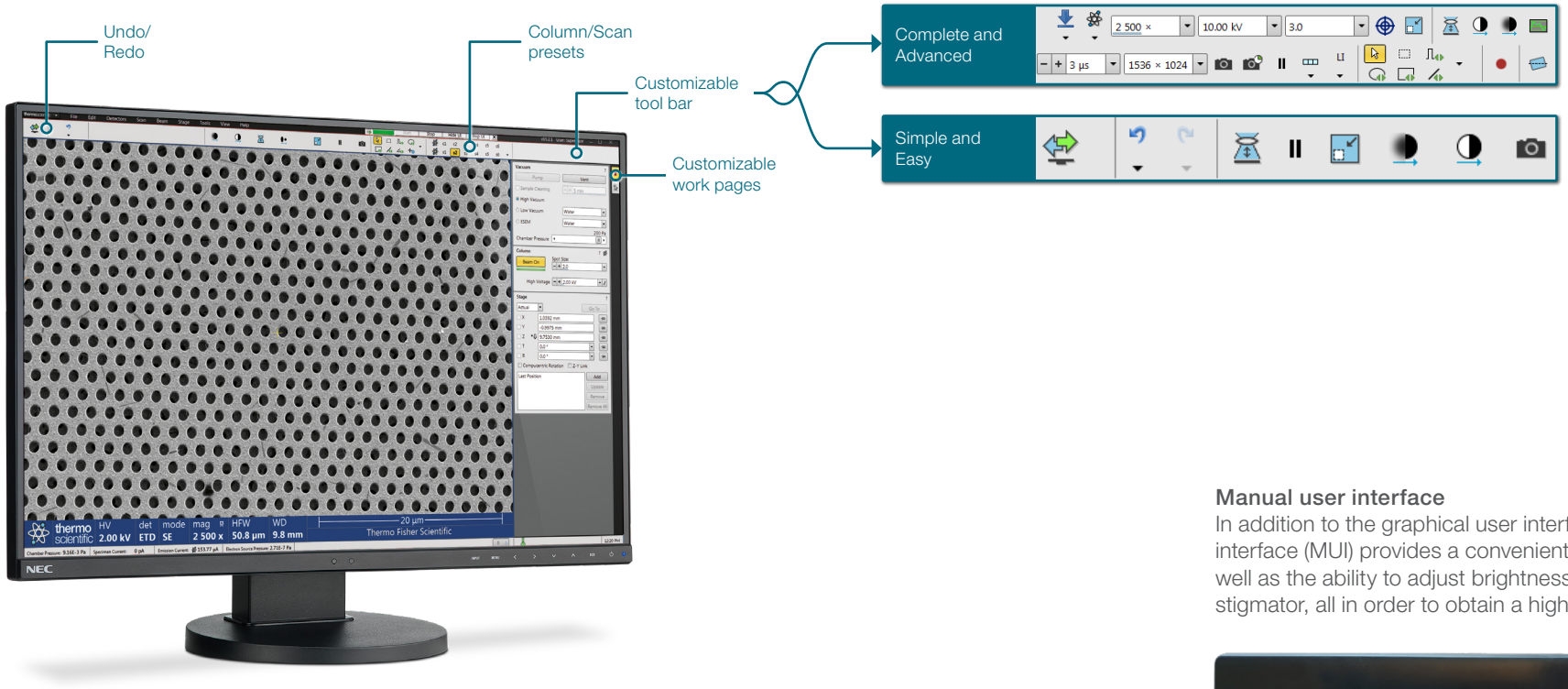
Nav-Cam montage navigation was used to precisely drive from position A and B for further analysis.

* Optional

Improved user interface

The improved xT user interface is designed to allow for full customization. Toolbar icons can be repositioned, added and removed, letting every user have their own personalized interface based on their experience and needs. Novice users will never get lost in too many options and experienced users will have the ability to get the best results they can by properly tuning the system. Of course, the default layout can be restored at a click of a button.

Notably, several new functions and options are now available including undo/redo, column and scan presents as well as customizable work pages.



Highlights of the new xT user interface. As it is fully customizable, users can personalize their interface based on their experience and needs.

Manual user interface

In addition to the graphical user interface, the manual user interface (MUI) provides a convenient way to set focus as well as the ability to adjust brightness, contrast and the stigmator, all in order to obtain a high-quality image.

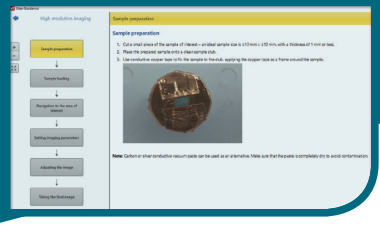
The manual user interface (mUI) unit.

xT UI highlight: User Guidance

User guidance functionality provides a set of easy-to-follow steps to help novice users get started and to ensure optimal use of the microscope. Each step is hyperlinked directly to the xT UI, allowing users to execute functions through the guide or simply use the guide as a learning tool.

