Синхротронная оптика для исследований, системы очистки фотошаблонов в фотолитографии PRT, платформы для актиничных EUV-измерений AIMS, системы регистрации и метрологии PROVE neXT

Технические характеристики

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What Drives Us

As the pioneer of scientific optics, we continue to challenge the limits of human imagination. With our passion for excellence, we create value for our customers and inspire the world in new ways.

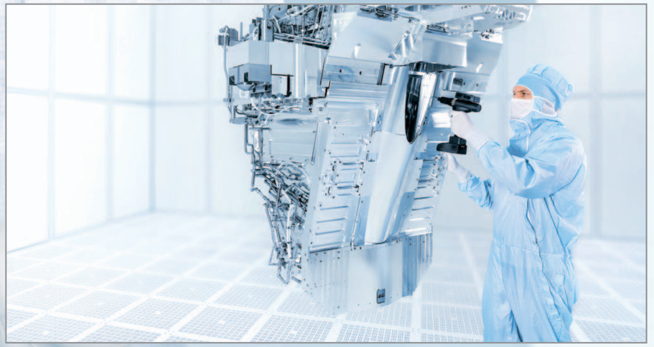
ZEISS Semiconductor Mask Solutions

Excellent Service

Great team

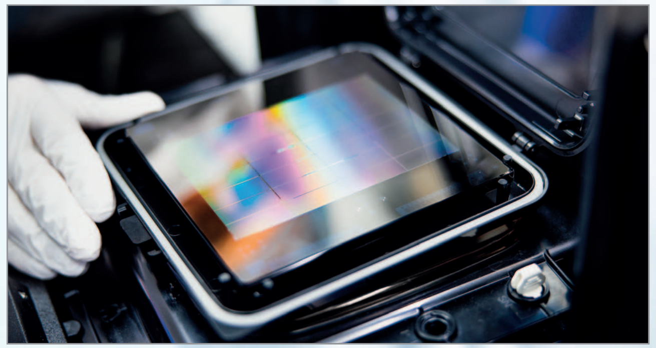
ZEISS is an internationally leading technology enterprise operating in the fields of optics and optoelectronics. For its customers, ZEISS develops, produces and distributes highly innovative solutions for industrial metrology and quality assurance, microscopy solutions for the life sciences and materials research, and medical technology solutions for diagnostics and treatment in ophthalmology and microsurgery.

Comprehensive experience in semiconductors



ZEISS is the global technology leader in the manufacture of systems and modules for microchip production. With semiconductor manufacturing optics, photomask systems and process control solutions, ZEISS supplies key technologies for the production of ultra-fine conductor track structures on silicon wafers.

