Apreo 2 SEM

Unmatched versatility powered by ChemiSEM Technology

thermo scientific

Since the introduction of electron microscopes in the 1930s, scanning electron microscopy (SEM) has developed into a critical tool for researchers in nearly every branch of science, technology and industry.

Modern SEMs meet a wide range of academic and industrial needs: the flexibility to handle the most challenging materials, the performance to resolve the smallest details, the versatility to extract all necessary information, and the ability to deliver this power to every researcher in a short amount of time.

Thermo Scientific™ ChemiSEM™ Technology revolutionizes and simplifies EDS analysis by fully integrating SEM and EDS functions into a single, cohesive user interface. Based on live quantification and building on decades of expertise in EDS analysis, the technology provides elemental information quickly and easily, guaranteeing reliable results. ChemiSEM Technology is now available on the Thermo Scientific Apreo™ 2 SEM.

High performance and extreme flexibility

The Apreo SEM has earned a reputation for its versatility and high-quality imaging performance—even on magnetic or other traditionally difficult samples. The Apreo 2 SEM improves its impressive resolution specifications and introduces live quantitative elemental mapping. A number of other new features are designed to make its advanced capabilities accessible for all users.

Highlights

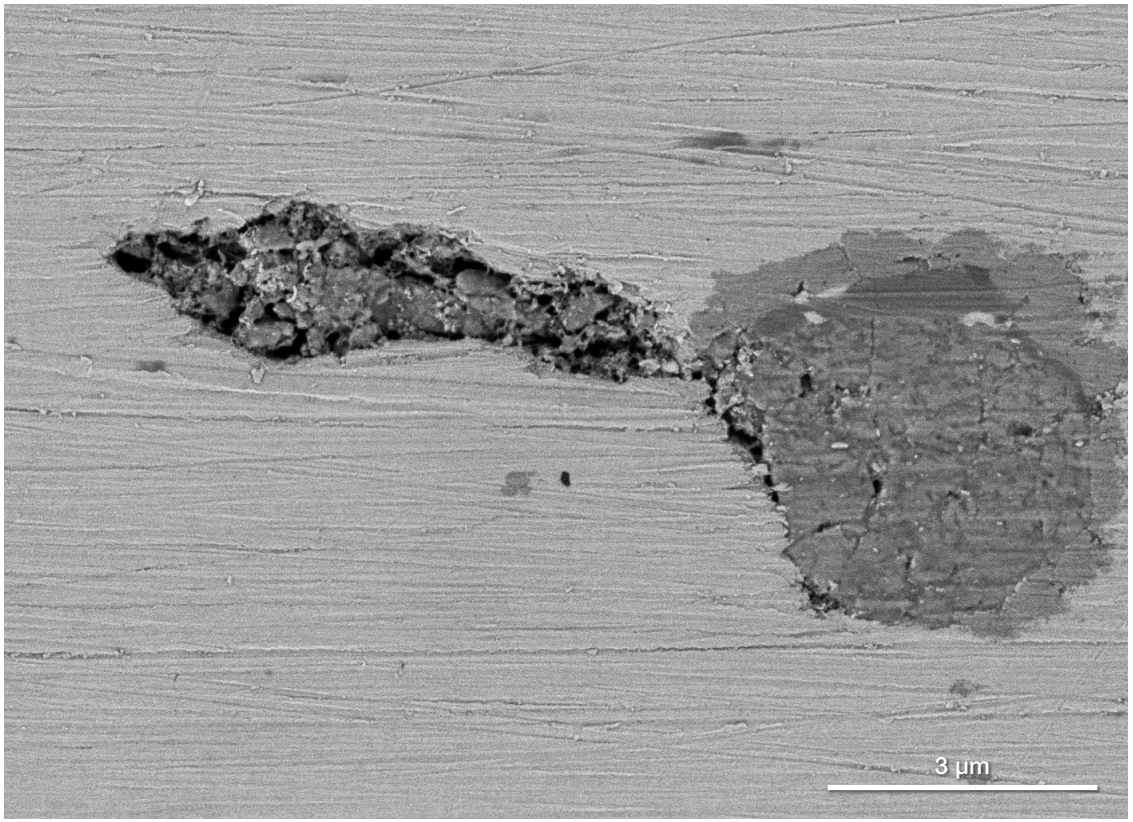
- High performance, resolution, and contrast: The combination of advanced optics, detection, and automation in the Apreo 2 SEM makes high-resolution imaging possible even for users new to SEM
- Wide range of sample types: The Apreo 2 SEM is designed for maximum flexibility, with unique optics, detection, and beam control options that make high-quality, high-resolution imaging possible regardless of target samples properties
- Live quantitative EDS: ChemiSEM Technology puts elemental information at your fingertips through live quantitative elemental mapping for unprecedented time to result and ease of use
- Quick and easy: Easy access to the stage, a convenient multi-sample holder, and fast pump down ensure no time is wasted loading samples; an automated routine to insert and remove a pressure-limiting aperture (PLA) allows for seamless switching between high and low vacuum without opening the chamber; and column presets allow you to save and reuse previously set parameters for easy access to the best imaging conditions
- Advanced automation: From optics to image acquisition, the Apreo 2 SEM provides a range of automated features to make imaging time as effective and efficient as possible; Flash Technology automates image fine tuning and the unique Undo function permits efficient exploration of imaging conditions; and Thermo Scientific Maps Software automates large area acquisition with up to four different simultaneous signals
- Performance at long working distances: The Apreo 2 SEM is the only SEM that offers high-resolution performance (1 nm) and excellent image quality at analytical working distance (10 mm); Sample morphology, topography, and surface information can all be simultaneously explored at a safe distance from the pole piece; thanks to its high-speed and high-sensitivity in-lens backscattered detector, BSE are still detected even at extremely low beam currents (as low as few pA); and there's no need to change the working distance for analytics

Best image quality for the widest range of materials

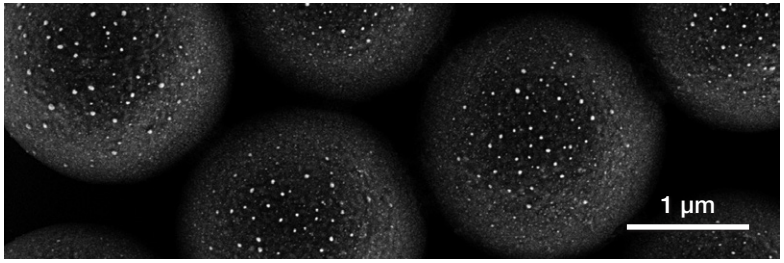
The constant search for improved performance and higher qualitative characteristics of the final products has always been key to the growing use of innovative materials. Furthermore, materials research focuses on the development of new advanced materials as the demand increases in several markets, such as energy storage, construction, and aerospace, but also customer goods (i.e., packaging).

Nanomaterials play an important role to improve various material characteristics due to their unique physical and chemical properties. The characterization of these nanomaterials is thus crucial for the design of new materials and later during the production phase. This requires microscopes with high-resolution imaging and high contrast levels.

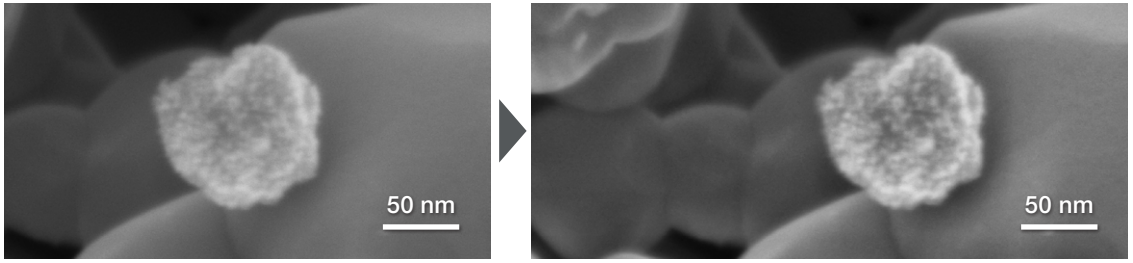
The new Apreo 2 SEM improves upon the popular original platform by improving its already impressive resolution specifications to be able to meet the needs for characterization of different type of materials. The electrostatic final lens enables simultaneous in-column detection at high resolution. Higher resolutions are available when combining the electrostatic final lens with magnetic immersion into a compound lens to further boost the performance and provide high-resolution results along with unique options for signal filtering.



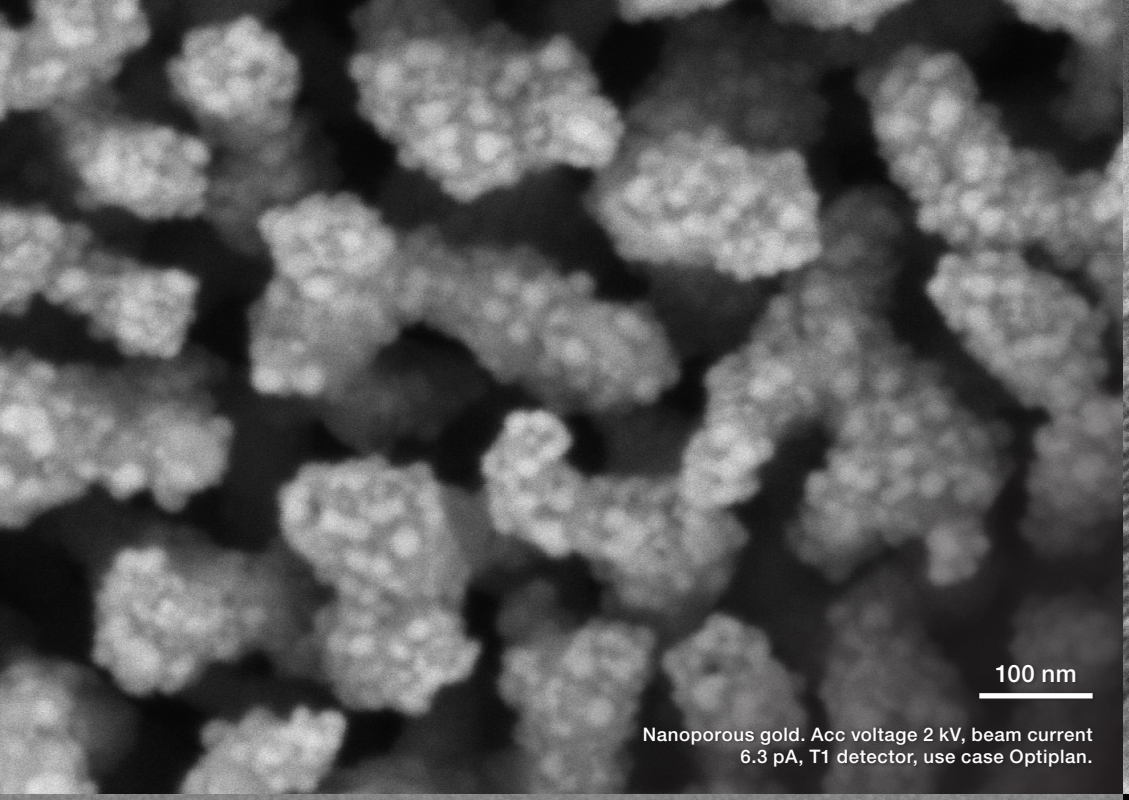
Inclusion in steel; backscatter image taken in magnetic immersion mode with the in-lens T1 detector.



