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Axia ChemiSEM

Instant fusion of chemistry and imaging

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Even though scanning electron microscopy (SEM) has made tremendous advances, it is still considered a complicated technique. Sample preparation, alignments, cost of ownership, and difficulties with analytical techniques prevent widespread adoption. We set out to resolve these challenges in order to make a truly accessible SEM without compromising on flexibility.

Our goal was to make microscopy an easy and enjoyable experience in which you should not have to fight the microscope to obtain quality data. The result is the Thermo Scientific™ Axia™ ChemiSEM, a system in which obtaining SEM-EDS data is no longer a chore. EDS is no longer just an afterthought—chemical data and imaging have now become one.

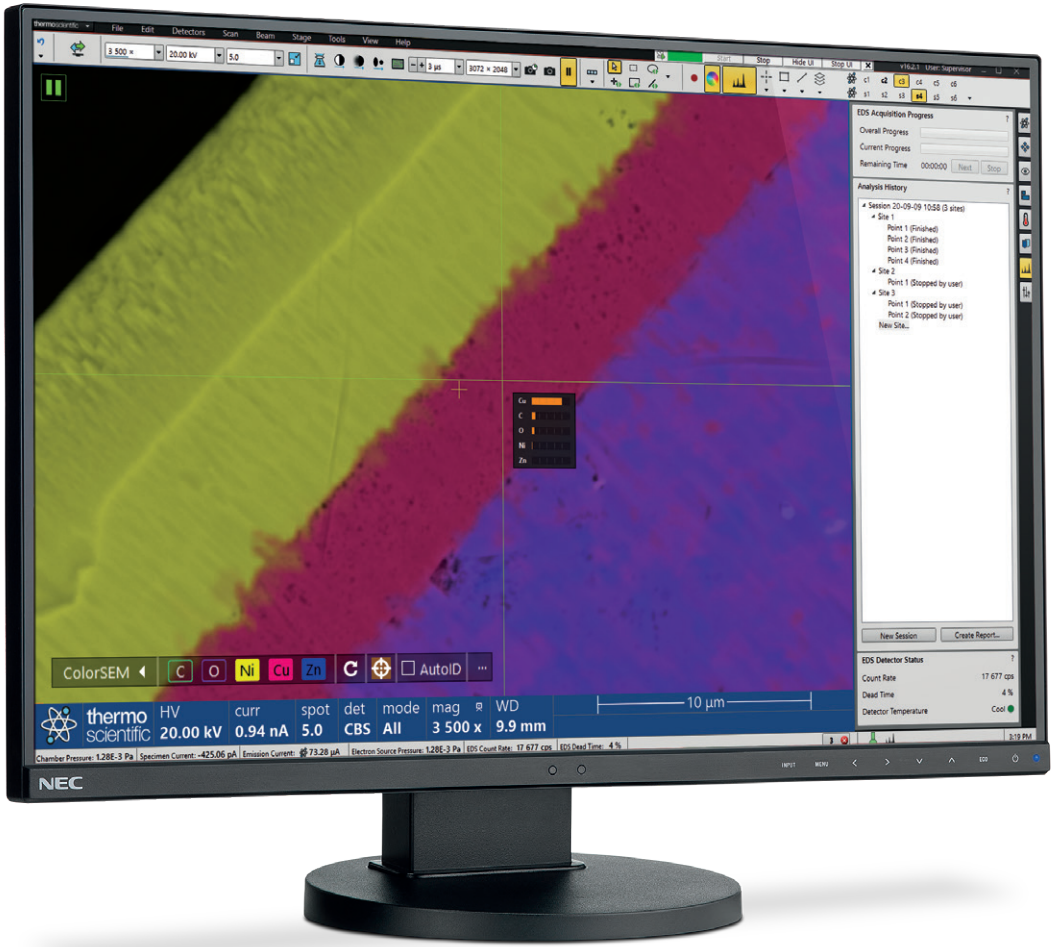
Introduction

The Axia ChemiSEM is a new generation of scanning electron microscope, designed to provide the most efficient SEM-EDS user experience possible. The Axia ChemiSEM combines alignment-free operation with unique instant access to quantitative elemental mapping, making it an approachable system, even for users never previously exposed to SEM. A completely new platform with the largest SEM capacity for weight, the Axia ChemiSEM provides a new level of robustness and flexibility.

Highlights

- Take the fastest route to elemental analysis and with unique live quantitative compositional imaging
- Stay focused on data collection with a system that is always aligned and ready to image
- Obtain results quickly with a user experience designed for improving time to data
- Accommodate samples up to 10 kg with a flexible stage
- Handle demanding tasks using the Axia ChemiSEM's excellent imaging performance
- Save on maintenance with a system designed for reliability

Live Quantitative Elemental Mapping



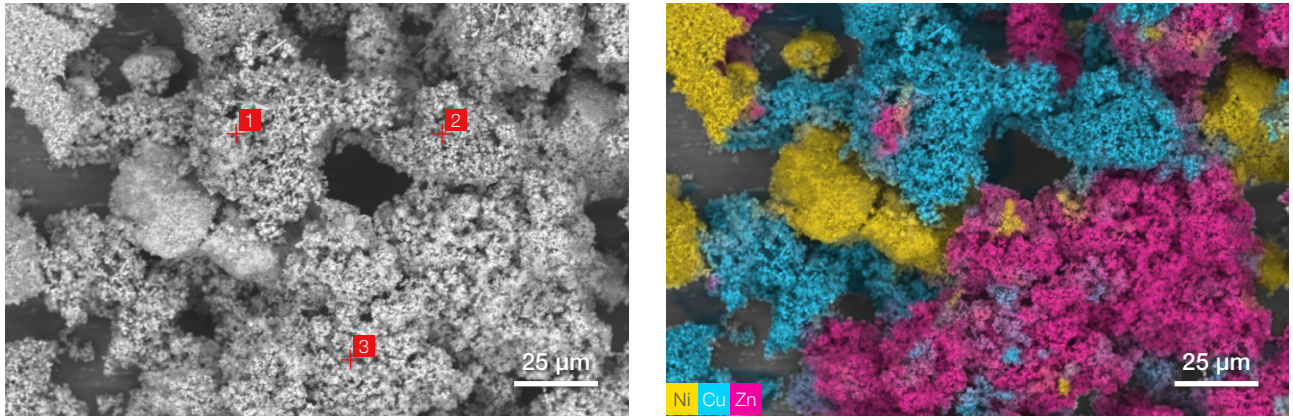
Zero-click elemental analysis. The distribution of elements is directly indicated by colors in the image. A tooltip shows the local composition. Sample: Cu and Ni-coated brass cross section.

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 of peak overlaps. From those maps, yet another set of post-processing steps is required to finally produce quantitative information.

The Axia ChemiSEM features an entirely new concept of EDS analysis that streamlines the process of collecting, processing, and presenting the compositional information of a sample. Using the Axia ChemiSEM, you will observe quantitative elemental information through colors in the image—as soon as the beam is turned on. In this way, relevant compositional information is available very early, and most of the conventional EDS workflow steps are eliminated. This greatly benefits speed, ease of use, and completeness of the analysis.

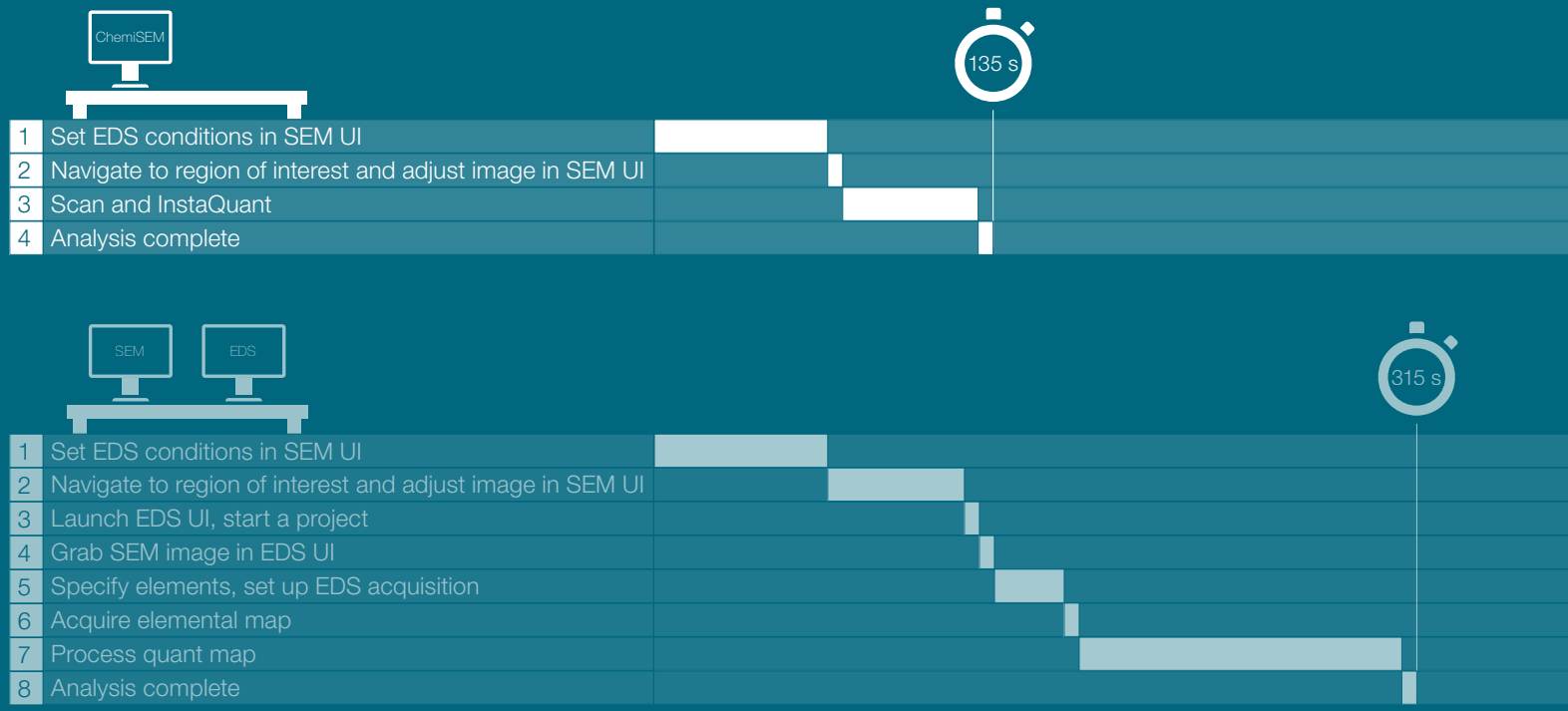
ColorSEM Technology is built on a tight SEM-EDS integration and advanced processing algorithms. A single scan generator controls both SE/BSE and X-ray acquisition, creating perfectly aligned EDS and imagery data. This avoids misalignments between SEM and EDS data, as might happen if they are derived from different systems. It also enables very fast scanning with dwell times as low as 100 ns. This is ideal for high-throughput applications and beam-sensitive materials. ColorSEM Technology employs proprietary routines to combine grayscale data (SE/BSE) with elemental data (EDS) and uses shapes in the image to assist with coloring, much like the human eye, in which rods provide detail and cones provide color. In the resulting map, the elemental composition is quantified for every pixel of the image and is accessible through a tooltip.

