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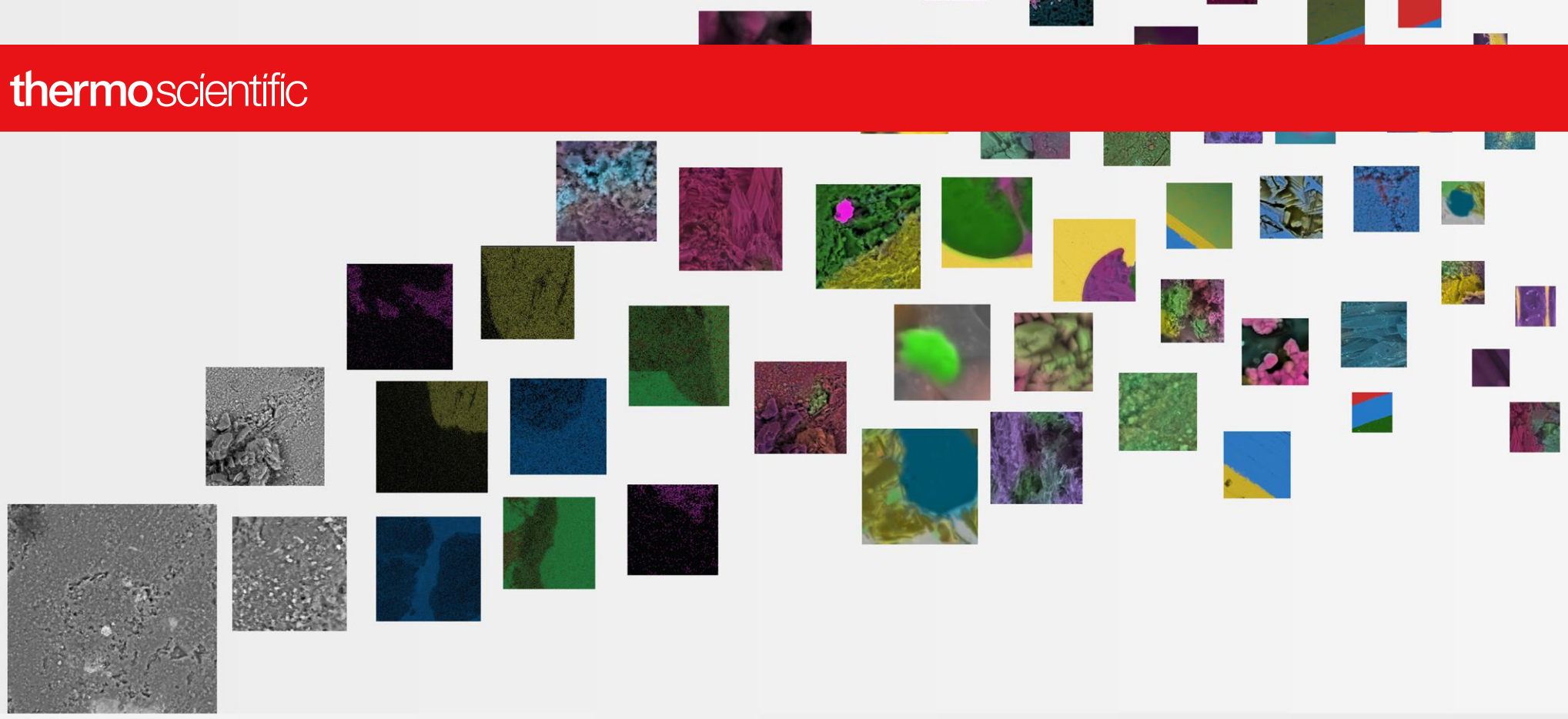


Apreo 2 SEM

Unmatched versatility powered by ColorSEM Technology

ThermoFisher 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 Fisher Scientific recently launched Thermo Scientific™ ColorSEM Technology, providing a step change in time-to-elemental-data. For the first time, ColorSEM Technology is available on a high-performance instrument with the introduction of the all-new Thermo Scientific™ Apreo 2 SEM.

Introduction

The Apreo SEM has earned a reputation for its versatility and high-quality imaging performance—even on magnetic or other traditionally difficult samples. The new Apreo 2 SEM improves upon the original by improving its already impressive resolution specifications and introducing live quantitative elemental mapping, as well as adding a number of other new features designed to make its advanced capabilities even more accessible.

Highlights

- All-round nanometer or sub-nanometer resolution performance on materials ranging from nanoparticles, powders, catalysts, and nanodevices to bulk magnetic samples, even at long (10 mm) working distance
- Extreme flexibility for handling a wide range of sample types, including insulators, sensitive materials, and magnetic samples, and for collecting the data that matters most to your application
- Less time spent on maintenance with an optics system that aligns itself (SmartAlign)
- Elemental information at your fingertips with ColorSEM Technology for live quantitative elemental mapping for unprecedented time to result and ease of use
- PivotBeam for easy access to crystallographic information
- Advanced automation including Undo, User Guidance, and Maps tiling and stitching

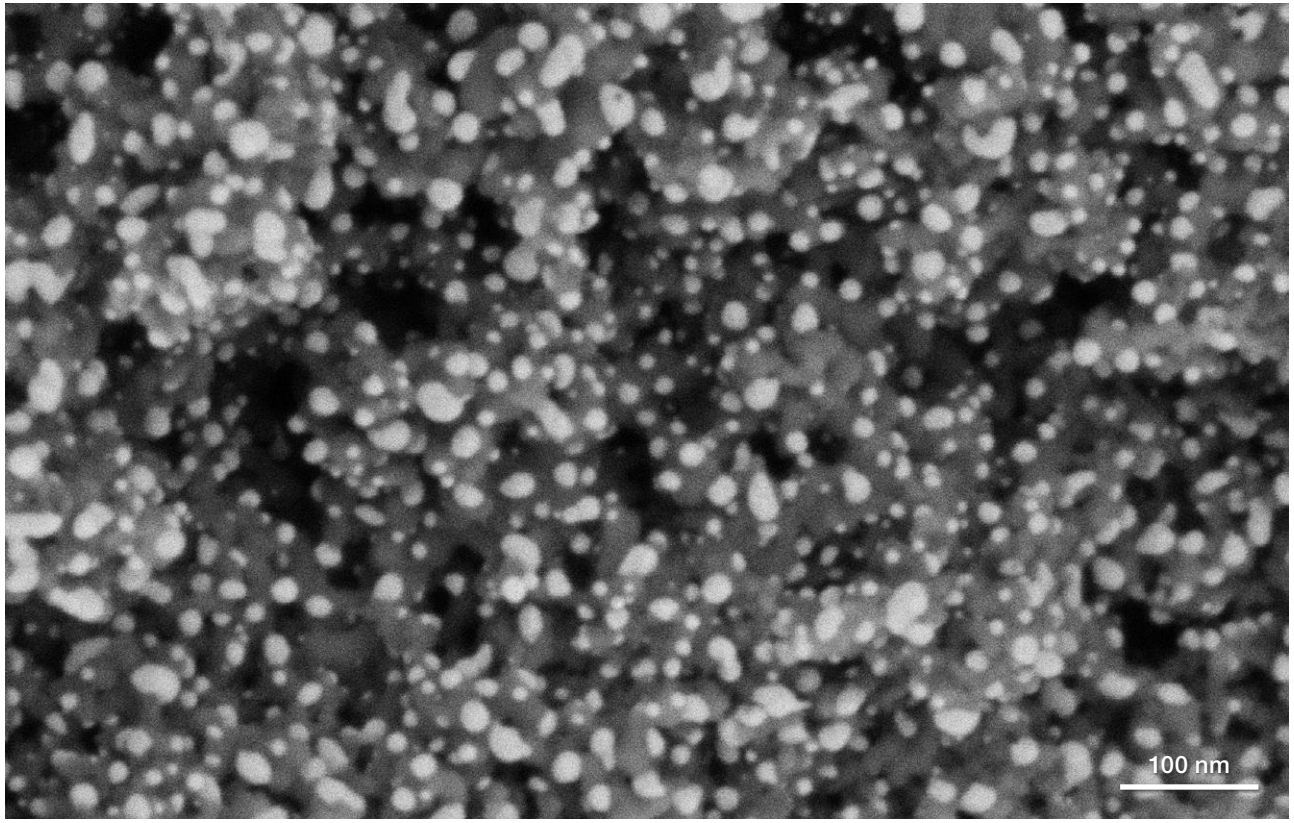
High performance and extreme flexibility

Best image quality for the widest range of materials

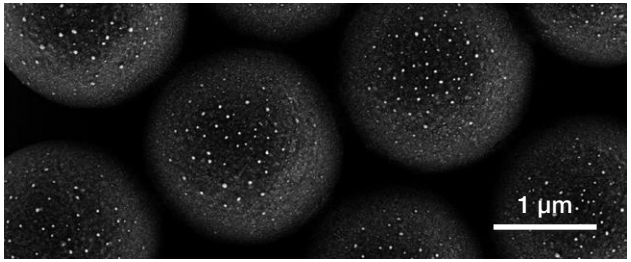
The constant search for improved performance and higher qualitative characteristics of the final products has always been key to the growing use of innovative materials. Furthermore, materials research focuses on the development of new advanced materials as the demand increases in several markets, such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

Nanomaterials have played an important role in this regard by helping to improve various characteristics thanks to their unique physical and chemical properties. The characterization of their behavior is crucial both when designing new materials and later during the production phase when assessing their final properties for a specific application. This requires tools with high-resolution capabilities and discrete flexibility for a wide range of applications.

