Good to See You.

Reveal the unseen.

ZEISS SEM

Scanning Electron Microscope Series

ZEISS

zeiss.com

Seeing beyond

Highest resolution & elemental analysis:
This image of zinc oxide dendrites aids detection of morphological changes in the electrodes of energy storage systems. It was captured with the field emission scanning electron microscope ZEISS Sigma.

More Information, More Possibilities.
Analyses for Industry

Scanning electron microscopy (SEM) is used for extremely precise component microstructure analysis featuring excellent depth of field and super-sharp resolution. This method generates image captures of the sample surface with very high magnification. X-ray microanalysis (EDX) can additionally be performed on the SEM, enabling the analysis of materials by determining their chemical element composition. The scanning electron microscope series from ZEISS offers a broad portfolio of systems for a wide range of quality assurance applications in industry.

ZEISS EVO is the conventional entry-level system, with a tungsten or LaB6 based filament, for daily repeatable imaging tasks, e.g. high-resolution material analysis, with largely automated and supportive workflows. The system offers flexibility for less demanding structure sizes.

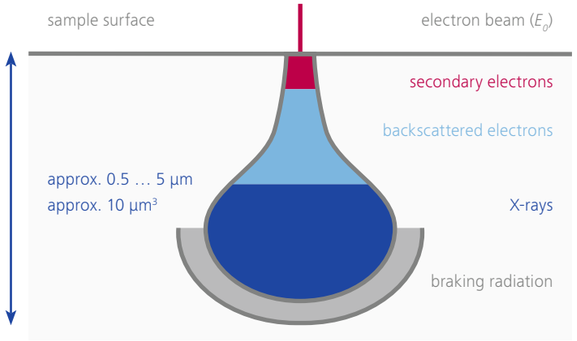
ZEISS Sigma is the field emission system for reliable high resolution imaging and analytics, offering more stability for smaller structures and finds your use for surface structures such as thin films. Easy operation, good optics, higher contrasts and simple handling characterize the system.

The high-end ZEISS GeminiSEM system for changing imaging, analyses and more complex tasks. With remarkable sub-nanometer resolution, you get more near-surface information in addition to low-voltage images - fast, precise and versatile.

The high-resolution field emission system of the premium class ZEISS Crossbeam, is additionally equipped with a focused ion beam (Ga-FIB) and an integrated femtosecond laser (optional). This provides insight into the interior of a sample by local material ablation and exposes high-contrast cross sections for SEM imaging, in the third dimension. Likewise, the system stands for automated TEM lamella preparation workflows.

ZEISS SEM Technology
What is SEM analysis?

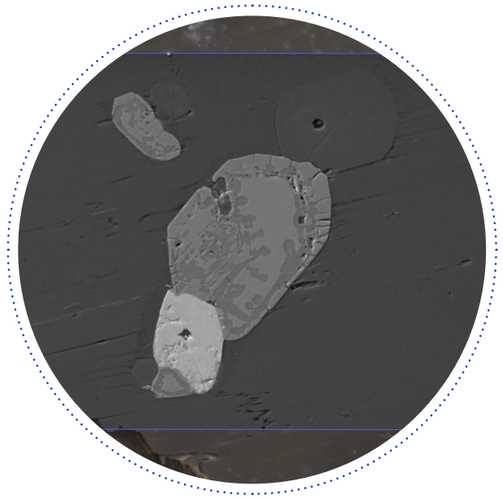
Scanning electron microscopy forms part of extended surface analysis and represents an important element within failure analysis. In SEM analysis, the component surface is bombarded by electrons in a scanning electron microscope. For this purpose, a primary electron beam is generated by means of an electron cathode for acceleration towards the anode. This electron beam is then focused through electromagnetic lenses onto the surface of the object requiring examination. The finely focused electron beam is passed in a line over the object to be imaged and the ensuing interaction of the electrons with the surface is analyzed. When the primary electron beam strikes the sample, this triggers a number of reactions in the surface.



Different excitation ranges for:
- *Characteristic X-ray radiation and background braking radiation*
- *Backscattered electrons (BSE)*
- *Secondary electrons (SE)*

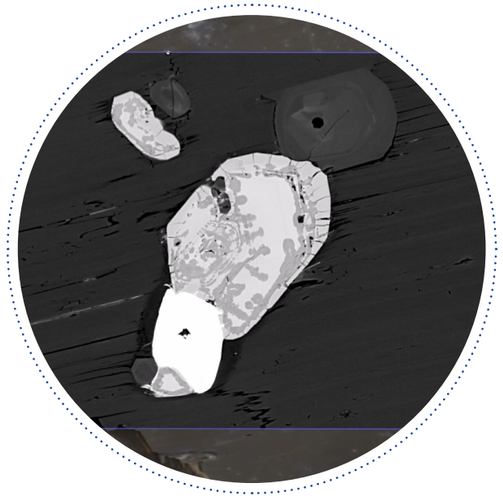
01
Secondary electron (SE) detection and imaging for topographical information
Imaging with secondary electrons provides topographical and near-surface information.

- Low energy
- Emitted from near sample surface
- Strong topographical information
- Fractured surface and failure analysis



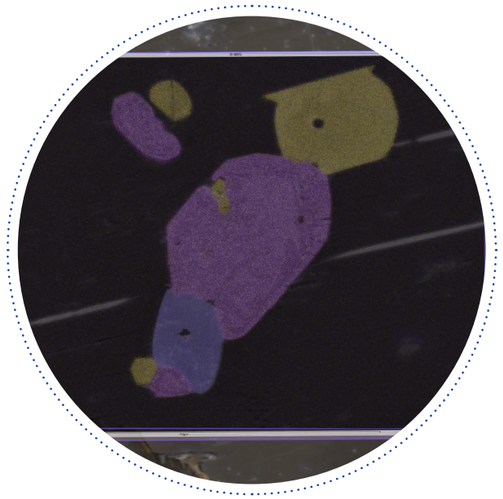
02
Backscattered electron (BSE) detection and imaging for compositional information
Imaging with backscattered electrons results in high material contrast. It is used to investigate the material composition of the sample.

- Higher energy
- Emitted from deeper within sample
- Compositional information
- Contrast imaging
- Identification of inclusions and impurities

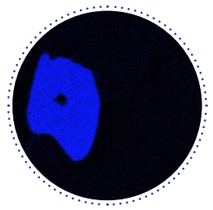


03
Energy dispersive X-ray spectroscopy (EDX) for mapping elemental information
EDX is used on the SEM to perform material analyses by determining the concentrations of chemical elements.

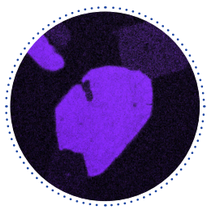
- Emitted from deeper within sample
- Material analysis
- Identification of elements and elemental compositions of inclusions
- Quantitative identification of chemical phases



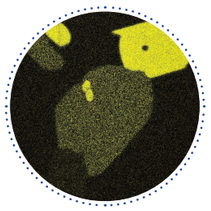
EDS mapping: thorium (Th), zirconium (Zr), phosphorus (P)



EDS map: Th



EDS map: Zr



EDS map: P

ZEISS EVO

The do-it-all electron microscope combining data quality with intuitive operation

The instruments in the ZEISS EVO family combine high-performance scanning electron microscopy with an intuitive, user-friendly experience that appeals to both experts and new users. With its comprehensive range of available options, ZEISS EVO can be tailored precisely to your requirements – no matter whether you are active in material sciences or routine industrial quality assurance and failure analysis.