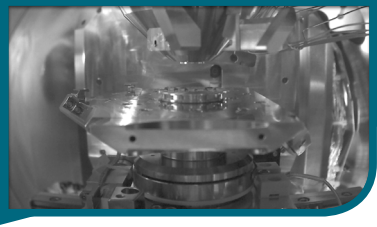
1

Sample preparation



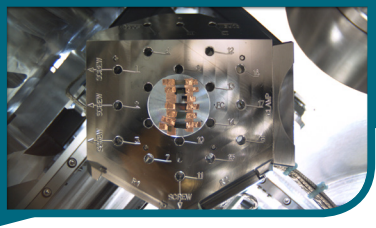
2

Sample loading



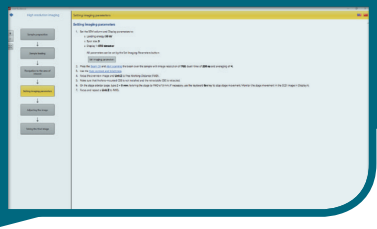
3

Navigation



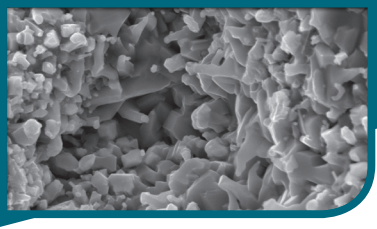
4

Setting imaging parameters



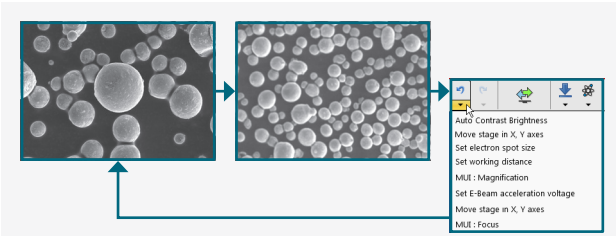
5

Adjust and taking the final image

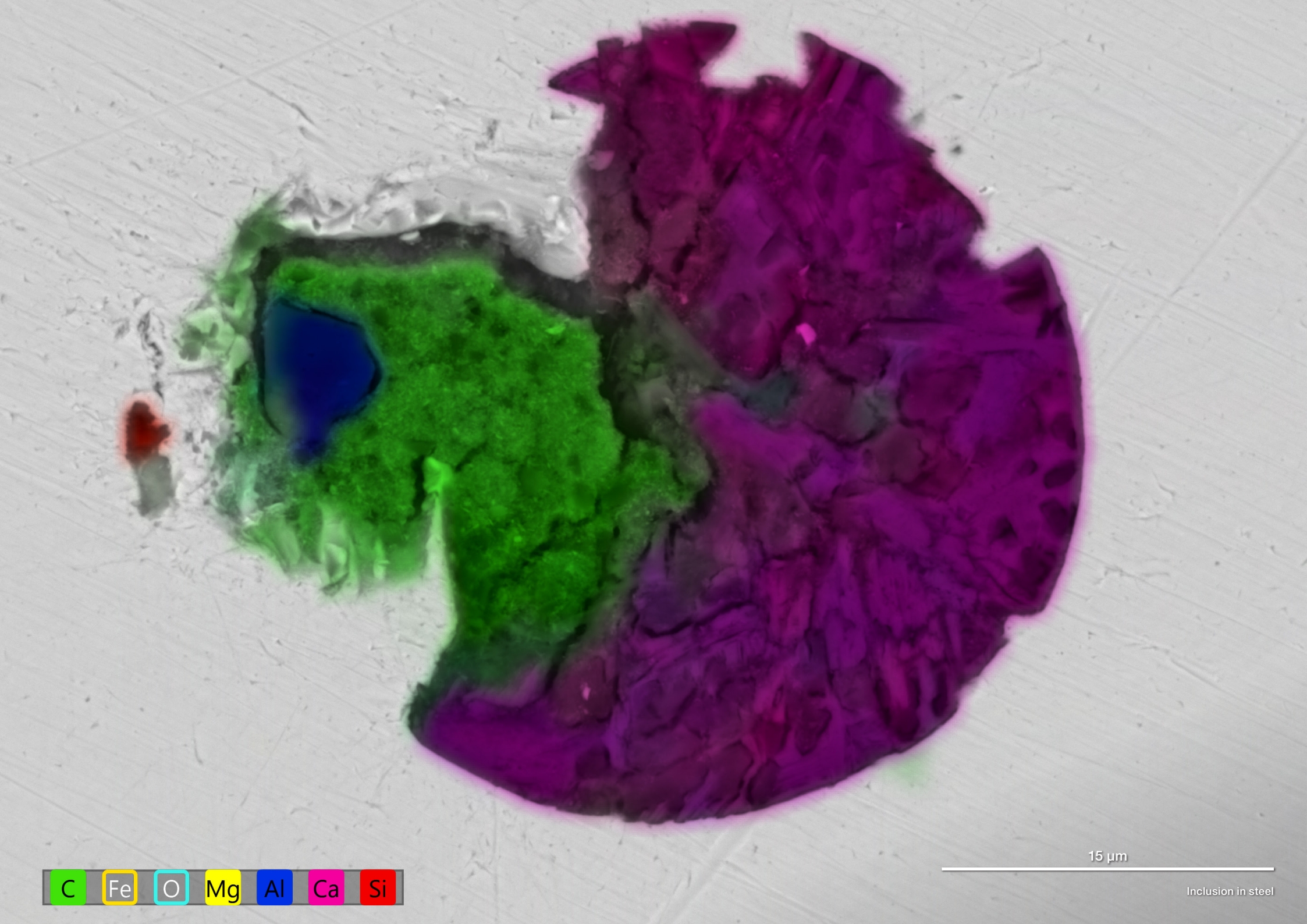


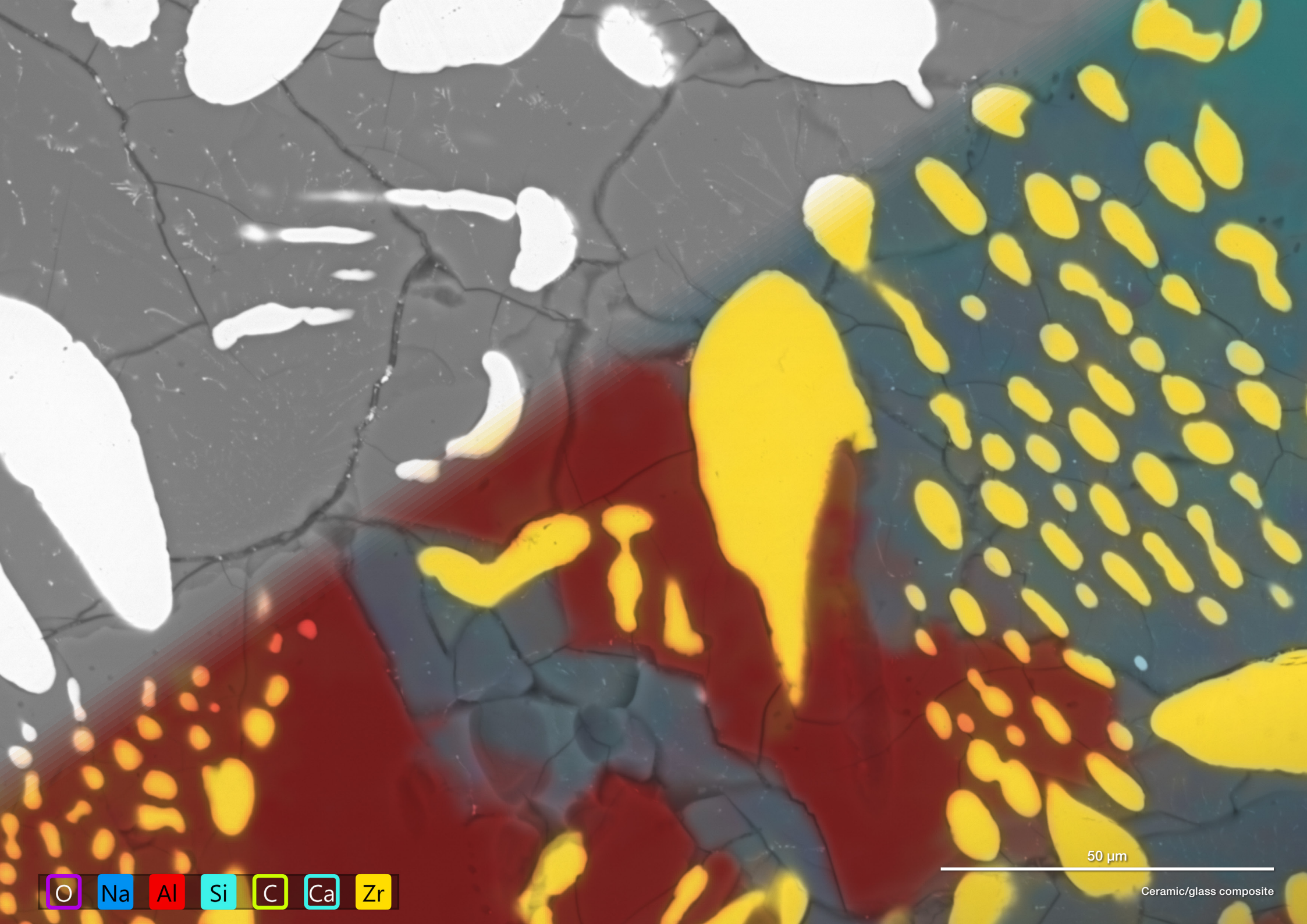
xT UI highlight: undo/redo

Undo/redo functionality allows you to recover multiple operations, encouraging experimentation in both novice and experienced users and saving time during the optimization of imaging conditions. This functionality makes highly effective operation possible for novice users, while enabling experts to do their work faster and with fewer mouse clicks.



Undo/redo functionality allows you to recover from unintentional operations or simply to go back to a previously imaged area.


C
Fe
O
Mg
Al
Ca
Si
15 µm
Inclusion in steel


O
Na
Al
Si
C
Ca
Zr
50 µm
Ceramic/glass composite

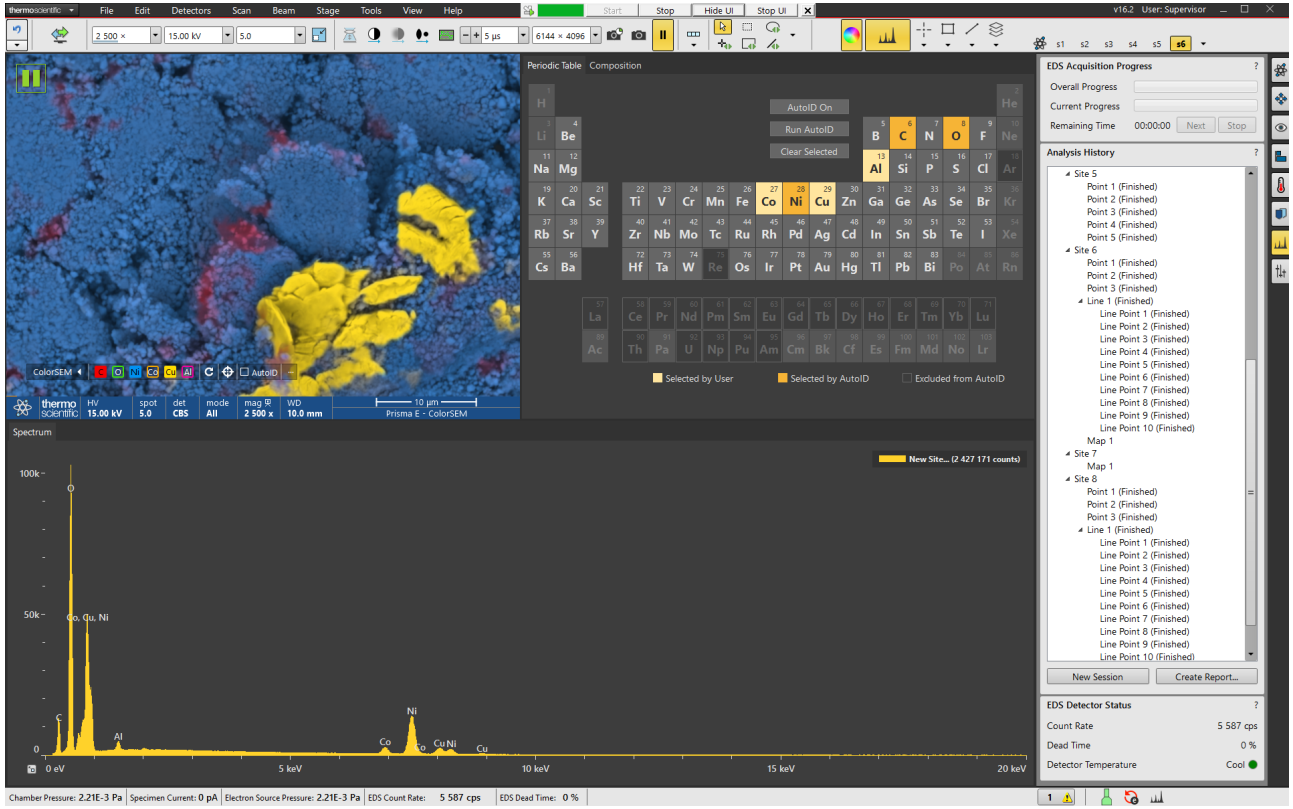
Features

ColorSEM Technology

Elemental information is now at your fingertips with ColoSEM Technology which provides integrated, real-time EDS to your SEM data 4x faster than conventional elemental analysis systems.

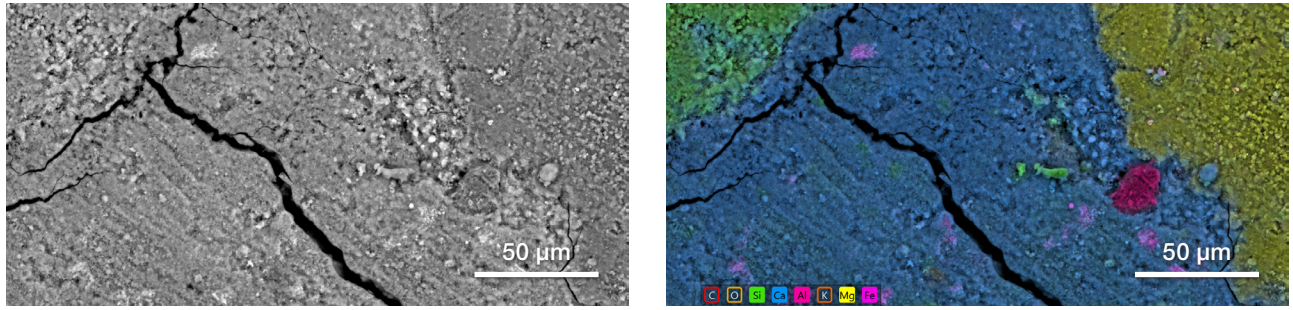
ColorSEM Technology enables the microscope UI to display live color images based on the sample's elemental composition. This is an entirely new approach to elemental analysis, providing a highly intuitive way to characterize your samples.

With ColorSEM Technology, EDS spectra are acquired simultaneously with secondary electron (SE) and/or backscattered electron (BSE) signal, even with a high scanning rate. Novel algorithms use information from both data streams to produce a color image where each color represents a chemical element. While the color image provides immediate qualitative information, conventional EDS functionality in the same UI gives access to quantitative information.



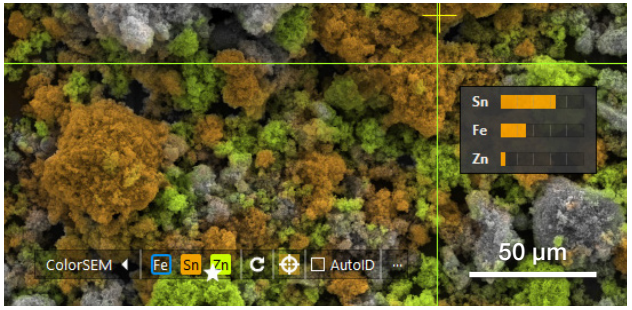
Observe compositional information 4x faster with live color imaging. A complete set of UI integrated EDS functions makes sure that traditional analytics is within very close reach.

Complete information



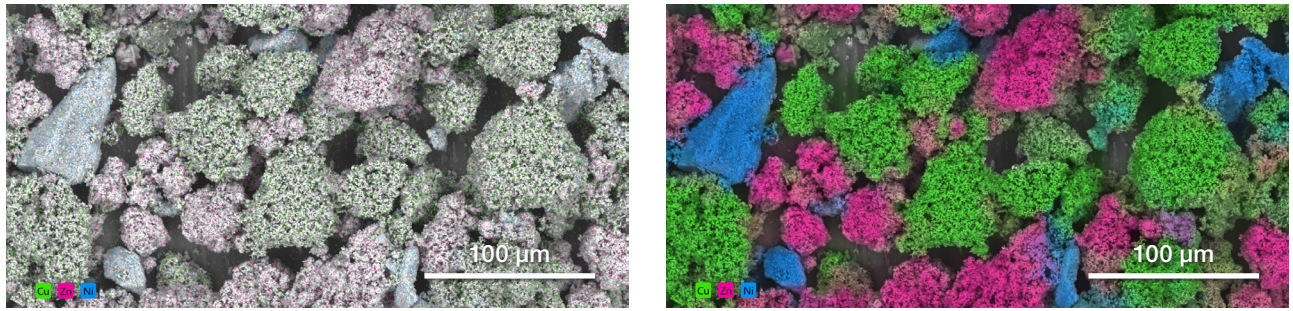
Cement imaged with conventional SEM (left) and with ColorSEM Technology (right). In the conventional backscattered electron image, the presence of areas with different elemental compositions is not evident, while the ColorSEM image (acquired in 60 seconds) provides a higher level of information. ColorSEM Technology is always on, meaning compositional differences will no longer go unnoticed.