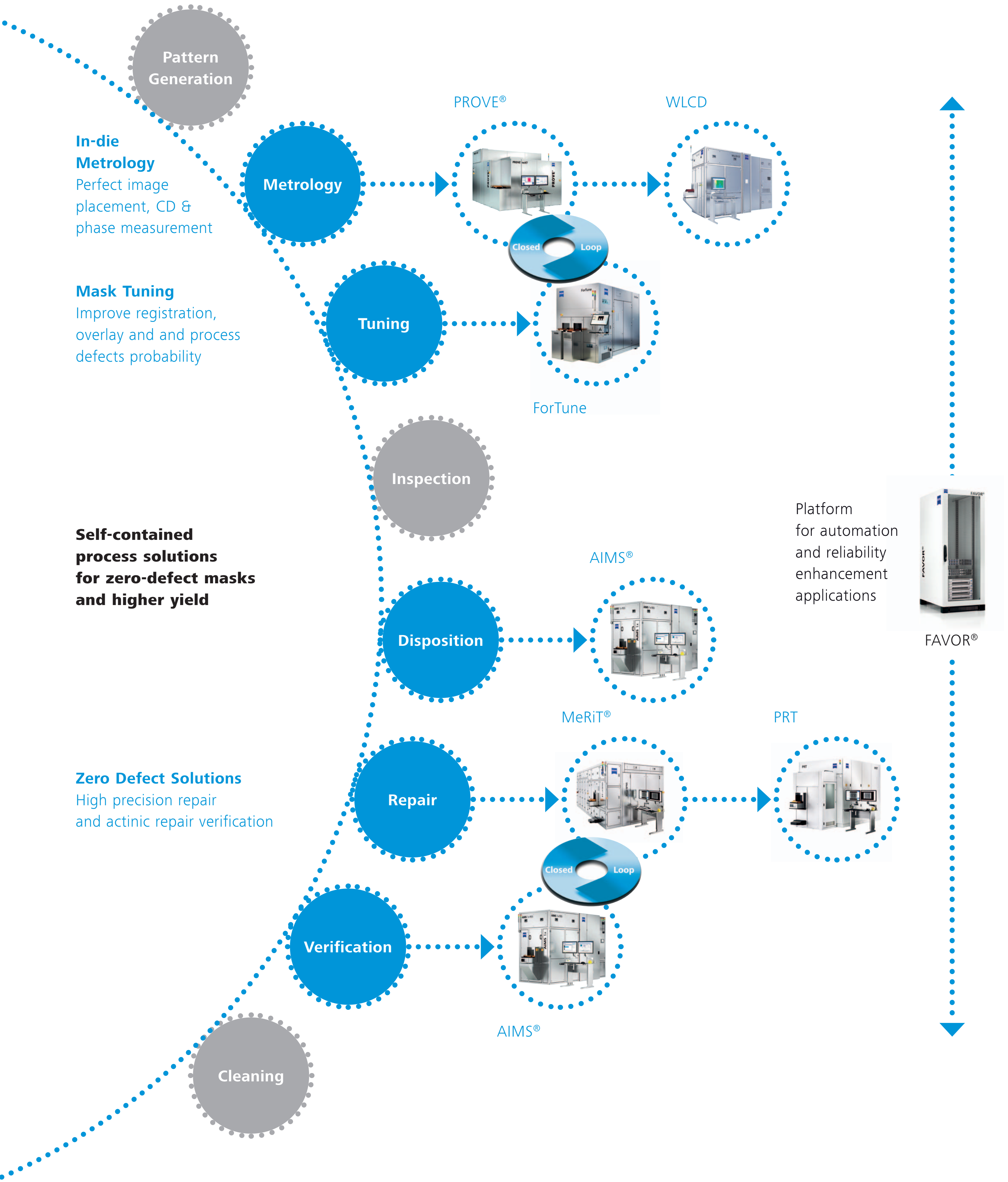
Dedicated to photomask technology



The ZEISS Semiconductor Mask Solutions provides unique solutions for the mask making industry to manufacture zero-defect photomasks. Our solutions cover EUV and DUV masks as well. Please find an overview of the available solutions in the following pages.

ZEISS Semiconductor Mask Solutions

ZEISS Perfect Mask Solutions



In-die Metrology
Perfect image placement, CD & phase measurement

Mask Tuning
Improve registration, overlay and process defects probability

Self-contained process solutions for zero-defect masks and higher yield

Zero Defect Solutions
High precision repair and actinic repair verification

Pattern Generation
Metrology
PROVE®
WLCD
Closed Loop
Tuning
ForTune
Inspection
Disposition
AIMS®
Repair
MeRiT®
PRT
Closed Loop
Verification
AIMS®
Cleaning