Take your inspection to the next level. ZEISS EVO offers you a menu of configuration options to meet your exact price and performance requirements. Match your desired resolution to your application and choose from three chamber sizes. You can also opt for high vacuum, variable pressure, or ambient pressure to suit your sample type. Then choose between SE, BSE, EDX, VP, and C2D-SE detectors to suit your application. With ZEISS EVO, you enjoy the benefits of electron microscopy at an affordable price.

Fields of application

- Quality analysis and quality control
- Failure analysis/metallography
- Cleanliness inspection
- Morphological and chemical analysis of particles to meet ISO 16232 and VDA 19 Part 1 & 2 standards
- Analysis of non-metallic inclusions

ZEISS EVO

for intuitive and easy operation in routine applications and failure analysis

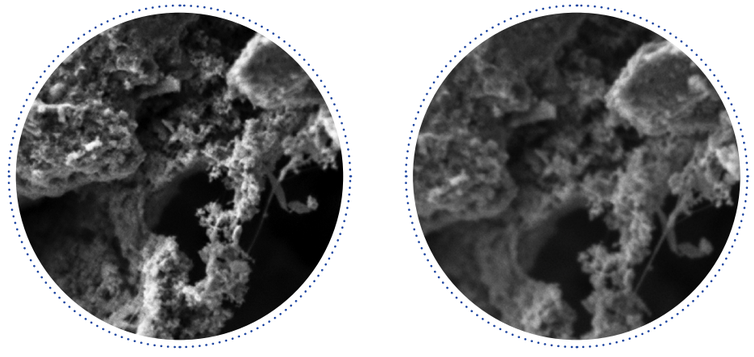
A versatile multipurpose solution
Configure a versatile multipurpose solution for your industrial quality assurance. Choose from different chamber sizes to meet all your application needs - even for large industrial parts and samples that can be challenging to process with SEM. Perform SEM examinations with maximum image quality by choosing the lanthanum hexaboride (LaB6) emitter, a proven technology that provides higher beam brightness for superior image resolution and noise reduction. Experience excellent imaging and analysis results on non-conductive samples with variable pressure operation. Benefit from a design that accommodates multiple analysis detectors to support your industrial applications.

Best-in-class usability
ZEISS EVO is designed for all users with the aid of a pair of user interfaces: SmartSEM Touch and SmartSEM. SmartSEM Touch, which can be run from a touchscreen, enables interactive workflow control. It is quick and easy to learn, enabling new users to capture stunning images within minutes. This user interface supports industrial users who need automated workflows for repeatable tasks. Experienced EVO users will find all the functionality they need for advanced imaging via the SmartSEM user interface.

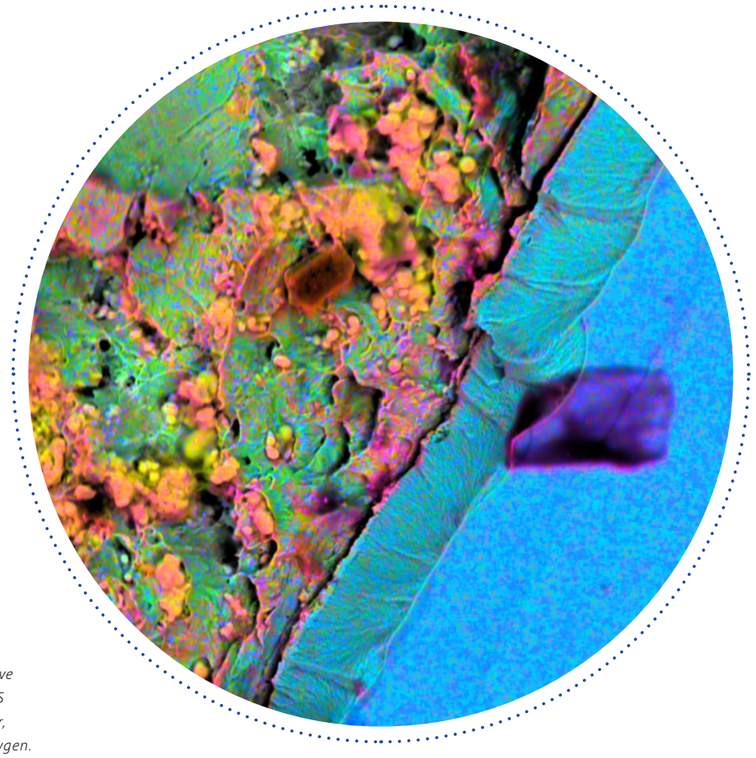
Excellent image quality
Image quality depends on how the sample is presented to the SEM. Variable pressure mode (VP) and our variable pressure and current cascade secondary electron (SE) detectors work together to provide the best possible image quality for all non-conductive samples. The advanced pressure mode, in combination with water vapor and the C2DX detector, ensures data quality for hydrated and heavily contaminated samples. The LaB6 emitter provides additional resolution, contrast, and signal-to-noise ratio.

Workflow automation and data integrity
ZEISS EVO plays well with others. This means the system can be configured as part of a semi-automated multimodal workflow, with tools that enable seamless relocation of regions of interest and ensure integrity of data collected from multiple modalities. Combine ZEISS EVO with the ZEISS digital light microscope ZEISS Smartzoom 5 – or any other compound light microscope – and combine light and electron microscope data for material characterization or parts inspection. Or combine ZEISS EVO with ZEISS light microscopes for correlative particle analysis.

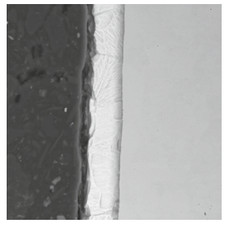
ZEISS EVO suits a range of industry applications
- Imaging and analysis of the structure, chemistry, and crystallography of metallic sample and inclusions
- Phase, particle, and weld analysis
- Visual inspection of electronic components, integrated circuits, MEMS devices, and solar cells
- Copper wire surface and crystal structure investigation
- Metal corrosion investigation
- Cross-sectional failure analysis
- Bonding foot inspections
- Capacitor surface imaging
- Morphology, mineralogy, and composition analysis
- Imaging and analysis of the structure metals, fissures, and non-metallic inclusions
- Morphological and compositional analysis of raw chemicals and active ingredients during micronization and granulation processes



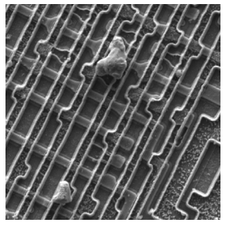
Fuel cells typically consist of polymer electrolyte membranes sandwiched between platinum electrodes. These critical components need to be imaged at low voltages to ensure surface detail information is obtained at high resolution. Cross section with an LaB6 source (left) and tungsten source (right) at 3 kV. LaB6 source provides more surface detail at low accelerating voltages.



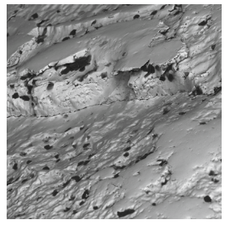
BSE images of representative corroded surfaces with EDS map: chrome, lead, copper, nickel, carbonium, and oxygen.



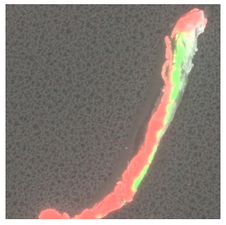
Cross section of galvanized mild steel, imaged using the SE detector on ZEISS EVO 15. Left: mounting resin; middle: zinc layer; right: mild steel.



Debris and contamination are evident on the surface of an integrated circuit. Imaged with the SE detector in high vacuum at 10 kV.



Surface of the ball bearing imaged with the BSE detector reveals cracking and flaking of the surface structure.



Particle from a particle filter: technical cleanliness analysis and quality control.