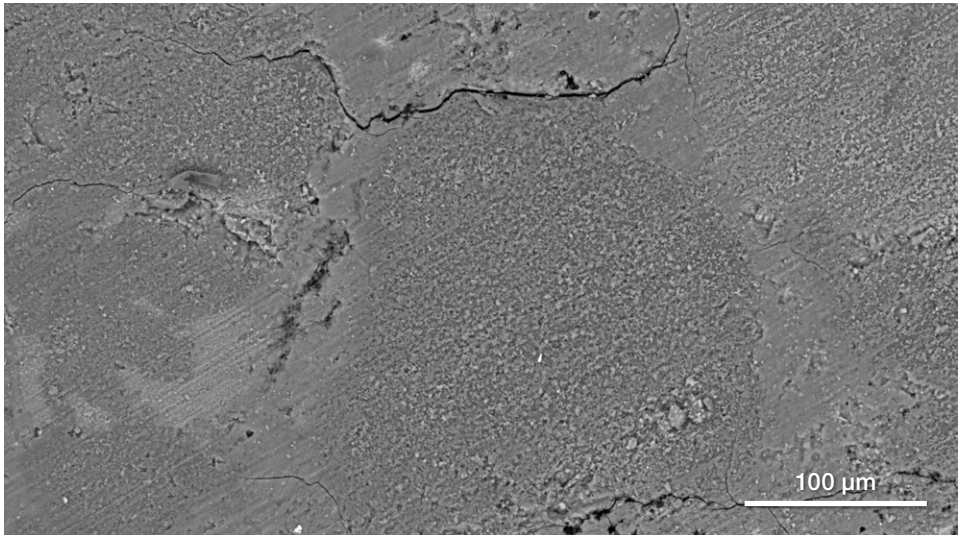
For failure analysis, quality control, and many other tasks, this initial result might answer enough questions to consider the job done. This saves an enormous amount of time compared to conventional workflows. In other cases, you might follow up with point & ID, linescan, or region analysis. Also, here, the live color display brings advantages, as it guides the placement of those points, lines, and regions.

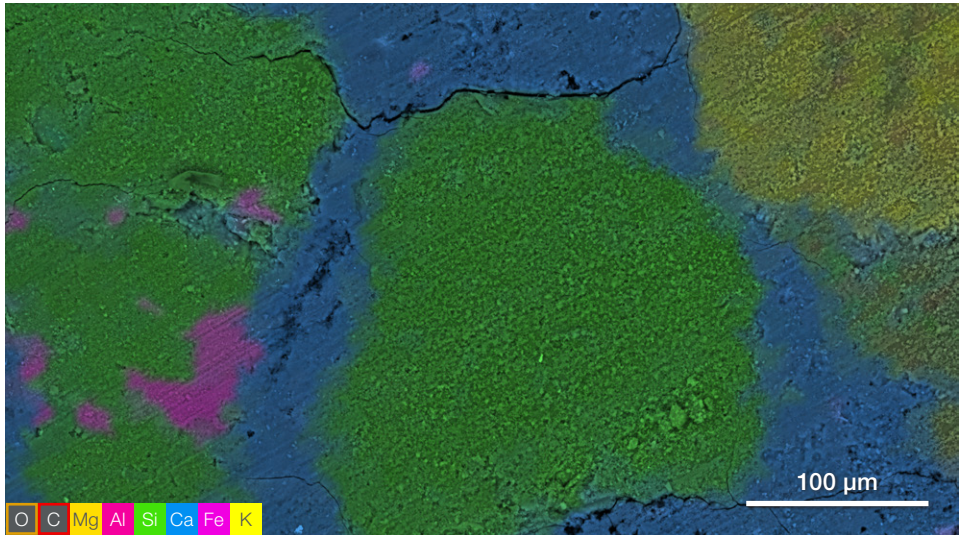


Analysis of a copper-nickel-zinc (Cu-Ni-Zn) alloy precursor. Using black-and-white images produced by an SEM (left), it is difficult to identify different materials, especially when there are only small differences in backscattered contrast. The Axia ChemiSEM image (right) presents each element as a different color, making it easy to distinguish all the materials in the sample. In a point & ID workflow, this is crucial information in order to select the relevant spots for further analysis.

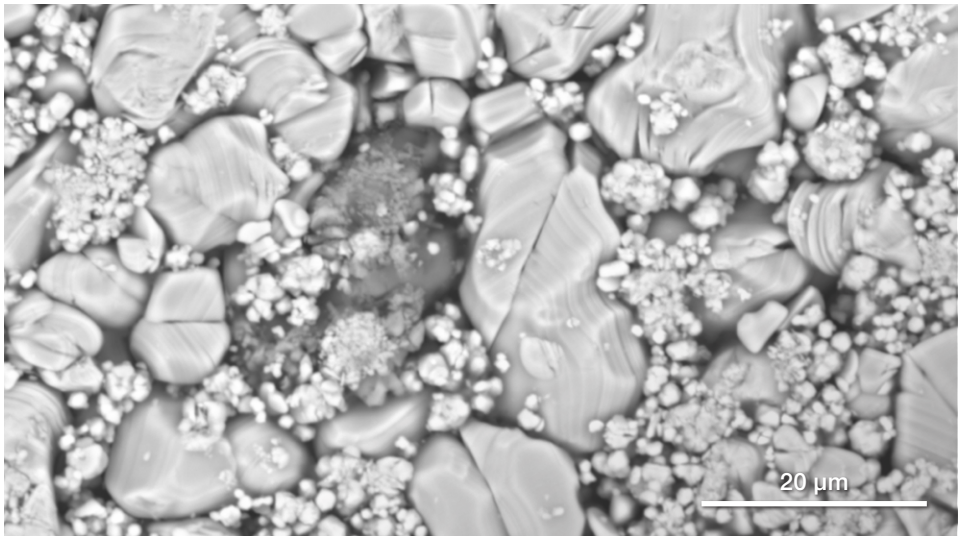
In a typical failure analysis workflow, including sample navigation, the time required to complete the task is sliced in half with the Axia ChemiSEM

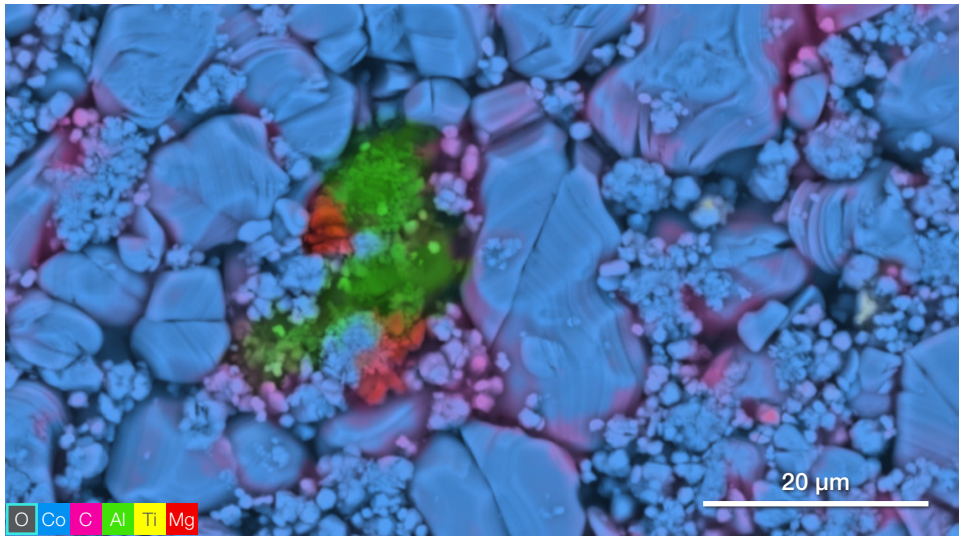




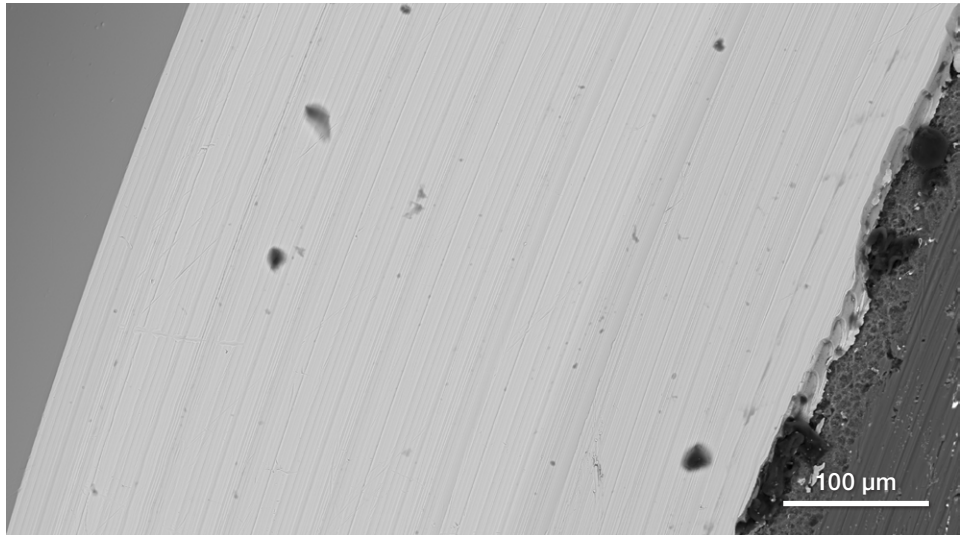


Polished cement surface. Quantitative elemental mapping has been obtained in 30 seconds. Acc voltage 20 keV, beam current 0.48 nA.