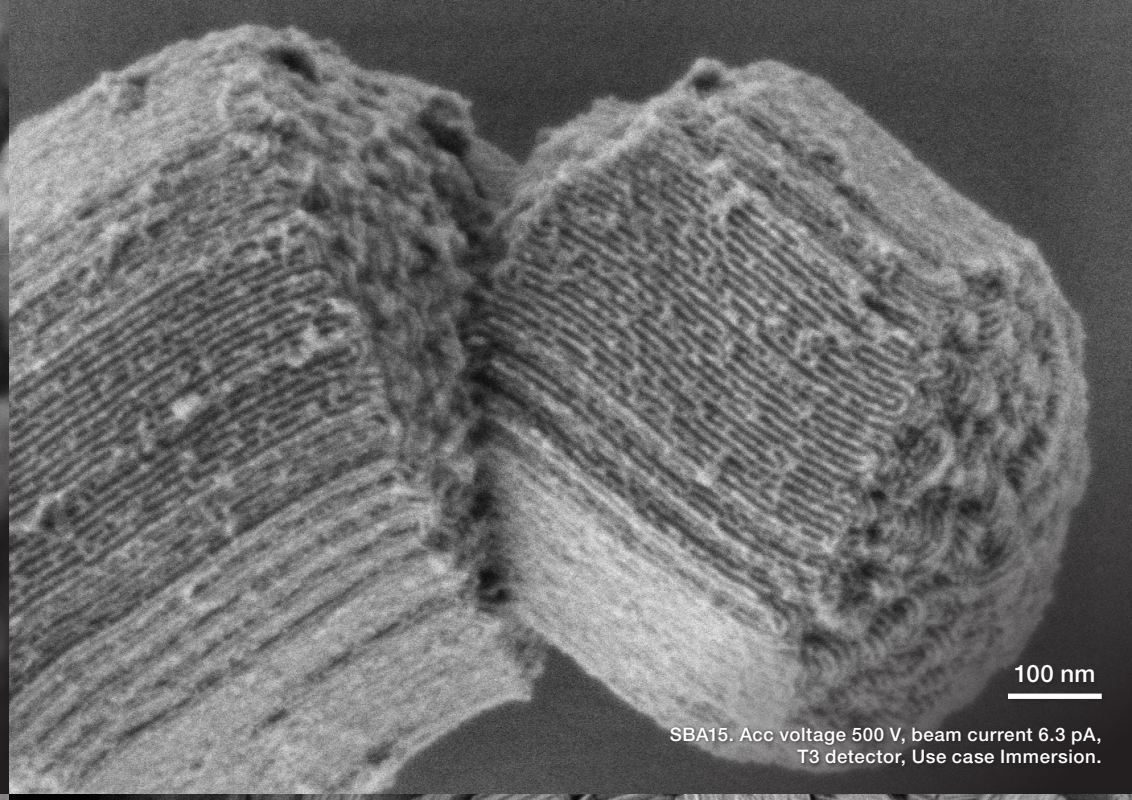
Fe_3O_4 NPs on polystyrene spheres. Acc voltage 1 kV, beam current 12.5 pA, T1 detector, use case Immersion. Compound lens filter on.



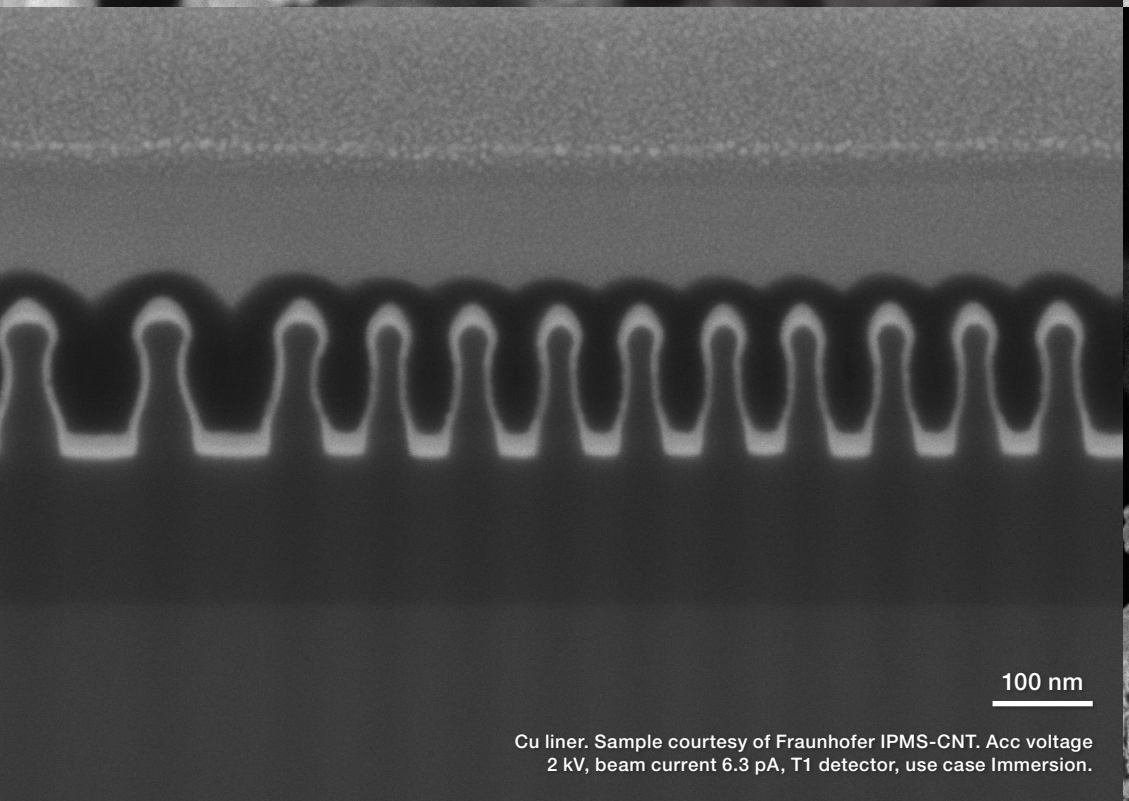
AuPdPt NPs on TiO_2. Acc voltage 5 kV, beam current 13 pA, T3 detector. Digital image improvement is available as a denoising feature. Available for images acquired with all the detectors, denoising is integrated in the SEM User Interface and can be applied in a post processing denoising of the images.



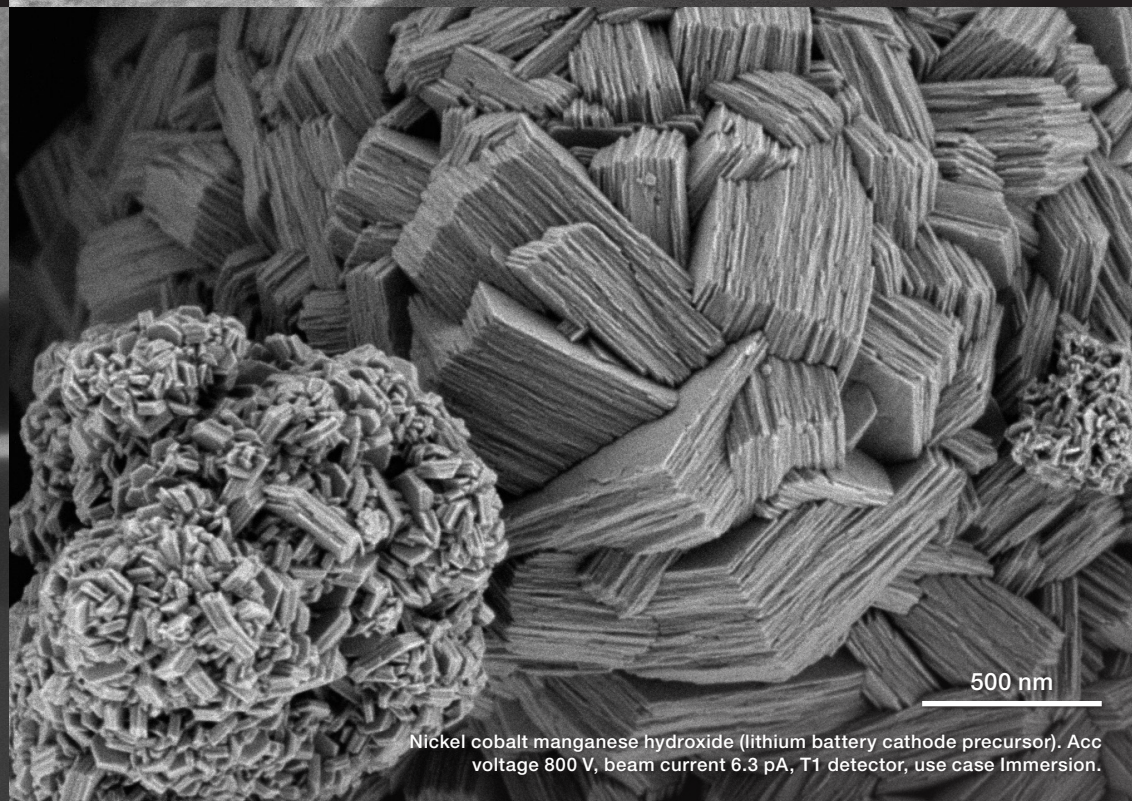
Nanoporous gold. Acc voltage 2 kV, beam current 6.3 pA, T1 detector, use case Optiplan.



SBA15. Acc voltage 500 V, beam current 6.3 pA, T3 detector, Use case Immersion.



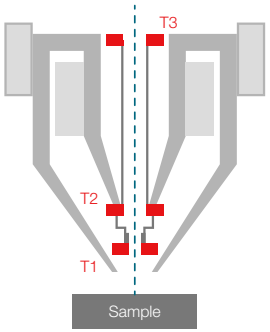
Cu liner. Sample courtesy of Fraunhofer IPMS-CNT. Acc voltage 2 kV, beam current 6.3 pA, T1 detector, use case Immersion.



Nickel cobalt manganese hydroxide (lithium battery cathode precursor). Acc voltage 800 V, beam current 6.3 pA, T1 detector, use case Immersion.

Trinity Detection System

The ability to tailor new materials' structure and composition is key to achieving specific properties (i.e., light weight, durability, stiffness, etc.). Therefore, a wide variety of information, ideally obtained at the same time, is needed for a complete characterization.