Field emission SEM

ZEISS Sigma

Access reliable high-resolution imaging and analytics

ZEISS Sigma is based on proven ZEISS Gemini technology. The Gemini objective lens design combines electrostatic and magnetic fields to maximize optical performance while reducing field influences at the sample to a minimum. This enables excellent imaging, even on challenging samples such as magnetic materials. The Gemini in-lens detection concept ensures efficient signal detection by detecting secondary (SE) and/or backscattered (BSE) electrons, thereby minimizing time-to-image. Gemini beam booster technology guarantees small probe sizes and high signal-to-noise ratios.

You can characterize all of your samples with the latest detection technology. Gather high-resolution topographical information with the novel ETSE detector and the InLens detector for high vacuum mode. Obtain crisp images in variable pressure mode with the VPSE or the C2D detector. Produce high-resolution transmission images with the STEM detector. And investigate the composition with the HDBSD or the YAG detector.

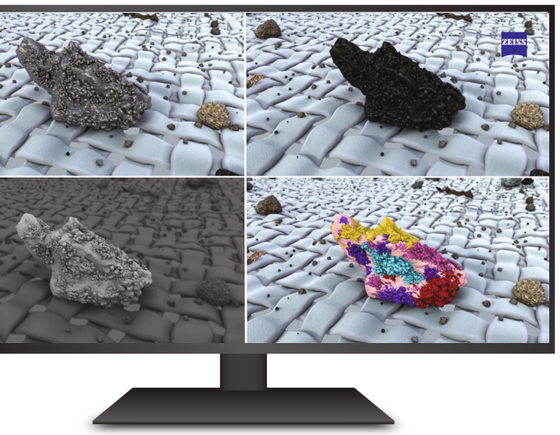
Fields of application

- Failure analysis of materials and manufactured components
- Imaging and analysis of steels and metals
- Inspection of medical devices
- Characterization of semiconductor and electronic devices in process control and diagnostics
- Acquiring chemical fingerprint of semiconductor materials and devices by identifying their unique vibrational and rotational energy level structure
- High-resolution imaging and analysis of novel nanomaterials
- Analysis of coatings and thin films
- Characterization of various forms of carbon and other 2D materials
- Imaging, analysis, and differentiation of polymer materials
- Performing battery research to understand aging effects and quality improvements

ZEISS Sigma

Automated particle analysis and multimodal correlative imaging

From manufacturing cleanliness and engine wear prediction to steel production, environmental management, and additive manufacturing – particle analysis solutions with an electron microscope from ZEISS automate your workflows and increase reproducibility.



Correlative Automated Particle Analysis
Correlated analysis spanning light and electron microscopy in a seamless integrated workflow

- ✓ Automatic integrated LM/EM reporting
- ✓ Pinpoint sources of contamination
- ✓ Make informed decisions faster
- ✓ Continually improve production quality
- ✓ Faster results: automated analysis instead of continuous individual analyses, plus faster particle inspection and testing with integrated machine learning algorithms

ZEISS SmartPI

ZEISS SmartPI has been designed for repeatable, high-volume analysis of routine samples in a production environment. The ability to identify, analyse, and report contamination data adds a new dimension to process control. Benefit from significant improvements in fully automated SEM particle analysis and classification. Let ZEISS SmartPI increase your productivity, increase your quality, and reduce your contamination cost.

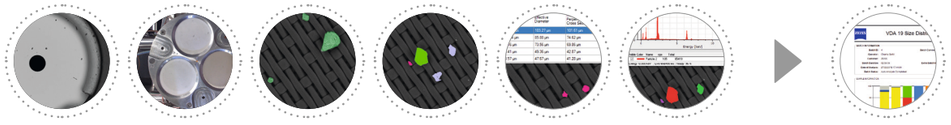
Automatically detects, measures, counts, and classifies particles of interest based on morphology and elemental composition.

- Industry-standard reports are generated automatically, such as VDA 19.1 & ISO 16232
- Fully integrated and compatible with Bruker & Oxford EDS systems

ZEISS SmartPI
Quantification & advanced classification

Reporting
SmartPI Reporter

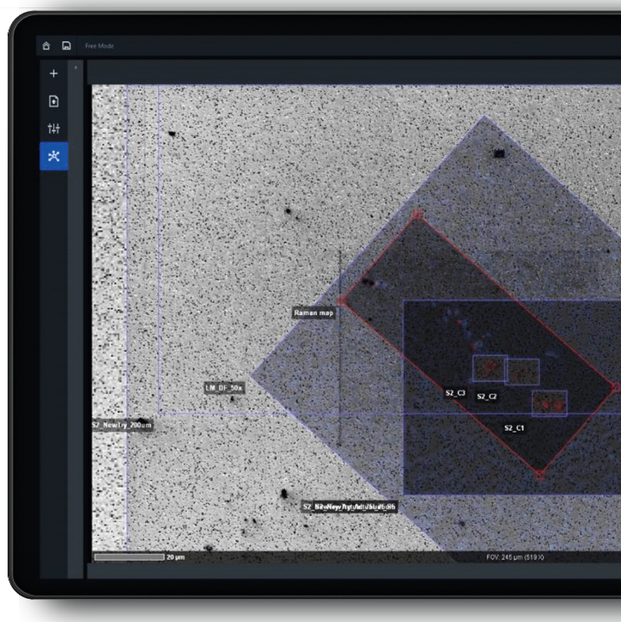
SOFTWARE

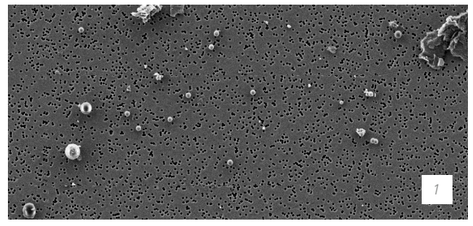


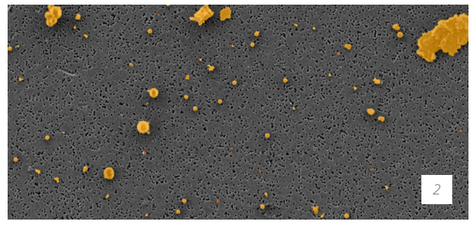
✓ Calibrate ✓ Move ✓ Capture ✓ Detect ✓ Measure ✓ Analyze ✓ Report

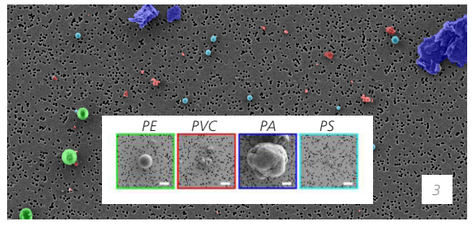
Multimodal Correlative Imaging of Microplastics Particle Analysis

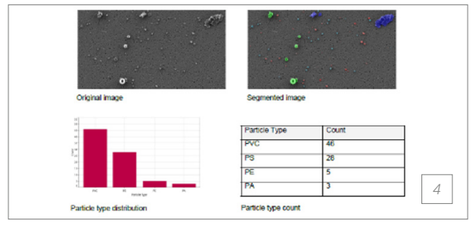
ZEISS ZEN Intellesis enables particle identification by machine learning. The results can be accessed via the powerful ZEISS ZEN connect software. ZEISS ZEN Intellesis then provides further insight into the particle distribution based on machine learning image segmentation and object classification. For an SEM image (1), Image Analysis is used to segment all particles (2) and measure chosen features. Measurements can be displayed in the form of size distribution, for example. Intellesis Object Classification is used to further classify segmented particles and sort these into their sub-types (3). The particle count per type can be executed using this information. Object classification is performed for standard nano- and microplastic particles (polystyrene (PS, light blue), polyethylene (PE, green), polyamide–nylon 6 (PA, dark blue), and polyvinyl chloride (PVC, red)) on a polycarbonate filter imaged with ZEISS Sigma. This correlative study combines the high resolution of an electron microscope with the analytical capabilities of a Raman microscope.