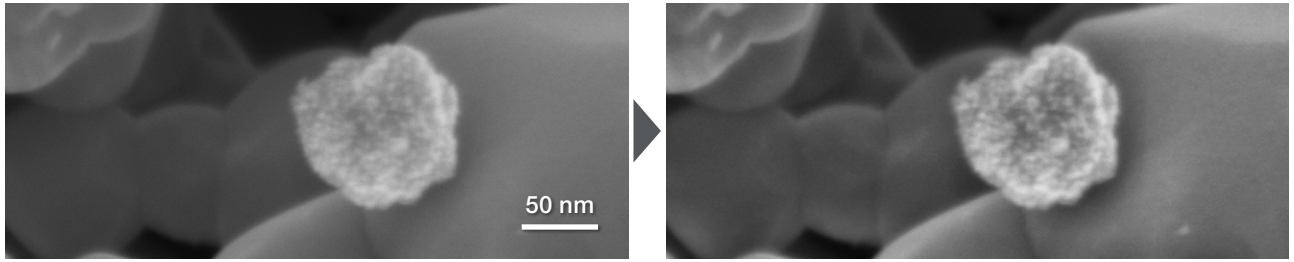
The new Apreo 2 SEM improves upon the popular original platform by increasing its already impressive resolution specifications to be able to meet the needs for characterization of different type of materials. The electrostatic final lens enables simultaneous in-column detection at high resolution. Higher 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.



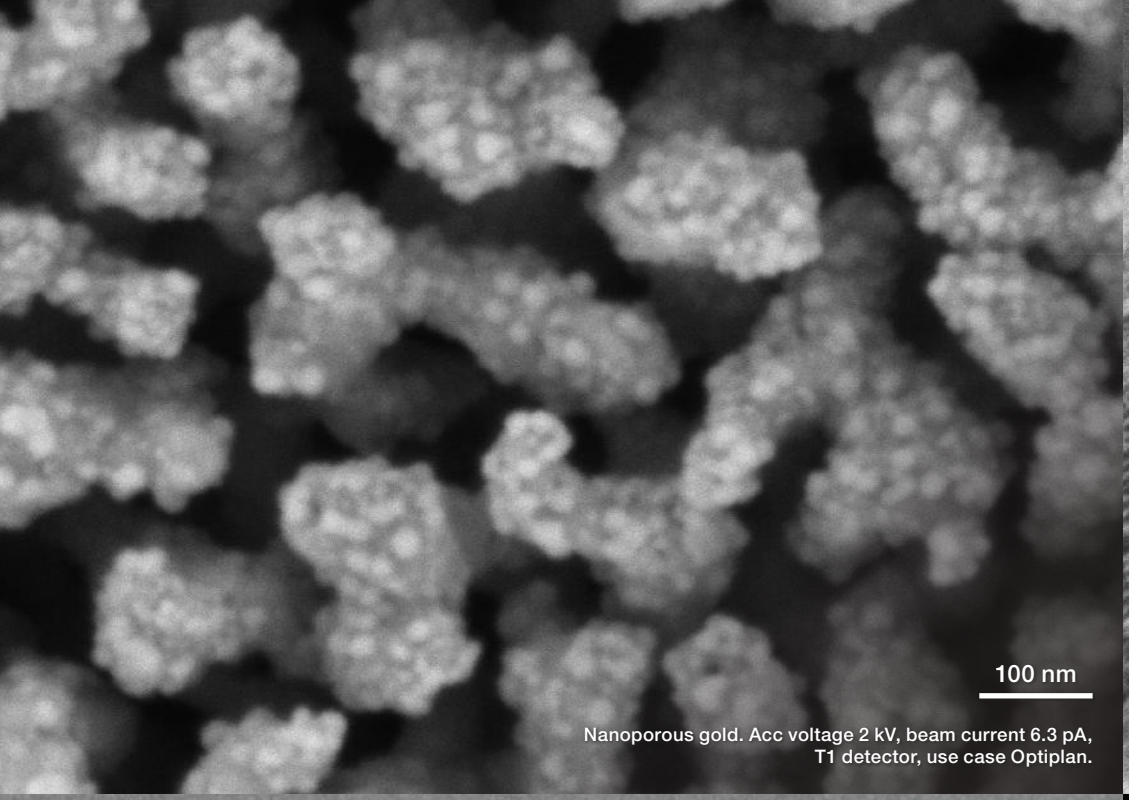
Ag NPs on TiO_2. Acc voltage 1 kV, beam current 6.3 pA, T2 detector, beam deceleration (BD) on, use case Immersion.



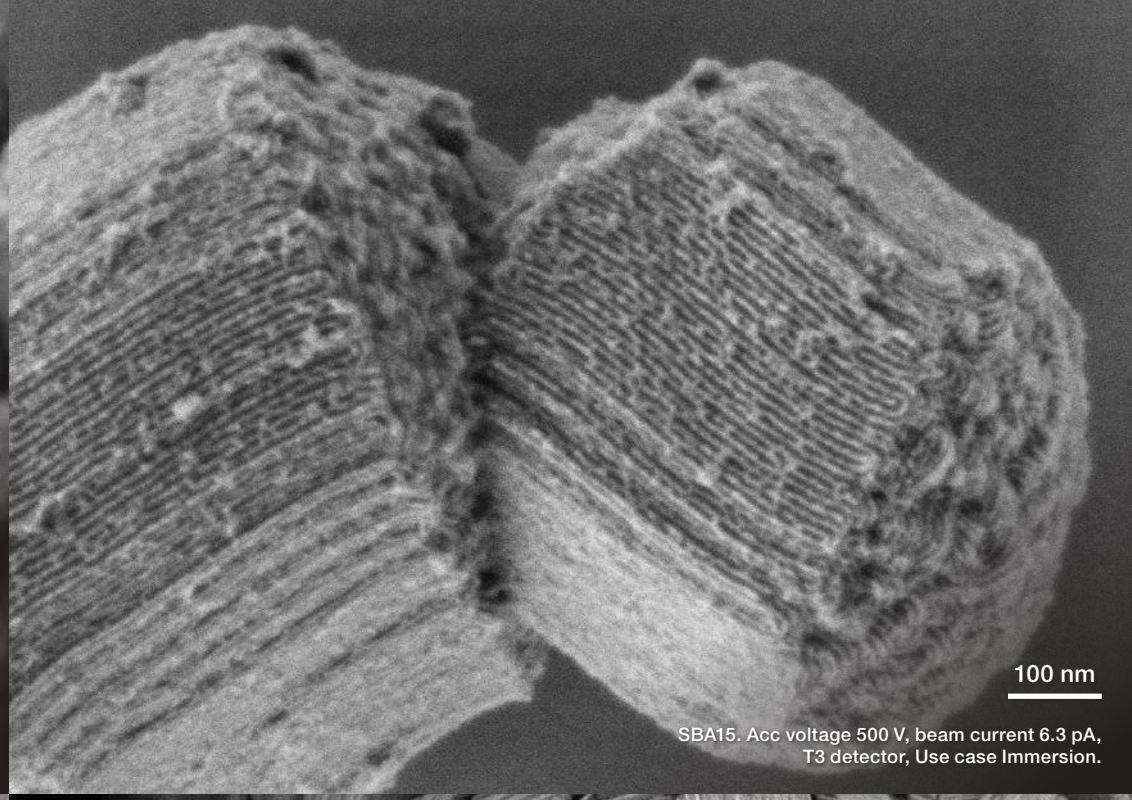
Fe_3O_4 NPs on polystyrene spheres. Acc voltage 1 kV, beam current 12.5 pA, T1 detector, use case Immersion. Compound lens filter on.