Intuitive elemental analysis



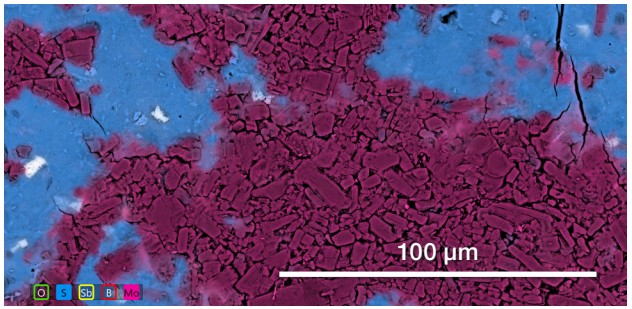
ColorSEM provides a qualitative point & ID, even available during live scanning.

Shorter time to results



CuNiZn sample, conventional mapping (left image) shows sparse information acquired in 30 s. In the same time ColorSEM (right image) provides a much higher information content thanks to proprietary data processing algorithms. (30 mm² detector, 1536x1094 pixels, 20 kV, 1 nA).

Reliable results



Quantification is running during live color imaging, meaning that even materials with overlapping peaks (such as molybdenum and sulphur) are correctly imaged.

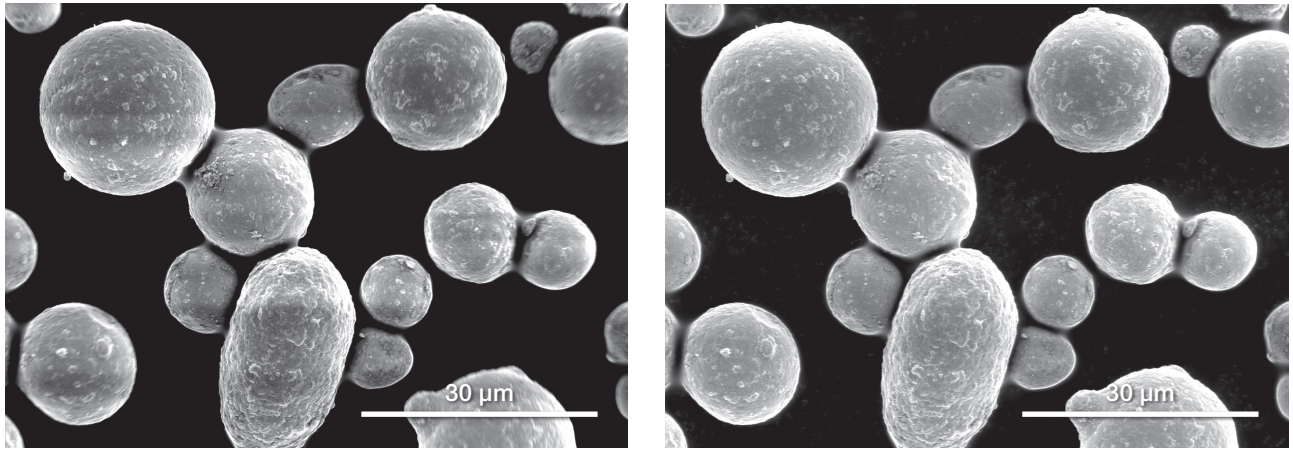
Advanced scanning strategies: SmartSCAN Technology

Thermo Scientific™ SmartSCAN™ Technology offers different imaging and scanning strategies to optimize image acquisitions and settings (256-frame averaging or integration, line integration and averaging as well as interlaced scanning).

Frame integration enables cumulative noise reduction with integration over a specified number of frames.

Line integration scans each line repeatedly several times. Collected signal data is integrated and displayed as an actual image line. This imaging method reduces sample charging (compared to a single pass with a longer dwell time) and allows the user to get higher signal to noise ratio.

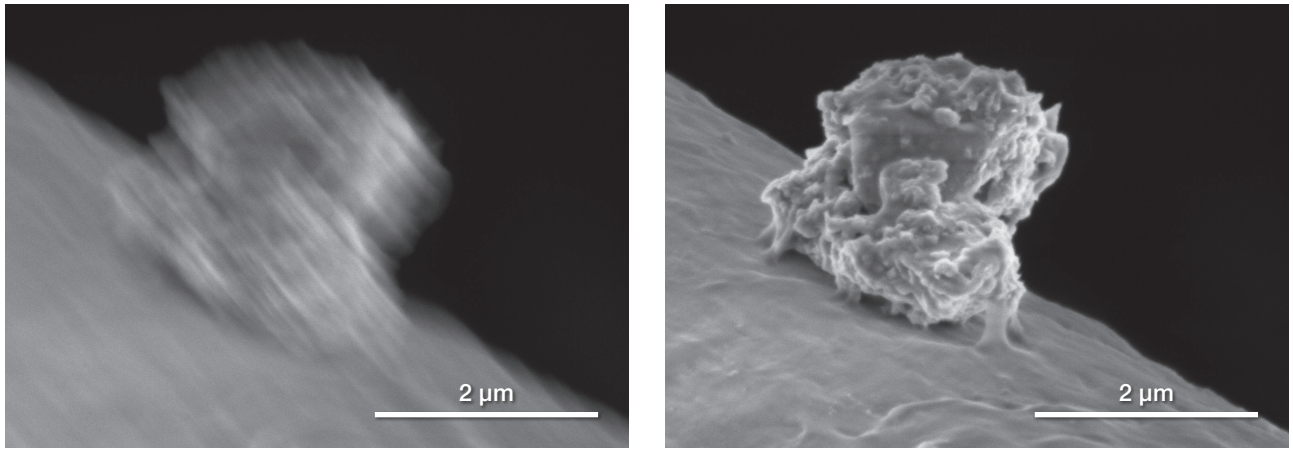
Interlaced scanning minimizes charge build-up while the electron beam is scanning



Brass alloy for selective laser melting manufacturing. The left image shows stripes due to charging. Using interlaced scanning (image on the right), there is more time for the charge to dissipate, yielding an artefact-free image. ***Sample courtesy of OTTO FUCHS KG, Germany. Images by Alice Scarpellini.***

Advanced scanning strategies: DCFI - Drift compensated frame integration

Drift compensated frame integration (DCFI) is an integration filter that corrects image drift in real time when active. Signal is integrated from several frames resulting in an image that is sharper than a single frame.

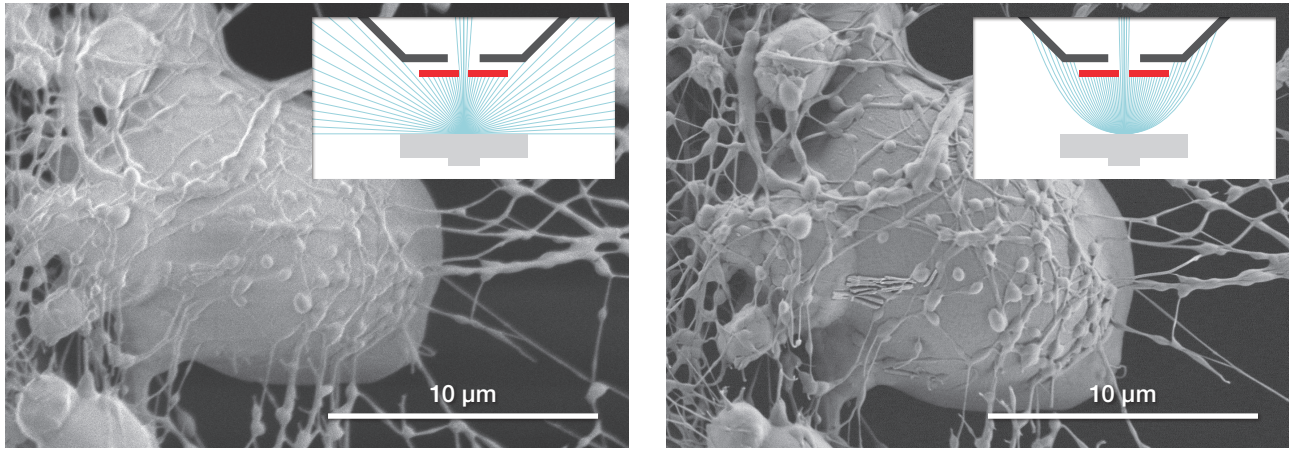


Polyamide fibers with polylactic acid and graphene flakes. Left: image drift due to charge buildup. Right: without changing beam energy or beam current, drift-compensated frame integration corrects for the drift and produces a sharp image. ***Sample courtesy of CNR IPCB, Italy. Images by Alice Scarpellini.***

Beam deceleration mode

Beam deceleration (BD) is an optical mode where the specimen is biased with a negative potential (max. stage bias = -4 kV) and primary electrons are decelerated before they land.

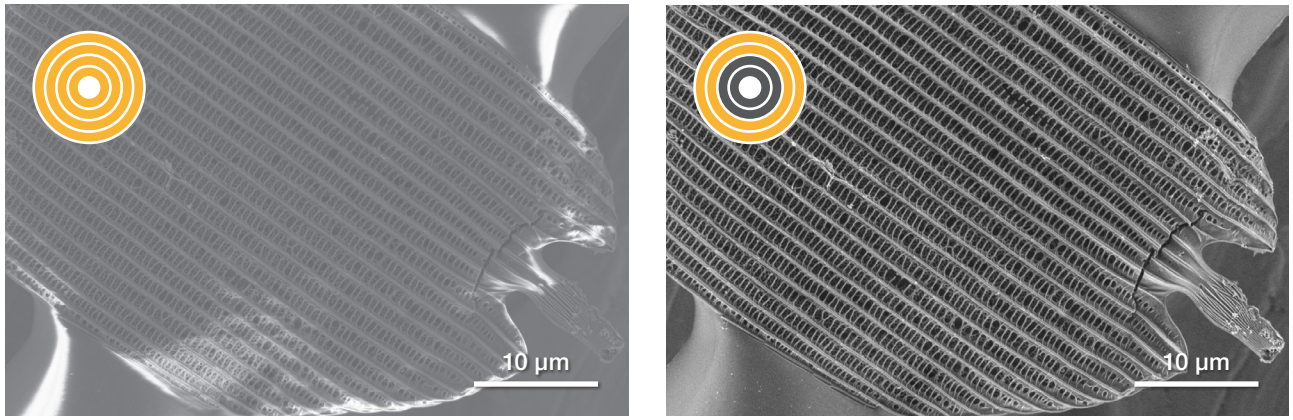
Thanks to an accelerating voltage higher than the landing energy, the final resolution is improved. BD also enables the detection of low angle backscattered electrons (BSE) that move nearly parallel to the surface of the sample, enhancing surface topography and eliminating charge from the image.



Beam deceleration off (left image) and on (right image). On this polymeric nanofibers sample, this imaging mode improves resolution and topographic information. *Sample courtesy of Contipro, Czech Republic. Images by Alice Scarpellini.*

Charge filtering with segmented backscatter detection

When coupled with an annular Directional backscatter detectoer (DBS), BD enables charge filtering even in high vacuum.



All segments of the backscattered detector active (left image) vs only the outer segments selected (right image). Beam deceleration coupled with a selective backscattered detection filters charge from this insect wing image. Landing energy: 2 kV, Bias applied: 4 kV.
Images by Alice Scarpellini.