Correlation of these two microscopic methods, SEM and Raman, is used to generate maximum information during analysis – especially for polymer particles. ZEN Connect serves to overlay with Raman for basic analysis and ZEN Intellesis for automated classification. The reporting tool is used to automatically create reports in ZEN core based on templates and saves them in pdf or doc format (4).

ZEISS GeminiSEM
The class leader in sample flexibility

Discover the unknown and meet the highest demands in sub-nanometer imaging, analytics, and sample flexibility with a field emission SEM.

The system enables high throughput analysis while providing excellent resolution at low voltage, high speed, and high probe current. With its generous field of view and extremely spacious chamber, it is easy to examine even very large samples. ZEISS GeminiSEM delivers efficient chemical composition and crystal orientation characterization with two diametrically opposed EDS ports and a coplanar EDS/EBSD configuration. Rely on shadow-free mapping at high speed. Customize and automate your workflows: If you need to test materials to their technical limits, ZEISS puts an automated in-situ heating and mechanical stress lab at your disposal.

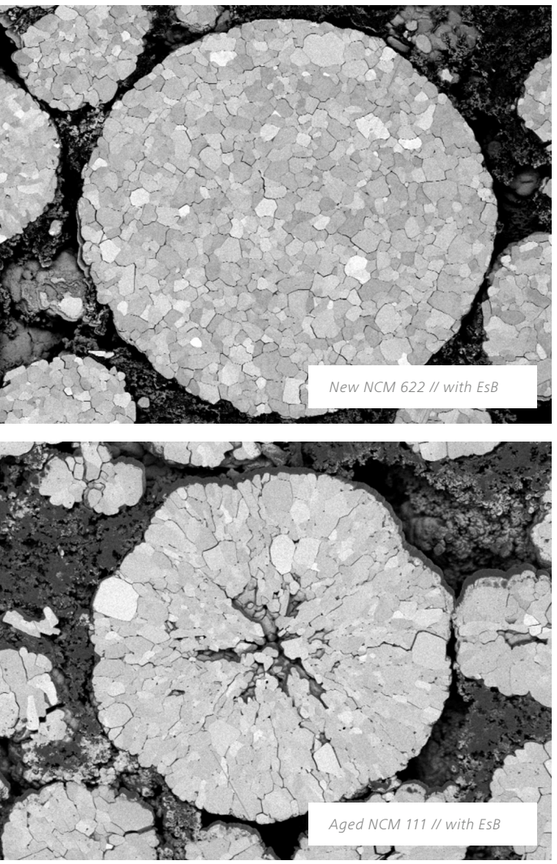
Fields of application

- Failure analysis on mechanical, optical, and electronic components
- Fracture analysis and metallography
- Surface, microstructure, and device characterization
- Compositional and phase distribution
- Impurity and inclusion determination

ZEISS GeminiSEM

Imaging and material analysis of lithium-ion batteries

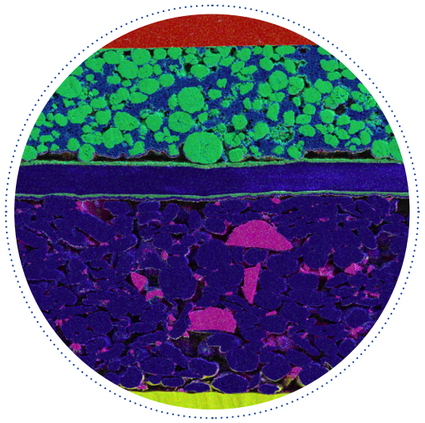
While the future of energy use depends on developing new functional materials and advanced devices such as batteries, solar cells, and fuel cells, how these devices perform is intricately linked to their microstructure and the microstructure of their materials. These complex material systems rely on the interplay between many different materials to operate effectively.

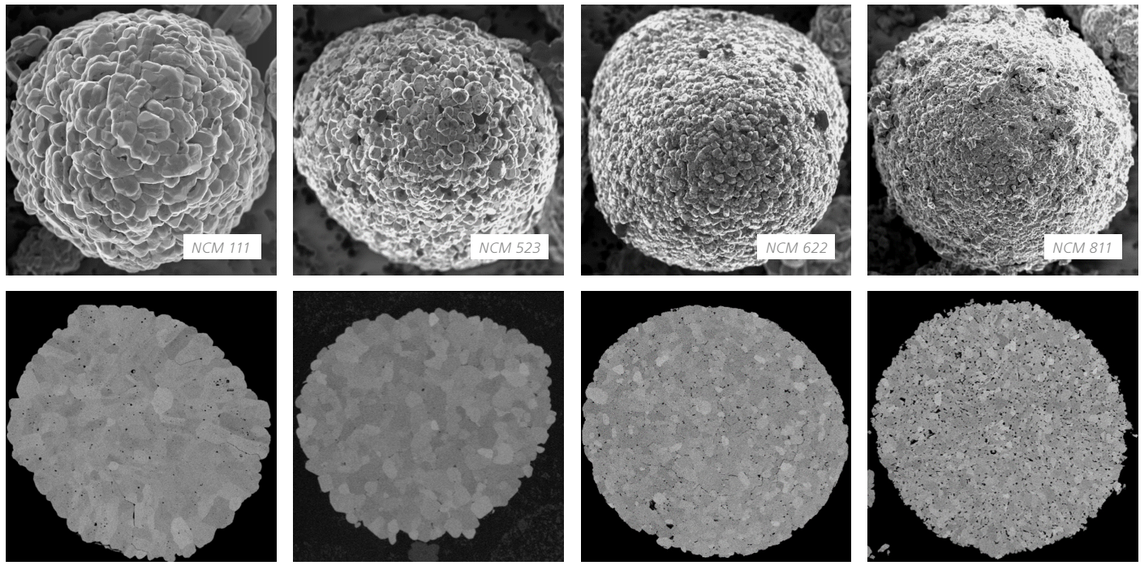


The example shows the cross section of a lithium-ion battery with NCM 111 as cathode. The charging and discharging of lithium-ion batteries leads to changes in the microstructure. Cracks form, resulting in a larger surface area of the SEI layer. Battery performance is reduced.

One of the key issues in automotive lithium-ion battery technology is the development of high nickel content cathode materials based on nickel, cobalt, and manganese. The terminology NCM111, 523, etc., refers to the ratios of nickel, cobalt, and manganese respectively. Cobalt as a raw material is notoriously expensive and its scarcity represents a supply risk to manufacturers. Reducing the ratio of cobalt is thus attractive from a material cost perspective. In addition, the performance of high-nickel cathode materials offers superior properties such as higher power with similar energy density. The trade-off is that NCM622 and NCM811 are presently very difficult to make at scale, and current manufacturing processes result in sub-optimal yields. Obtaining economic yields of nickel-rich NCM cathode powder at scale is at the core of the competitive strategy for battery giants such as the leading battery manufacturers. Using an electron microscope, we can see that there are structural differences between the NCM variants when other production factors are fundamentally accounted for. When seen in cross section, the primary particles of 811 are much smaller than those of 532 or 111. This excellent material contrast of the sub-grain structure is visible only with a feature unique to ZEISS electron microscopes – the Energy Selective Backscatter (EsB) detector.

Cross section of full-stack lithium ion battery cell: EDS mapping (O, Al, F, Si, and C). It is possible to use energy dispersive spectroscopy (EDS) to confirm the elemental composition of objects under investigation in the microscope. This image confirms high levels of residual fluorine on the cathode side, as expected in an aged sample. Fluorine is found in the electrolyte and joins an SEI layer that increases with aging. The boehmite separator shows aluminum and oxygen signals, as expected. Carbon is used as a conductive agent in the binder. As the polymer of the separator is a hydrocarbon, this means carbon can be seen throughout the battery.