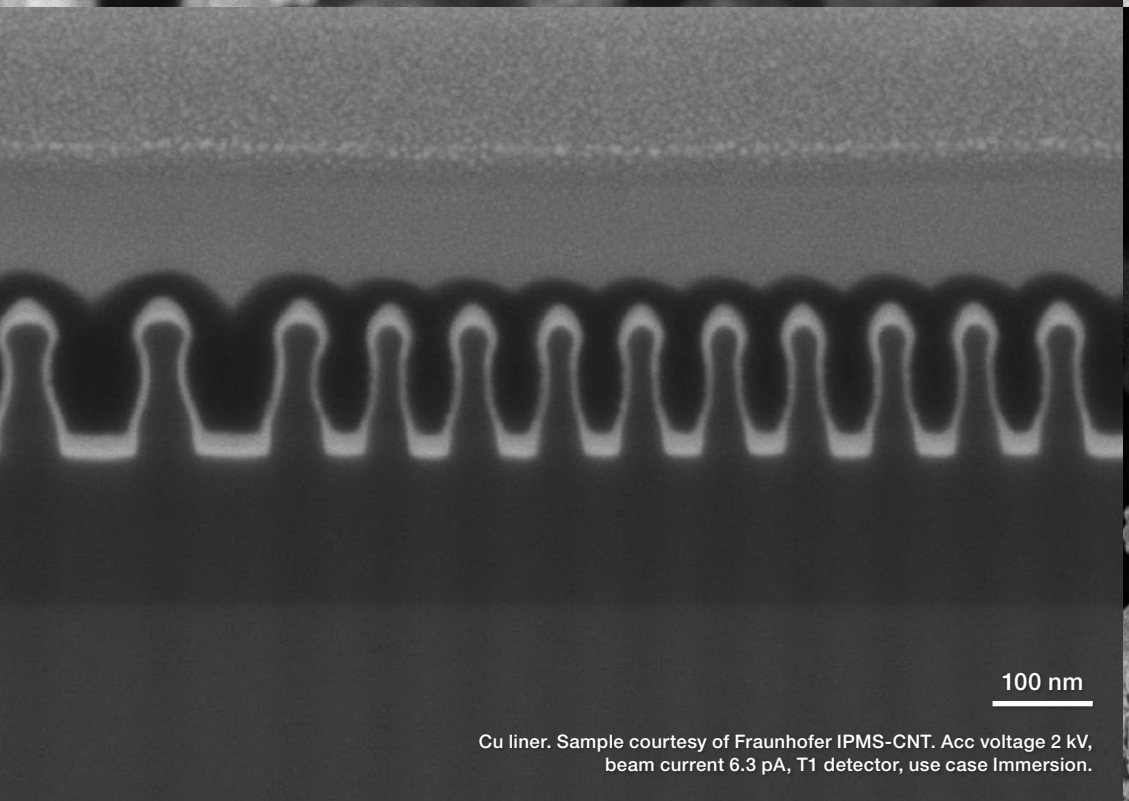
AuPdPt NPs on TiO_2. Acc voltage 5 kV, beam current 13 pA, T3 detector. Digital image improvements is available as a denoising feature. Available for images acquired with all the detectors, is integrated in the xT User Interface and can be applied in a post processing denoising of the images.



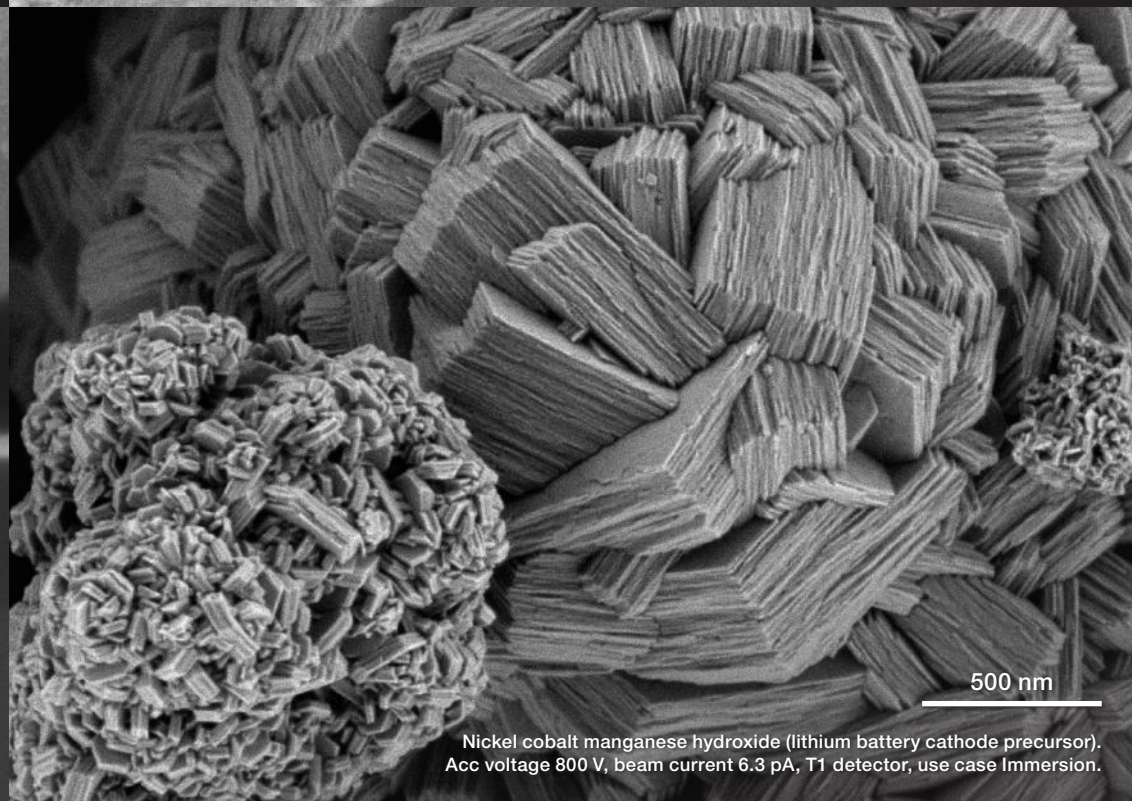
Nanoporous gold. Acc voltage 2 kV, beam current 6.3 pA, T1 detector, use case Optiplan.



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.

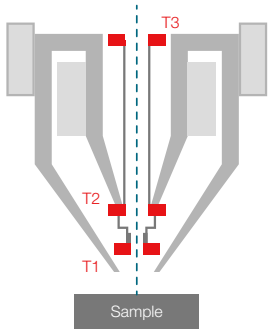


Nickel cobalt manganese hydroxide (lithium battery cathode precursor). Acc voltage 800 V, beam current 6.3 pA, T1 detector, use case Immersion.

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.

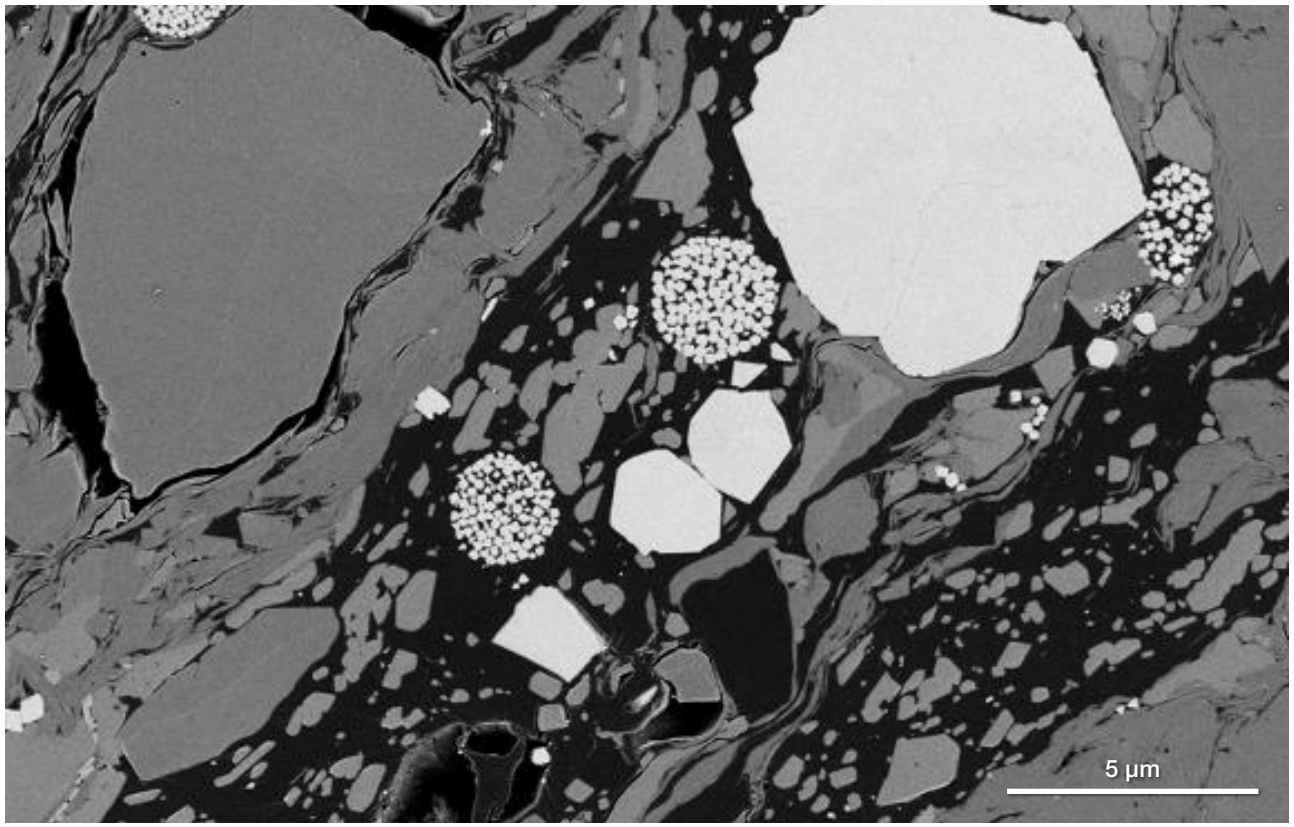
The Thermo Scientific Trinity Detection System is the Apreo 2 SEM's unique in-column and in-lens detection system. It consists of three detectors: two in-lens (T1, T2) and one in-column (T3). This unique system provides different levels of detailed information from the sample composition, morphology,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