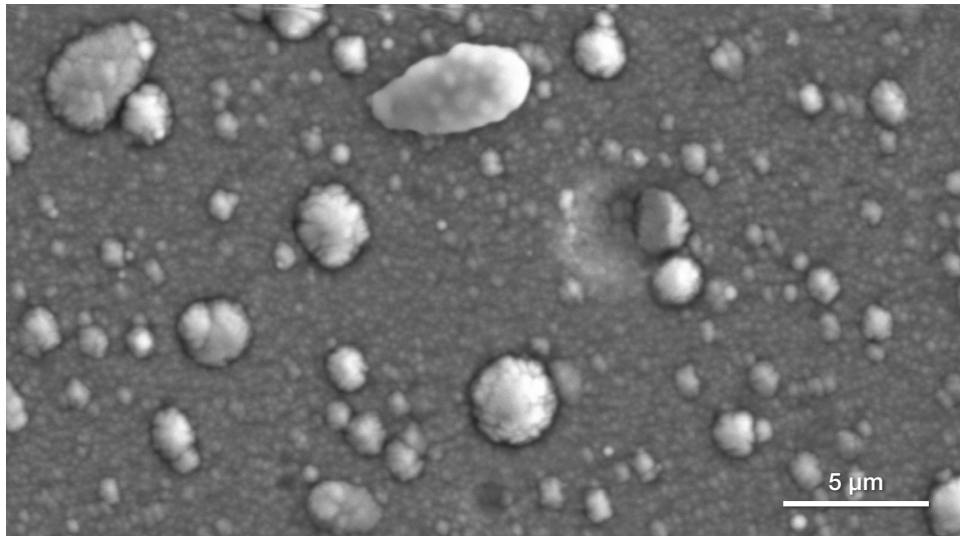


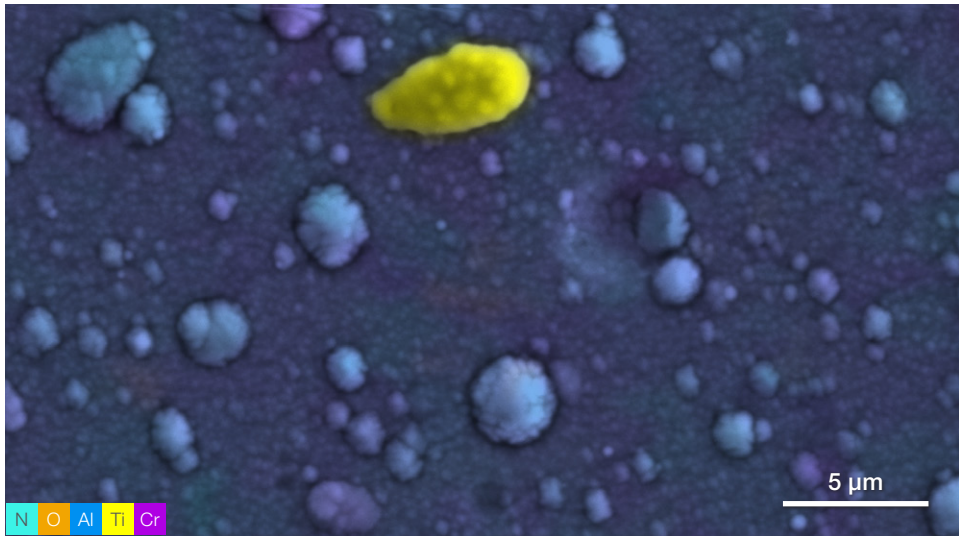


Magnesium and aluminum contaminations in a Li-ion battery cathode. The chemical variations within this area would have gone unnoticed without the Axia ChemiSEM's live quantitative elemental mapping. Acc voltage 20 keV, beam current 3.6 nA.



Copper and nickel-coated aluminum alloy. As Cu and Ni have similar atomic numbers, the compositional contrast is not enough to clarify where a coating ends and where the next begins. The Axia ChemiSEM image provides such information within seconds. Acc voltage 20 keV, beam current 3.6 nA.





Ti impurities in an AlCrN coating on WC/Co substrate. Impurities are not immediately visible, but, thanks to the live quantitative elemental information provided by the Axia ChemiSEM, the titanium distribution is shown in one click and in a short time to result (60 s). Acc voltage 15 keV, beam current 0.85 nA. *Sample courtesy of Platit.*

The unique experience, speed, and fun of using the Axia ChemiSEM are best experienced from a moving picture.

Customer testimonials

"It's really broad, I need that every time I use the microscope to analyze the morphology and chemical composition of the samples. It's incredible the way in which I immediately get the results to my questions when we analyze the samples. Everything is displayed in near real-time on the screen."

Carlo Angeles Chavez, Mexican Petroleum Institute

"It's really *in situ*. If you have a new user, it may take two weeks to get used to the microscope while with ColorSEM, everything is easy, and you can get into the work. From a catalyst point of view, you can immediately see where the support is and where is the catalyst."

Cedric Barroo, Université Libre de Bruxelles

"ColorSEM happens on the fly, it takes ten percent of the time. We analyze a wide variety of samples: in geological samples, for example, we look for clays which have certain morphology characteristics but not highly visible compared to the background. However, they do have chemical segregation, and ColorSEM is going to help a lot: we will be able to see where the clays are, zoom right into them, verify, and move to another task."

Dennis and Maria Manuel, Houston Electron Microscopy

"(Axia) allows you to simultaneously see all the type of signals thanks to the secondary electrons' detector and the backscattered electrons detector. With ColorSEM, you have also the EDS in the same time. In the past, you had to switch back and forth from different imaging modes. Now, you have all the information simultaneously, it's much faster. It's easy to use, and if you know how to play video games, you will know how to use ColorSEM."

Lifeng Dong, Hamline University Minnesota

Easy to Get Started

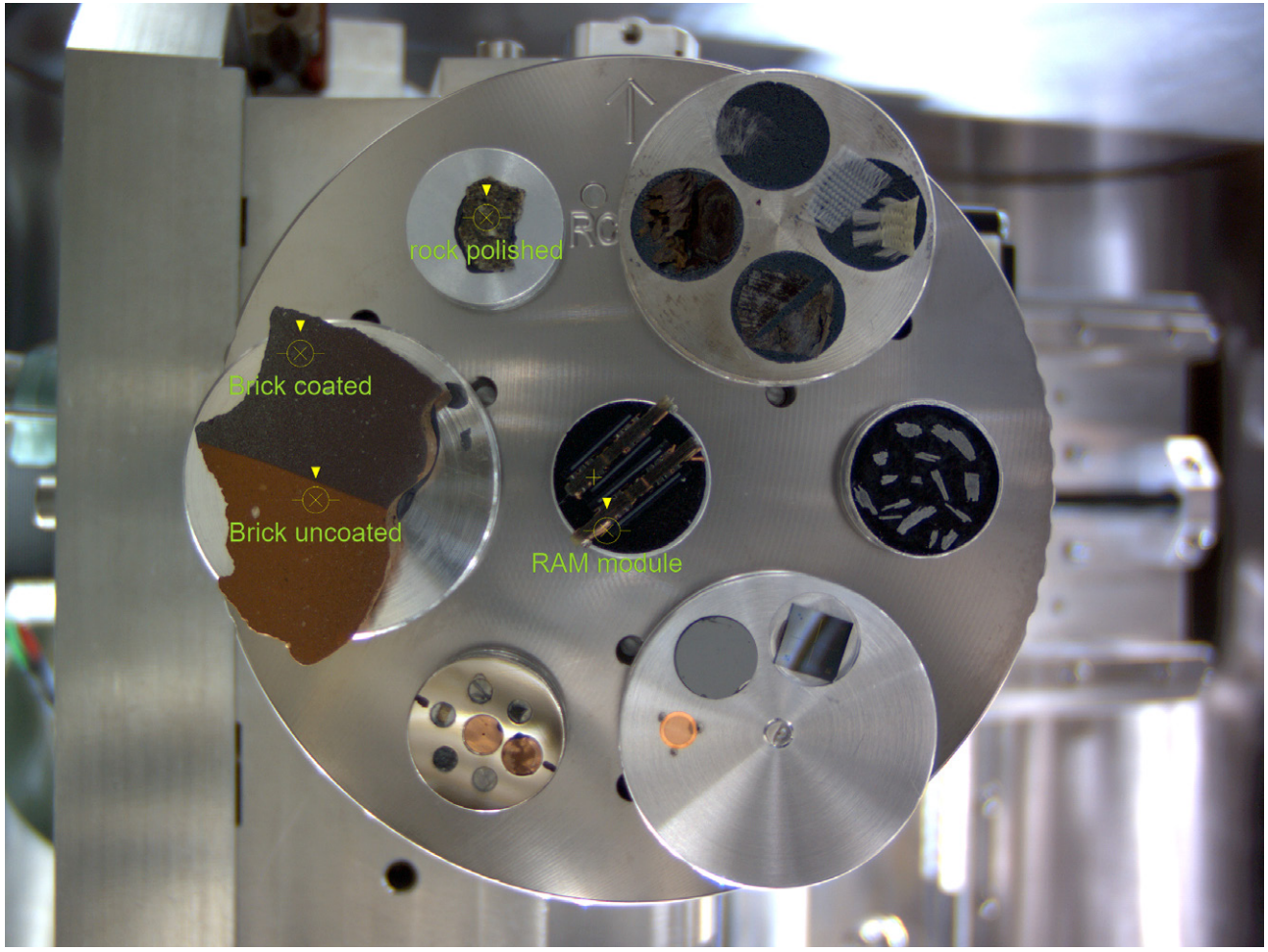
When buying a SEM, you want to ensure that everyone in the lab will be able to acquire the results they need. The Axia ChemiSEM boasts several features that make it easy to deploy in characterization labs.