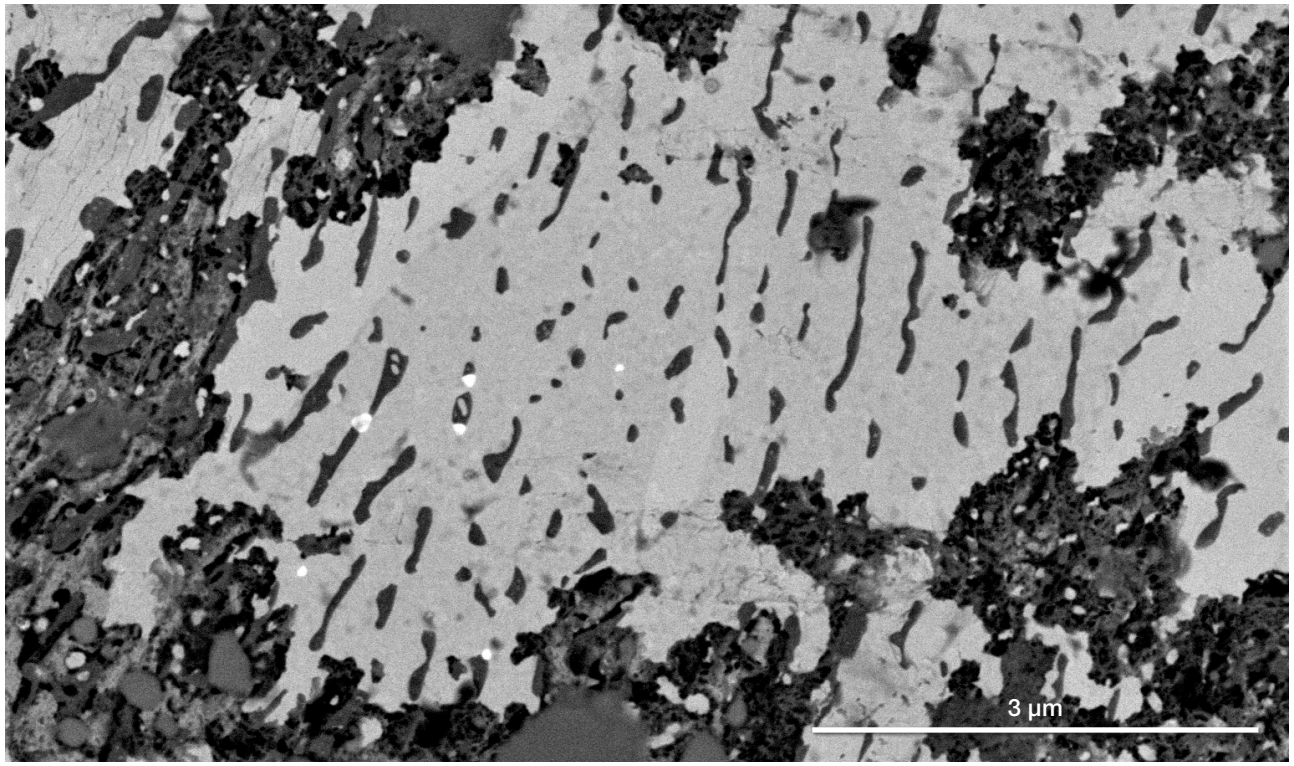


The Thermo Scientific Trinity Detection System is the Apreo 2 SEM's unique in-column and in-lens detection system. It consists of three detectors: two in-lens (T1, T2) and one in-column (T3). This unique system provides detailed information from the sample composition, morphology, and surface features.

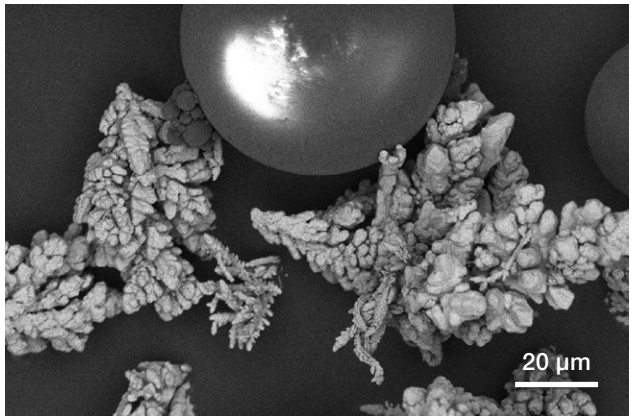
The Apreo 2 SEM ensures a short time to data with its T1 in-lens backscatter detector, which is positioned inside the tip of the final lens, close to the sample to collect the maximum amount of signal. T1 is a high-speed, high-sensitivity detector that makes materials contrast available, even when tilted.

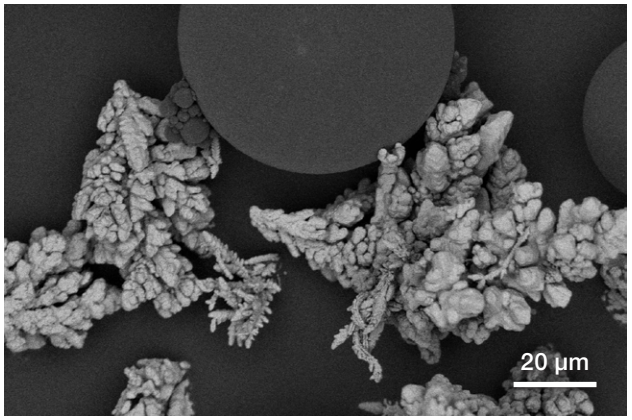
T1 Benefits

- Clear backscattered image at short or long WD and at tilt
- High speed and freedom to navigate with TV-rate BSE signal
- High sensitivity, with currents as low as a few pA
- Imaging of charging and sensitive materials



ZnAl alloy, showing excellent BSE contrast and sharpness while imaging at low voltage (2 kV), low beam current (50 pA), and at long, analytical working distance (10 mm).





Cu dendrites and polymer spheres. Acc voltage 1.5 kV, beam current 25 pA. Left image: dwell time 10 µs. Right image: dwell time 300 ns (frame integration applied). T1 enables fast and interlaced scanning.

High quality results on insulating materials in high vacuum

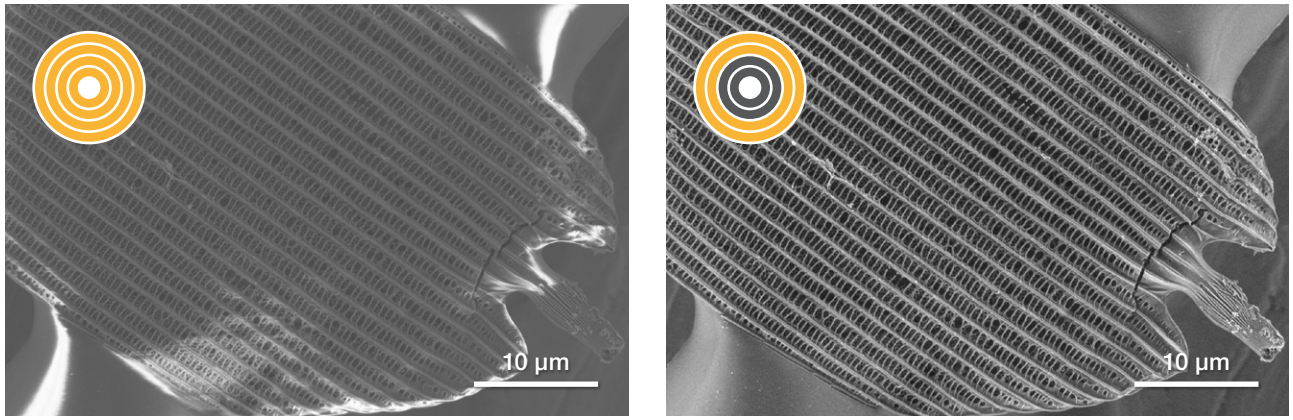
Microscopic characterization is often required for non-conductive and beam sensitive materials. Different approaches can be pursued, such as coating the materials with a conductive film or avoiding the coating and using low vacuum by injecting gas in the microscope for charge neutralization. However, both approaches are not advised in the case of sensitive nanomaterials, as they lead to decreased performance and limit the level of information that can be obtained.

The Apreo 2 SEM provides charge mitigation strategies such as different charge filtering approaches. The top images to the right have been made with the directional backscattered detector (DBS), while the bottom images show both charge filtering and contrast enhancement thanks to the compound lens filter.

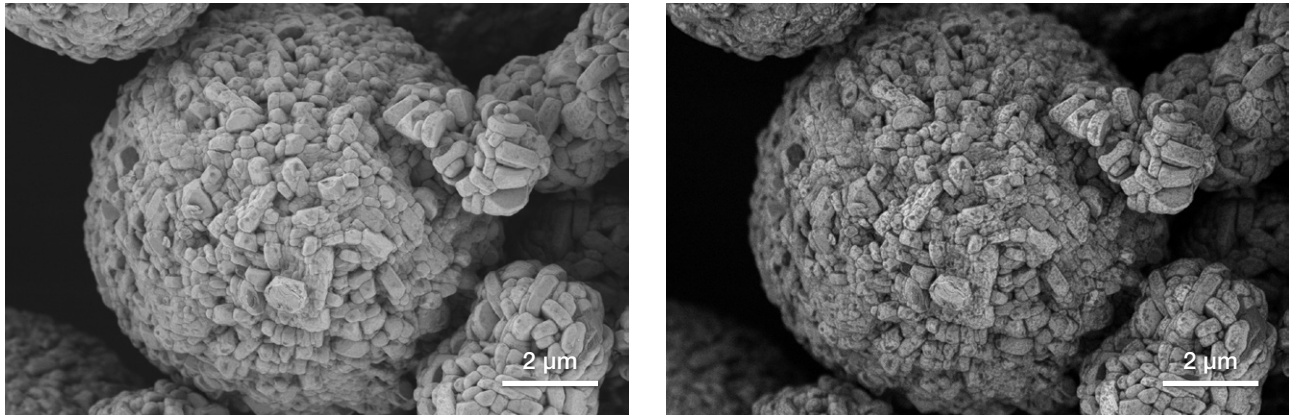
Furthermore, SmartScan and drift compensated frame integration (DCFI) allow you to achieve excellent resolutions and high material contrast on insulating samples in high vacuum.

Thermo Scientific SmartScan Technology offers different imaging and scanning strategies to optimize image acquisitions such as frame integration (enables cumulative noise reduction with integration over a specified number of frames), line integration (scans each line repeatedly several times), and interlaced scanning (minimizes charge buildup while the electron beam is scanning).

Drift compensated frame integration (DCFI) is an integration filter that corrects image drift in real time. The signal is integrated over several frames, resulting in a sharper image.



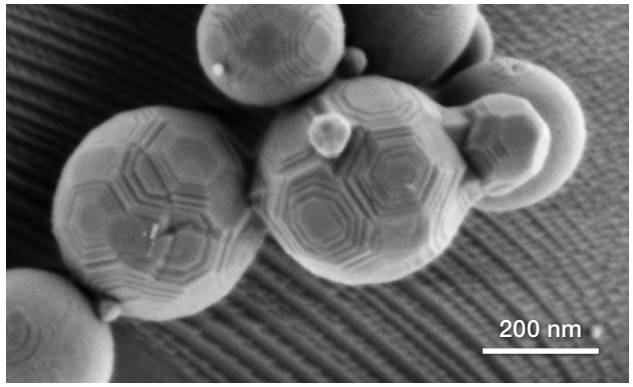
Beam deceleration coupled with selective backscattered detection filters charge from this insect wing image. Left image shows several artifacts due to the charging that are removed when deselecting the inner segments of the DBS detector. Acc voltage 2 kV, bias applied 4 kV.



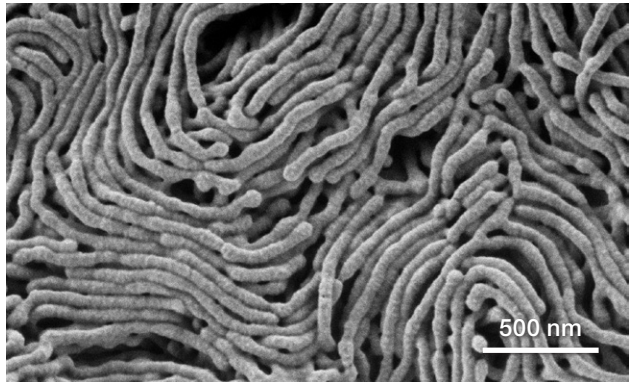
Lithium ion battery cathode with an organic coating layer. Acc voltage 1 kV, beam current 0.2 nA, T1 detector.