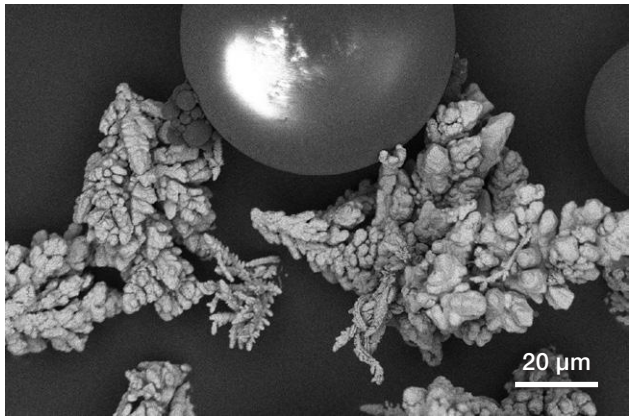
The Apreo 2 SEM ensures a short time to data with its T1 in-lens backscatter detector, which is positioned inside the tip of the final lens, close to the sample to collect the maximum amount of signal. T1 is a high-speed, high-sensitivity detector that makes materials contrast available at all times,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

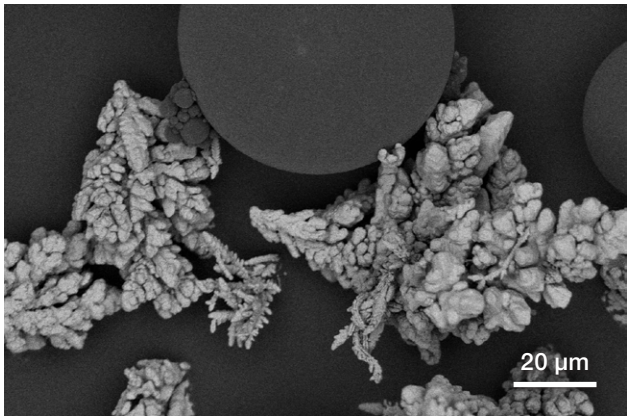
T1 Benefits

- High flexibility, 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
- No need to worry about collisions
- Enables imaging of charging and sensitive materials



Shale sample – using only a 25 pA beam current, hydrocarbon leakage is prevented. Acc. voltage 1 kV, beam current 25 pA, T1 detector.





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

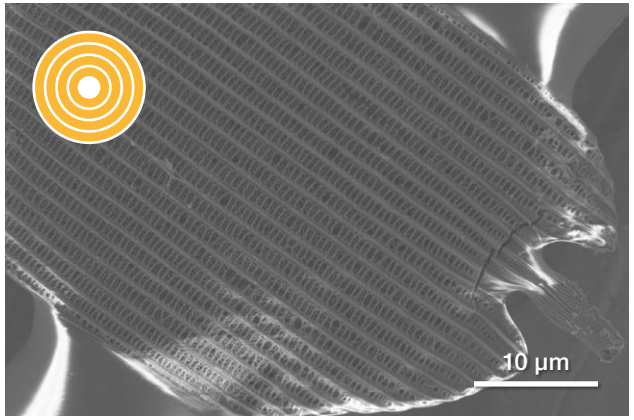
Microscopic characterization is often required for non-conductive and beam sensitive materials. Different approaches can be pursued, such as coating the materials with a conductive film or avoiding the coating and using low vacuum by injecting gas in the microscope for charge neutralization. However, 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.

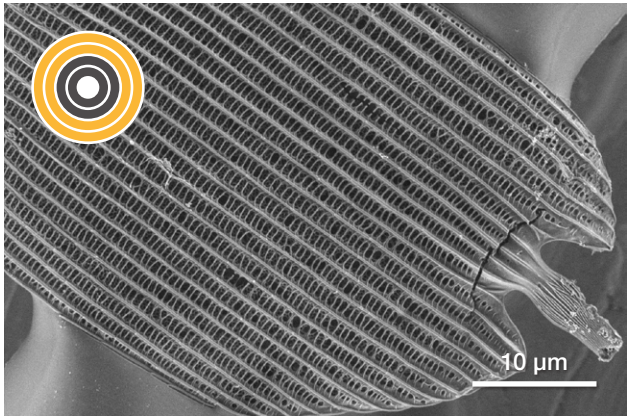
The Apreo 2 SEM provides the widest range of charge mitigation strategies to deal with the most challenging applications, such as different charge filtering approaches. The top images to the right have been achieved with the directional backscattered detector (DBS), while the bottom images show the possibility to obtain 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.

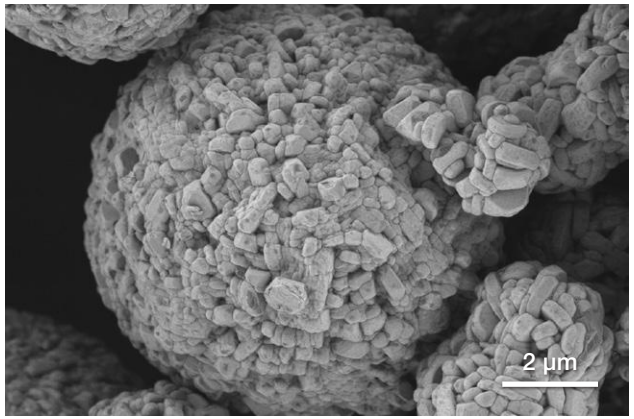
Thermo Scientific SmartScan Technology offers different imaging and scanning strategies to optimize image acquisitions through settings such as frame integration (enables cumulative noise reduction with integration over a specified number of frames), line integration (scans each line repeatedly several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

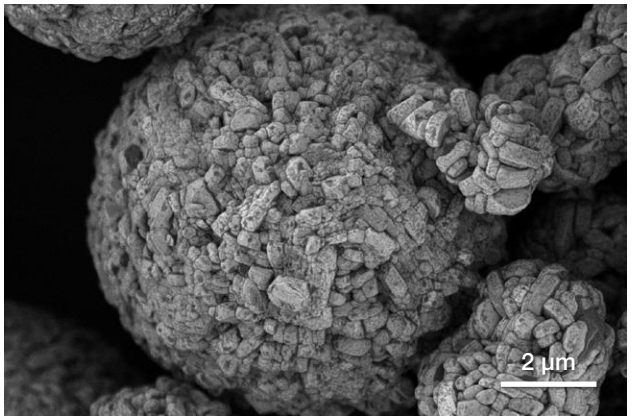
Drift compensated frame integration (DCFI) is an integration filter that corrects image drift in real time when active. The signal is integrated from several frames, resulting in an image that is sharper than a single frame.





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.

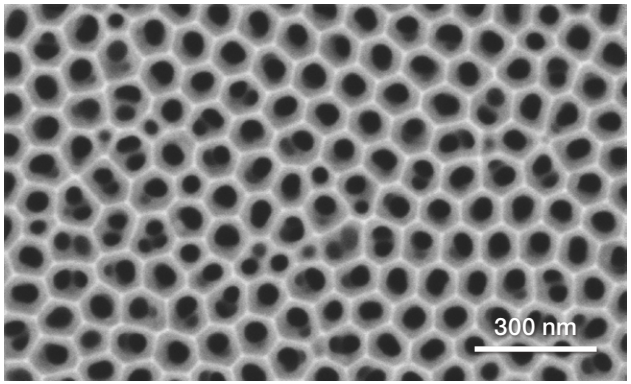




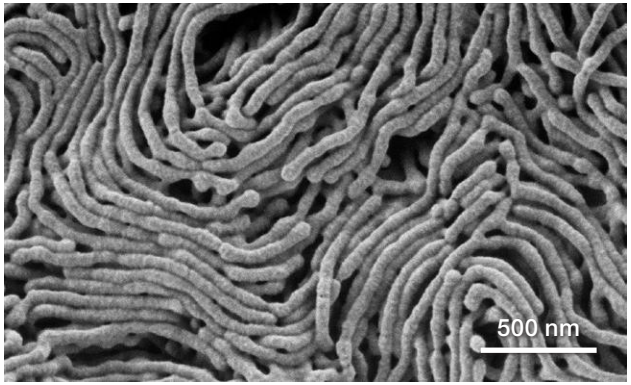
Lithium ion battery cathode with an organic coating layer. Acc voltage 1 kV, beam current 0.2 nA, T1 detector.