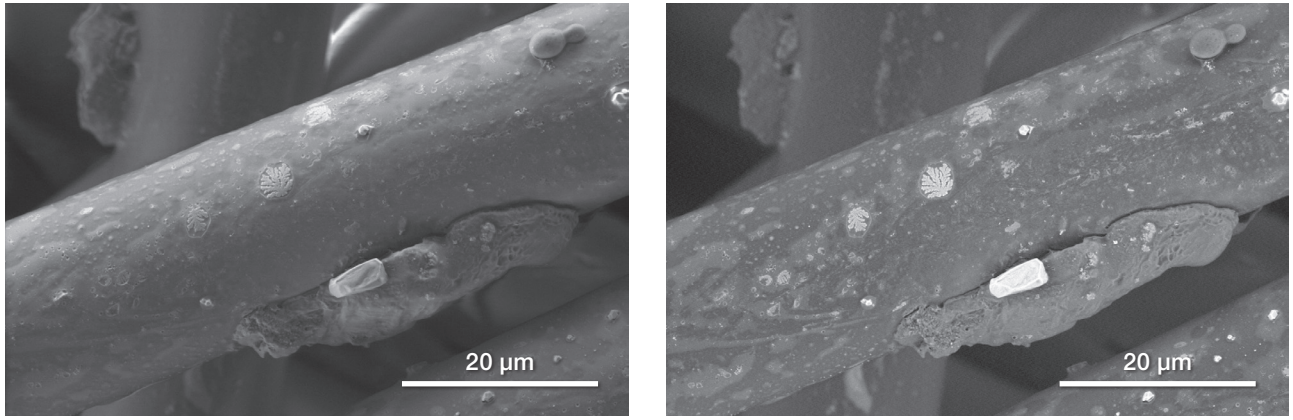
Unique vacuum modes

The Prisma E SEM supports an extensive range of samples with its three operating modes; high vacuum, low vacuum and environmental SEM (ESEM). As it is possible to adjust the pressure between different vacuum modes, there is no need for coating, drying or any other special preparation prior to imaging.

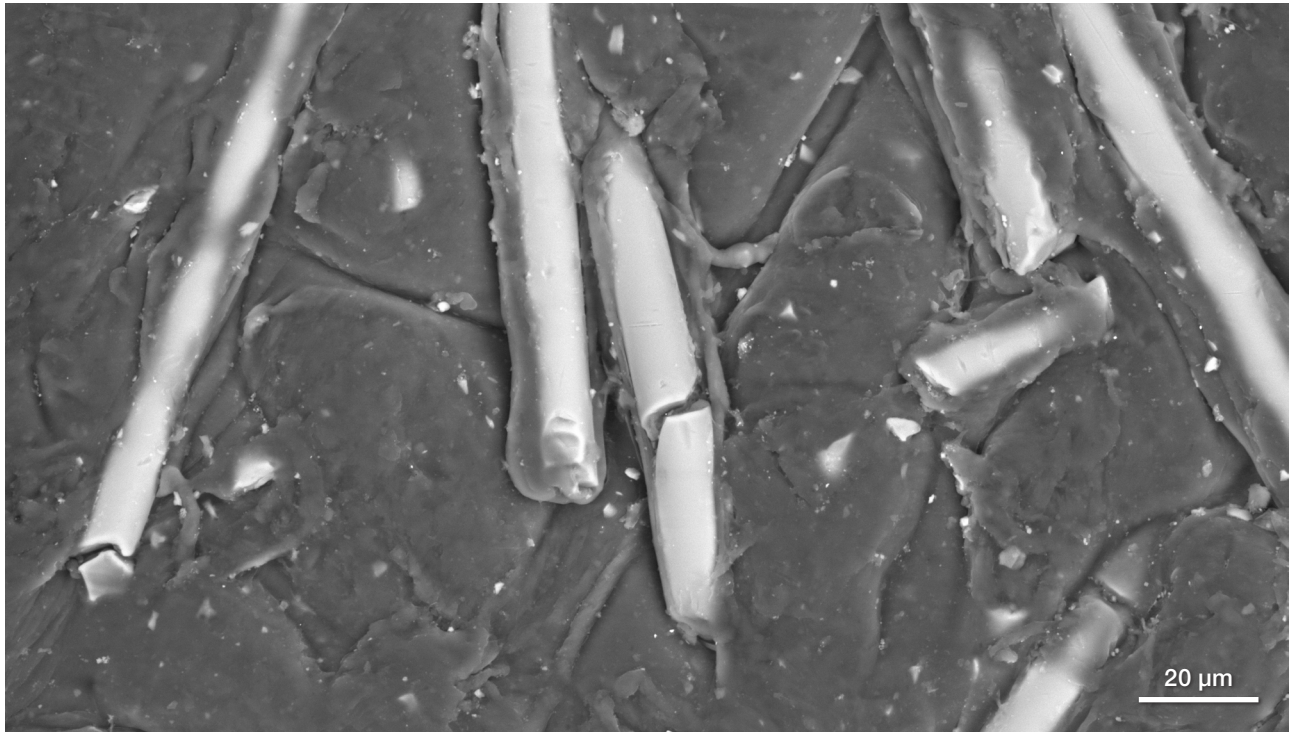
The high vacuum mode gives excellent contrast and provide holistic sample information, from topography to material contrast.

Mitigating charge with low vacuum mode

Low vacuum mode provides a substantial advantage when imaging non-conductive samples. It enables charge-free imaging and analysis of insulated materials at pressures up to 130 Pa. Several detectors are available specifically for low vacuum mode to extract all necessary information from your samples, ranging from topography to materials contrast. Additionally, most of the detectors can be biased, which provides an easy way to increase the signal-to-noise ratio. As a result, Prisma E provides best in class combined low vacuum, low kV image quality to make sure no surface detail is lost.



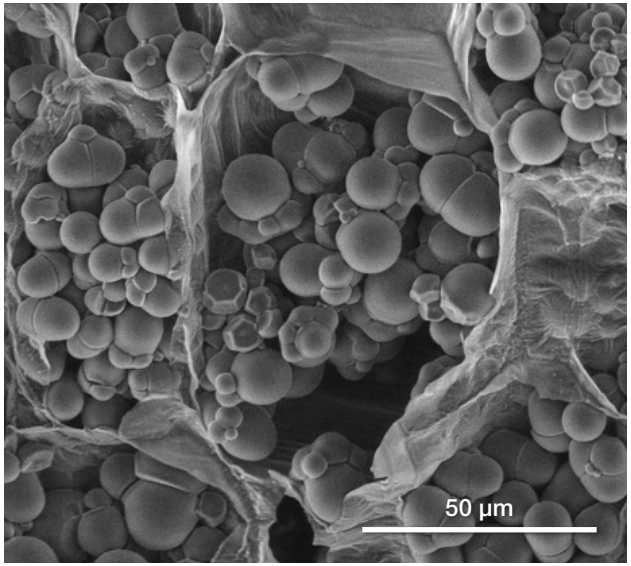
Polymeric nanofibers. Topography (left) and material contrast (right) are available in low vacuum mode. Accelerating voltage: 3 kV. Pressure: 70 Pa. *Sample courtesy of Contipro, Czech Republic. Images by Alice Scarpellini.*



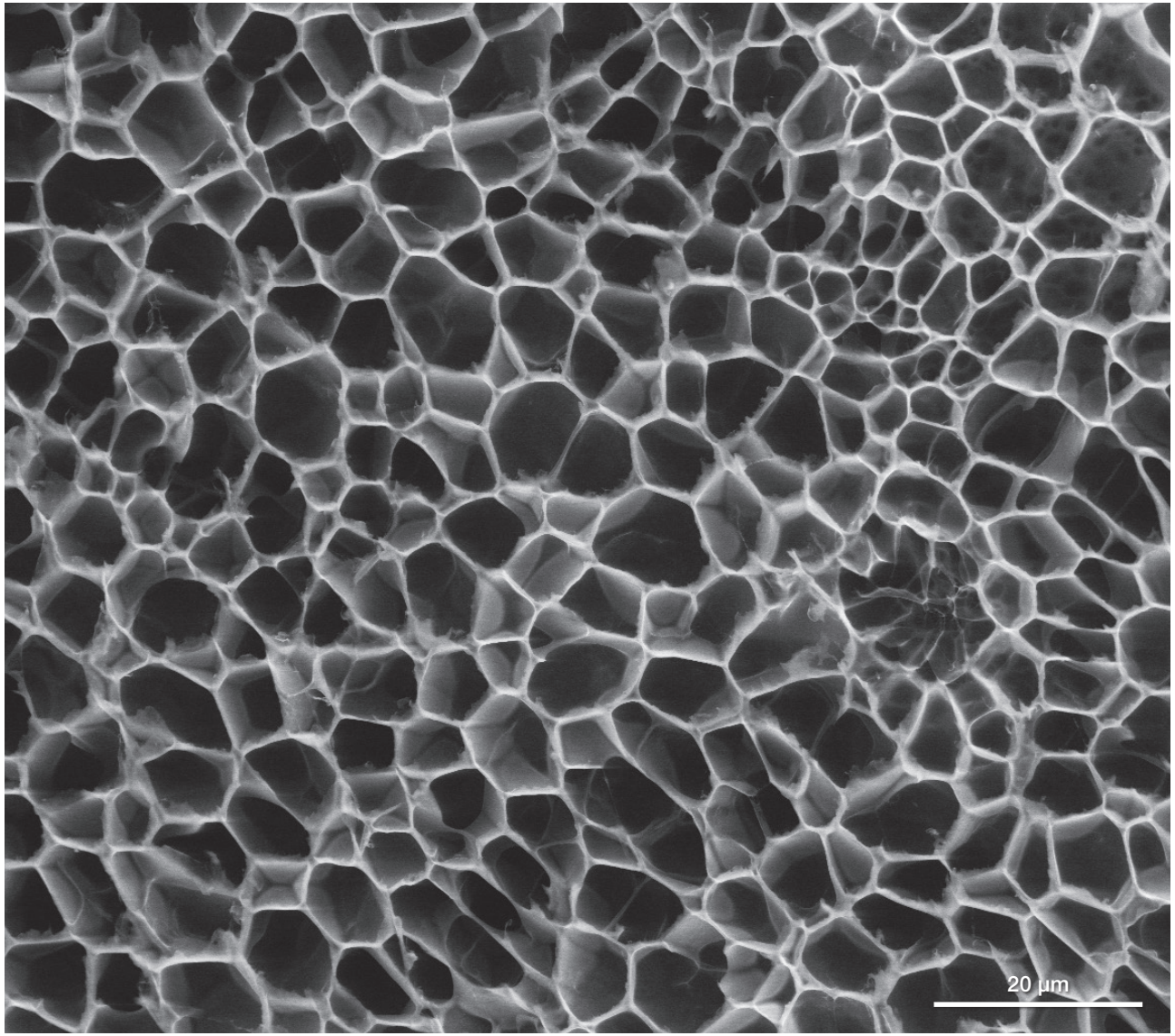
This image shows a fiber-reinforced polymer imaged at 15 kV and 70 Pa chamber pressure.