The microstructure of NCM battery materials is different depending on the ratio of nickel, cobalt, and manganese used. Higher nickel content typically leads to smaller grain size if all other factors remain equal. Charging and discharging lithium-ion batteries leads to changes in the microstructure. Cracks form, leading to a larger surface area of the SEI layer. Battery performance is reduced. Better electrolyte chemistry can reduce the physical deterioration of the cathode materials. Better chemical processes can produce cathode materials with larger grain particles – which offers potential for the next generation of all solid-state batteries.

ZEISS Crossbeam
Targeted for the third dimension

The combination of scanning electron microscope (SEM) and focused ion beam (FIB) makes it possible to specifically cut into material on the smallest scale (nanometer range) and directly image the material structure below the surface. Typical applications include precise localization and chemical analysis (EDX) of local defects.

Prepare thin lamellae for their analysis in TEM (Transmission electron microscopy) or STEM (Scanning transmission electron microscopy). ZEISS Crossbeam offers a complete solution for preparing TEM lamellae, even in batches. The low-voltage performance of the ion-sculptor FIB column supports high-quality lamellae and avoids amorphization of delicate specimens. Use a simple workflow to get started and wait for automatic execution. Benefit from endpoint detection software that provides accurate information about the thickness of your lamella.

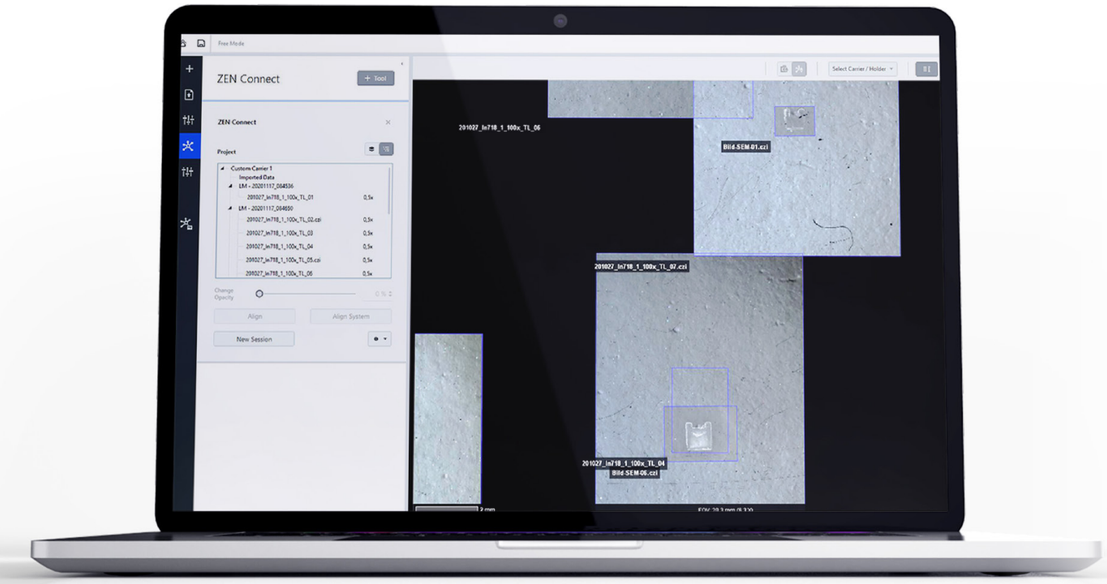
Fields of application

- Local cross sections, e.g. at defect sites (growth defects of thin films, corrosion, trapped particles, etc.)
- TEM lamella preparation
- High-resolution cross-section investigations in transmission (STEM)
- 3D tomography of microstructure or local defects
- Processing of structures via targeted material removal

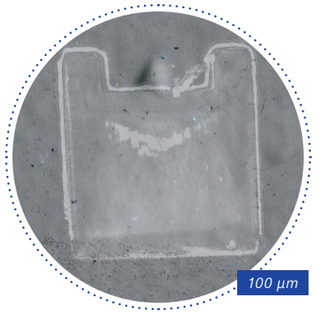
ZEISS Crossbeam

FIB-SEM failure analysis on automotive body parts

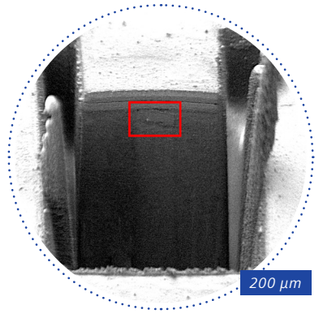
Due to greater manufacturing quality and cutting-edge surface finishing technologies, defects are now smaller and less frequent. Microscopic methods must therefore be used to find, locate, prepare, and investigate surface defects and their root causes. This brochure outlines a correlative microscopy approach for efficient investigation during failure analysis. In this context, light microscopy tasks are handled by the ZEISS Smartzoom 5 digital microscope, preparation and investigation are carried out with the ZEISS Crossbeam laser, and both systems are correlated by ZEISS ZEN connect for precise defect relocation in the FIB-SEM.



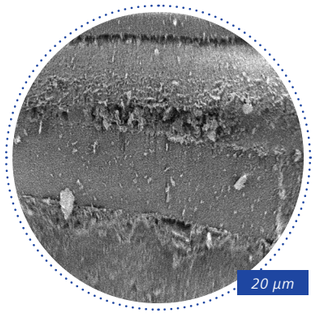
Overlay of laser-milled trench on light microscope image of ROI; SEM, SESI, 450x.



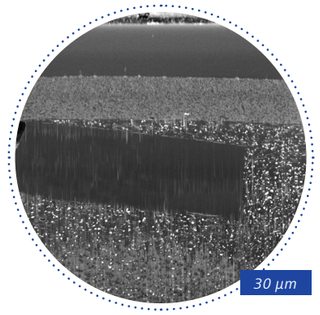
Overlay of laser-milled trench on light microscope image of ROI.



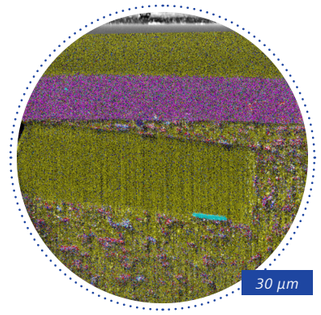
Laser-milled cross section through surface defect, suspicious feature visible beneath paint layers; SEM, SESI, 50x.



Suspicious feature in base material underneath paint, laser-milled surface; SEM, SESI, 450x.



FIB post-polishing, good surface finish with clearly distinguishable features; SEM, InLens, 450x.



EDS element mapping of FIB-polished area; yellow: C intensity, blue: Al intensity, pink: Ti intensity, red: Si intensity.

Finding the root cause of sparsely distributed and small defects on large samples for efficient failure analysis requires a convenient workflow of locating, documenting, re-locating, preparing, and investigating regions of interest. Focused ion-beam equipped scanning electron microscopes (FIB-SEM) exceed the limits of standard materialographic target preparation methods. But since the narrow field of view typically provided by EMs means it is sometimes easier to perform location with a light microscope, operators require a method for location in the LM and relocation in the FIB-SEM.

The ZEISS ZEN connect software solution combines with ZEISS ZEN data storage to provide exactly this. The new femtosecond laser for the ZEISS Crossbeam family also offers location-specific preparation in large areas. With the help of fs-laser and FIB cross-section polishing and EDS analysis, the cause of the surface defects in the above example was determined as carbon fiber scraps. The correlative microscopy approach also enables efficient investigation of more than one area of interest. All results are subsequently saved in a coherent project, with the ZEISS ZEN data storage option ensuring full accessibility for further investigation or reporting.