Apreo 2 SEM features for charge mitigation in high vacuum:

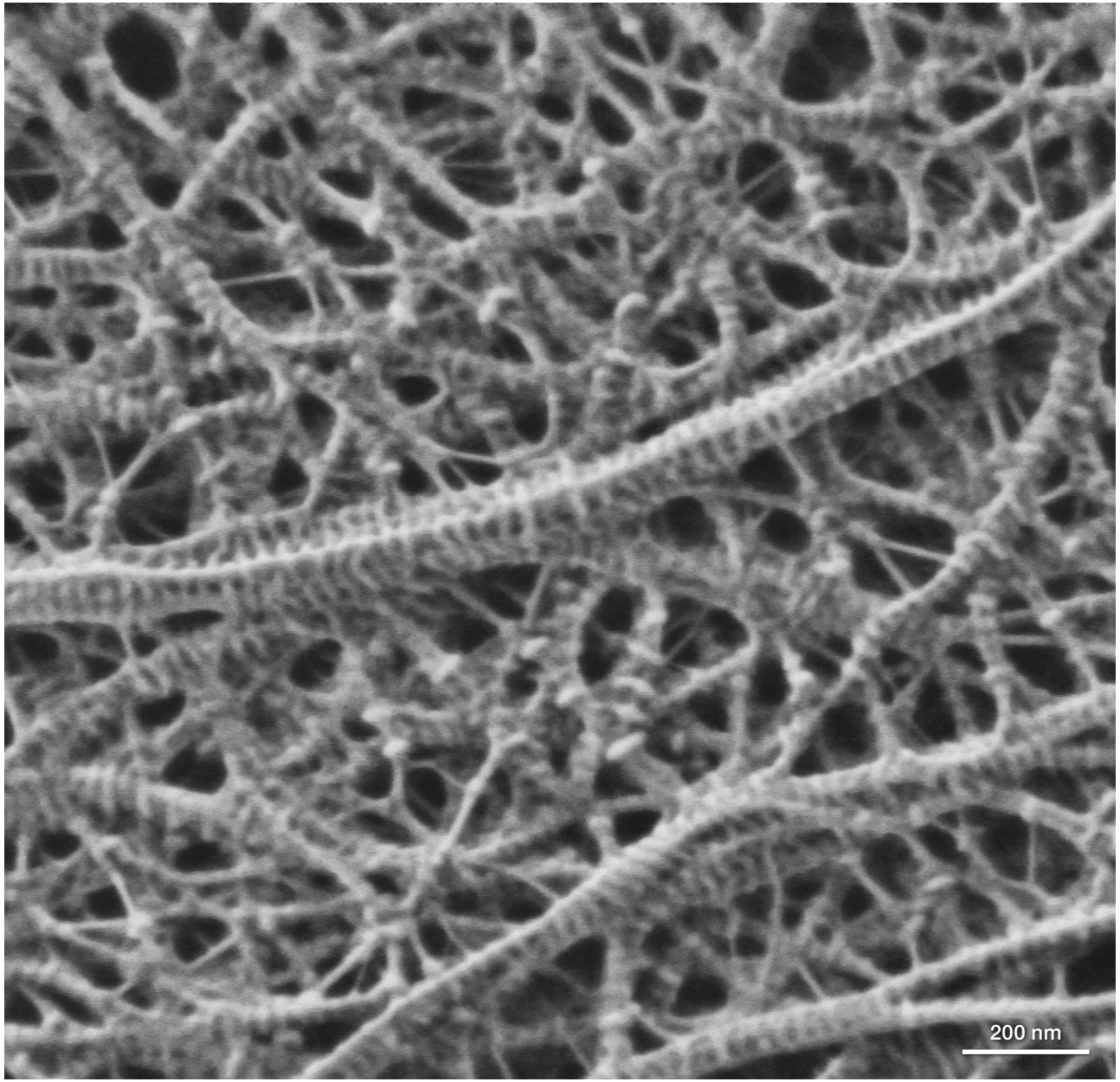
- High performance at low kV
- Low beam current can be used with high sensitivity detector (T1)
- SmartScan Technology
- Drift compensated frame integration (DCFI)
- Charge filtering with the directional backscattered detector
- Charge filtering with the compound lens filter.



Polymer film with 40 nm pores. Acc voltage 1 kV, beam current 6.3 pA, T2 detector, use case Immersion.



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

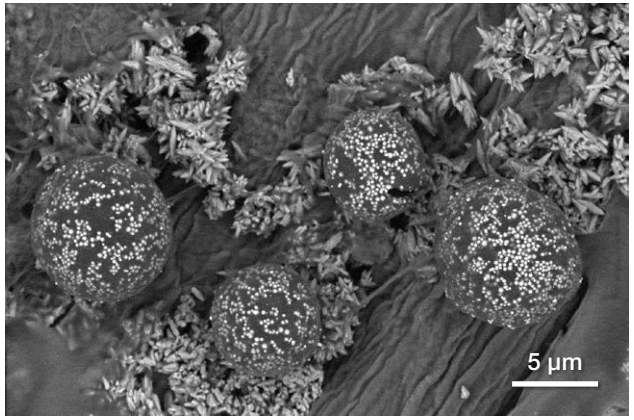


Battery separator. Acc voltage 200 V, beam current 6.3 pA, T1 detector, BD on, use case Immersion.

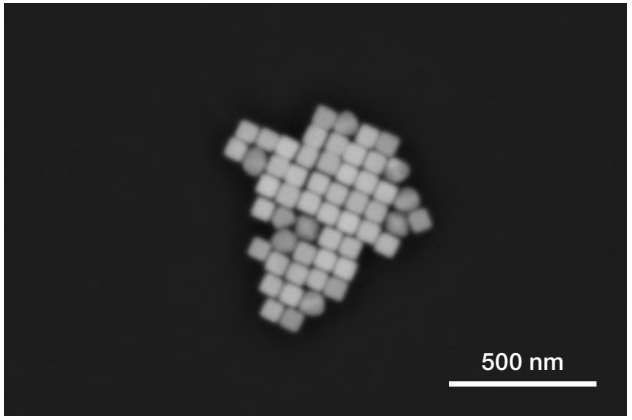
High quality results on insulating materials in low vacuum

As previously noted, nanomaterial characterization can achieve its best resolutions in high vacuum. However, several applications do not require extremely high resolution in the first place but may require compositional information on heavily charging materials. To increase the material contrast or to be able to employ 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 excellent resolution and large analytical currents with field-proven through-the-lens differential pumping and 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) that allows a seamless switch between high vacuum and low vacuum. This allows you to focus on choosing the right conditions for imaging rather than stopping to vent the chamber and manually mount the PLA.



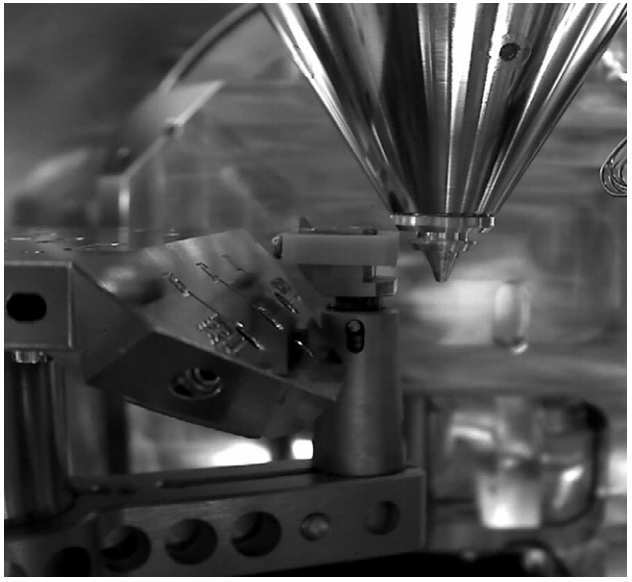
Toner. Acc voltage 5 kV, beam current 0.1 nA, GAD-CBS detector, use case Standard, pressure 100 Pa.



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.