Observing materials in their natural state with ESEM
Environmental SEM is one of the distinctive features of the Prisma E SEM, made possible by the microscope's ability to sustain a water vapor pressure from 10 Pa up to 2600 Pa. ESEM technology offers researchers the unique opportunity to match the environment inside the SEM to the needs of the sample, rather than adapting the sample to meet the needs of the microscope. This unique approach has many advantages for both materials and life sciences.

Not only can samples be imaged with minimal preparation, but the addition of variables such as hydration, thermal cycling and chamber gases enable *in situ* characterization of dynamic changes. Using water vapor and a temperature control stage, some of the "impossible to image samples," such as dirty (highly outgassing) and naturally hydrated samples (whose properties will change with drying), are easily characterized.



A fresh sweet potato (Ipomoea batatas) imaged in ESEM mode. Accelerating voltage: 7 kV. Pressure: 300 Pa. Dedicated detectors enable high resolution, high contrast and low noise imaging in ESEM mode.

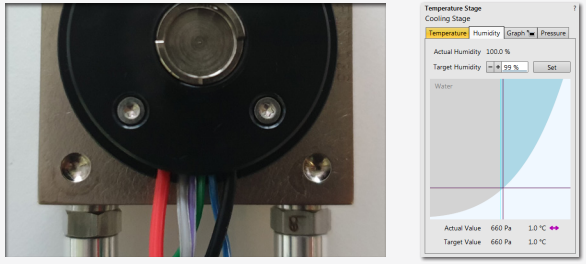


Hydrogel with a water content over 80% imaged in ESEM mode. Pressure: 70 Pa. Cold stage temperature: -25 °C.

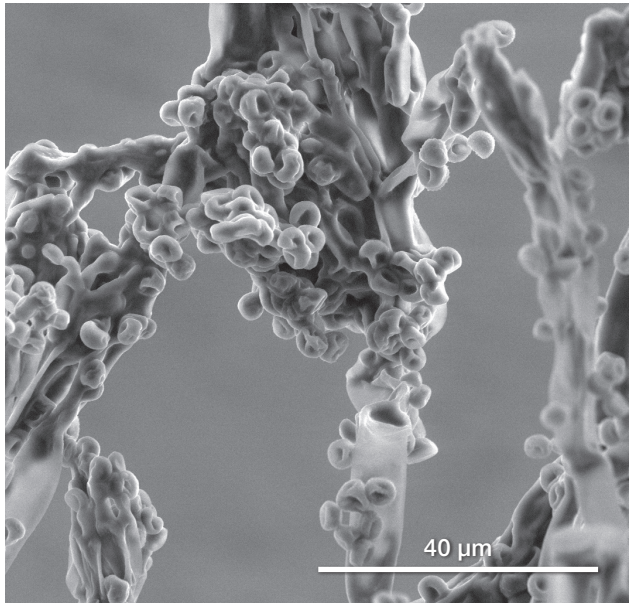
Cooling stages for *in situ* dynamic experiments

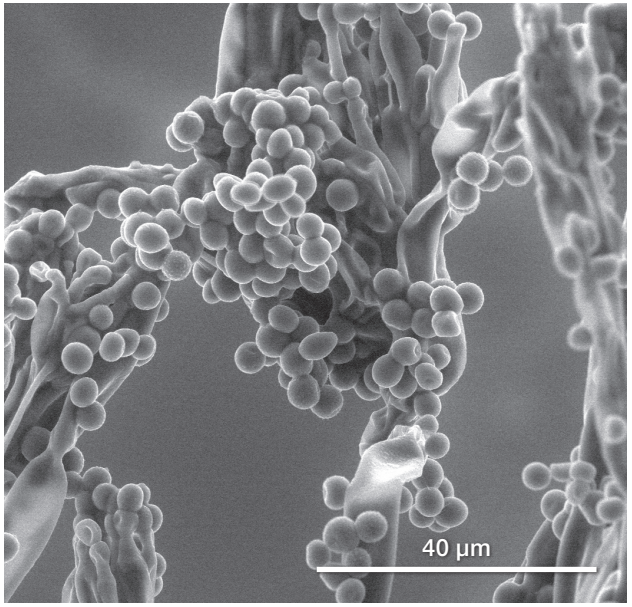
Pairing ESEM with a cooling stage allows for maintenance of any hydration state by varying temperature (from -25°C to +55°C), pressure and humidity (0-100% relative humidity). In particular, the ability to change humidity presents new possibilities for materials testing.

In conjunction with specimen chamber water vapor pressure, the cooling stage can be used to create water condensation on the sample surface to keep it hydrated.



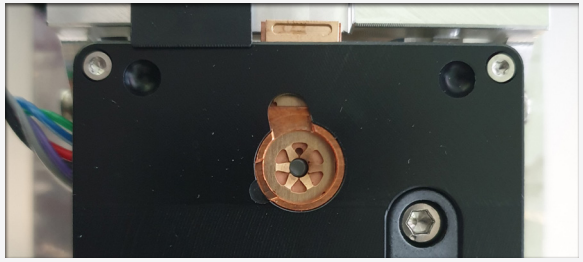
Settings, parameters and controls are embedded in the Prisma UI; both temperature and humidity can be set directly or set by adding a ramp with a target value along with a ramp speed.



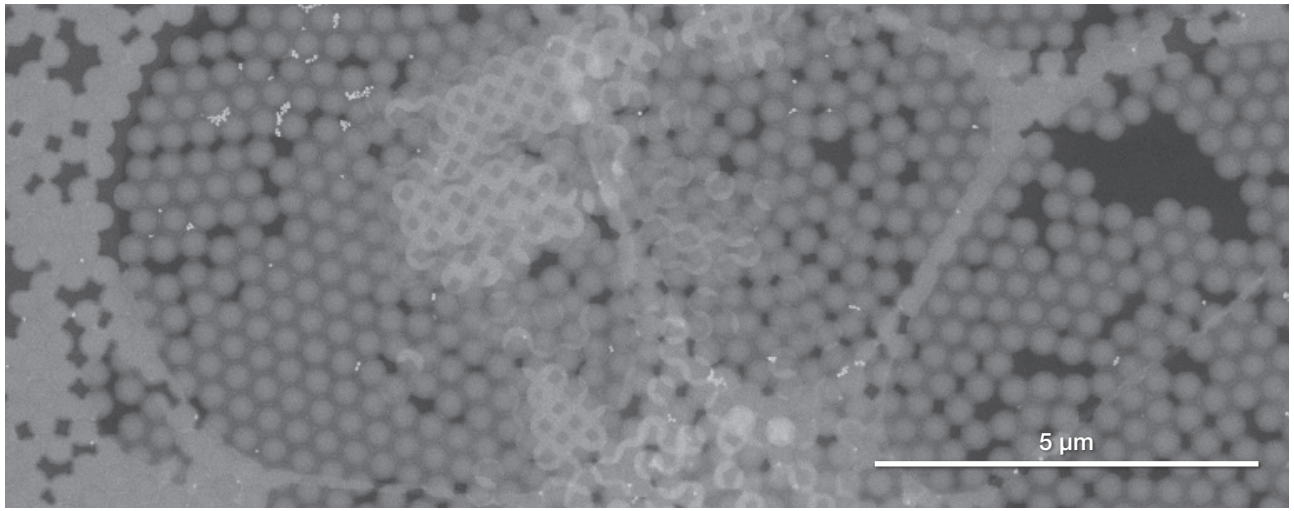


Mold spores contain water, which leads to shrinking in conventional low vacuum mode due to evaporation (left, pressure: 200 Pa). The Prisma E SEM allows higher chamber pressures with 100% humidity, enabling observation of this structure in its natural hydrated state (right, pressure: 800 Pa). Both images were taken at 10 kV accelerating voltage and a stage temperature of 2 °C.

Thermo Scientific™ WetSTEM Technology enables observation through thin membranes of water by using a solid-state detector under the sample, which is mounted on a thermally controlled TEM grid. Fine adjustments in temperature and pressure allow the same dynamic control as is possible with bulk samples in traditional ESEM.



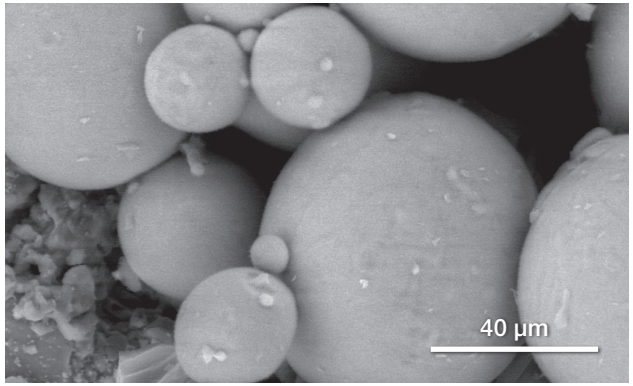
The WetSTEM stage. The hole in the stage allows for humidity-controlled STEM characterization of thin, electron-transparent samples. The stage also functions as a regular cooling stage when a bulk sample is mounted.

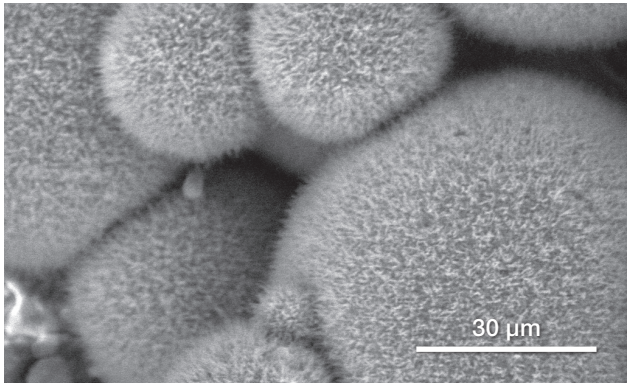


Self-assembly of polystyrene spheres (300 nm) and gold nanoparticles (40 nm) observed *in situ* at 1 °C and a pressure of 600 Pa.

Heating stages for *in situ* dynamic experiments

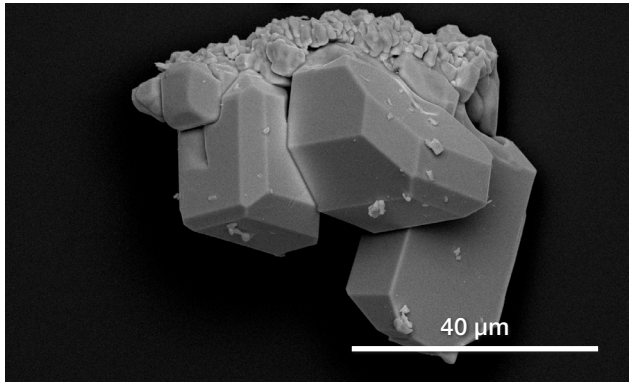
The Prisma E SEM offers two different types of heating stages for low vacuum mode; one for temperatures up to 1000°C and the other for temperatures up to 1400°C. The heating assembly is designed as a micro-furnace; samples are heated from the sides (not just from the bottom) which allows for more uniform temperature gradients around the sample.