Platform for automation and reliability enhancement applications
FAVOR®

Mask Qualification

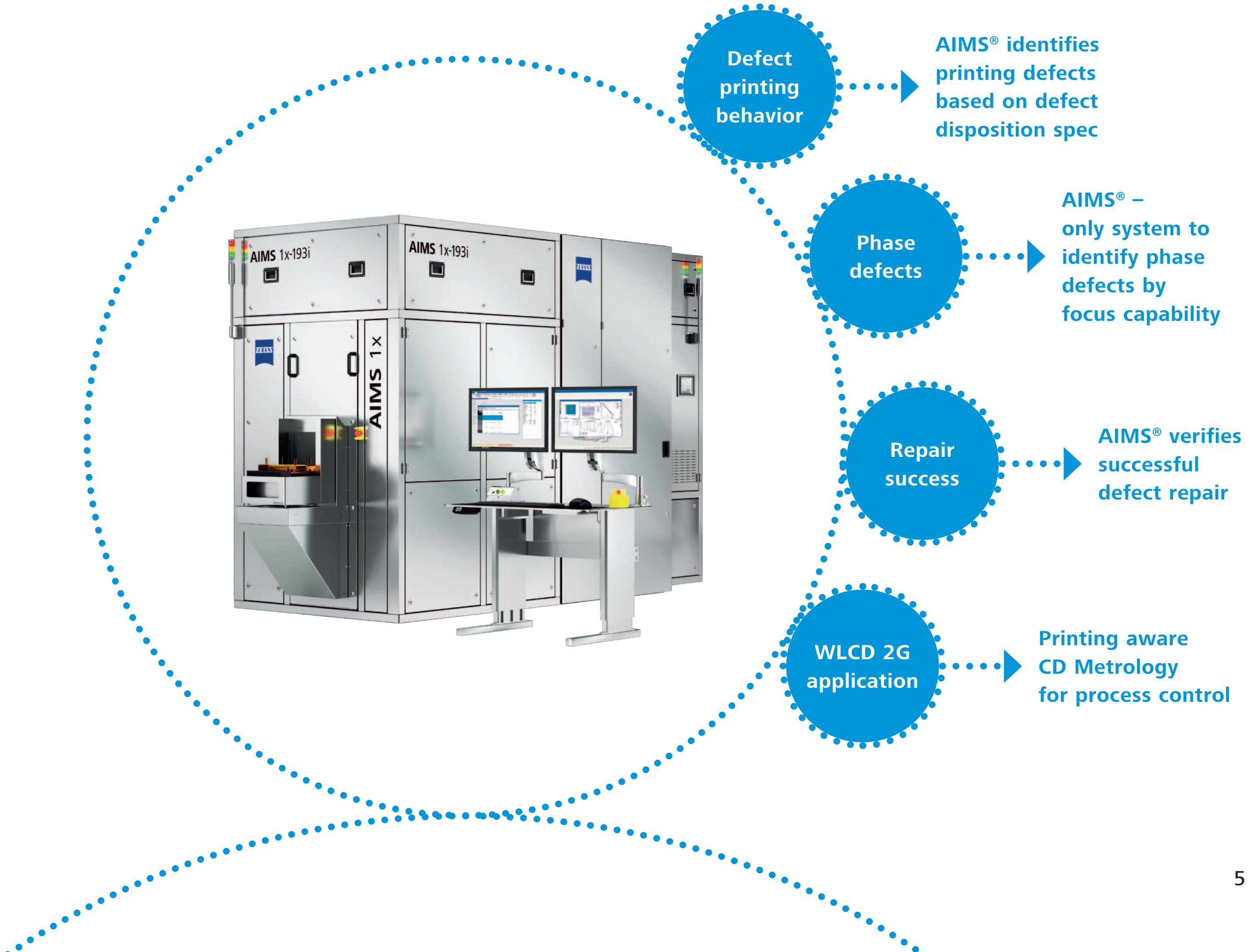
ZEISS AIMS – Aerial Image Measurement for DUV and EUV

AIMS® – The industry standard for defect review and repair verification!

AIMS® (Aerial Image Measurement System) is a unique mask qualification system for defect review, printability analysis, and repair verification of todays and future generation photomasks.

The product portfolio supports ArF immersion, KrF and EUV lithography. By measuring and analyzing the aerial image of the photomask under the same optical conditions as in the wafer printing process the ZEISS AIMS technology provides reliable characterization of mask defects with respect to their real effect in the lithographic process. Based on the AIMS® 1x platform ZEISS offers the WLCD 2G application providing the capability to measure the CD in aerial image capturing OPC, MEEF and mask 3D effects. It addresses the CD metrology challenges of advanced lithography nodes with high MEEF pattern having an increased risk to fail in wafer printing.

For reviewing defects on EUV masks, ZEISS offers the next generation of its AIMS® EUV. With its high precision stage for defect location accuracy and the employment of an EUV plasma Source, AIMS® EUV meets the industry production requirements for manufacturing defect-free EUV photomasks.