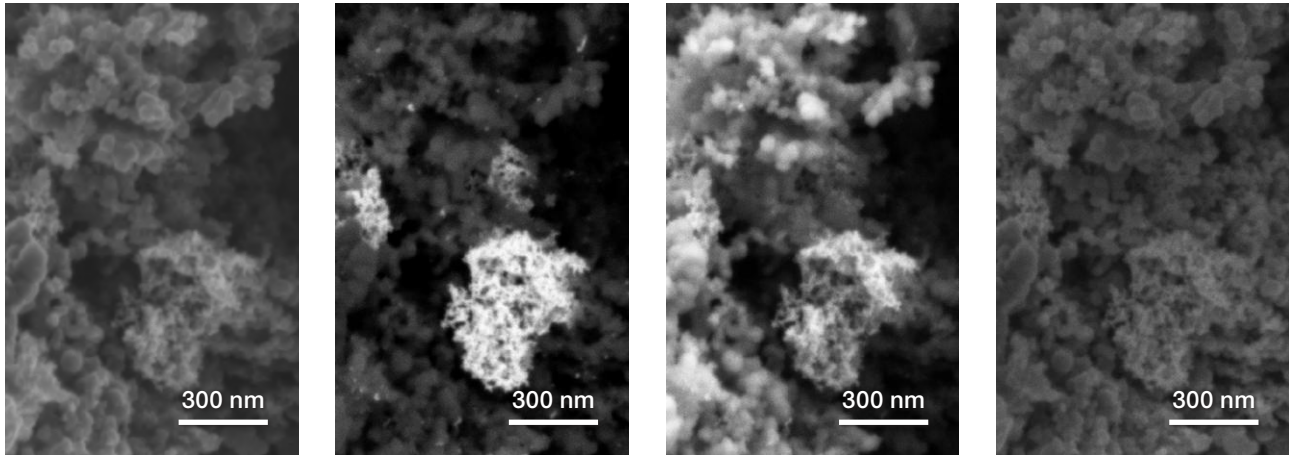


As soon as the PLA is mounted, the stage moves aside and the system is ready for low vacuum imaging up to 500 Pa chamber pressure.

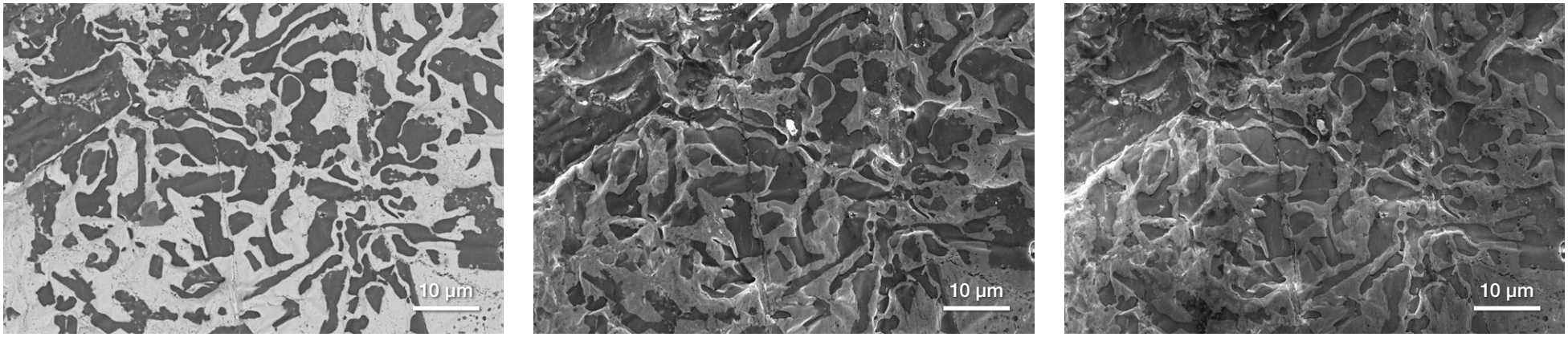
Quality results for all users

Long working distance performance

Conventional SEMs often require very 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 ColorSEM Technology chapter), so that switching between imaging and analysis takes very little time.



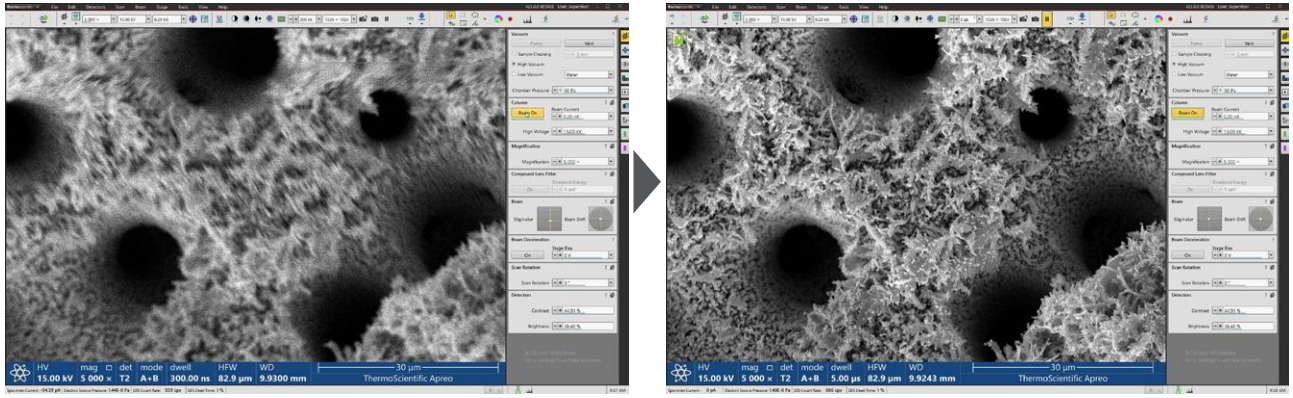
PdCeO NPs. Acc voltage 2 kV, beam current 0.1 nA, WD 10 mm, use case Optiplan. Detectors, from left to right: ETD, T1, T2, T3.



Sn-Al-Si alloy. Acc voltage 10 kV, beam current 0.1 nA, WD 10 mm, use case Optiplan. Detectors, from left to right: T1, T2, T3.

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
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

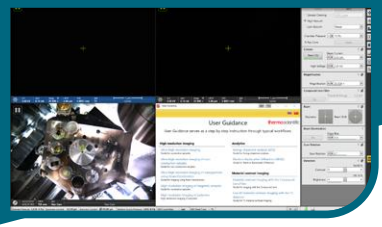
The Apreo 2 SEM makes sure it is always aligned, thanks to a series of automated alignments that can be scheduled to run unattended, requiring minimum effort to keep the system at optimal conditions. The automated source tilt alignment helps ensure the source is always aligned and will run every time 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 xT UI, allowing you to execute functions through the guide or simply use the guide as a learning tool.

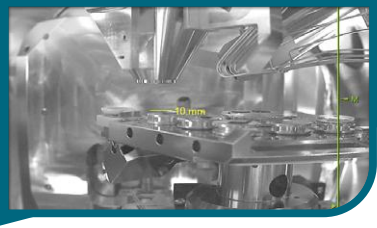
1

Sample loading



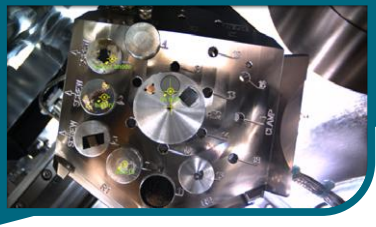
2

Sample navigation



3

Setting imaging parameters

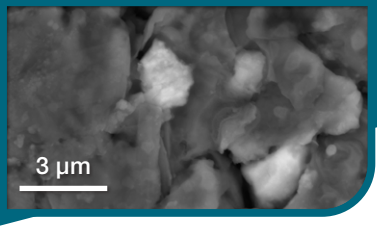


4

Adjusting the image

5

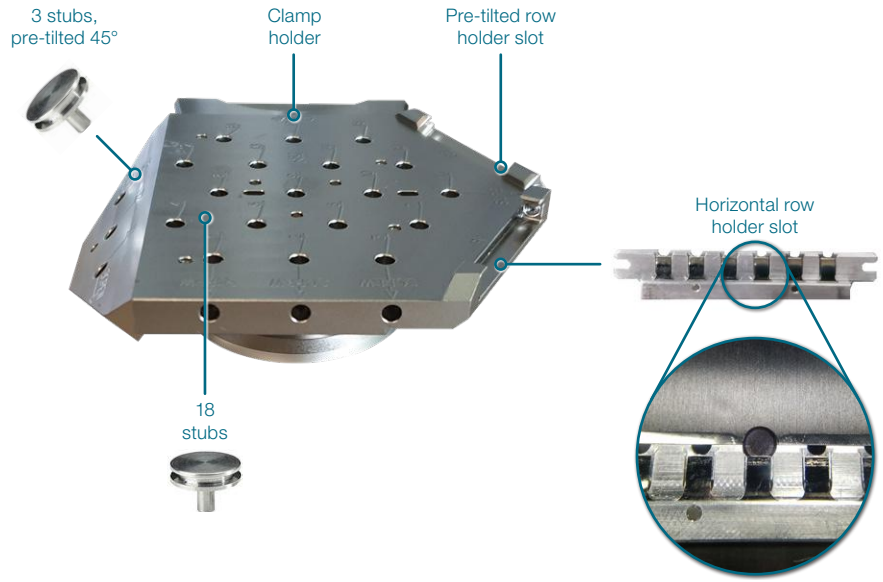
Taking the final image



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.