Apreo 2 SEM features for charge mitigation in high vacuum:

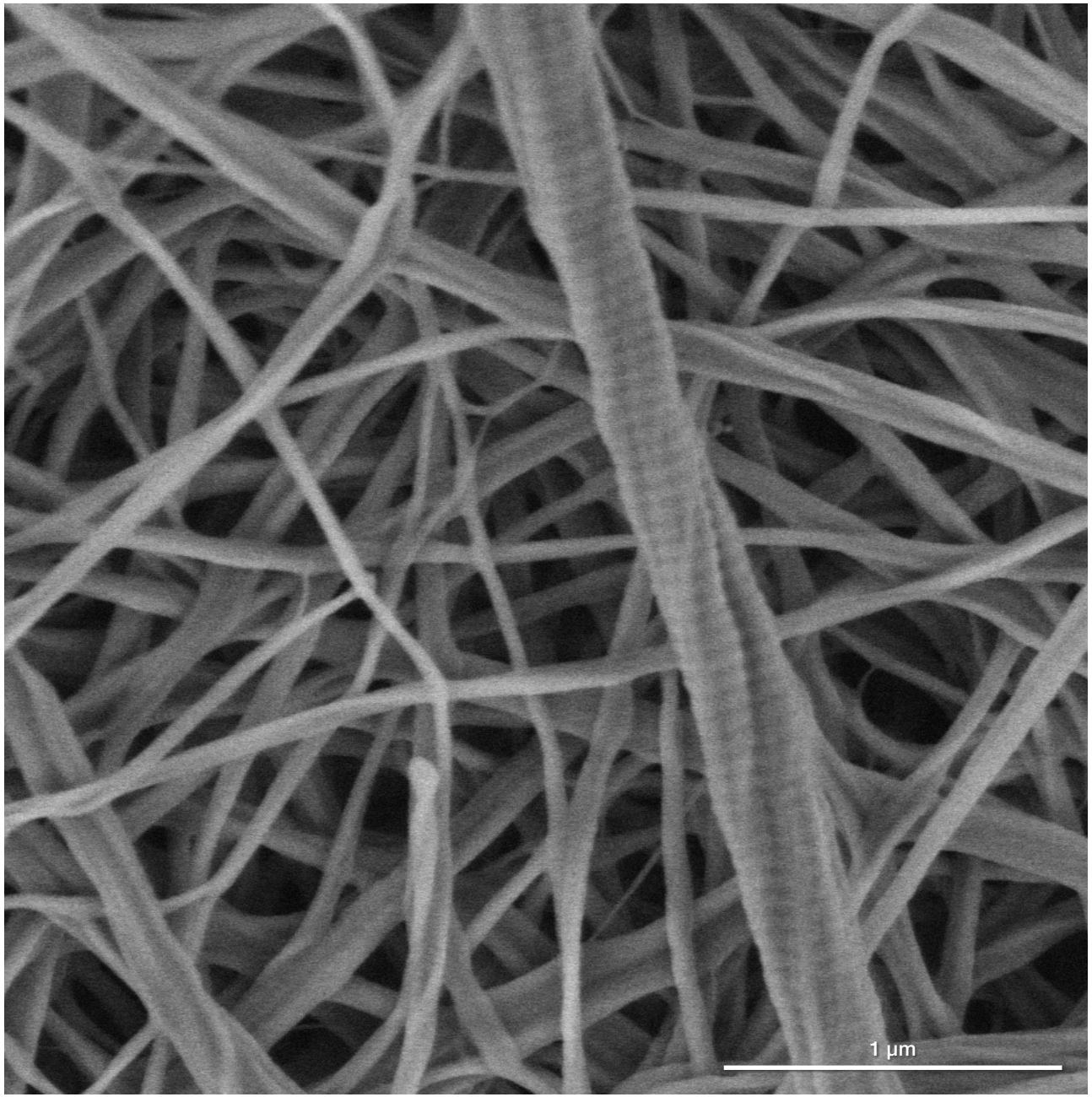
- High performance at low kV
- Low beam current can be used with high sensitivity detector (T1)
- SmartScan Technology
- Drift compensated frame integration (DCFI)
- Charge filtering with the directional backscattered detector
- Charge filtering with the compound lens filter



Alumina particles, imaged at 1 kV landing energy, 13 pA beam current.



Polystyrene and polyacrylic acid blend co-polymer. Acc voltage 500 V, beam current 3.1 pA, T1 detector, use case Immersion.

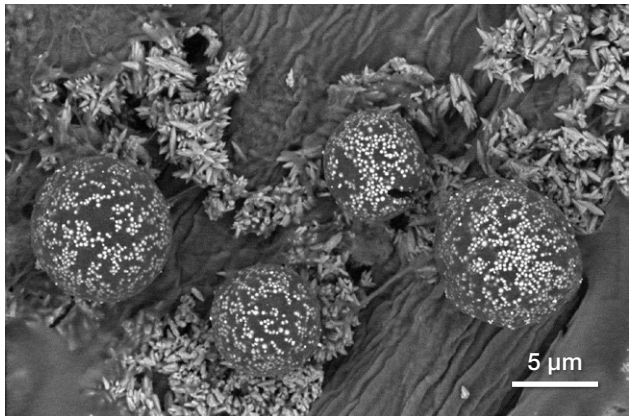


It is challenging to image polymer fibers while preserving the nanostructure. Here, they were imaged at extremely-low dose conditions: 1 kV landing voltage and 3.1 pA beam current.

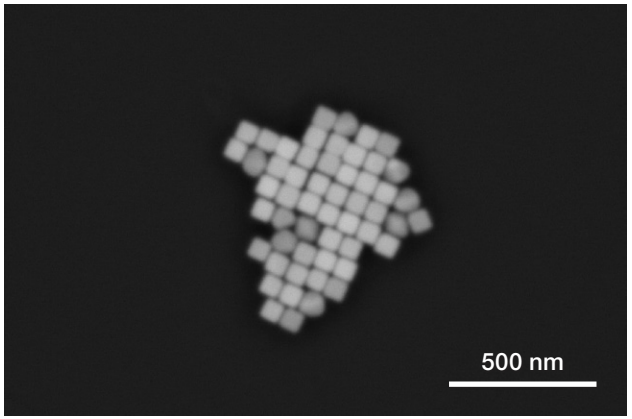
High quality results on insulating materials in low vacuum

Several applications that do not require high-resolution imaging require compositional information on charging materials. To increase the material contrast or to be able to use high beam current to perform a chemical analysis in insulating samples, low vacuum is needed. The Apreo 2 SEM allows an optional low-vacuum mode up to 500 Pa, maintaining the resolution. In this mode, large analytical currents can still be used in combination with dedicated low-vacuum detectors such as the gaseous analytical detector (GAD-DBS).

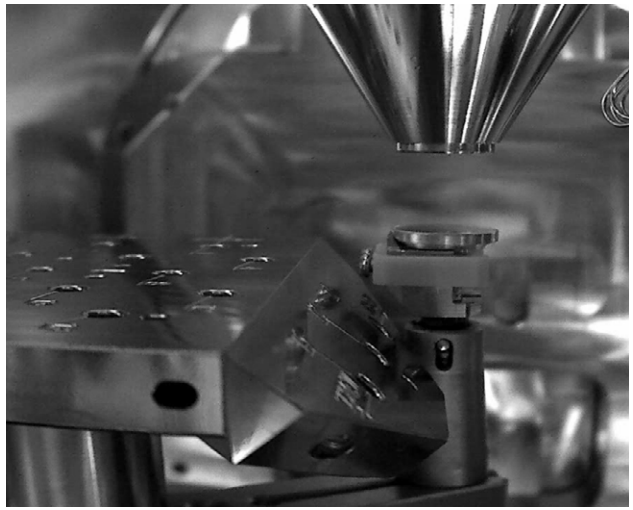
Low vacuum is now easier thanks to an automated routine to insert and remove the pressure limiting aperture (PLA). The PLA allows a seamless switch between high vacuum and low vacuum. Now you can choose the right conditions for imaging rather than stopping to vent the chamber and manually mount the PLA.



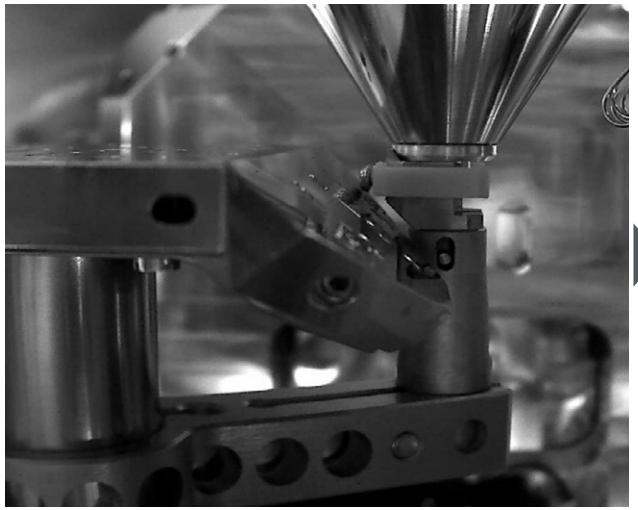
Toner. Acc voltage 5 kV, beam current 0.1 nA, GAD-CBS detector, use case Standard, pressure 100 Pa.



Au nanocubes. Acc voltage 3 kV, beam current 0.2 nA, GAD-CBS detector, use case Optiplan, pressure 50 Pa.



The pressure limiting aperture (PLA) is pre-mounted on the side of the multipurpose sample holder.

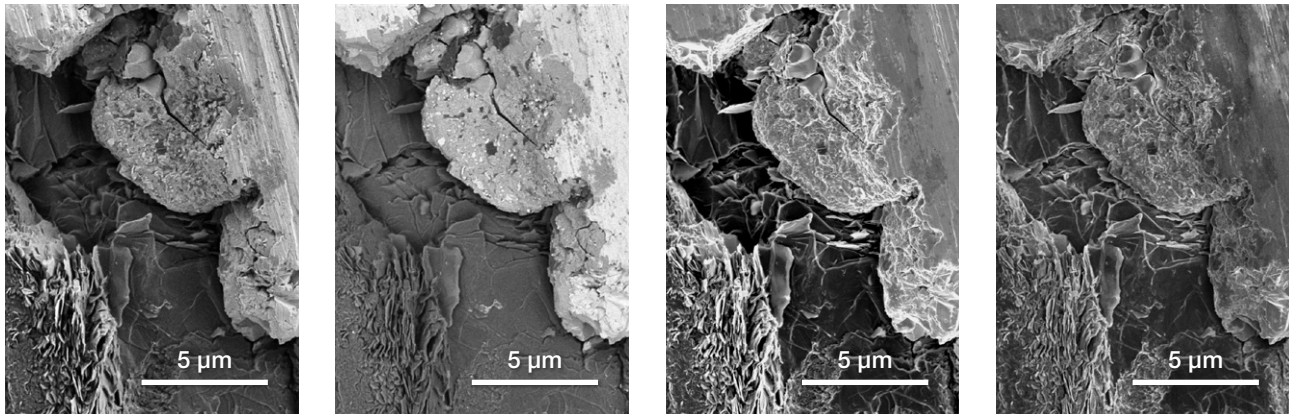


An automated routine moves the stage in order to insert the PLA when switching between high vacuum and low vacuum.