The solutions to meet your needs

ZEISS scanning electron microscope (SEM) series

ZEISS EVO family

Standard entry-level system

Conventional scanning electron microscope dedicated to challenging analytical EDS workflows

- Handles routine applications
- Double condenser for best material feedback in your EDS routine
- Flexible, powerful, and affordable
- The smart alternative to tabletop SEMs for material analysis
- Short time to result and high throughput

Simplified user interface: ZEISS SmartSEM Touch
Predefined workflows and typical parameters for non-experts in multi-user environments.

Extended Pressure Mode
Hydrated contaminated samples kept in natural state via through-the-lens pumping.

Large chamber
Examine large samples or multiple samples to increase efficiency.

Longevity
An excellent investment that delivers well over a decade of usage.

ZEISS SmartPI (Smart Particle Investigator)
Fully automated particle analysis solution for meeting ISO 16232 and VDA 19 Part 1 & 2 standards.

Resolution at 1 kV: 9 nm

Further information on the ZEISS EVO family:
www.zeiss.com/evo

ZEISS Sigma family

Advanced system

Field emission scanning electron microscope for high-quality imaging and advanced analytical microscopy

- Accurate reproducible results from any sample
- Quick and easy experiment setup
- Based on proven Gemini technology
- Flexible detection for clear images
- Sigma 500 features best-in-class EDS geometry

Simplified user interface: ZEISS SmartSEM Touch
Predefined workflows and typical parameters for non-experts in multi-user environments.

RISE (Raman Imaging and Scanning Electron)
Integrated solution for confocal Raman analysis of the same ROI.

Inlens duo detector
Acquire high-resolution topographical information in high vacuum mode.

ZEISS SmartPI (Smart Particle Investigator)
Fully automated particle analysis solution for meeting ISO 16232 and VDA 19 Part 1 & 2 standards.

3D surface modelling with 3DSM
Live topography reconstruction with 4-channel parallel BSD for quick quantitative information.

Resolution at 1 kV: 1.3 nm

Further information on the ZEISS Sigma family:
www.zeiss.com/sigma

ZEISS GeminiSEM family

High-end system

Field emission scanning electron microscope for the highest demands in sub-nanometer imaging, analytics, and sample flexibility

- Highest image quality and versatility
- Advanced imaging modes
- High-efficiency detection, outstanding analytics
- ZEISS Gemini technology perfected over 25+ years
- Large variety of detectors for best coverage

NanoVP
Market-leading variable pressure vacuum of up to 500 Pa to reduce charging effect of non-conductive samples.

Inlens EsB detector
Inlens energy selective backscatter for highly surface-sensitive material contrast, e.g. for fiber thickness measurement.

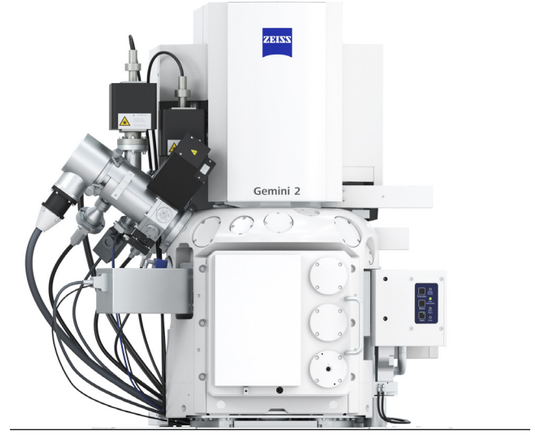
Smart autopilot
New electron optical engine delivers clear, crisp images within seconds.

Analytics
Featuring Gemini 2 and double condenser, ideal for EBSD and EDS analytics in the most challenging workflows.

In-situ mechanical tests
Automated heating and tension experiments while plotting stress-strain curves on the fly.

Resolution at 1 kV: 0.8 nm

Further information on the ZEISS GeminiSEM family:
www.zeiss.com/geminisem



ZEISS Crossbeam family

Premium-class system

Field emission scanning electron microscope for high-throughput 3D analysis and sample preparation

- Best 3D resolution in FIB-SEM analysis
- Two beams, ions, and electrons
- Sample preparation tool
- Comprehensive sample characterization
- EDS, EBSD, WDS, SIMS, plus more on request
- Maximize sample insights through targeted analysis in the third dimension

TEM (transmission electron microscope) sample preparation
Holistic automated batch preparation of TEM lamellae via simple three-step workflow for accurate thickness information.

Combining laser and FIB
Add a femtosecond laser to your ZEISS Crossbeam and benefit from massive material removal and minimal damage.

Increased FIB sample throughput
Intelligent material removal strategies cut experiment time by up to 40%.

Resolution at 1 kV: 1.4 nm

Further information on the ZEISS Crossbeam family:
www.zeiss.com/crossbeam

ZEISS Efficient Navigation – ZEN

ZEISS ZEN core: your software suite for connected microscopy and image analysis

Complete overview at a glance: one user interface for all microscopy results
ZEISS ZEN core not only handles microscopy imaging, it is the most comprehensive suite of imaging, segmentation, analysis, and data connectivity tools. ZEISS ZEN core is your hub for connected microscopy. Customize its functions to your specific applications and define workflows that consider the experience level of the microscopists in your multi-user environment.

During processing, data from different devices are merged into a single analysis result. Take quality assurance, for instance: No matter whether you check electronic parts or painted car body parts for defects, the part is always subject to a visual inspection under the light microscope as a first step. Once the defect has been located, the cause analysis starts. And this is where the scanning electron microscope comes in handy with material analysis or resolution imaging.

Although the specimen looks entirely different under various microscope types, ZEISS ZEN core is able to relocate a flagged area during the analysis process. Data and images are merged, meaning that painstaking searches for the test point across different microscope types are now a thing of the past. The images are automatically overlaid or combined, thus revealing the information. This facilitates collaborative and cross-site work with data.

Automated microscopy workflows at the push of a button
When workflows are fully automated using artificial intelligence (AI), productivity hits new heights.

Automated image acquisition with an AI-supported system to flag interesting areas has already become a standard feature. The AI can segment images – a groundbreaking feature which had to be performed by humans until recently and which can now be automated – in addition to performing analyses and reporting.

However, accurate results require more than just correct recognition of particles or phases: The automated classification of inspected objects in the microstructure must also be correct and can be enhanced by machine learning.

Customized workflow from the SolutionsLab

- **1 Input**
- **2 Image Acquisition and Processing:** e.g. AI denoising
- **3 Image Segmentation:** Deep learning from the SolutionsLab
- **4 Classification/Measurement:** Analysis with ZEN core
- **5 Report:** ZEN core report

Get more information:
www.zeiss.com/solutions-lab

A spotlight on correlative microscopy.
ZEISS ZEN Connect.

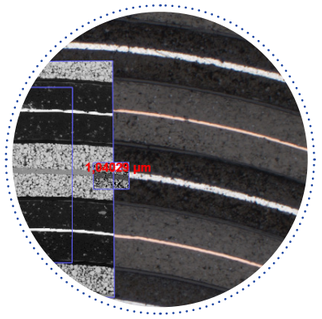
ZEISS ZEN Connect enables correlative image presentation from different microscope types (e.g. light and electron microscopes) in a connected map. This is highly beneficial for detailed investigation of large overview images, such as with battery cells.