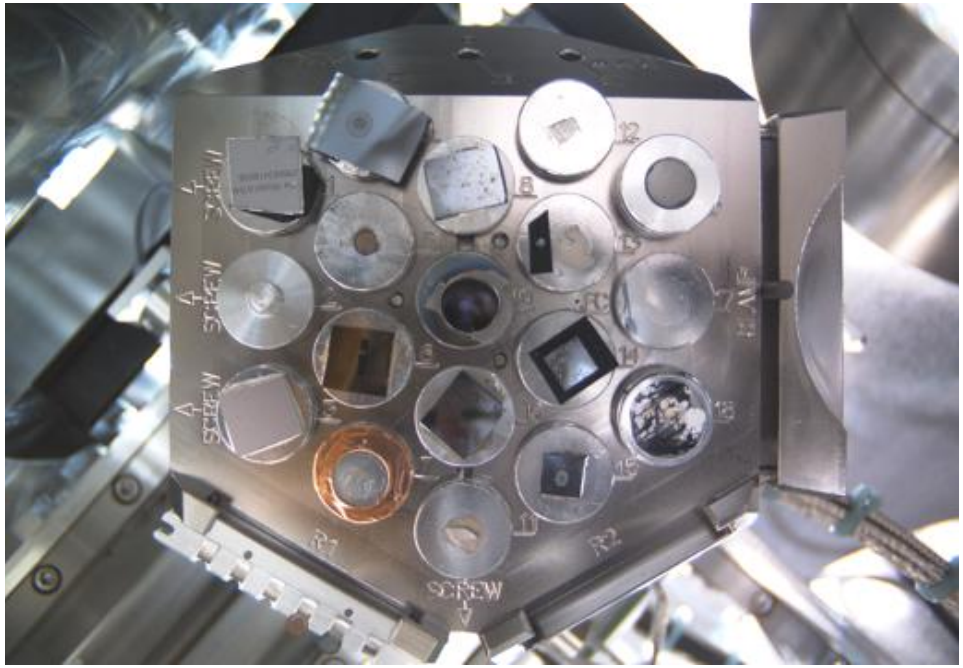


Schematic highlighting key features of the multipurpose sample holder.

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 xT 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



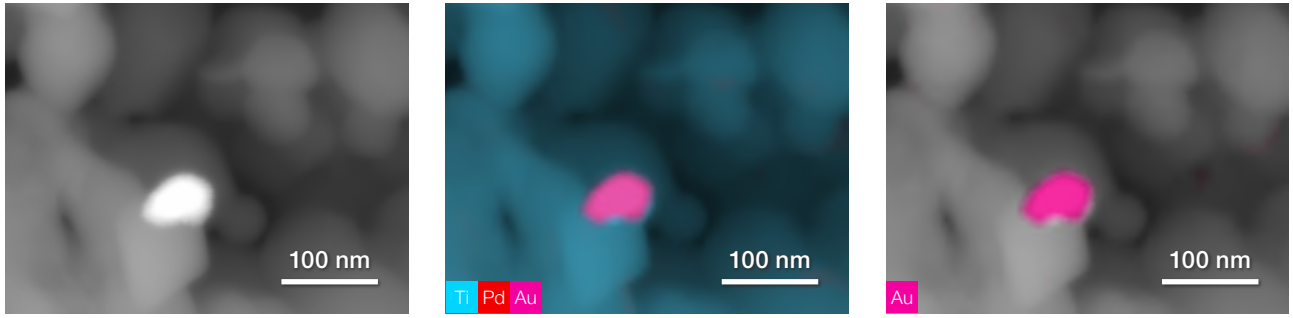
Nav-Cam camera image of the multi-purpose sample holder.

Live quantitative elemental mapping with ColorSEM Technology

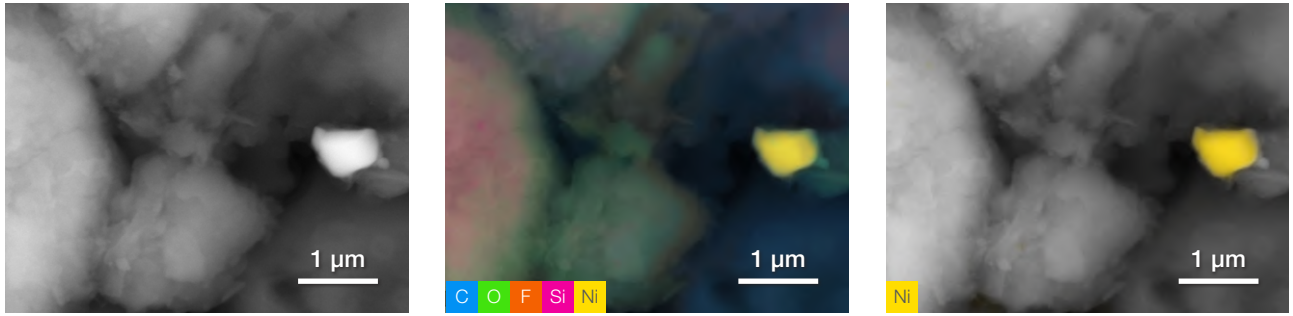
Most SEMs available on the market provide surface analysis capabilities thanks to energy dispersive X-rays detectors (EDS). Often, however, EDS detectors are purchased as separate systems, leading to the need to deal with separate vendors. Additionally, this creates a situation where you need to operate different hardware and software to switch from the SEM user interface to the EDS-related system. This takes time and makes the process complex. In addition, EDS requires knowledge of the technique in order to properly set the correct parameters and understand the results. All of this may very well be overwhelming for new users or even users who only occasionally use the microscopes.

The Apreo 2 SEM overcomes these hurdles with Thermo Scientific ColorSEM™ Technology. SEM and EDS are integrated within a single interface, providing a streamlined user experience with all the tools needed to interpret the data in one place. The Apreo 2 SEM's set of features expands to analytical capability by integrating ColorSEM Technology into the main microscope user interface. ColorSEM Technology is an always-on EDS system, providing real-time quantitative compositional information and live reliable quantification (Noran quantification) in a short time to data.

ColorSEM Technology integrates compositional mapping with the traditional imaging capabilities of the SEM. Once turned on, the result is an instant colorized image showing the high-fidelity microstructural details overlain with compositional information in the same image. ColorSEM Technology improves the time to data for basic EDS information and makes moving to phases or key areas of interest an easy task rather than a long journey.

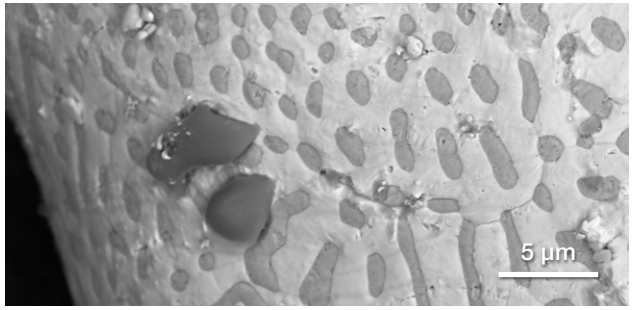


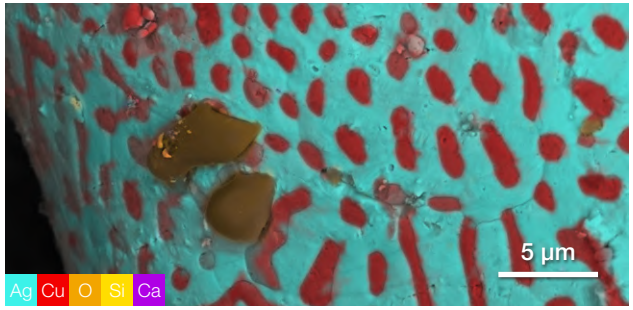
AuPdPt NPs on TiO_2. Acc voltage 10 kV, beam current 1.6 nA, T1 detector, pixel dwell time 5 µs, acquisition time 60 s. ColorSEM Technology capabilities are combined with the high-end imaging performance of the Apreo 2 SEM, providing high-resolution results.



Nickel contamination in a Li-ion battery anode. Acc voltage 10 kV, beam current 0.8 nA, T1 detector, pixel dwell time 3 µs, acquisition time 80 s. From left to right: grayscale image, ColorSEM Technology image, ColorSEM Technology image with Ni selected. ColorSEM Technology allows you to select and deselect each detected element in order to focus on only the relevant information.