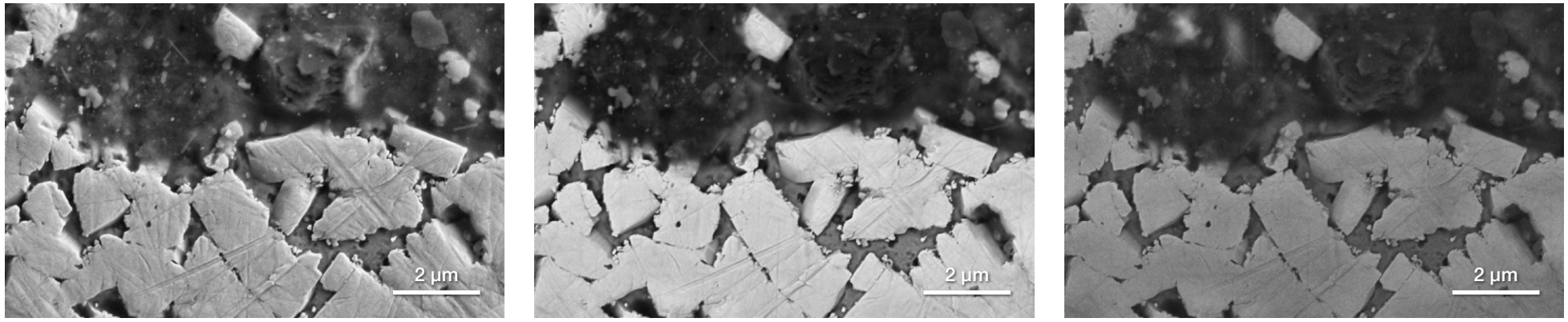
As soon as the PLA is mounted, the stage moves aside and the system is ready for low vacuum imaging up to 500 Pa chamber pressure.

Long working distance performance

Conventional SEMs often require short working distances to achieve high resolutions, making the systems difficult to run. This is especially true when multiple samples are loaded or when tilting is required. This also leads to reduced performance for novice users who prefer to stay at longer working distances. The Apreo 2 SEM is the only SEM with high-resolution performance (1 nm) and excellent image quality at analytical working distance (10 mm), offering worry-free operation for all users. Analytical working distance provides immediate access to elemental information with EDS (see also the ChemiSEM Technology chapter), so that switching between imaging and analysis is fast.



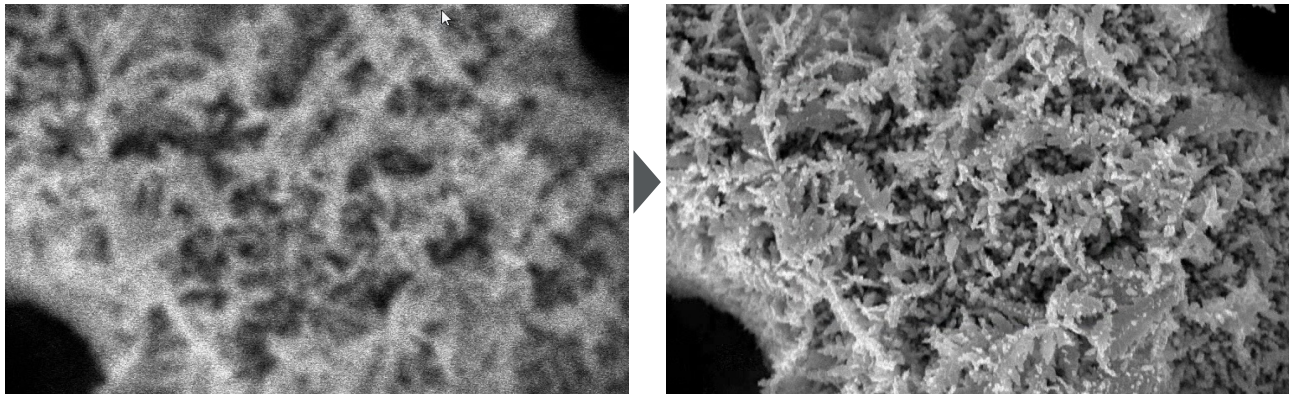
Some samples feature an interesting surface topography, multiple material types, as well as surface charge variations or very thin layers. Using ETD, T1, T2, and T3 detectors, all those features are picked up in a single scan. Top: cross section of a carbon fiber / brazing alloy composite. Bottom: polycrystalline diamond cutting tool.



Section analysis of a PDC cutting image acquired at 5 kV, 0.1 nA and 10 mm WD. Use case OptiPlan. Detectors from left to right: ETD, T1, T2.

FLASH Technology

FLASH Technology removes the need for user alignments by automatically setting the correct lens alignment, centering, astigmatism, and focus needed for a specific area of interest and imaging settings (accelerating voltage and beam current). It automates, with just a few mouse clicks, all the fine-tuning processes required for high-resolution imaging. This ensures the best alignments for every user and also excellent results at high magnification. FLASH Technology works with all the available detectors.



Before (left) and after (right) FLASH.

Alignment		Previous generation	Apreo 2 SEM
User alignments	Focus, stigmator	Every image	Managed by FLASH
	Lens alignment	Daily / kV / current	Managed by FLASH
Supervisor alignments	Tip drift compensation	Every 2-3 months, manual start	Unattended (scheduled)
	Full system alignments	Every 6-12 months, over weekend	Every 6-12 months, 3 hours

SmartAlign: Expert results from any user

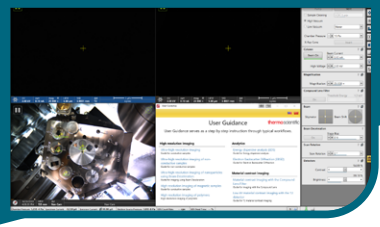
The Apreo 2 SEM makes sure it is always aligned, thanks to a series of automated alignments that can be scheduled to run unattended, requiring minimum effort to keep the system at optimal conditions. The automated source tilt alignment helps ensure the source is always aligned and will run every time the system changes its condition (both if the accelerating voltage or the beam current are changed).

User guidance

The user guidance function 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 SEM UI, allowing you to execute functions through the guide or simply use the guide as a learning tool.

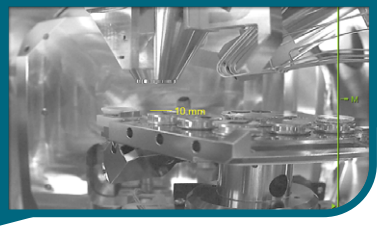
1

Sample loading



2

Sample navigation

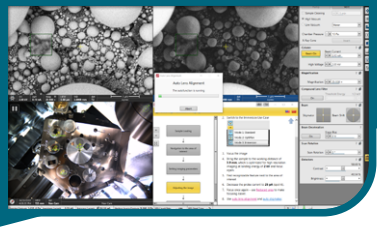


3

Setting imaging parameters

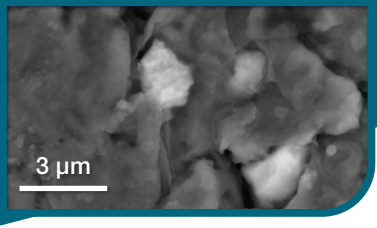
4

Adjusting the image



5

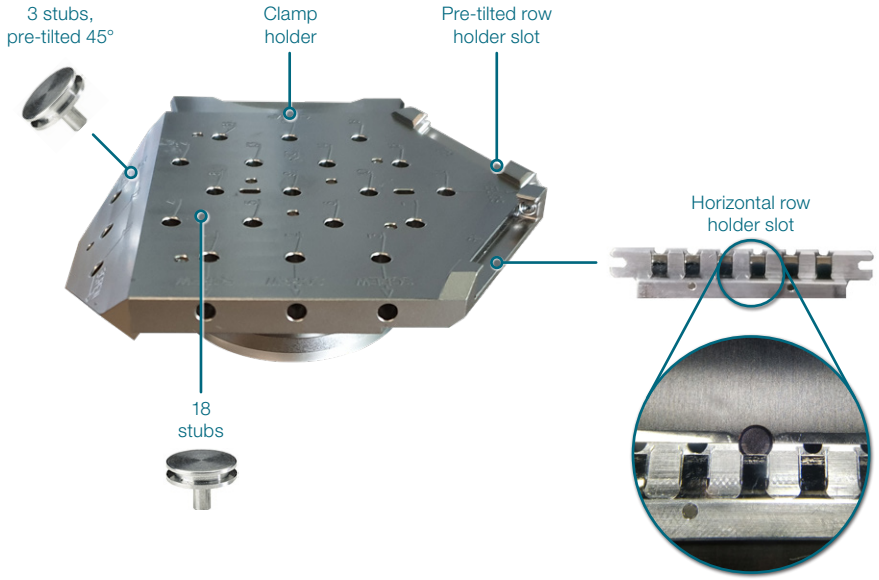
Taking the final image



Easy sample loading

Research facilities and industrial R&D labs often face the need to accommodate many users or, alternatively, to be able to accommodate a high number of samples. Both situations lead to a requirement for increased throughput and higher usage flexibility.

The Apreo 2 SEM multi-purpose sample holder meets these needs, as it uniquely mounts a wide range of different sample types directly onto the stage without the requirement of mounting tools. All stub positions are marked for easy navigation.

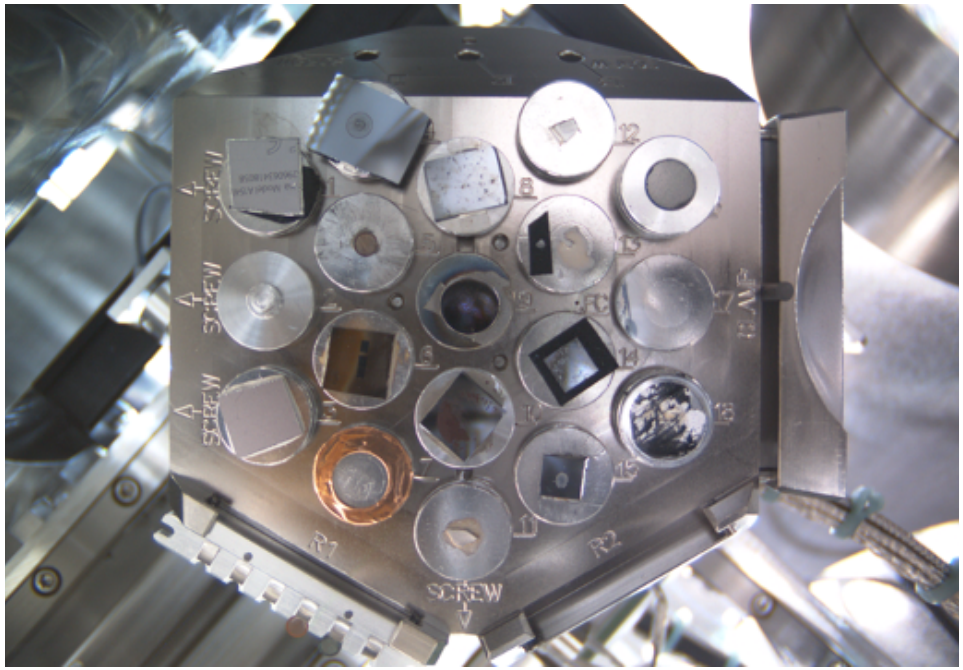


Schematic highlighting key features of the multipurpose sample holder.