Defect printing behavior → **AIMS® identifies printing defects based on defect disposition spec**

Phase defects → **AIMS® – only system to identify phase defects by focus capability**

Repair success → **AIMS® verifies successful defect repair**

WLCD 2G application → **Printing aware CD Metrology for process control**

Mask Repair

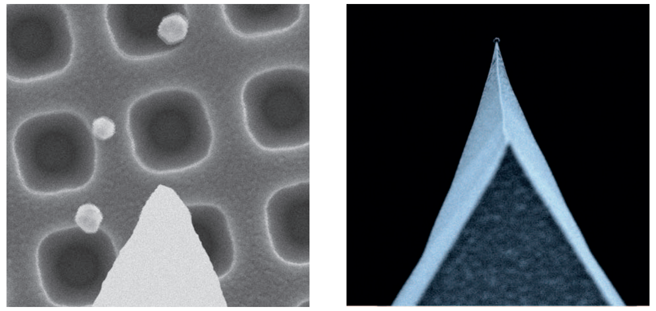
ZEISS PRT – Fast Particle Removal on Photomasks

PRT – Control your repair process!

Review SEM, material analysis and repair in one tool – that is the Particle Removal Tool (PRT). It removes even the smallest particle from photomasks, blanks and EUV pellicles.

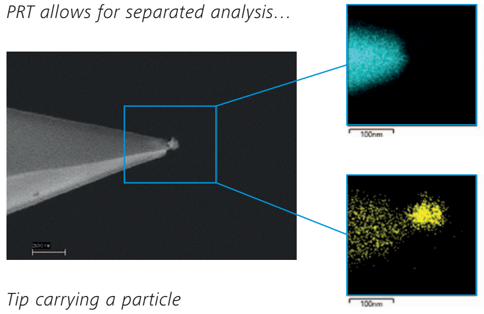
The system picks particles out of very small features such as EUV contact holes. The real-time imaging capability gives the user real-time feedback and the ability to fully control the removal process.

PRT measures the particle material with EDX, enabling to identify and eliminate the root cause.



Removal of particle from contact hole

PRT allows for separated analysis…



…of tip material and…

…particle material

Tip carrying a particle

Particle Removal – Removes extreme small particles using real time imaging

Material Analysis – Particle is measured with EDX allowing for material analysis

Root Cause Identification – Material analysis enables to identify and eliminate root cause

Mask Repair

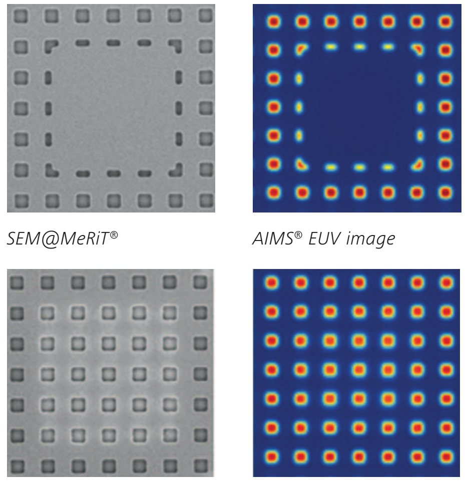
ZEISS MeRiT – E-beam based Mask Repair Technology

MeRiT® – Elevating your repair performance!

MeRiT® enables the repair of all kind of photomask defects with the highest precision. Based on e-beam technology the system covers opaque and clear defect repair in one platform. MeRiT® achieves superior resolution and accuracy for repair, while the repair process causes no unwanted transmission loss and no contamination. The system is able to repair all mask materials including EUV photomasks.

Pre-Repair image

Post-Repair image



SEM@MeRiT® *AIMS® EUV image*

SEM@MeRiT® *AIMS® EUV image*

Defect repair – Clear and dark defect repair on DUV and EUV reticles

Review SEM – Fully automated defect imaging and qualification

AutoRepair – Full- and semi-automated removal of defects

Tool Monitoring – Equipment health monitoring and FDC interface

Mask Metrology

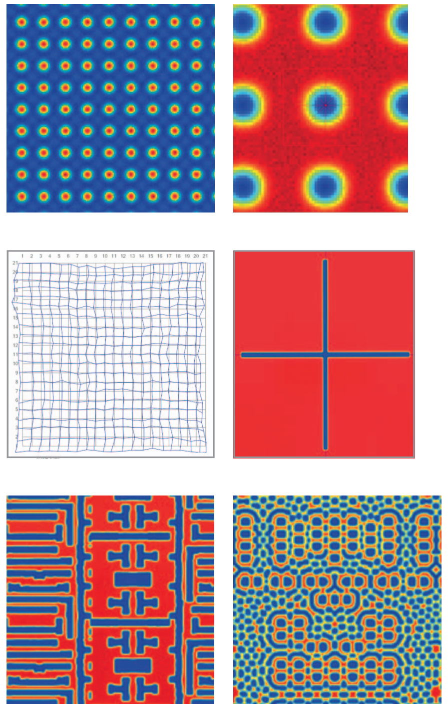
ZEISS PROVE – A high precision pattern placement metrology tool

PROVE® – You can correct what you can measure!