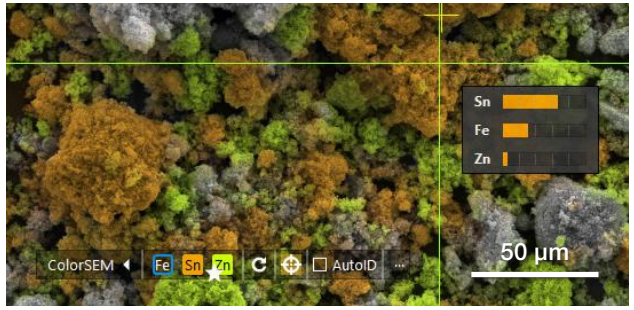
Complete information





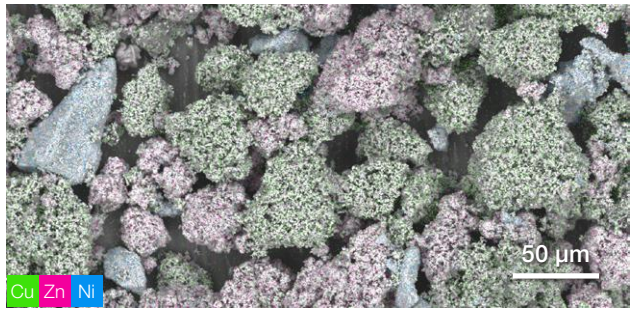
Si and Ca-rich contamination on a AgCu particle. Acc voltage 10 kV, beam current 0.8 nA, T1 detector, pixel dwell time 1 µs, acquisition time 70 s.

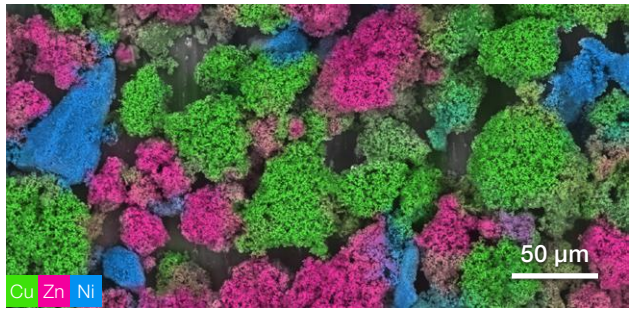
Intuitive elemental analysis



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

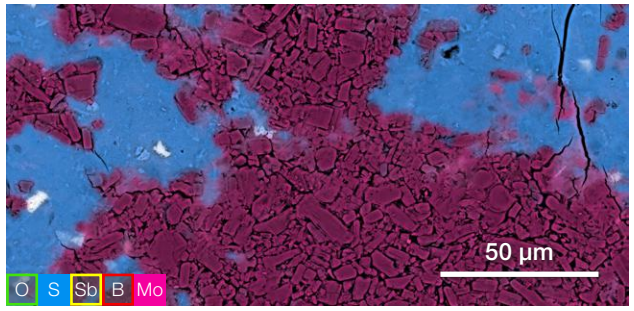
Shorter time to results





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



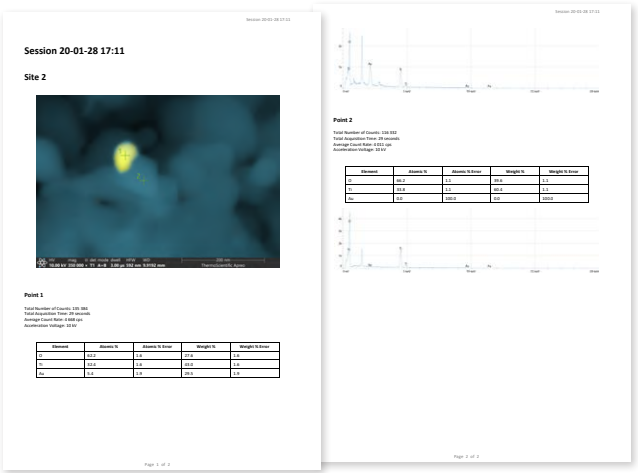
Quantification is running during live color imaging, meaning that even materials with overlapping peaks (such as molybdenum and sulphur) are correctly imaged.

Conventional EDS functions in a state of the art implimentation

The live color information is complimented by the addition of traditional EDS functions, including Point analysis, line scan, and area mapping, directly integrated into the main UI with a state-of-the-art implementation.

The full integration of ColorSEM Technology into the xT UI makes several functions available live, including spectra comparison and raw data extraction for post processing and analysis.

ColorSEM Technology is fully integrated in the xT user interface to allow a seamless switch from conventional imaging to elemental analysis.

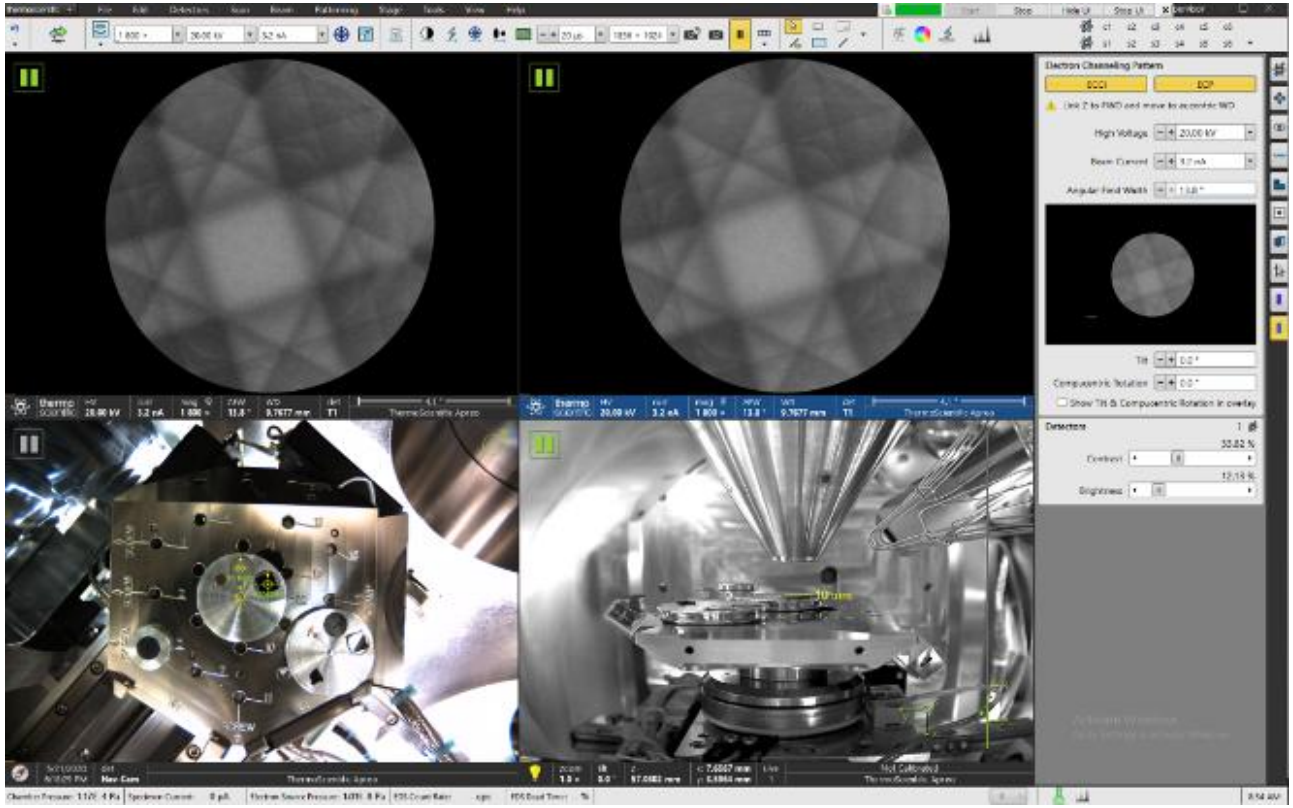


The reporting tool tracks the locations and data associated with X-ray map, line scan and point analyses. A single click generates a report that preserves all location information as well as spectral and quantified compositional tables.

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 xT UI.

Automation

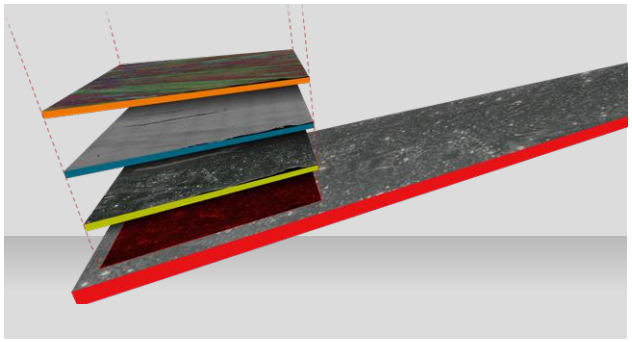
Maps Software

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

thermo scientific

We support you across the lifetime of your system

NanoPorts

No matter where you are, we have you covered. Thermo Fisher Scientific supports you at the early stage with demonstrations and application support. The teams at our four NanoPorts around the world provide valuable resources for you by defining tailored solutions to your application needs and providing dedicated on-site or remote demonstrations or act as research collaboration centers. In addition, our NanoPorts give full support to R&D, Factory, and Field Service teams in providing optimized outcomes and improved solutions.

Global service logistics and field service assistance

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.

Service innovation

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.

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

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