Easy sample navigation

For increased ease of use and navigation, you can take advantage of the Thermo Scientific Nav-Cam™ Camera, which enables you to track saved positions as well as the current imaging location. It is fully integrated into the SEM user interface and graphically shows holder rotation and beam location.

The Nav-Cam Camera allows you to quickly traverse the entire sample holder with point-and-click navigation, letting you reach your area of interest with ease. As the camera displays a color image, it is easy to differentiate between different samples, letting you take advantage of any multi-sample holder. It provides the easiest sample handling and navigation and, in combination with the multi-purpose sample holder, saves you time by loading multiple samples at once.

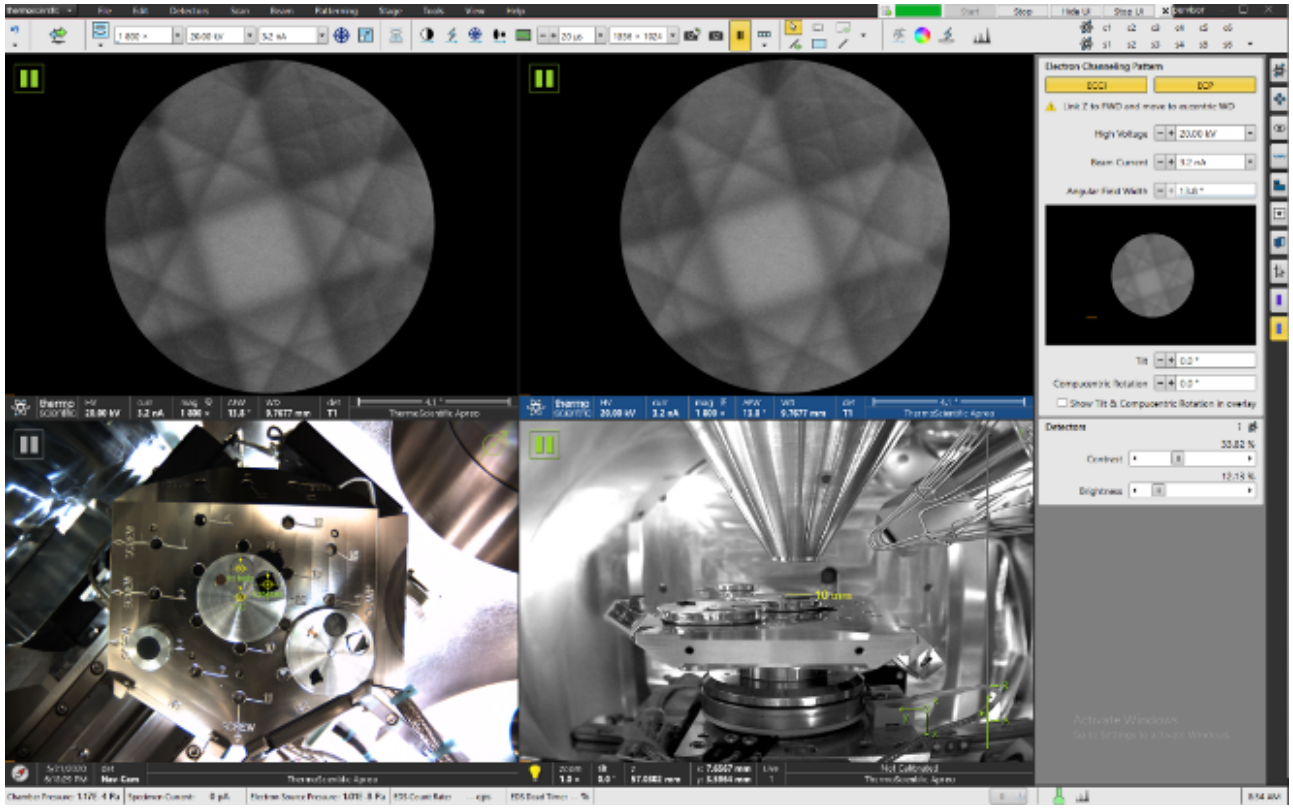


Nav-Cam camera image of the multi-purpose sample holder.

Easy access to crystallographic information with PivotBeam

The nature and distribution of dislocations or lattice defects is regularly studied with EBSD or TEM. However, without the need for those techniques, the SEM is uniquely able to visualize individual defects on bulk samples using electron channeling contrast imaging (ECCI). ECCI requires that the crystal of interest is oriented in order to meet the channeling condition. As a result, it appears dark in a backscatter image, while the defects show up as bright. It is typically a challenge to bring the sample into the correct orientation using stage rotation and tilt.

The Apreo 2 SEM introduces PivotBeam for selected area electron channeling (also known as “rocking beam” mode). When orienting a sample for ECCI, you are no longer working in the blind, but instead, directly observe the channeling conditions as bands in a k-space image. PivotBeam keeps the beam on a single area (<10 µm diameter) while scanning the incident angle over more than 4.5 degrees. It comes as an integrated routine, is fully automated, and available with a single click.



PivotBeam routine is integrated in the SEM UI.

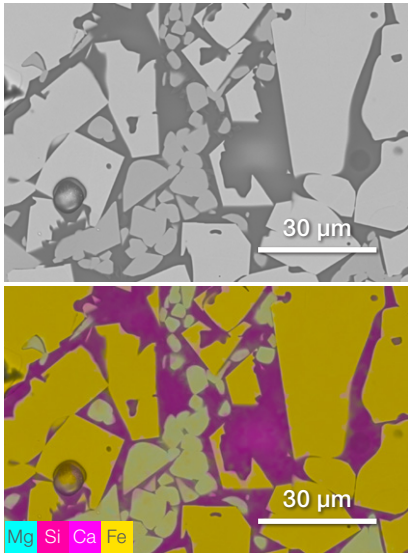
ChemiSEM Technology

The advantage of SEM is that, besides resolution, it provides elemental microanalysis (EDS). In traditional EDS systems, you usually navigate through complex workflows to get to your answer. This is not only time consuming because of the need to set up the acquisition with the proper parameters, but also overwhelming for new users as there is a certain level of knowledge required to acquire reliable results. Moreover, many EDS solutions present you with gross X-ray counts maps, which can easily lead to misinterpretation in the case, for example, of peak overlaps. From those maps, yet another set of post-processing steps is required to finally produce quantitative information.

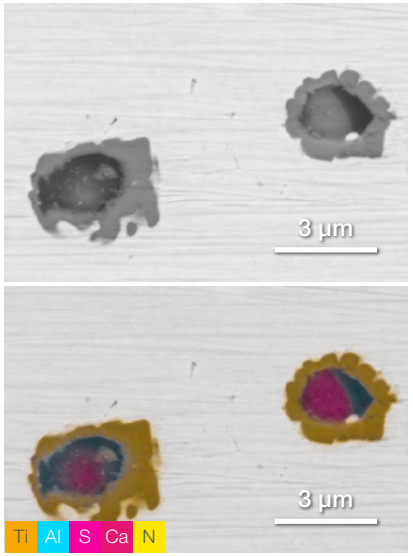
Thermo Scientific™ ChemiSEM Technology offers a leap forward in usability, convenience, and speed of analysis. It integrates state-of-the-art elemental analysis with the electron image in real time.

Within one software interface, you can:

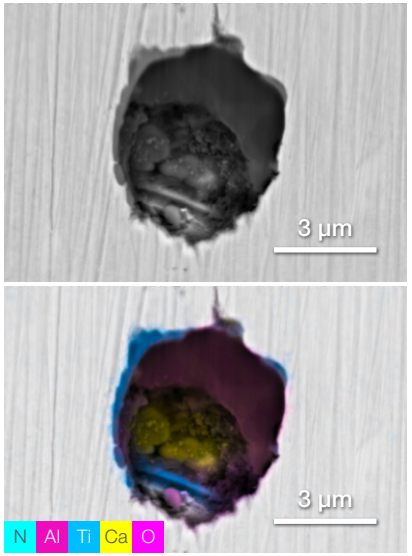
- View the sample image from any electron detector
- See areas of different chemical composition on the sample surface
- Create viewpoint and area compositional analyses with a single click
- Chart compositional changes across the sample
- Create maps of elemental or phase distribution across the sample



Mg, Si, Ca Fe quantitative overlays within a complex section. Acquired at 15 kV, 1.6 nA.



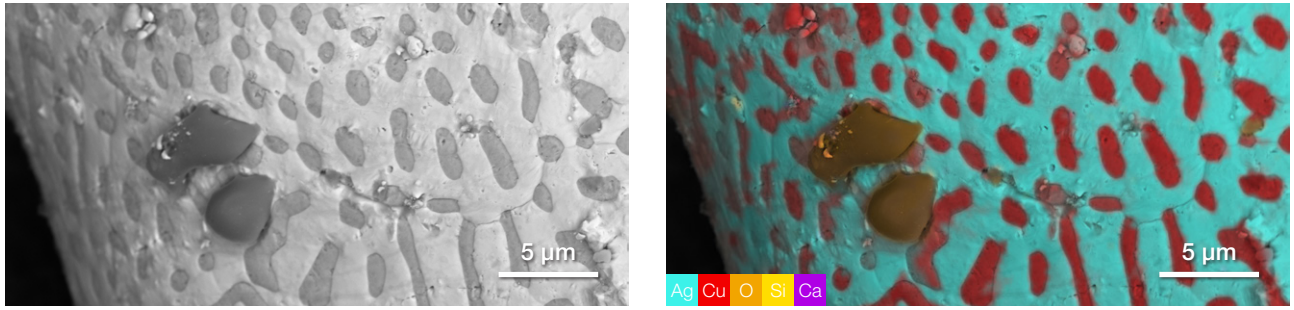
Inclusions in steel.



Inclusion in steel.

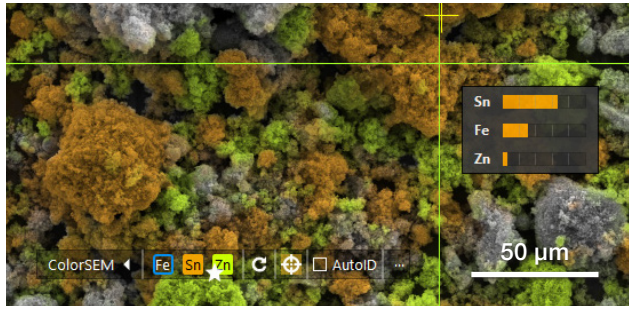
ChemiSEM Technology revolutionizes and simplifies EDS analysis by fully integrating SEM and EDS functions into a single, cohesive user interface. Based on live quantification and building on decades of expertise in EDS analysis, the technology provides elemental information quickly and easily, guaranteeing reliable results. And because ChemiSEM Technology is always on, it can dramatically shorten time to results, highlight features that would have previously gone unnoticed, and provide more complete information.