The photomask registration and overlay metrology system ZEISS PROVE measures image placement with sub-nanometer repeatability and accuracy.

The key component of ZEISS PROVE is the diffraction limited, high resolution imaging optics operating at 193 nm – corresponding to at-wavelength metrology for the majority of current and future photomask applications.

The high precision stage is actively controlled in all six degrees of freedom. The only moving part in the metrology system is the stage.



Pattern Generator Calibration → PROVE® calibrates and corrects the pattern placement of writing tools (E-Beam & Laser)

Mask Process Control → Registration is an integral part of any standard mask qualification process

In-die Metrology → PROVE® provides detailed registration information of production features

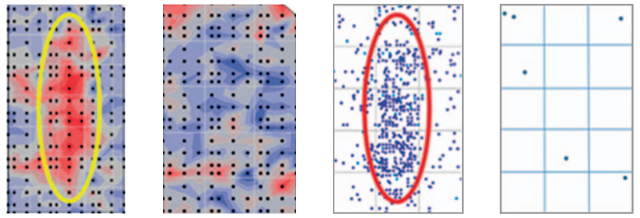
Mask Tuning

ZEISS ForTune – Intra-Field solutions of High Lateral Resolution

ForTune – Exceeding the boundries of lithography!

ForTune helps IC manufactures in several ways to meet tightest specification in terms of wafer Critical Dimension Uniformity (CDU), mask registration or On-Product Overlay (OPO). The CD correction process (CDC application) improves intrafield CDU, which reduces process defects on wafers significantly. The RegC® application will either improve mask registration or wafer On-Product Overlay. For EUV masks a new system has been developed which allows RegC® application on EUV mask (70 nm TaB backside coating).

Improved CDU leads to significant defect reduction on wafer



Pre CDU *Post CDU* *Pre Defects* *Post Defects*

Registration correction application → ForTune improves On-Product Overlay (OPO) by 0.2-0.5 nm on top of scanner correction

CDU improvement application → ForTune reduce CDU 3 Sigma down to 0.2 nm resulting in process defects reduction

Digital Solutions

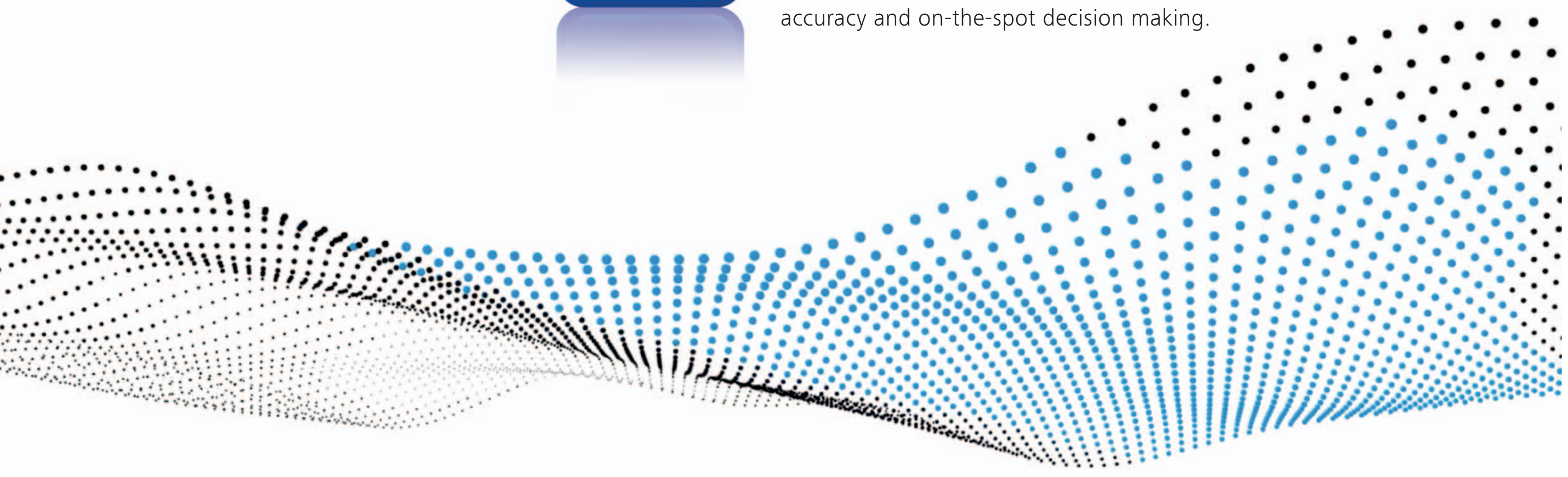
Every ZEISS mask solution can be enhanced by a prevailing software application. All applications run on the new generation FAVOR® 3.0, one of the most modern platforms for realizing HPC requirements and the creation of a centralized and homogenized ecosystem.