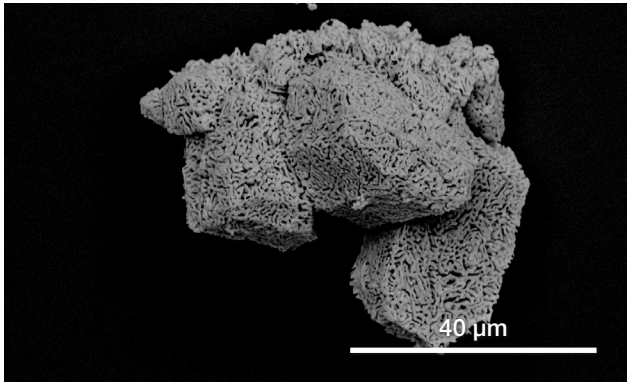




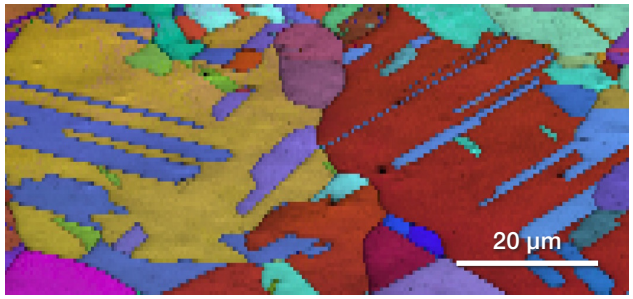
Texture development on implant material. As the temperature increases from 700 °C to 1300 °C we can observe a completely different surface structure. Pressure: 120 Pa.

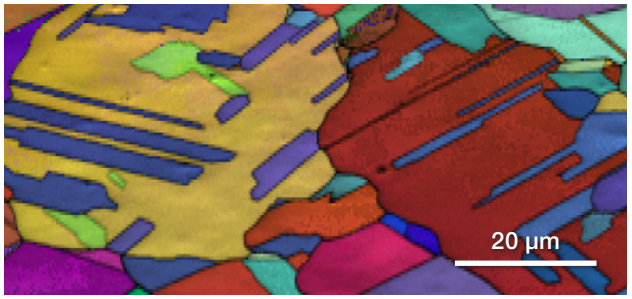
The high vacuum heating stage (HVHS) allows for sample heating up to 1100°C while preserving excellent image quality. It can mount samples up to 10 mm in size; these are covered by a shield with a 3 mm hole. The use of the HVHS also offers higher cleanliness while minimizing oxidation.



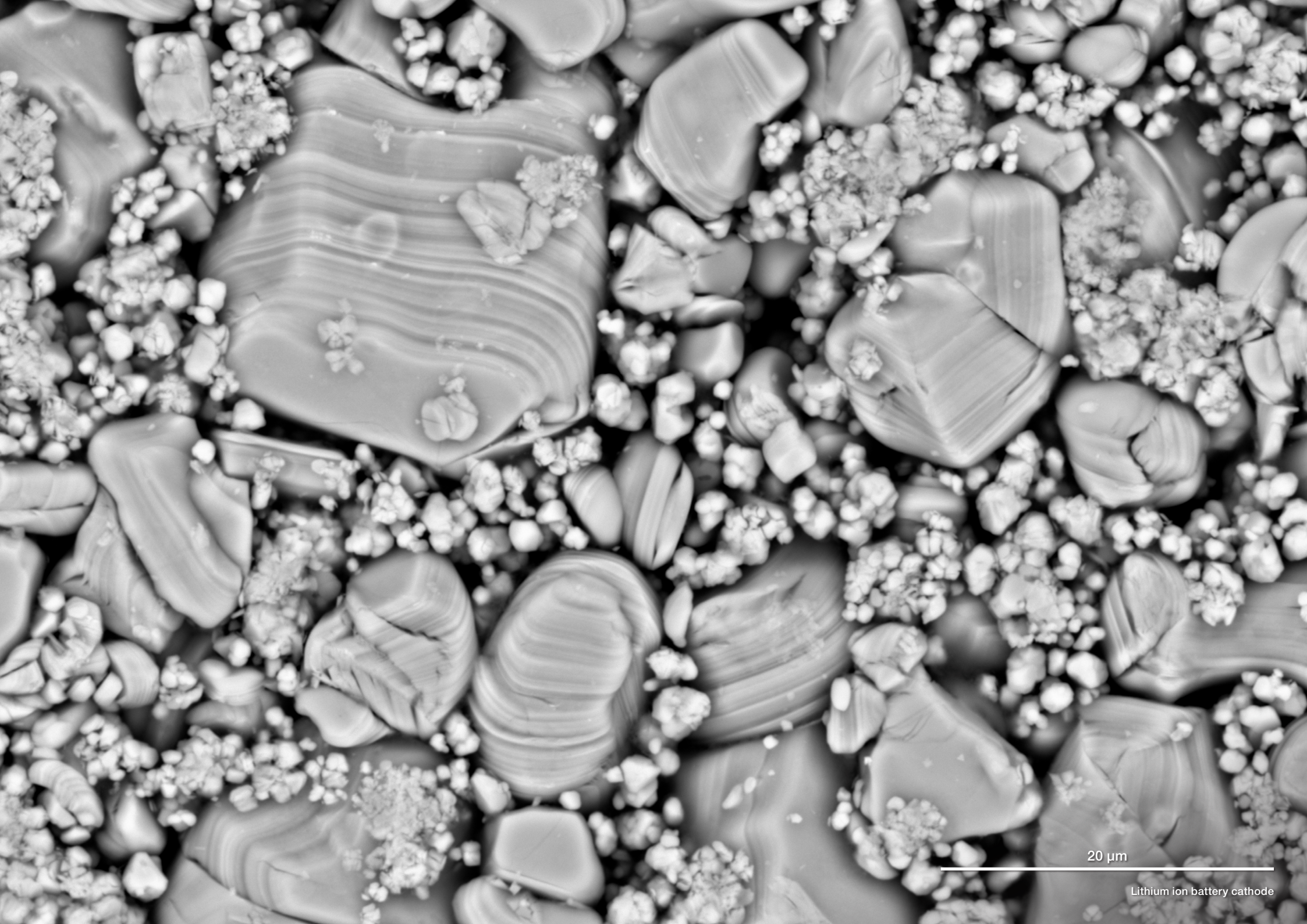


Two phase Co-Sb alloy during heating up to 700°C in the high vacuum heating stage. The antimony-rich phase sublimated during heating, causing exposure of the second phase