Complete information



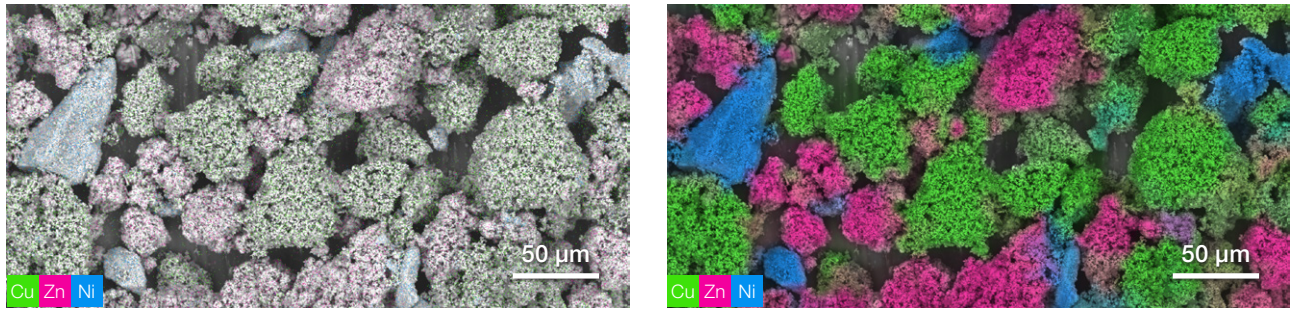
Si and Ca-rich contamination on a AgCu particle. Acc voltage 10 kV, beam current 0.8 nA, T1 detector, pixel dwell time 1 µs, acquisition time 70 s.

Intuitive elemental analysis



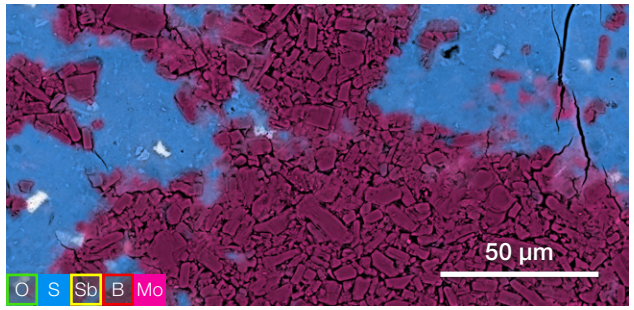
ChemiSEM provides a qualitative point & ID, even available during live scanning.

Shorter time to results



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

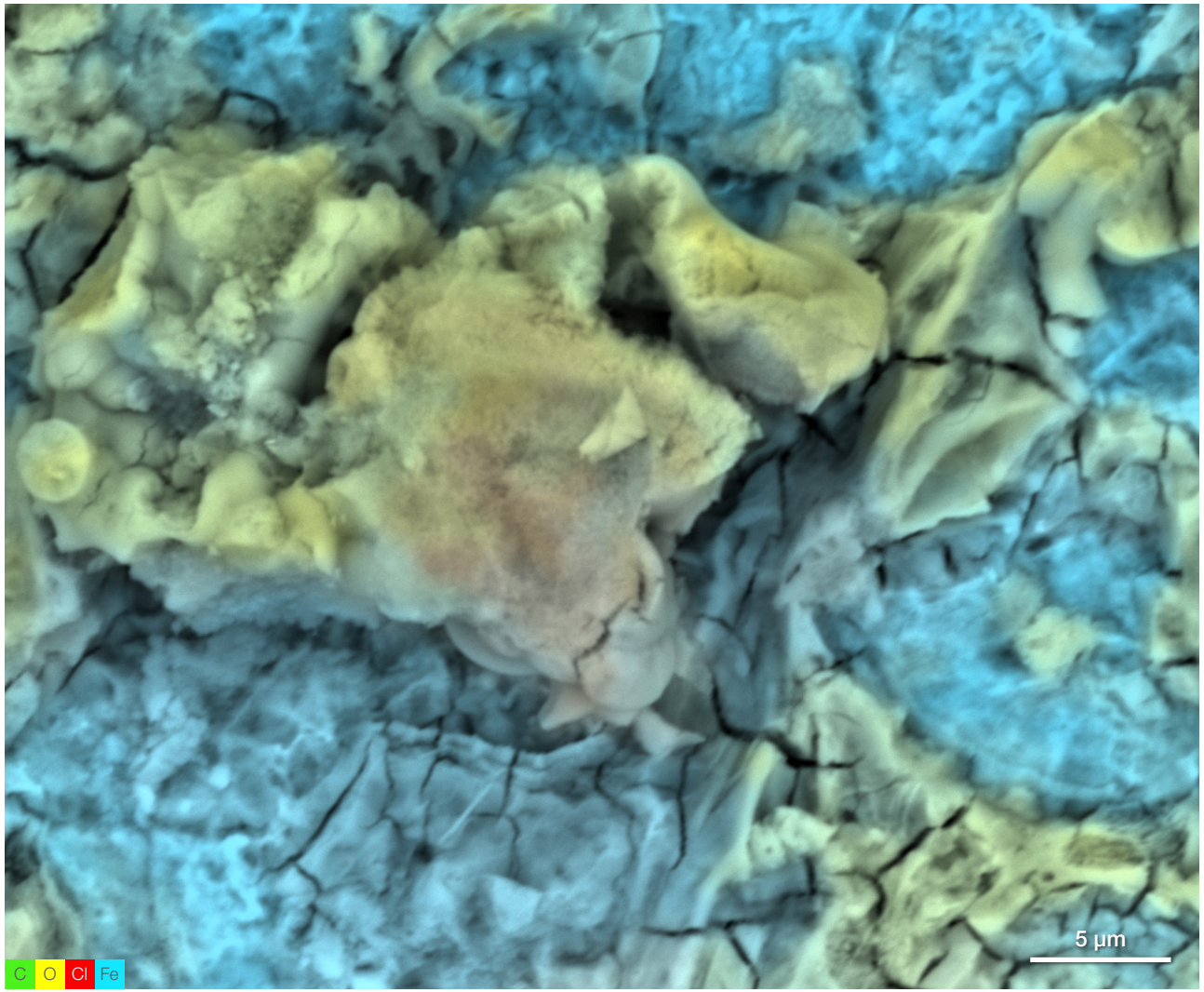
Reliable results



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

Benefits of ChemiSEM Technology

- Always on: Eliminate the need to move from SEM imaging to EDS analysis for each sample. ChemiSEM is always on and continuously collects the EDS signal during SEM imaging, collecting a full EDS spectrum at every point in the image.
- Faster data acquisition: Access elemental information much faster than conventional techniques with novel data segmentation approaches based on machine learning, ultrafast signal processing, and the tightest possible SEM EDS integration.
- Reliable results: Get accurate qualification and quantification over the widest range of operating conditions, including beam energy, sample size, and working distance.
- Complete information: See the big picture with comprehensive micro-scale elemental composition. Immediate color results reveal defects or imperfections you might have otherwise missed.
- Multi-data viewing: See SED and elemental information in a single frame for complete characterization of your sample at a glance.
- Simplified operation: Immediately view compositional results that make elemental information accessible to everyone and easily increase the number of scientists or engineers who can use your facilities.



ChemiSEM analysis of corrosion in etched steel, showing presence of Cl rich regions. Acquired at 1.2 nA, 15 kV.

A seamless SEM-EDS workflow

ChemiSEM Technology was built from the bottom up to provide full control over all SEM and EDS functions within a single user interface. Experiment setup, image processing, and spectral analysis functions are intuitively grouped, making data management straightforward. And the system features a quadrant format and project tree to highlight the most important data.

Interface functions:

A. View your sample

B. Switch between quantitative maps, count maps, and phase distribution maps

C. Generate a full-color overlay from any number of quantitative X-ray maps

D. Analyze any area of the ChemiSEM datacube using extract tools

E. Select and unselect elements of interest in the periodic table

F. Manage all data acquisitions in the project tree and easily generate reports

G. See either the atomic% or the weight% in quantitative maps

Identify unique phases using advanced statistical analysis

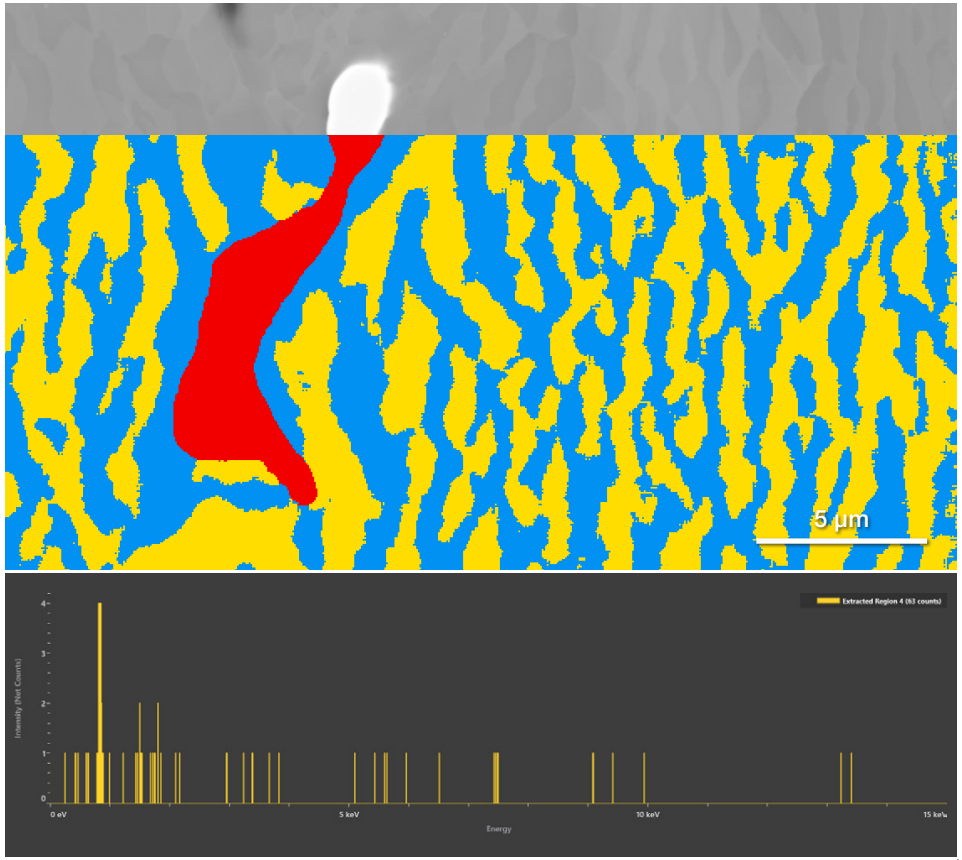
ChemiPhase analysis uses a big data approach to detect all statistically significant spectra within the datacube. It provides a simple probability that each pixel belongs to each detected significant spectrum. This makes interpretation of complex samples much more straightforward and intuitive because each pixel can only belong to a single phase.

ChemiSEM user interface showing combined SEM-EDS operation in a single display.

ChemiPhase analysis is a comprehensive, unbiased statistical engine. This avoids problems with traditional methods, which often yield erroneous results if unexpected elements are missed due to overlapping peaks or insufficient intensities. Traditional phase determination is highly dependent on assumptions about the sample.