Easy Sample Navigation with the Nav-Cam Camera and Navigation Montage

When you turn to SEM for analysis, you might have no idea what your sample's microstructure looks like. But you will know what your sample looks like with the naked eye or an optical microscope. For that reason, the Axia ChemiSEM includes a navigational camera that allows for intuitive navigation to the region of interest based on an optical image.

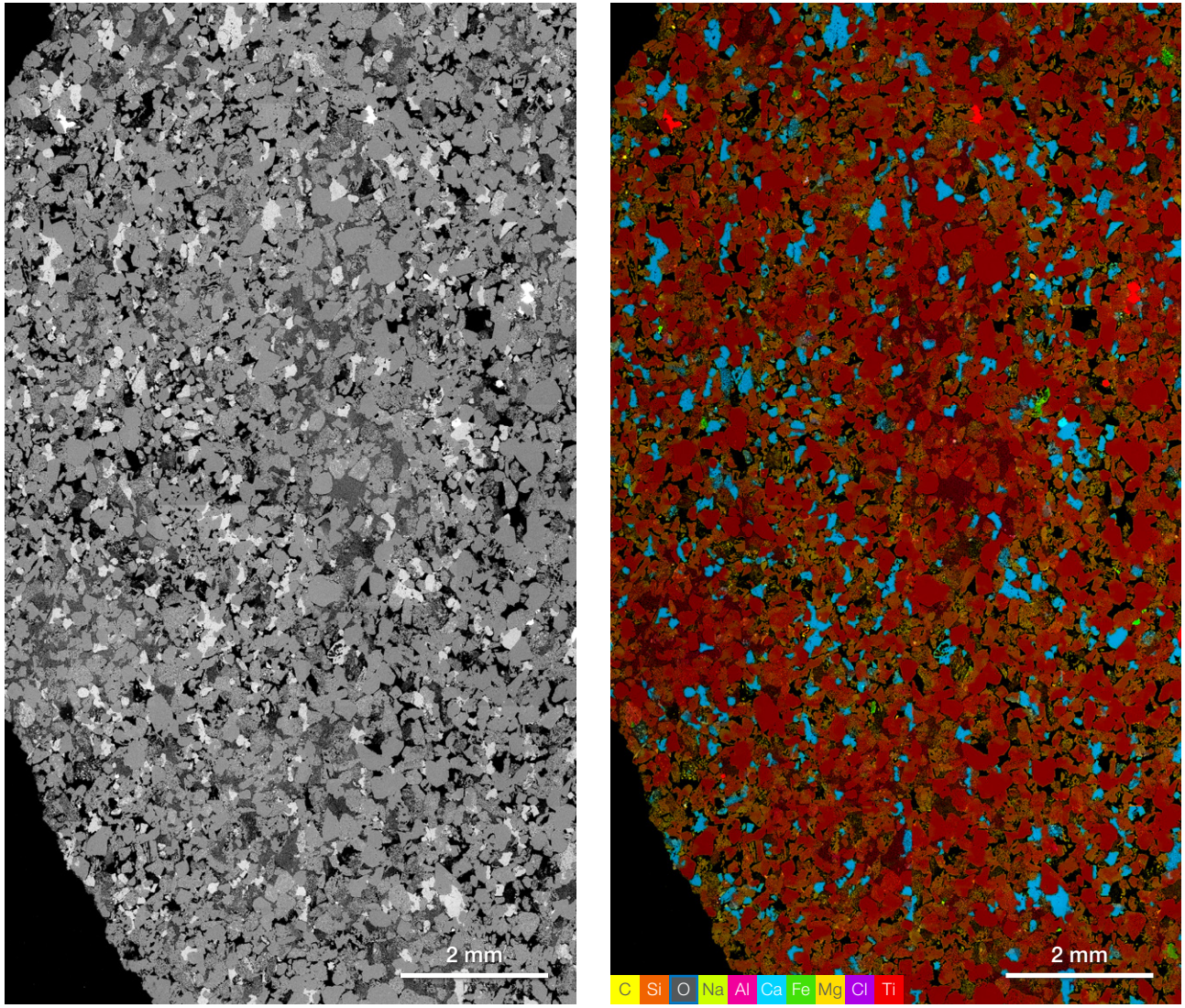
The Thermo Scientific Nav-Cam™ Camera enables you to always know the actual imaging location, track saved positions, and reload previously imaged areas of interest. The Nav-Cam Camera is fully integrated into the ChemiSEM user interface and provides an intuitive view of the saved locations and exact stage position, even when a rotation is applied. A digital zoom of the image is available to enlarge features of interest.

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, taking even more advantage of the possibility to load multiple specimens at once, which saves you time to focus on the real job.



NavCam image of fully loaded sample holder.

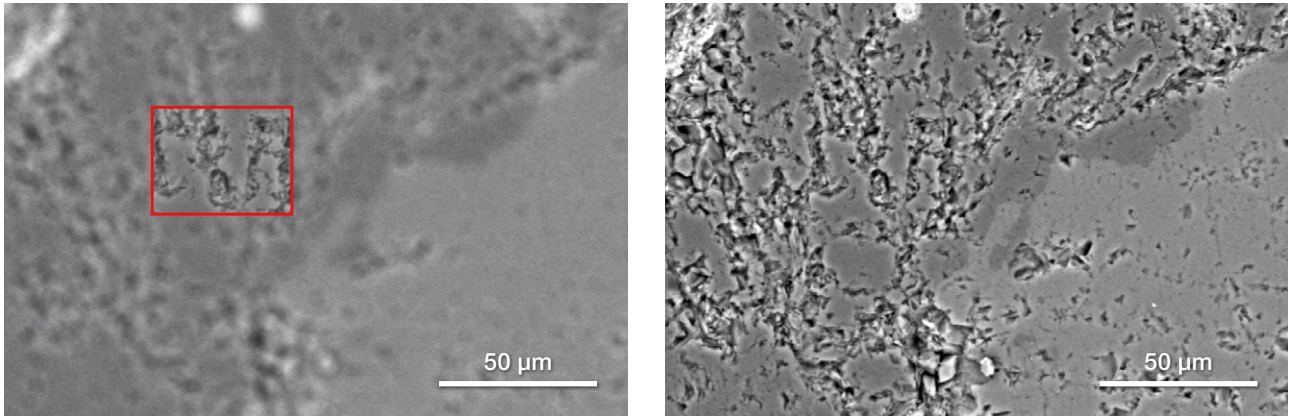
If, instead of using an optical image, you want to navigate from SE/BSE contrast, it is easy to make a very large montage. The navigation montage feature provides a quick and detailed overview of your sample. The montage collects multiple images automatically, creating a single low-magnification image for point-and-click sample navigation. The resulting montage provides a large field of view and, thanks to the sample navigation function, offers a precise way to move along the acquired montage and center a feature of interest by automatically driving to its stage position. Example navigation montages are shown in the images on the right.



Grayscale and Axia ChemiSEM navigation montage of a geological section.

Alignment-Free Operation

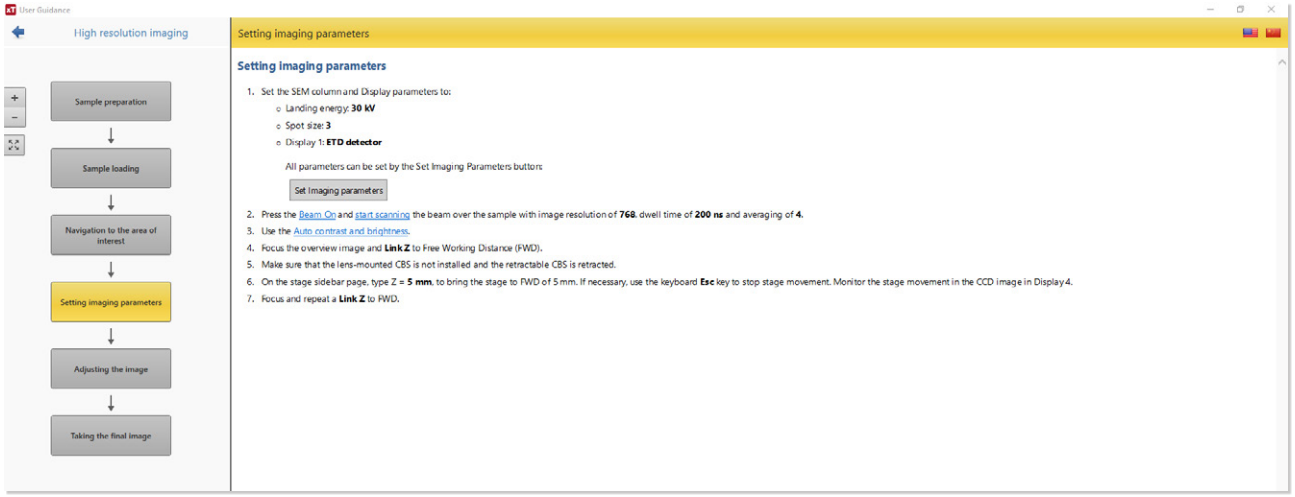
The Axia ChemiSEM drastically improves workflow efficiency and data quality. SEM operation is often viewed as a complicated exercise requiring specialized knowledge. This is especially evident when watching a user explore the imaging parameter space while looking for ideal imaging conditions on a sample. For example, every time accelerating voltage is changed, you have to follow a multi-step process to align and prep the beam for imaging. With the new Axia ChemiSEM, alignments are managed by the tool automatically. SmartAlign technology keeps the column parameters managed, so you can focus on getting right to the task at hand—analyzing your sample. SmartAlign enables this along with other, newly developed automatic functions that provide a much smoother user experience and offer an SEM that is always ready to image.