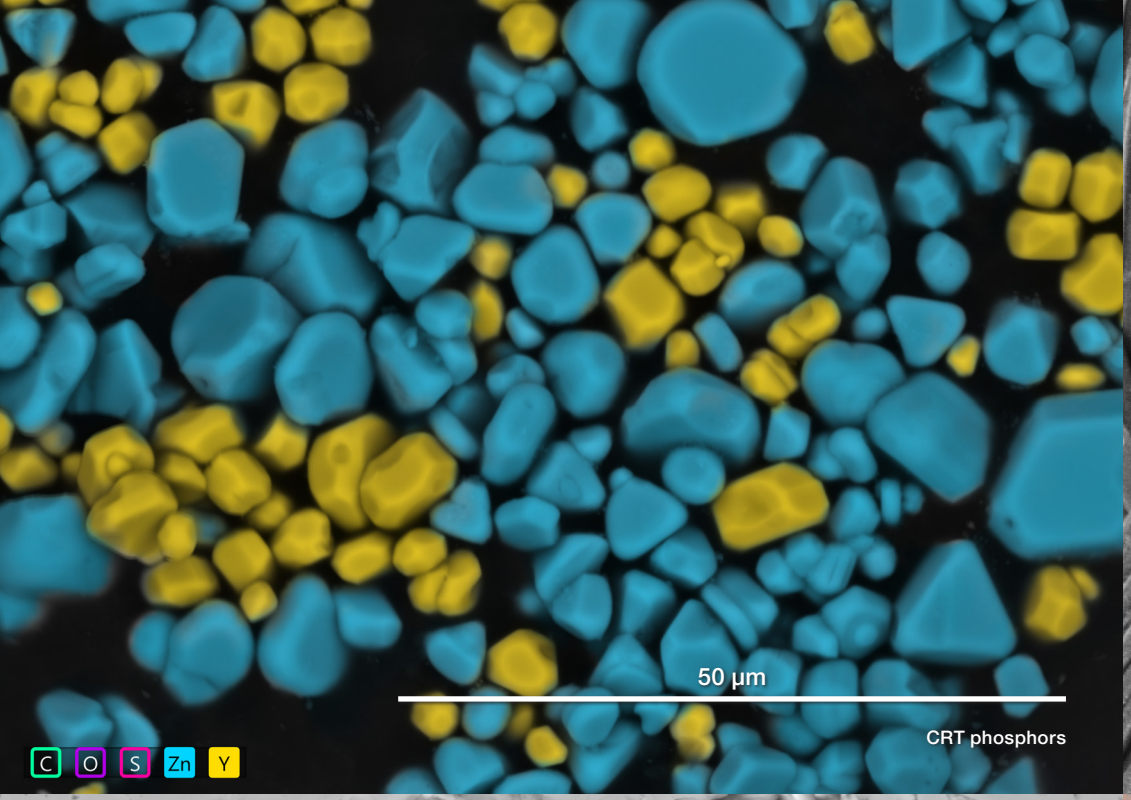


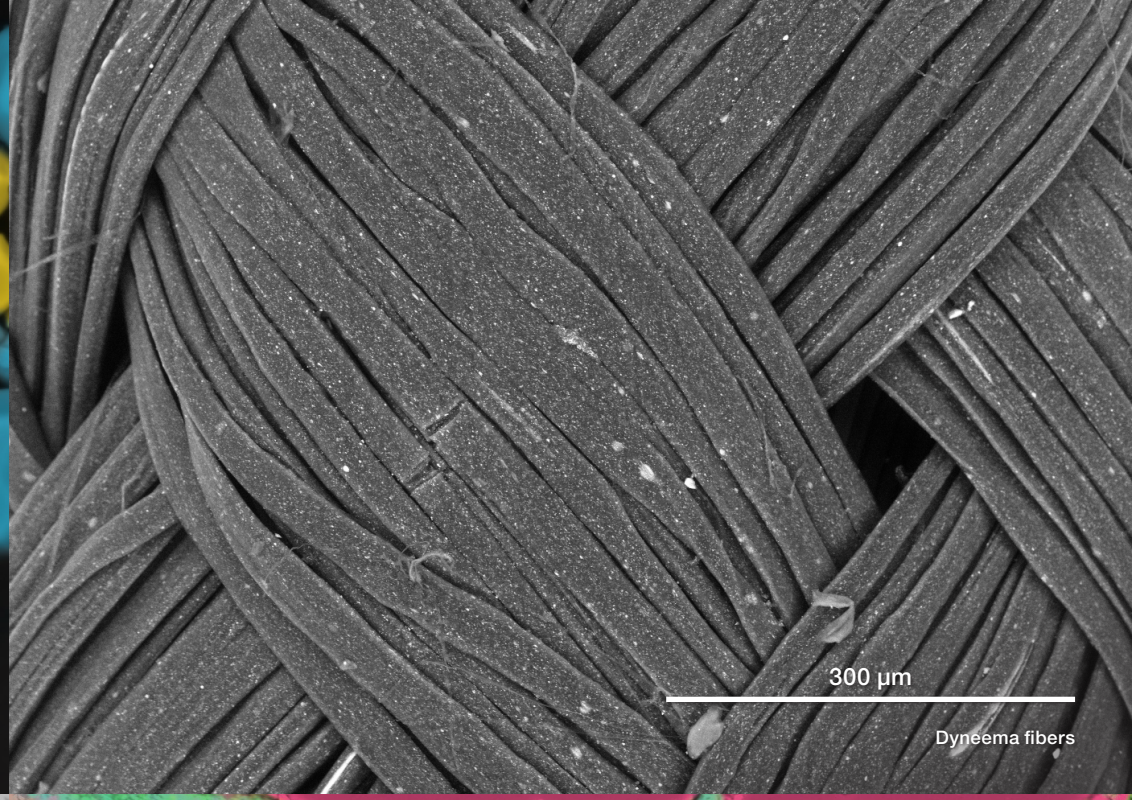


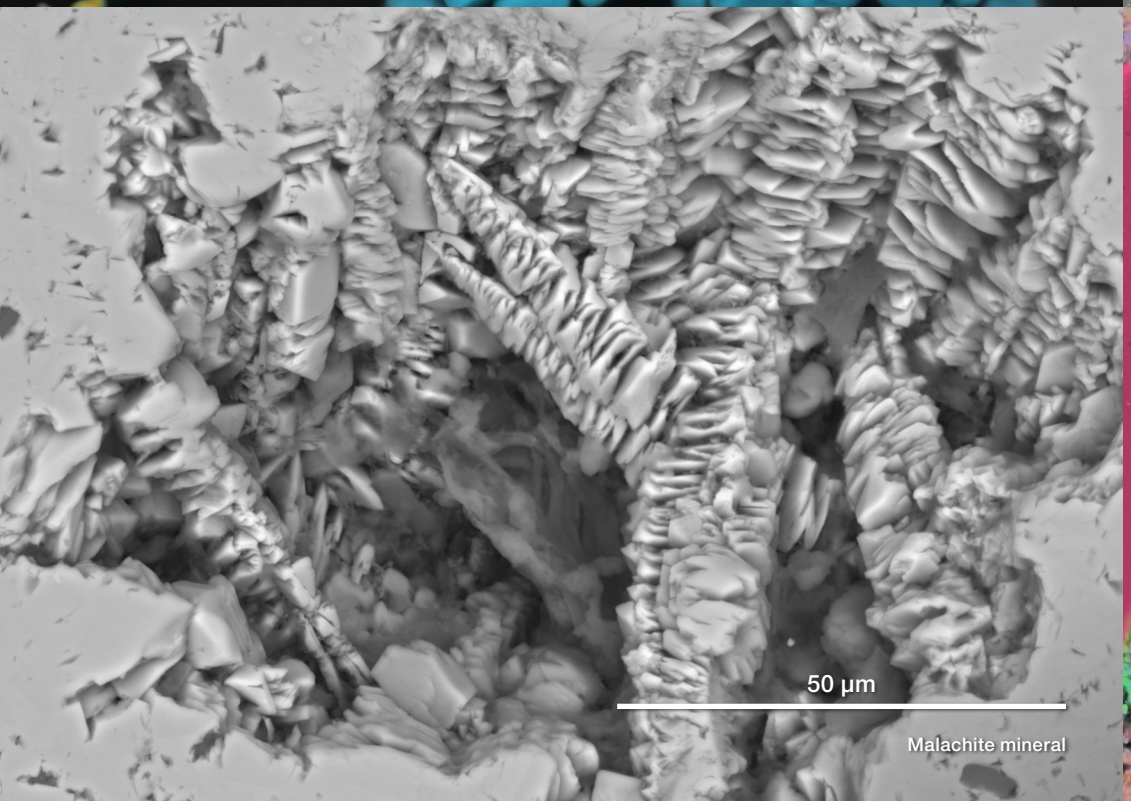
EBSD map of a copper surface. The images show high quality EBSD results even at high temperature.

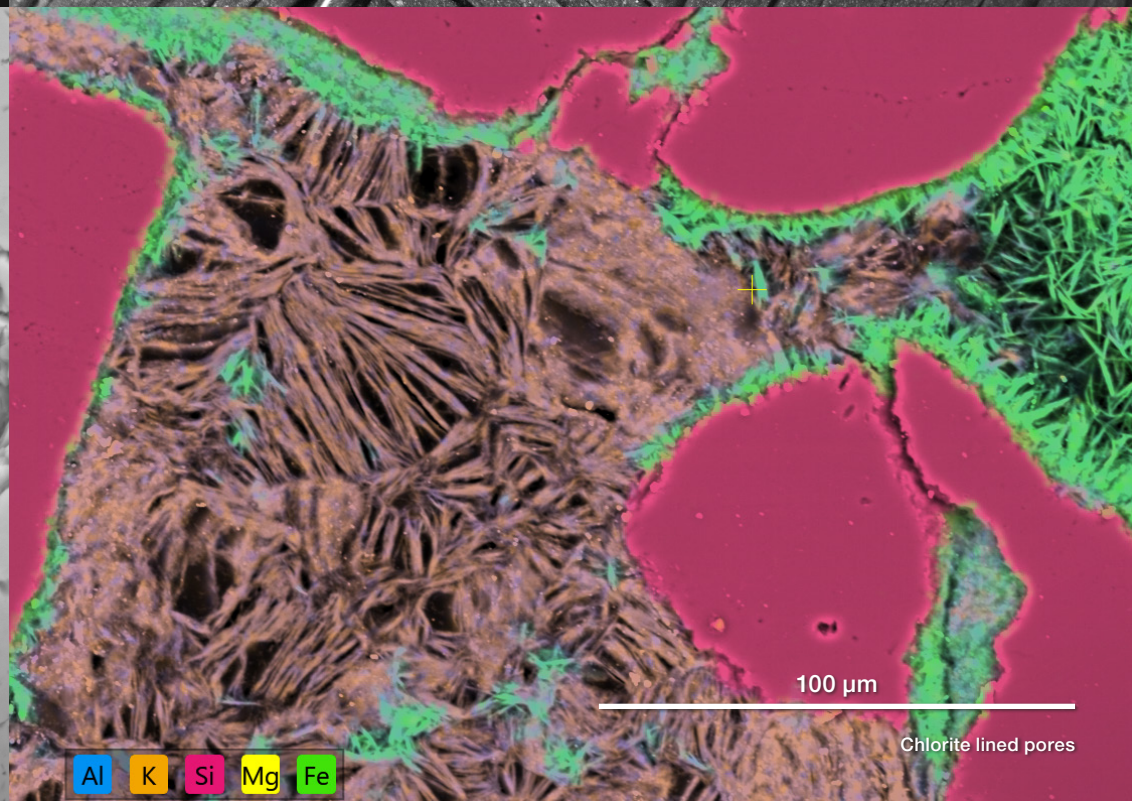


Lithium ion battery cathode


50 µm
CRT phosphors
C
O
S
Zn
Y


300 µm
Dyneema fibers


50 µm
Malachite mineral

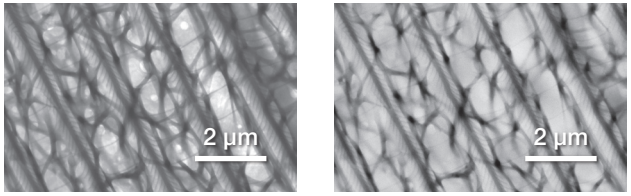

100 µm
Chlorite lined pores
Al
K
Si
Mg
Fe

Detectors

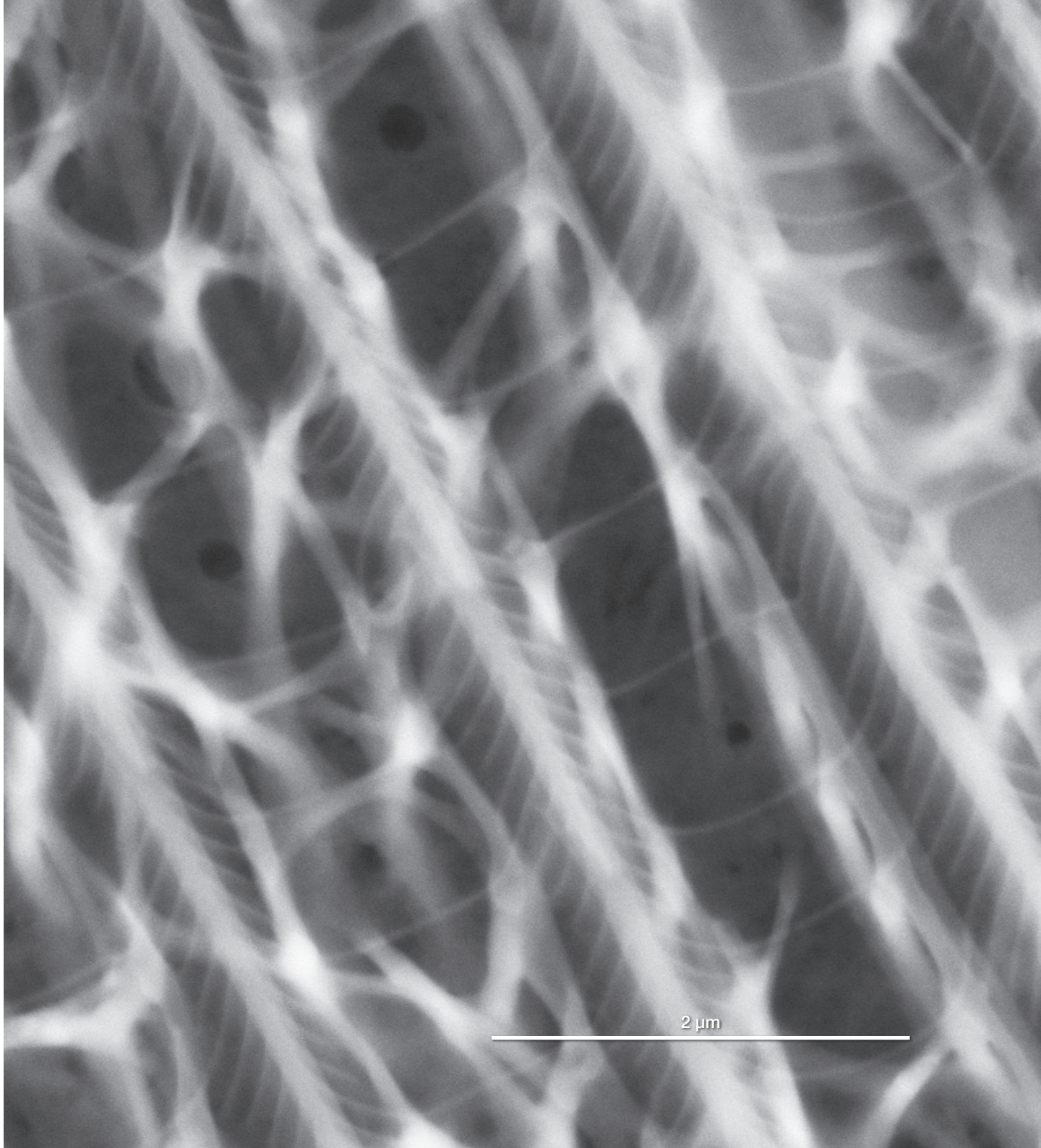
STEM3 Detector

The Thermo Scientific™ STEM3 Detector is a retractable detector that offers 11 individually addressable components with flexible segmentation. Its sensitivity and versatility bring highly advanced imaging to the Prisma E SEM.

The level of retrieved information can be enhanced by selecting between STEM3+ and STEM3 configurations (bright field, dark field from different scattering angles, high angle annular dark field (HAADF) and the possibility to customize your selection).