Benefits of ChemiPhase analysis

- No user bias
  - Run the fully automated process with no prior identification of elements
  - Locate minor and trace elements without extensive experience
- Complete and comprehensive analysis
  - Unambiguously identify major and minor components down to a single pixel
  - Locate unique components where peak overlaps obscure significant elements
- Fast acquisition
  - Start phase determination with very little X-ray data—as few as 10 counts per pixel
  - Complete most acquisitions in less than a minute, even for complex phase maps
- Reduced complexity
  - View a simple image-spectrum pair for each distinct phase
  - Automatically optimize all spectra for more confident analysis



Element	Ni	Co	Cr	W	Ta	Al	Re
wt.% γ’	Bal	6.8	4.9	4.6	8.2	6.6	1.2
wt.% γ	Bal	9.4	9.6	7	3.8	4.4	4.7

ChemiPhase identification in a Rene N5 Ni-based superalloy. The image shows a tantalum carbide in the base alloy, which is made of two phases: gamma (blue) and gamma prime (yellow). ChemiSEM quantification of each of the phases was calculated from only 30 average counts per pixel, as shown in the extracted point spectrum from the gamma phase.

Software automation

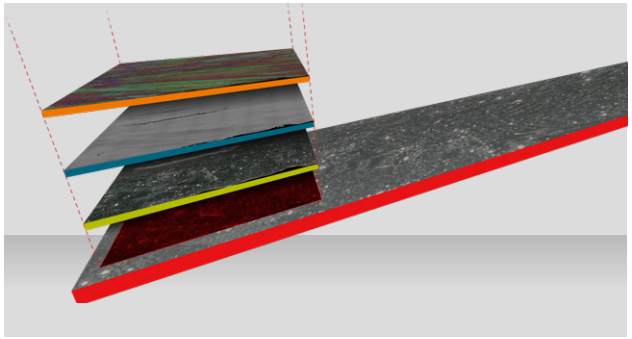
Maps Software

Thermo Scientific Maps™ Software is an intuitive automation and correlative workflow software suite for Thermo Scientific SEM, DualBeam™ FIB-SEM, and TEM platforms. Maps Software offers distinctive key features such as the ability to automate your acquisitions by running multiple samples in a series to increase system productivity or to automatically acquire up to four simultaneous signals. You can even plan to do this overnight or across a weekend. Furthermore, Maps Software offers a multi-scale, multi-layered visualization environment in which 2D and 3D data and imagery from other modalities (e.g., EDS maps, EBSD) can be imported from any source, easily and accurately correlating layers.

System automation

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

- Included with all SEM/SDB (small DualBeam) platforms
- Automate single frames to large mosaics
- Auto functions that ensure quality imaging
- Offload routine imaging to nights and weekends



Correlative microscopy

Explore and interpret all your data efficiently while ensuring that the context of multi-modal collections is preserved.

- Import and register any image format
- Multi-modal interpretation and navigation
- Support for 3D data import
- Workflow support for image registration

Visualize, annotate, and share

Maps Software enables basic visualization, even outside the office. It also features a free offline viewer.

- Correlative functions with full offline version
- Annotation supported online and offline
- Measure angles, lines, and choose ROIs

AutoScript 4 Software

Thermo Scientific Autoscript™ 4 Software is a Python-based application programming interface (API) that offers control of the Apreo 2 SEM and other Thermo Scientific systems. It opens up the microscope to a world of advanced functions that can be used for powerful automation.

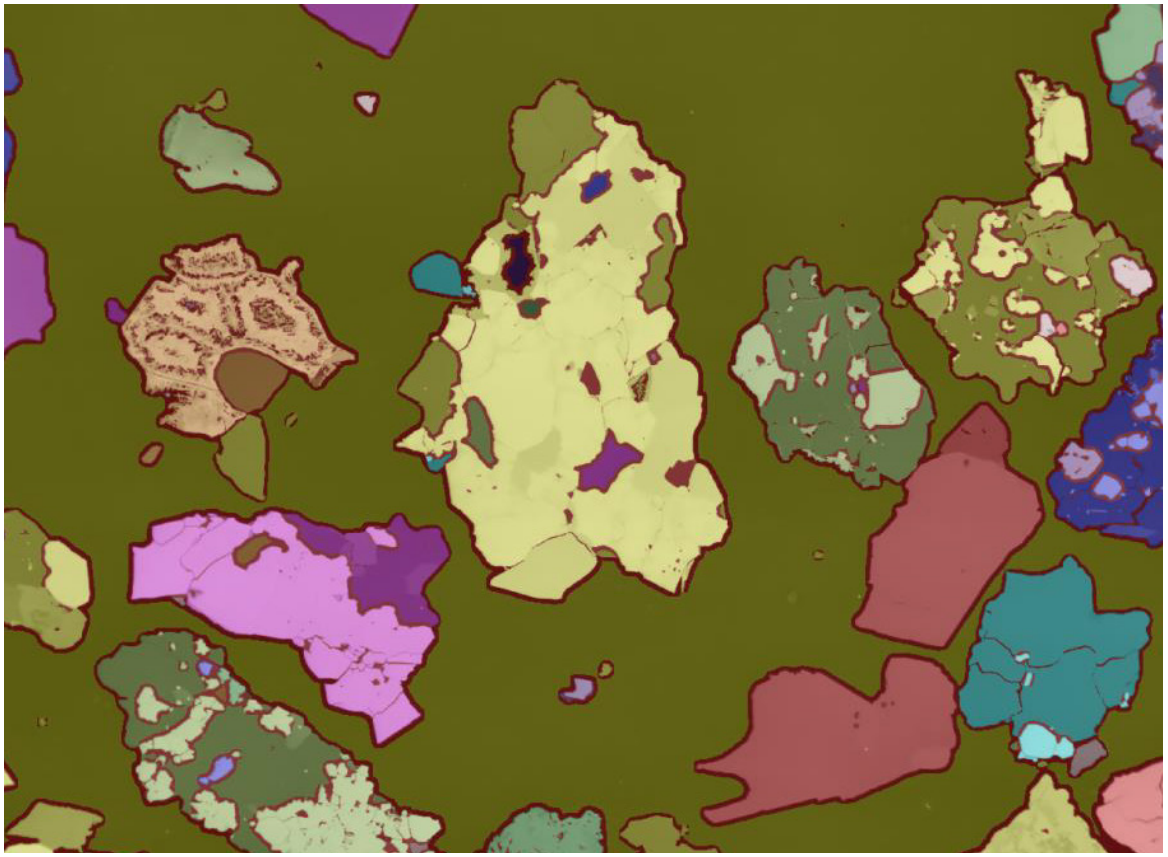
Key benefits

- 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 greatly 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.

About Thermo Fisher Scientific

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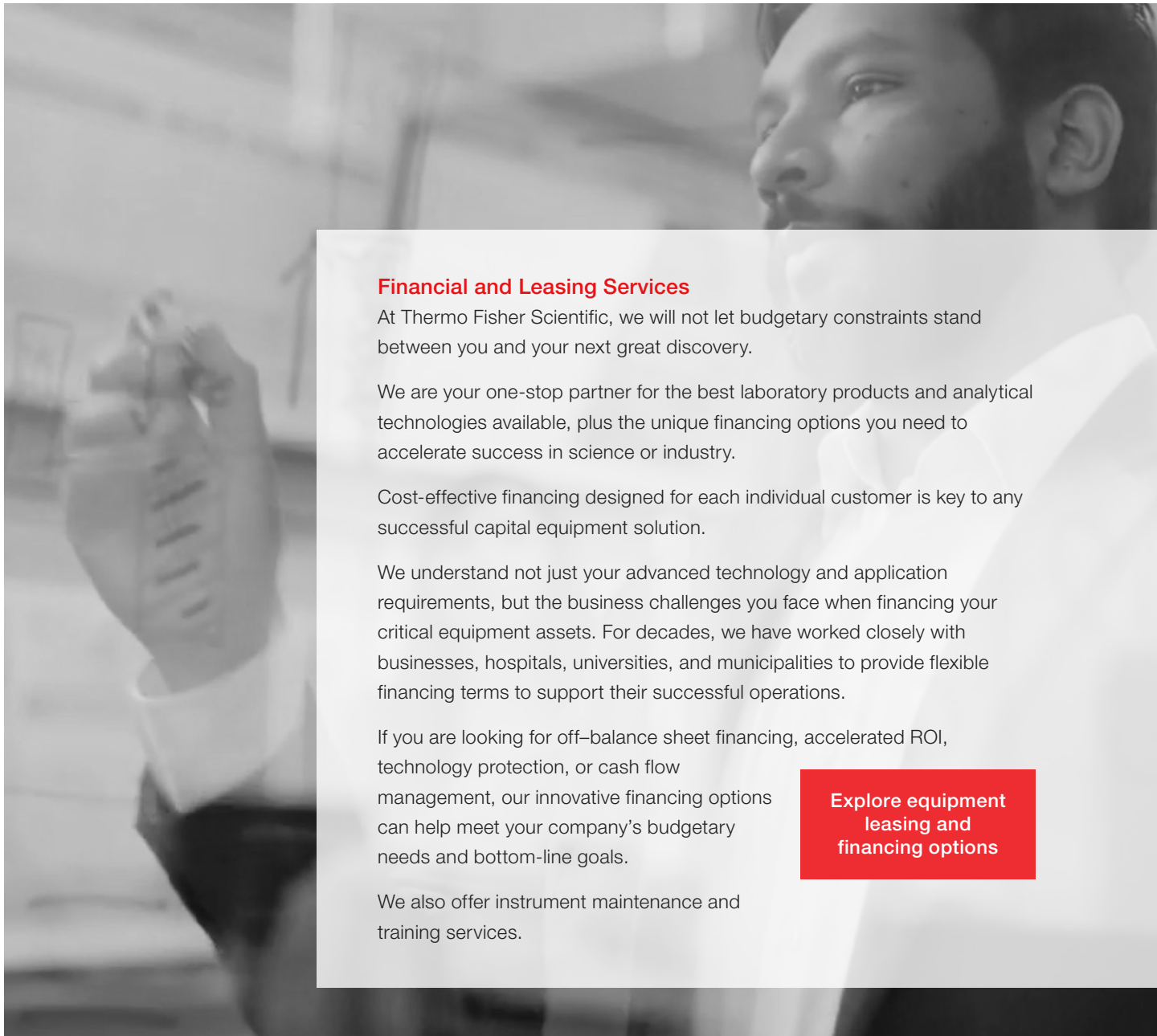
Our innovative solutions for electron microscopy, surface analysis, and microanalysis help materials science researchers advance their sample characterization to gain deeper insight into the physical and chemical properties of materials from the macroscale to the nanoscale. Our multiscale, multimodal solutions cover a broad range of applications across dozens of industries and research fields, serving customers in academia, government, and industry. Our TEMs, DualBeam™ FIB-SEMs, comprehensive portfolio of SEMs, XPS, and microanalysis solutions, combined with software suites, take customers from questions to usable data by combining high-resolution imaging with physical, chemical, elemental, mechanical, and electrical analysis across scales and modes.



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At Thermo Fisher Scientific, we will not let budgetary constraints stand between you and your next great discovery.

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We support you across the lifetime of your system

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Thermo Fisher Scientific maintains an extensive global service logistics network of central warehouses, regional hubs, and local stock locations. This allows us to be able to fulfill customer needs in a short time from request. We use a multi-level resources approach to support each field service engineer, providing them with comprehensive service network in order to deliver the best customer service. The moment you purchase a Thermo Scientific system, your success becomes our utmost priority. From installation services to on-site and remote maintenance agreements, our team of experts is here to support you at every step.

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Our service innovation team is focused on improving our customer's experience by collaborating with R&D to drive reliability and supportability of next-generation systems. Service innovation focuses on anticipating future service needs and trends by developing new tools and capabilities to improve system performances.

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