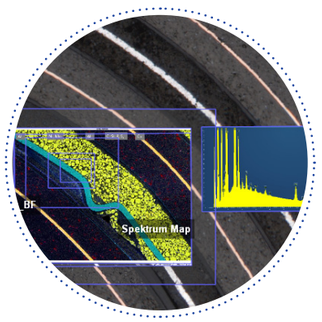
Organize and visualize different microscopy images to connect multimodal data – all in one place. This open platform enables you to move quickly from general overviews to advanced imaging, even when using third-party technology. Not only can all image data be aligned, overlaid, and shown in context, ZEN Connect is able to retain the metadata of external images that adhere to the well-established Bio-Formats standard. Transfer samples and image data between different electron and light microscopes as desired.

Since all regions of interest are automatically relocated and shown in context following one-off alignment in ZEN Connect, you acquire the maximum amount of relevant data with a minimum of effort. You can also organize data from multiple modalities and select from a range of options to ensure perfect alignment.

All images acquired with ZEN core are saved in well-structured database projects, including an intuitive label attached automatically to each image file. Each overlay image and its connected dataset is easy to find, and users can additionally search for microscope type and imaging parameters via the new filter function. Further processing is performed through integrated reporting functions and advanced export functionalities such as videos.

- Visualized data collection: supports import and attachment of non-image data such as reports and descriptions (pdf, pptx, xlsx, docx, etc.).
- Easy navigation: click overview image to examine or re-evaluate any ROIs in full image overlay.



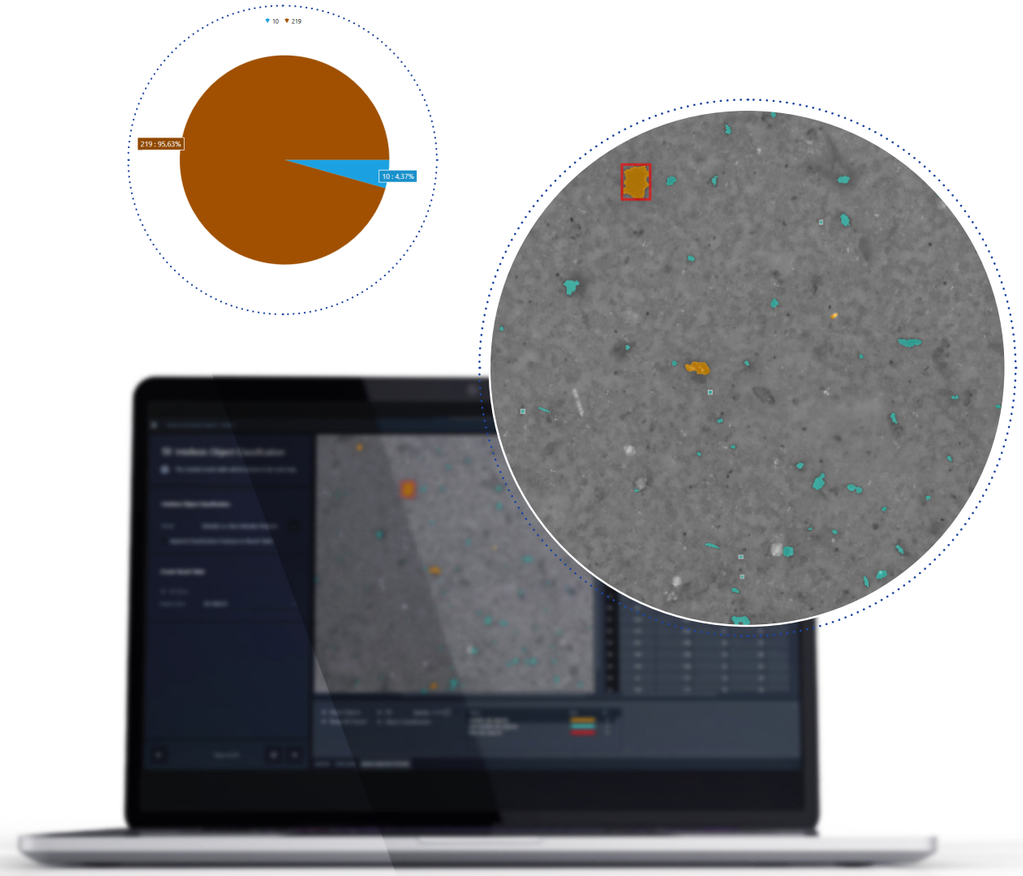


ZEISS ZEN Connect even enables the import and correlation of non-image data such as EDS results. Compatible with the leading EDS system manufacturers.

More intelligent.
More time-saving.
ZEISS ZEN Intellesis.

Using established machine learning techniques such as pixel classification or deep learning, ZEN Intellesis enables even non-experts to generate robust and reproducible segmentation results. Simply load your image, define your classes, label the pixels, train your model, and perform segmentation.

After training the software once on just a handful of images, you can segment batches of hundreds of images automatically to save time and minimize user bias. All time-consuming segmentation steps on the many similar images are handled by powerful machine learning algorithms. Complex multidimensional and multimodal data can be analyzed regardless of its origin, and you can also import and use your own deep learning models.



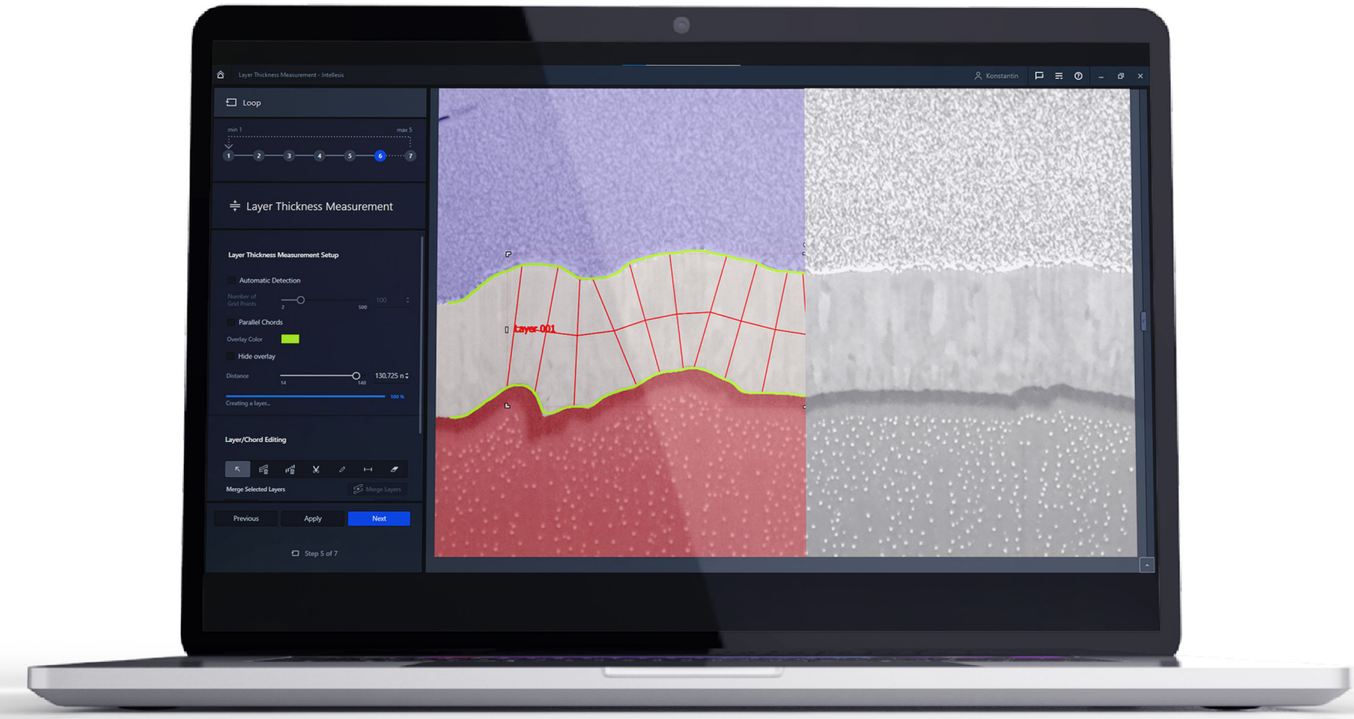
ZEISS ZEN Intellesis enables particle identification by machine learning and provides higher accuracy for particle identification, learning image segmentation, and object classification.