As these images of a butterfly wings show, STEM3 enables very high resolution results and complete information thanks to the ability of the detector to distinguish dark field (left), high angle annular dark field (center) and bright field (right) contrasts.



Retractable RGB cathodoluminescence detector

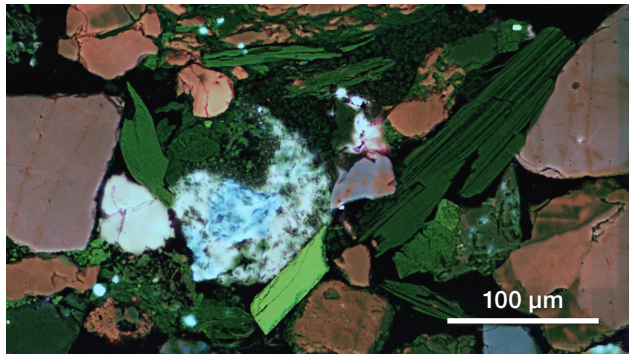
In several cases where SE, BSE or EDS do not show contrast, cathodoluminescence (light emitted from the sample) is able to map (trace) composition, crystal defects, or photonic properties. With its novel, flat detector design, the RGB cathodoluminescence detector (CLD) provides real color cathodoluminescence data without compromising on ease of use, simultaneous detection or field of view.

Key features

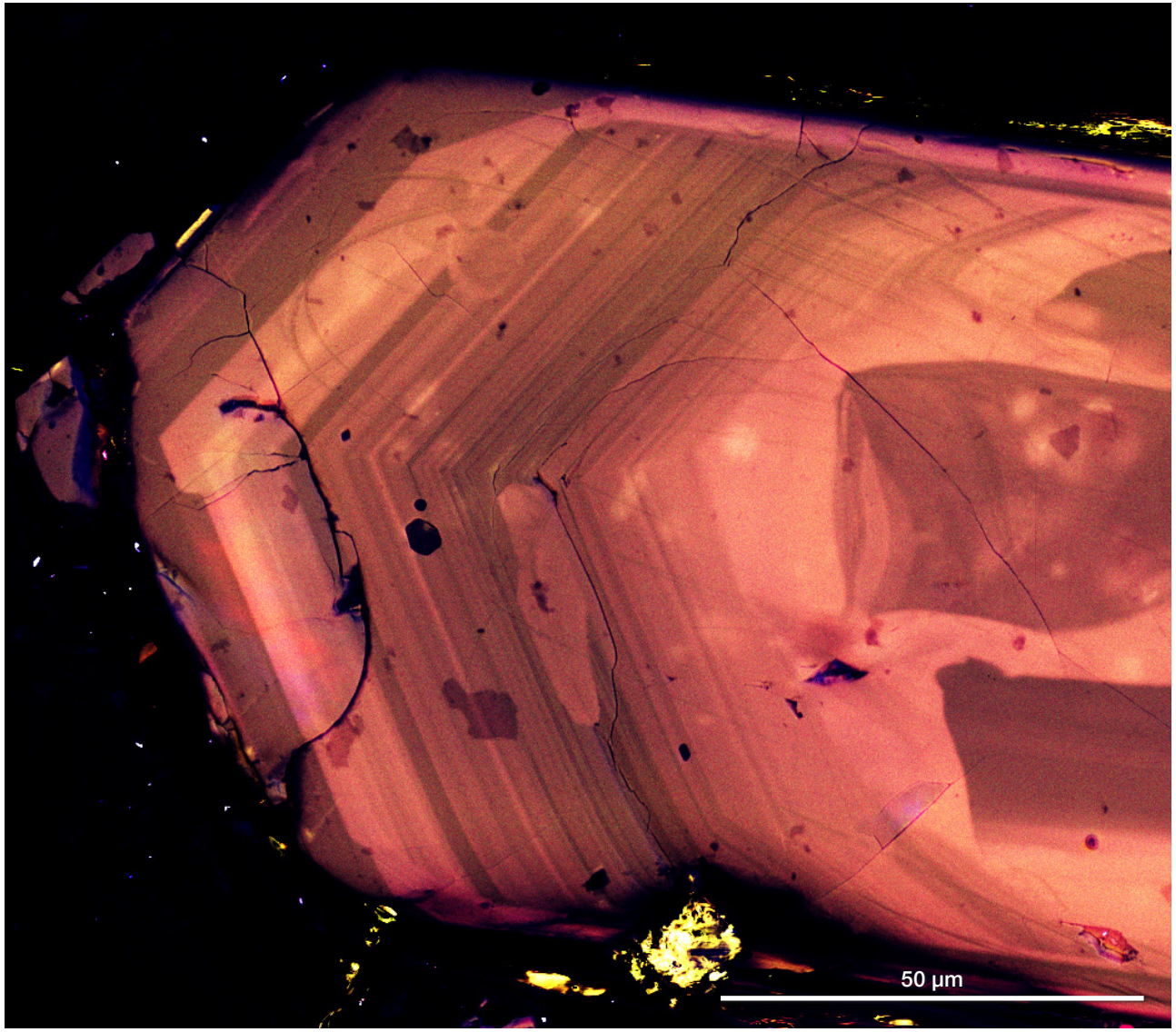
- Retractable mechanism is integrated into the UI
- No optical alignment necessary
- Short time to results with real-time RGB color display
- Enhanced compatibility
  - Simultaneous acquisition of CL data with SE, BSE and even EDX is possible
  - Operable in low vacuum mode

Technical specification

- Wavelength detection range: 350-900 nm
- Large field of view (not limited by the detector)
- Flexible working distance



Sandstone sample imaged with the CLD. Cathodoluminescence contrast can be used to differentiate between muscovite (mica) and illite, which have similar composition.



Zircon imaged with the CLD. The distribution of regions provides information about the history of the zircon grain. *Sample courtesy of UC Santa Cruz.*

Software

Maps Software

Thermo Scientific™ Maps™ Software is an intuitive automation and correlative workflow software suite for Thermo Scientific SEM, DualBeam™ and TEM platforms.

Maps Software allows you to easily and automatically acquire large 2D mosaic datasets or automate regular, repeat imaging of samples. It also provides users with an easy way to import, align and co-visualize multi-modal, multi-scale imagery.

Key features

System automation

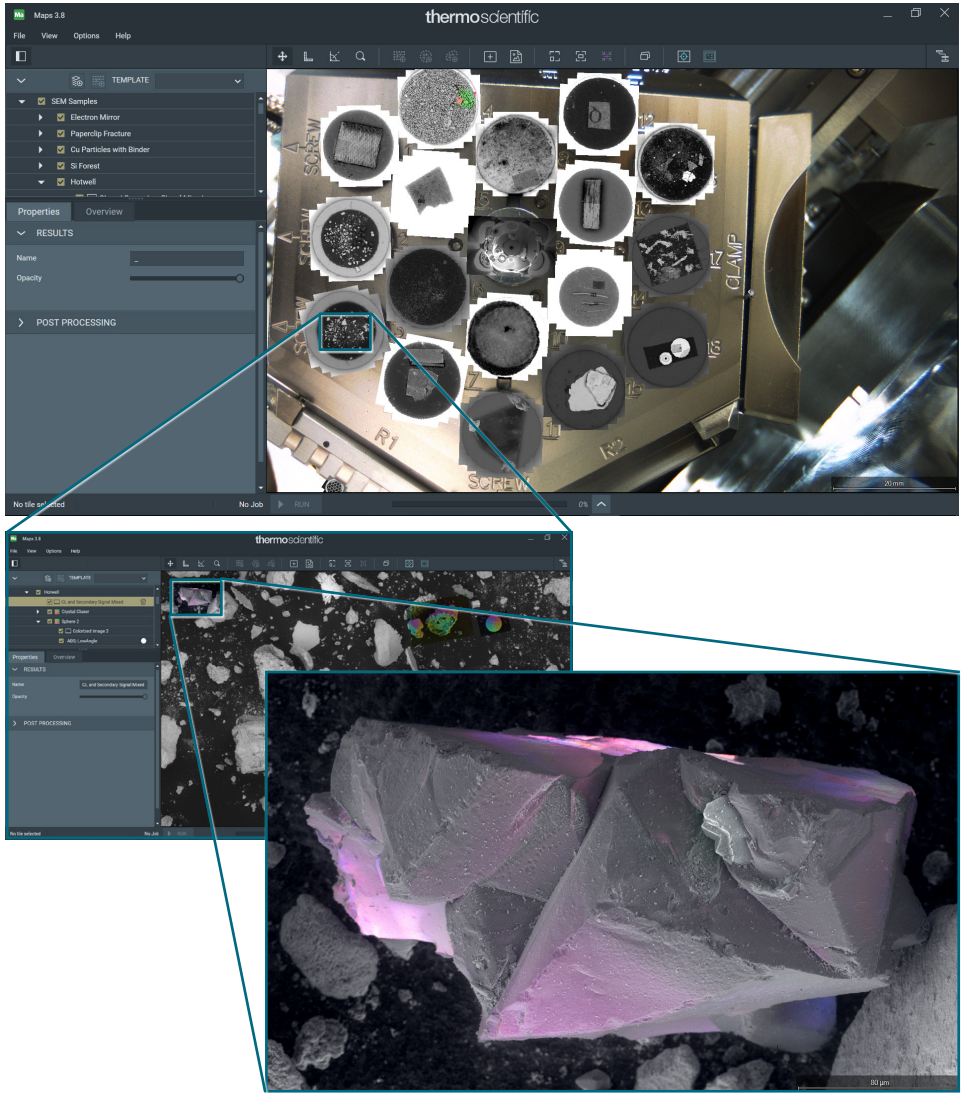
Maximize the productivity of your microscope by automating imaging routines overnight.

Correlative microscopy

With Maps Software, you can import 2D and 3D images from any source, correlating layers easily and accurately. Explore and interpret all your data efficiently while ensuring that the context of multi-modal collections is preserved.

Visualize, annotate, and share

With its free offline viewer, Maps Software enables basic visualization even outside the office. Access full correlative power anywhere and share multi-scale observation with colleagues.



Demonstration of the correlative workflow enabled by Maps Software.

Autoscript Software

Thermo Scientific™ Autoscript™ 4 Software is a Python-based application programming interface (API) that offers control of the Prisma E SEM and other Thermo Scientific systems. It opens up the microscope to a world of advanced functions that can be used for powerful automation.

Key benefits

- Autoscript Software gives access to new possibilities for acquisition, analysis, interfacing, imaging, patterning and data display that were previously inaccessible to manual operators.
- Scripting of repetitive or tedious tasks leads to much improved reproducibility and accuracy for higher quality results.
- Unattended, high throughput imaging and patterning makes more effective use of your time, and of SEM time.
- Supported by Python 3.5-based scripting environment: Python, the most popular programming language available and the standard in scientific computing, provides access to a vast collection of pre-installed libraries for scientific computing, data analysis, data visualization, image processing, documentation and machine learning.
- An integrated development environment (IDE) supporting object browsing and syntax highlighting with auto completion and object browsing makes it easy to get started.

Application examples

- Automated region-of-interest identification and imaging
- Parameter sweeps (acquire images at different kV, currents, etc.)
- Feature tracking and drift compensation
- On-the-fly feature measurement and image processing

For more information, see the Autoscript Software datasheet.

Feature-based image segmentation of a geological sample.

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Notes

Find out more at **thermofisher.com/prisma**

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