Left image shows the user interface view during the automatic focus. Right image shows a focused image, which can be obtained in one click and in less than 6 seconds.

User Guidance

When you encounter a new material or sample type, you might need some guidance on how to best image it. Or, when revisiting a material after a long time, you might not remember the best settings. User Guidance provides a set of workflows that suggests the correct steps and parameters depending on the application of interest. It provides a set of easy-to-follow steps to help you get started and ensure optimal use of the microscope. Each step is hyperlinked directly to the SEM graphical user interface, allowing you to execute functions through the guide or simply use the guide as a learning tool.



Newly developed workflows guide the users through the optimum steps for a specific material.

Flexible Sample Loading

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.

For many FA labs, cutting or otherwise altering some sample types to fit inside an SEM can lead to additional damage that potentially obscures the cause of the original failure. The Axia ChemiSEM provides a large sample capacity with a door that provides access to the entire chamber as well as a stage with a capacity of 10 kg. The Axia ChemiSEM will allow all labs to ensure sample integrity and expand the type and size of samples they can add to their characterization routines.

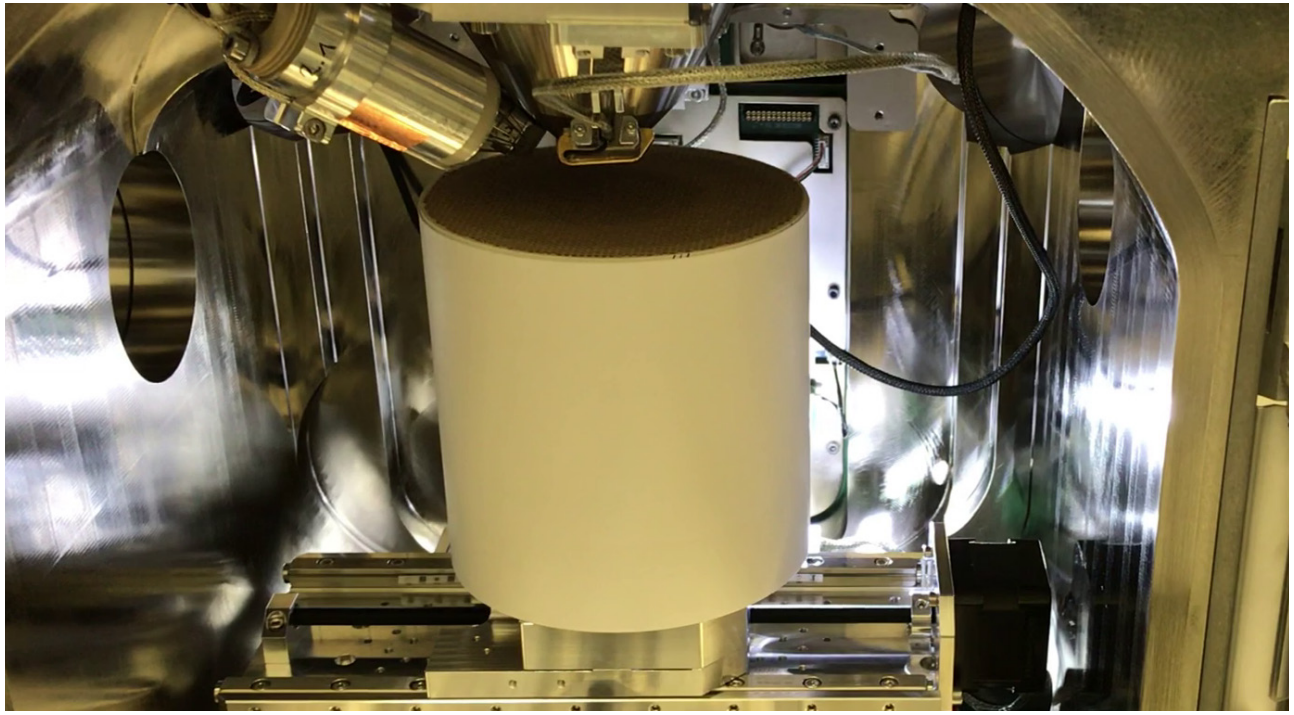
The Axia ChemiSEM offers a new level of robustness and flexibility. Thanks to its new design, the Axia ChemiSEM accommodates the highest weight ever—up to 10 kg. This will allow you to save time cutting your samples and to avoid extended and needless sample preparation.

Furthermore, by simply removing the bottom part of the sample holder, the Axia ChemiSEM can easily and quickly fit large samples, up to 138 mm in height and a maximum width and length of 240 mm and 280 mm, respectively.

The Axia ChemiSEM provides the easiest sample loading through the door, which can be fully opened. An improved pumping system will allow the beam to be turned on in less than two minutes.

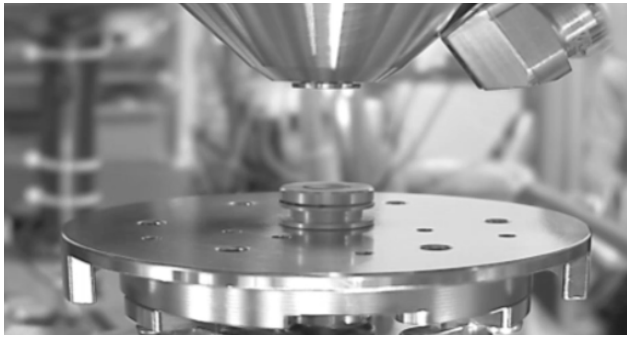
Sample Holder

The Axia ChemiSEM sample holder accepts a maximum sample diameter of 280 mm and, alternatively, when many samples are available, it can fit up to 7 sample stubs.



A ceramic catalytic converter honeycomb mounted inside the Axia ChemiSEM's chamber, ready to be imaged. No sample preparation or special mounting is required.

Newly designed sample holder.



CCD (charge-coupled device) image of the chamber.

Excellent Imaging Performance

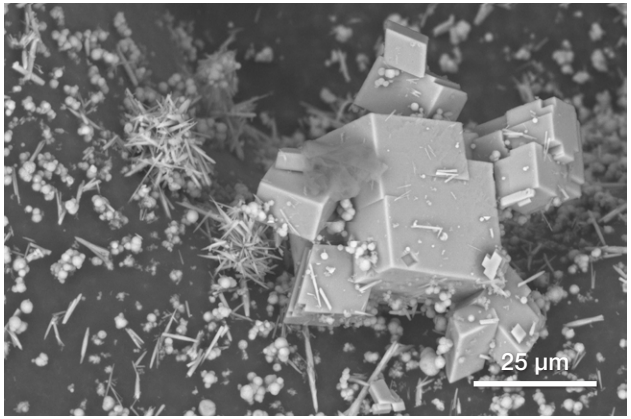
Industrial and advanced materials characterization facilities are often dealing with unknown materials and the most varied types of requests. As such, they face the need to access the most complete solution that combines analytical capabilities with the ability to deal with insulating or beam-sensitive samples.

Wide Range of Materials

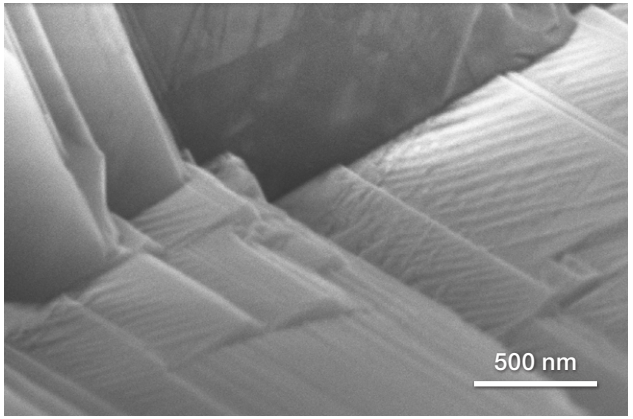
The new Axia ChemiSEM offers remarkable all-round performance to obtain the most information from the characterization of different type of materials.

Electron microscopy investigations are commonly required for beam-sensitive and charging materials. When characterizing a non-conductive material, different strategies can be approached and, conventionally, the easiest solution would be coating with metallic/conductive layers. However, a coating is not always advised, as it may mask important details and reduce (or eliminate) any material contrast.

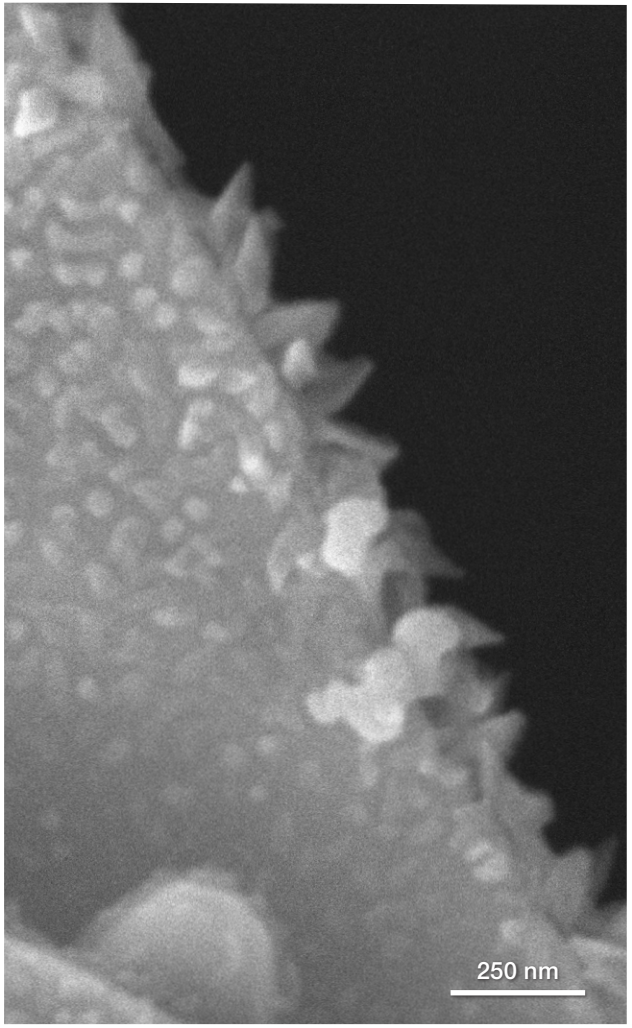
The Axia ChemiSEM supports the widest range of samples thanks to its low-vacuum mode and the ability to adjust the pressure up to 150 Pa. Low-vacuum mode will provide several advantages when dealing with non-conductive samples. Not only does it enable charge-free imaging, but it also allows an increase in the material contrast and the use of higher beam currents to perform chemical analyses.