Intellesis Object Classification is used to further classify segmented particles and sort these into their sub-types. This information can then be used to count particles per type.

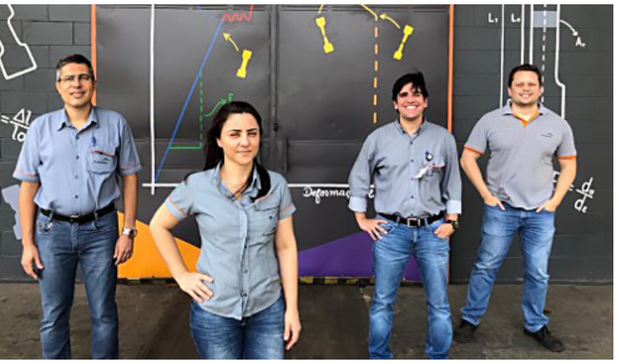
ZEN Intellesis supports easy segmentation of multidimensional images from numerous different imaging sources including widefield, super-resolution, fluorescence, label-free, confocal, light sheet, electron, and X-ray microscopy. ZEN's evaluation modules then enable automatic report creation and measurement according to industrial standards.

When it comes to post-segmentation classification by type, ZEN Intellesis takes an innovative approach. Instead of looking at individual pixels as a typical machine learning solution would, its object classification model uses more than 50 measured properties per object to distinguish and classify them automatically. Based on tabulated data, this classification process is much faster than segmentation performed by specifically trained deep neural networks.

Layer thickness:
FIB cross section overlay of CIGS solar cell layers: result from Crossbeam 550 InLens detector (right) and after ZEN Intellesis machine learning segmentation (left).



Developing Smarter Steel
with AI-Powered Software Analysis



ArcelorMittal, the world's leading steel and mining company, is focusing on creating smarter steels that are cleaner, stronger, and reusable.

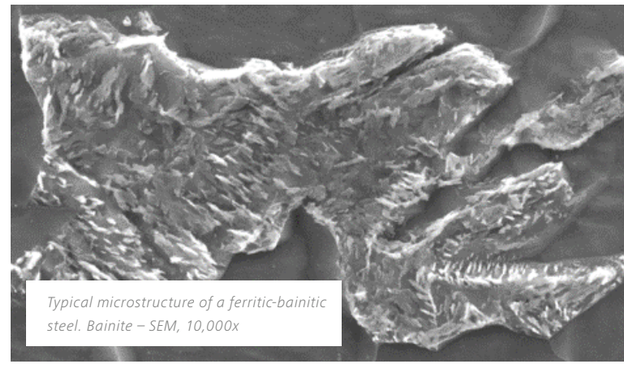
> *We use ZEISS ZEN Intellesis for auto-segmentation and improved analysis of our second-phase constituents in steel. This changes the way we characterize materials, boosting both speed and reliability.*
>
> ***The ArcelorMittal Tubarão team***

ArcelorMittal uses its metallurgical expertise to develop alloy design and process parameters for meeting specific customer needs. A series of quality control parameters drafted on this basis serve to guarantee that the steel is suitable for a given application.

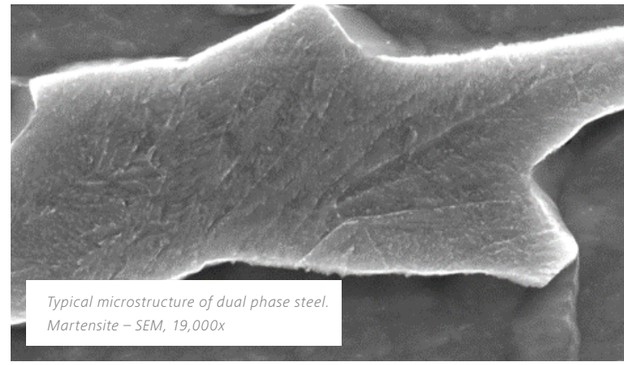
See the whole customer story here:
zeiss.ly/40a8

The company benefits from scanning electron microscopy and artificial intelligence (AI) with ZEISS Intellesis.

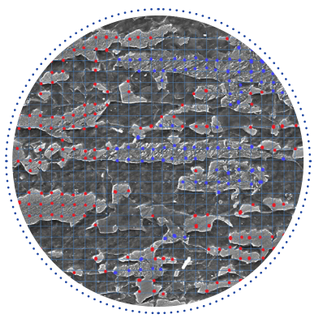
Machine learning classifications are much more noise tolerant than their traditional counterparts. They are used to distinguish features that have little or no difference in their SEM grayscale values and can only be differentiated based on texture. This can outperform typical software characterization that relies solely on 2D images and grayscale differences. Under different process conditions, the same steel can end up generating very different and complex microscale interactions of microstructural constituents with varying mechanical properties. Characterizing these phases in a large area with high reliability and speed is of paramount importance for applications such as the development of new products and failure analysis. Industries and research institutions that intend to play a leadership role in the development of new and more advanced steels need to improve their process simulation and product characterization capability and capacity. These aspects are essential for keeping pace with increasingly complex and challenging technical developments in steel production.



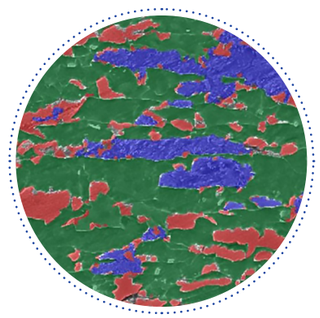
Typical microstructure of a ferritic-bainitic steel. Bainite – SEM, 10,000x



Typical microstructure of dual phase steel. Martensite – SEM, 19,000x



Percentages: Martensite 22.86% // Bainite 12.16% // Ferrite 64.98%
Time: 18 min



Martensite 22.82% // Bainite 13.39% // Ferrite 63.79%
Time: 2 min

Subdivision into bainite, martensite, and ferrite. Left: The points used in counting the lattice of this steel, and especially the use of two different colors, enable precise distinction between the different phases in the same microstructure. Right: In this case, ZEISS ZEN Intellesis distinguishes the steel phases more quickly on the basis of the colors and is much more efficient. The primary phase is ferrite (green) and the secondary phases are bainite (blue) and martensite (red).

GLOBAL **Quality** NETWORK

ZEISS Industrial Quality Solutions is a world leader in quality assurance and inspection. Over 4,600 employees from more than 100 sales and service centers support customers around the world. ZEISS is recognized as a leading partner for the automotive, aerospace, mechanical engineering, medical technology, electronics, and plastics industries.

The range of solutions includes coordinate measuring machines, optical 3D scanning, 3D testing, computed tomography, and microscopy. ZEISS combines trusted hardware with powerful software to inspect, analyze, and evaluate quality data.

All key components, such as controllers, software, measuring systems, and sensors, are developed and manufactured in-house. ZEISS ensures seamless integration into customers' quality assurance processes with its thorough expertise in loading and automation systems and its complete turnkey solutions. These benefits are complemented by a broad product portfolio, enabling customers to overcome current and future challenges.

38
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245
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11
Production Sites

4,600
Employees

60
Quality Excellence Centers

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