Mixture of carbonates (aragonite, calcite, vaterite) imaged in low vacuum with a pressure of 50 Pa. Acc voltage 15 keV, beam current 0.44 nA.



Polycrystalline alumina (PCA). Acc voltage 15 keV, beam current 7.9 pA.



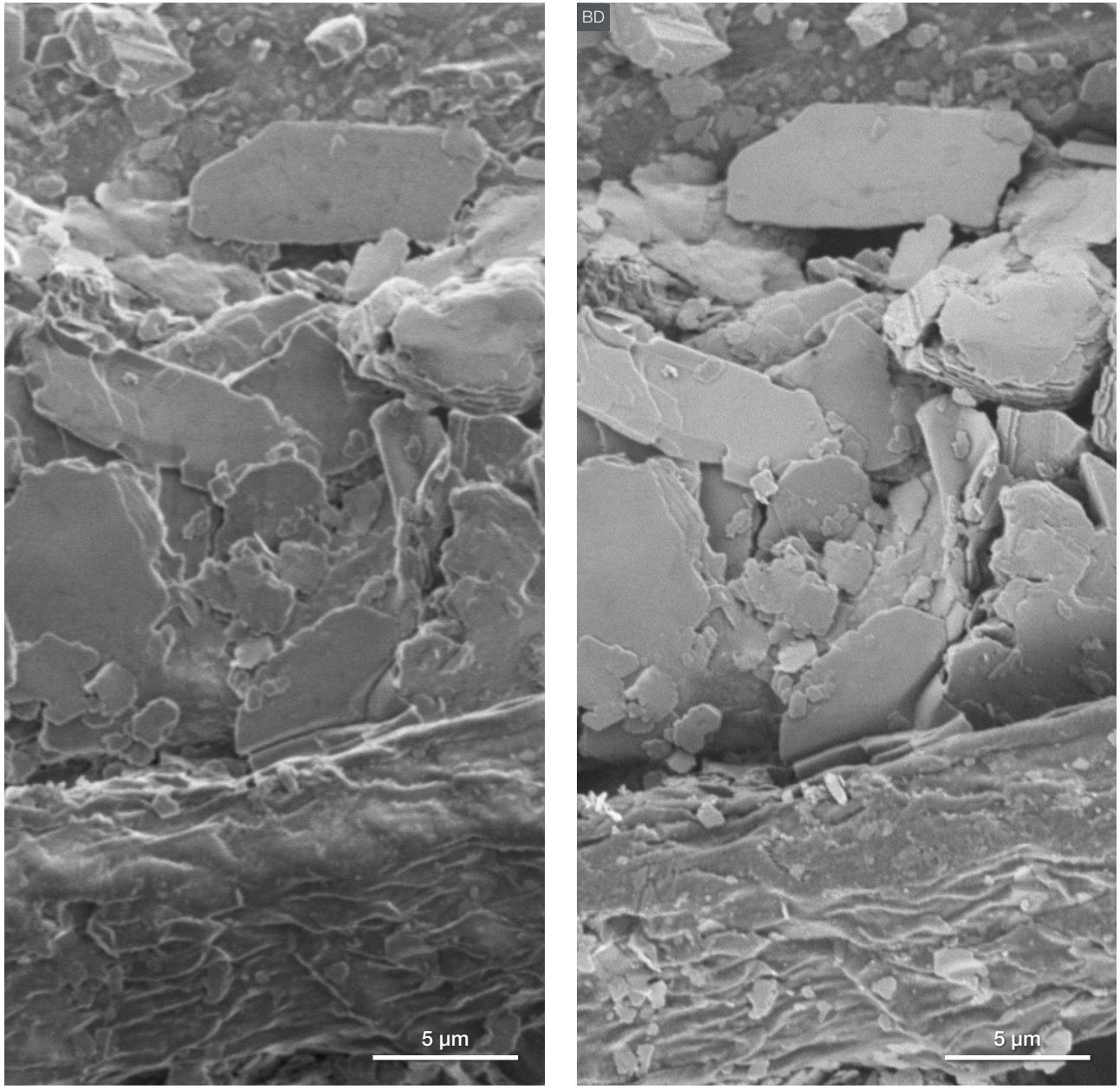
Nanometer-sized silver features on gold nanosheets.

The low-vacuum mode is not always the preferred solution, as, for example, low landing energies may be needed to highlight surface details that would be flattened with high acceleration voltages. However, an insulating material would require a compromise in the choice of the imaging parameters.

The Axia ChemiSEM offers the most effective charge mitigation strategy that allows the imaging of beam-sensitive samples in high vacuum: beam deceleration (BD) mode. BD is an optical mode in which the sample is biased with a negative potential applied to the sample holder that causes the primary electrons to be decelerated before they land. Due to an acceleration voltage higher than the landing energy, the final resolution is improved. Furthermore, BD mode enables the detection of low-angle backscattered electrons (low-angle BSE) heading nearly parallel to the surface of the sample, enhancing the surface topography.

Images presented on the right show a clear improvement in the quality of the image when beam deceleration is applied. The benefits of using the beam deceleration are highlighted in the comparison on the right, which shows:

- Increased resolution
- More topographical details
- Less flatness
- Enhanced morphology



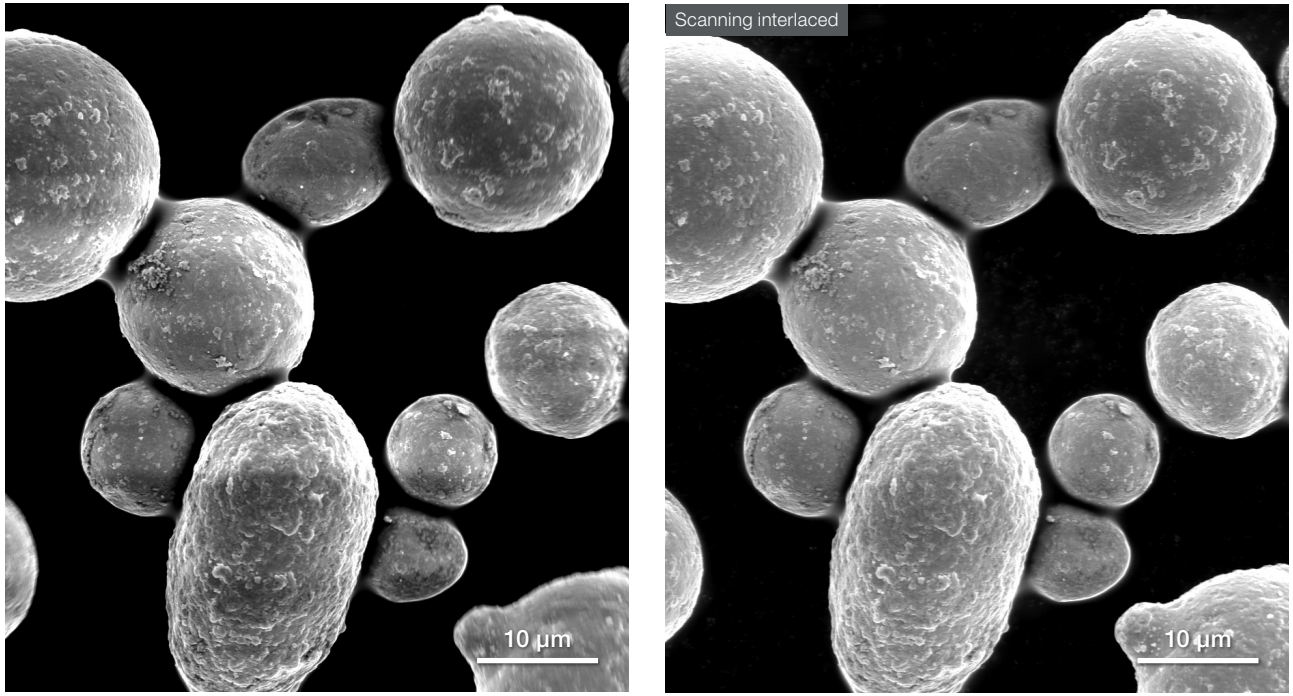
Example of fillers in paper. Left image: Acc voltage 2 keV, beam current 78 pA. Right image: same parameters with beam deceleration of 4 keV applied.

Advanced Imaging Functions

The Axia ChemiSEM is designed to offer high-quality results and deal with the most challenging applications. In addition, this newly designed SEM will allow you to get your results in a short time to data to boost your productivity. To do this, the Axia ChemiSEM offers several different imaging and scanning strategies to optimize image acquisition and increase throughput.

SmartSCAN Technology

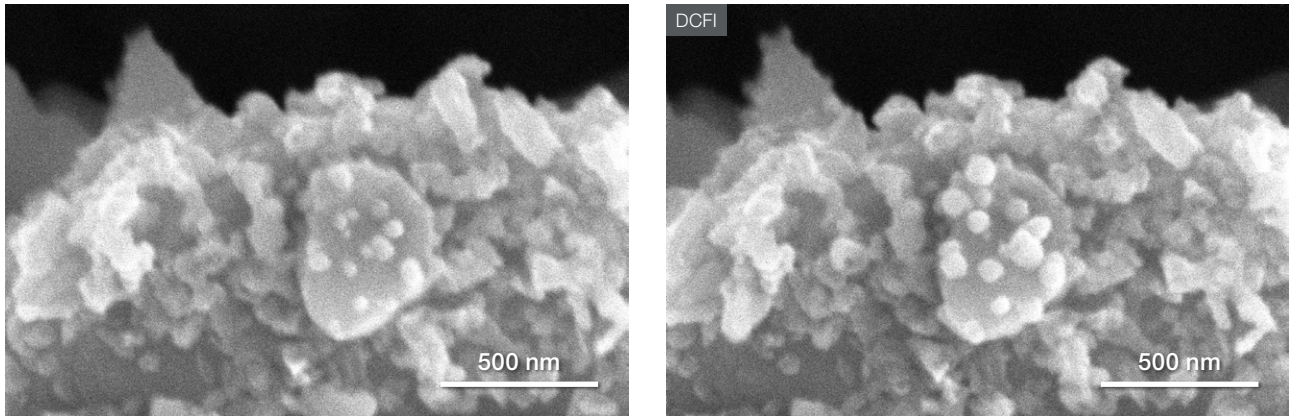
Thermo Scientific SmartScan™ Technology is based on settings such as frame integration, line integration, and interlaced scanning. Frame integration provides the possibility to average up to 256 frames. The integration over a specified number of frames allows for lower dwell times and enables cumulative noise reduction. Line integration, as suggested from the name, provides a different approach that scans each line repeatedly several times. The signal is collected, 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 you to get a higher signal to noise ratio. With interlaced scanning, the electron beam is scanned in different areas of the image instead of scanning each line progressively, resulting in minimized charge buildup.



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.***

DCFI: Drift Compensated Frame Integration

Drift compensated frame integration (DCFI) is an integration filter that corrects image drift in real time when active. While the signal is integrated from several frames, the system realigns each frame to compensate for any possible drift in the image. Furthermore, the integration of the signal provides higher clarity and sharpness to the image than that obtained from a single frame.

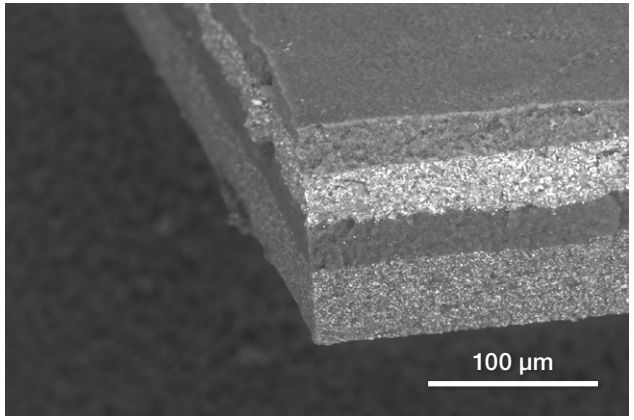


Nanosilver on gold. Left image shows the presence of drift as most of the features appear elongated and the integration of misaligned frames generate a blurry image. Right image shows the same image acquired using the same scanning strategy (dwell time and number of frames integrated) but with the DCFI. Acc voltage 15 keV, beam current 7.9 pA.

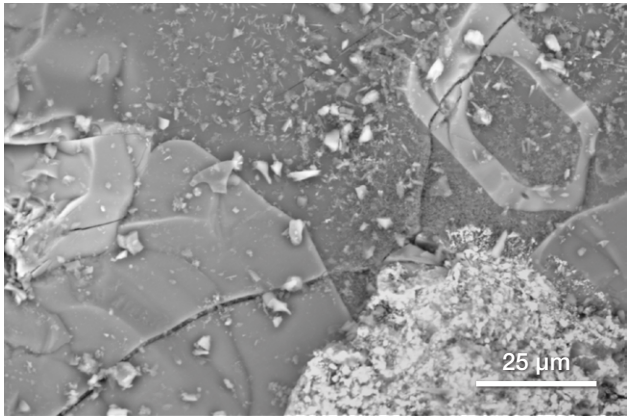
Retractable backscattered electron detector

Many of the previously mentioned applications make use of composite materials, which are combinations of two or more constituent materials. Composites are largely employed over traditional materials because they improve the properties and characteristics of the individual components and tend to expand their range of applications. In this regard, a key point is the investigation of the different material contrasts of the constituent materials in order to assess their distribution.

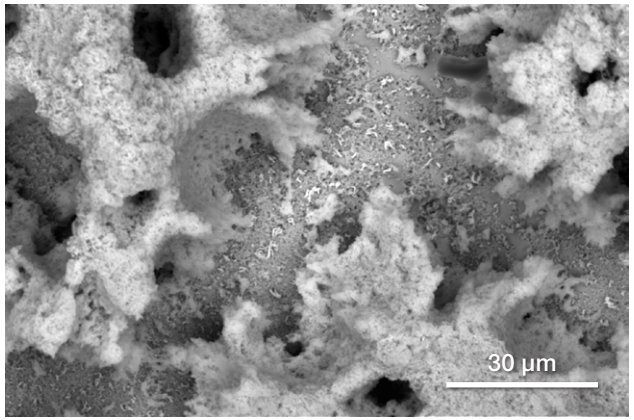
The Thermo Scientific backscattered detector is a retractable detector that offers two different segments for more tunable contrast. In fact, the inner segment captures the high-angle backscattered electrons (BSE) that will provide pure material contrast, while the outer segment receives low-angle BSE for topographical information.

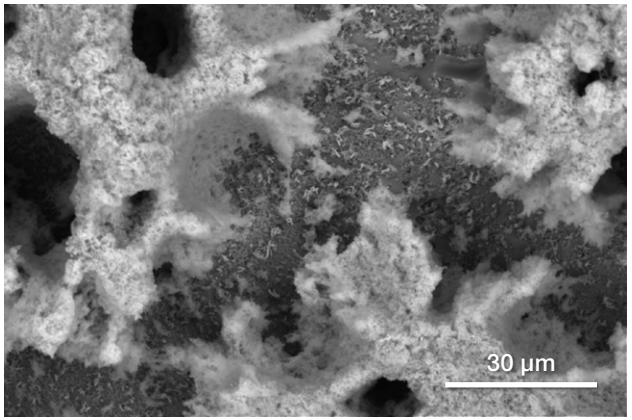


Cross section of coatings highlighting the different layers. Acc voltage 20 keV, beam current 3.6 nA.



Cross section of a tire. The backscattered electrons detector reveals fillers and additives with different composition; the different composition is highlighted thanks to the different greyscale levels. Acc voltage 20 keV, beam current 0.48 nA.





Electroplated bimetallic metal foams used as catalysts for the electrochemical reduction of CO_2. Left image shows the contribution provided by the inner ring of the backscattered electron detector, which higlights compositional contrast. Right image shows enhanced topography as it shows the contribution provided by the outer ring of the backscattered detector, which captures the low angle BSEs. Acc voltage 20 keV, beam current 3.6 nA. *Sample courtesy of Prof. Dr. Peter Broekmann, Department of Chemistry and Biochemistry, University of Bern.*

Retractable RGB Cathodoluminescence Detector

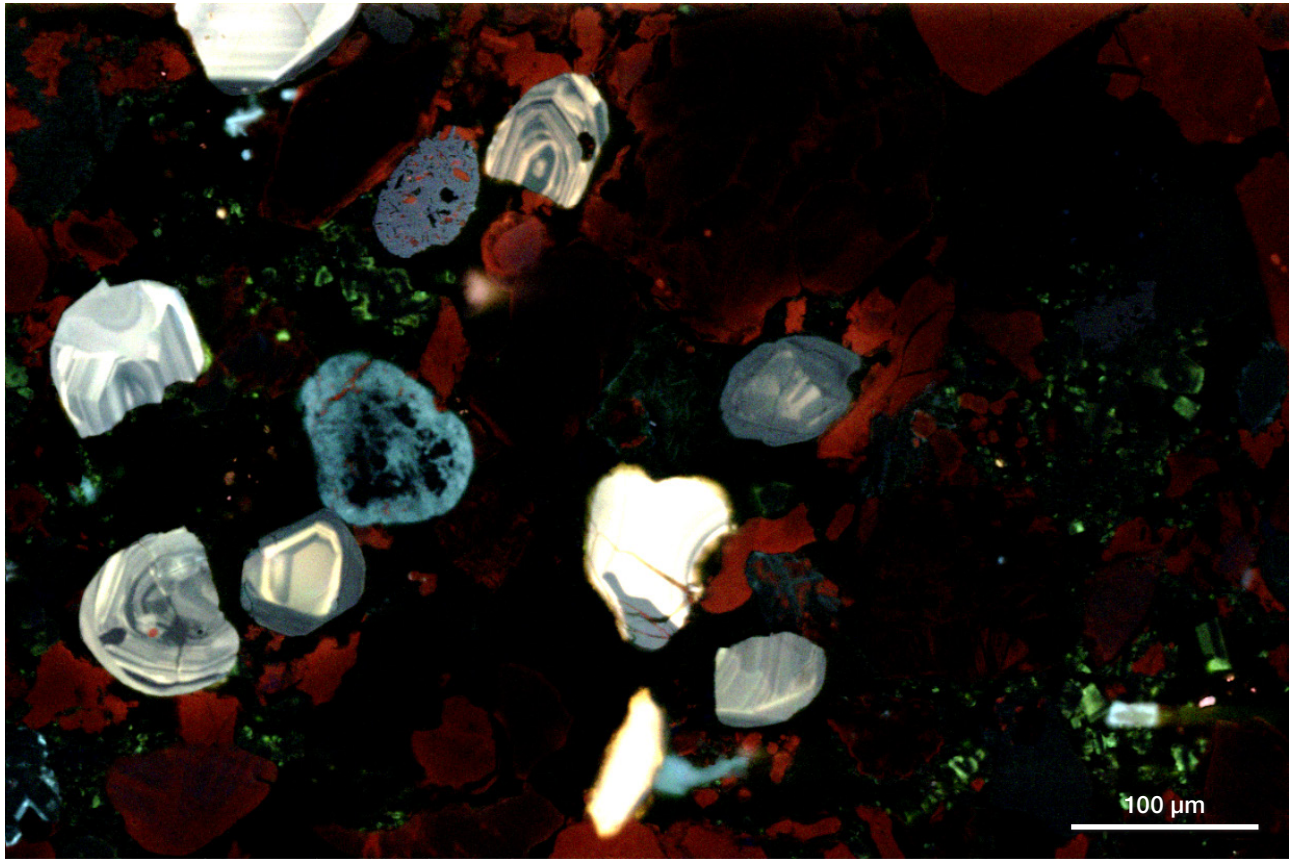
In several cases where SE, BSE or EDS do not show contrast, cathodoluminescence (light emitted from the sample) is able to map (trace) composition, crystal defects, or photonic properties. With its novel, flat detector design, the RGB cathodoluminescence detector (CLD) provides real color cathodoluminescence 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

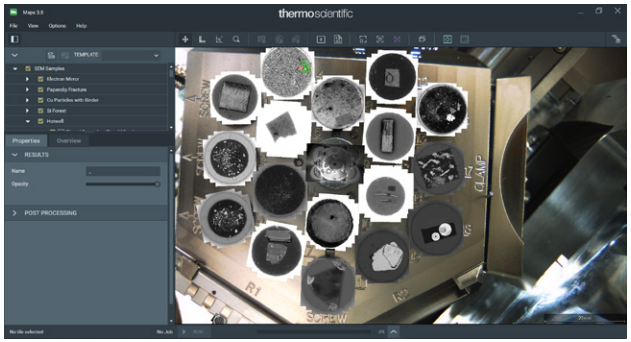


Sandstone sample showing zircons' zonation.

Application Software

Maps Software

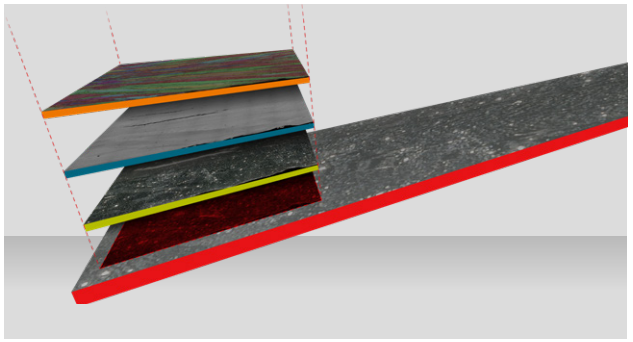
Thermo Scientific Maps™ Software is an intuitive automation and correlative workflow software suite for Thermo Scientific SEM, DualBeam™, and TEM platforms. Maps Software offers distinctive key features such as the ability to automate your acquisitions by running multiple samples in a series to increase 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.

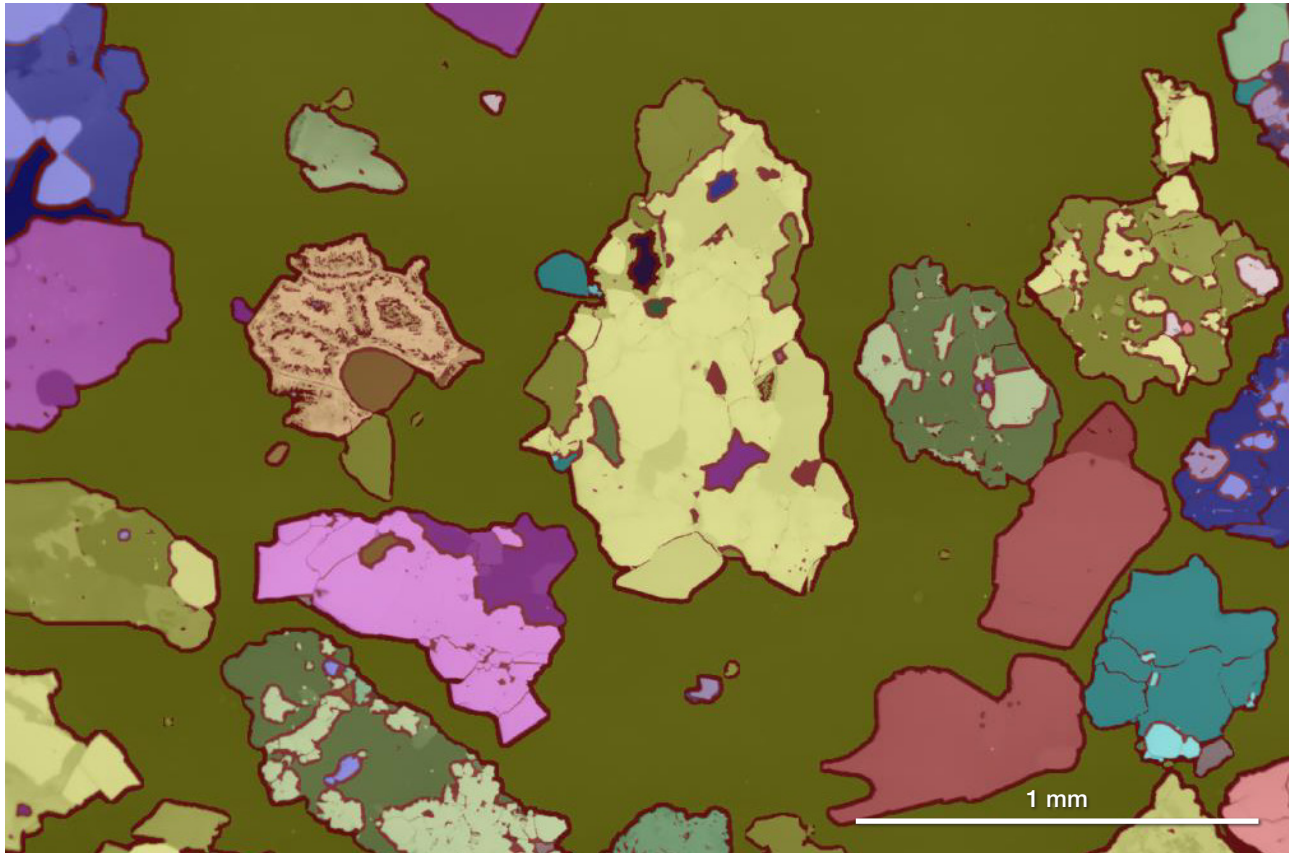
Key benefits

- 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.

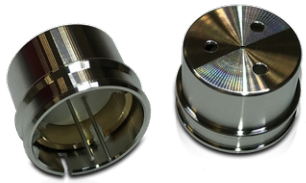


Feature-based image segmentation of a geological sample.

Less Maintenance

Easy source exchange

The newly designed exchange mechanism consists of a fully mounted and pre-centered filament within the Wehnelt cap. This allows you to simply plug it in and pump the chamber without cleaning an already used Wehnelt and subsequently aligning the filament.



Furthermore, filaments are pre-heated, eliminating the need to saturate them after pumping the chamber for the first time.

Improved self-serviceability and self-diagnostics

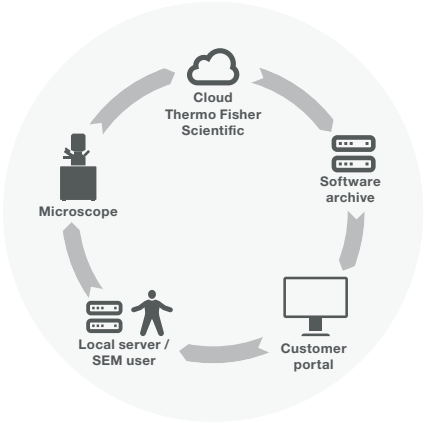
With an increased level of robustness and flexibility, the Axia ChemiSEM requires less service maintenance and intervention, thanks to a full set of automated alignments, which will improve the user experience.

Automated alignments

- Automatic gun alignments (heating, gun tilt, gun shift)
- Automatic stage alignments

Self-diagnostics

- Automatic software updates
- Self-diagnostic tools
- Guided maintenance (manual, videos)



Key Specifications

Electron beam resolution

- High-vacuum imaging
  - 3.0 nm @ 30 kV (SE) / 4.0 nm @ 30 kV (BSE)
  - 8.0 nm @ 3 kV (SE)
- High-vacuum imaging with beam deceleration
  - 7.0 nm @ 3 kV (BD mode* + BSED)
- Low-vacuum imaging
  - 3.0 nm @ 30 kV (SE) / 4.0 nm @ 30 kV (BSE)
  - 10 nm @ 3 kV (SE)

Detectors

Detects up to four signals simultaneously from any combination of the available detectors or detector segments:

- ETD: Everhart-Thornley SE detector
- Retractable under-the-lens backscatter detector
- TrueSight X EDS detector. Solid angle 13 mSr, resolution 129 eV. Optional upgrade to TrueSight LX - 38 mSr, 132 eV
- Low-vacuum SE detector (LVD), standard on LoVac model
- IR camera for viewing sample in chamber
- Thermo Scientific Nav-Cam™ Camera: color optical camera for sample navigation
- Photon Cathodoluminescence Detector for UI-integrated real color CL imaging*
- Current measurement*
- Third party detectors possible

Stage and Chamber

- Type: 5-axes motorized
- XY: 120×120 mm
- Repeatability: <5.0 µm (@ 0° tilt)
- Motorized Z: 55 mm
- Rotation: n×360°
- Tilt: -15° / +90°
- Max. sample height:
  - Clearance 72 mm to analytical working distance (10 mm), no sample holder
  - Clearance 128 mm to analytical working distance (10 mm) with ZTR axes removed
- Max. sample weight:
  - 500 g in any stage position
  - Up to 10 kg with ZTR axes removed
- Max. sample size:
  - 138 mm diameter with full XY moves, rotation, no tilt (larger samples possible with limited stage travel or rotation)

* Optional

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/Axia-ChemiSEM**

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