AIMS® AutoAnalysis (AAA) allowing for fully automated analysis of aerial images, data flow and information processing. The image processing and evaluation runs in parallel to the AIMS® measurements therefore eliminating time consuming, post measurement analysis. AutoAnalysis shortens cycle time and increases reliability ensuring your quality targets are met. The application is available for DUV AIMS® Systems as well as for AIMS® EUV.

MeRiT® AutoAnalysis (MAA) automatically analyzes the repair images captured by MeRiT®, which means manual measurements are no longer necessary to a very large extent. Using MAA saves time and costs.

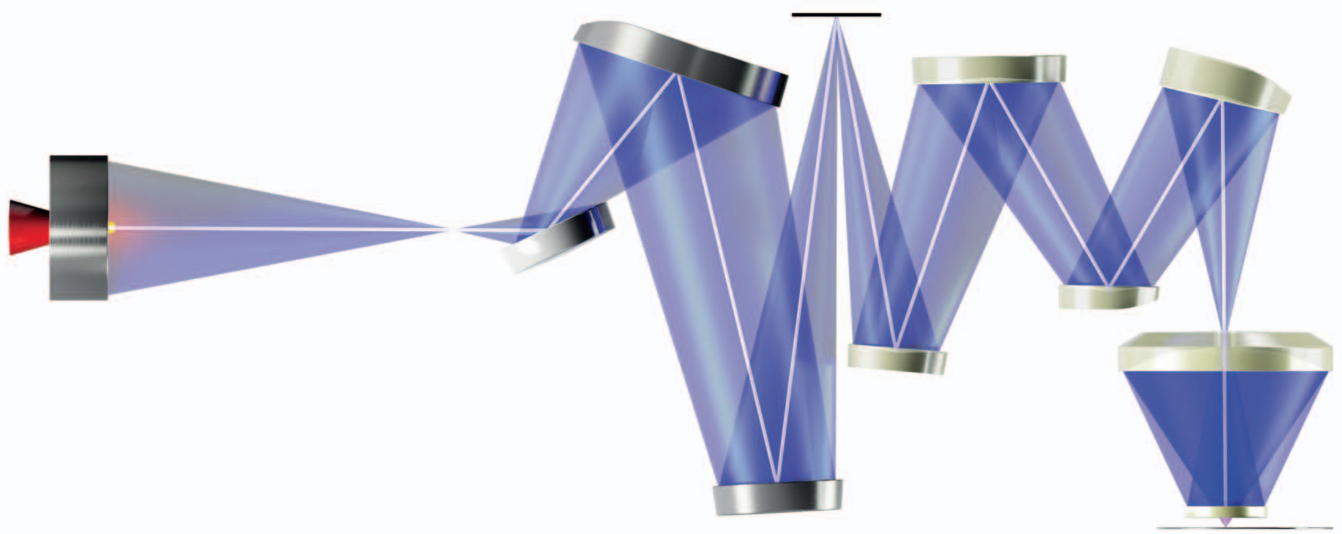
The **Advanced Repair Center** (ARC) is a powerful software solution facilitating effective data management and process flow optimization for the entire defect handling process. Repair enhancement features provide tools to improve repair success. ARC allows you to significantly reduce mask returns and cycling time.

The **ForTune Tuning Module** (FTM) enhances the performance of the ForTune Mask Tuning System. It facilitates recipe creation as well as extensive data analysis and simulations prior to the process. This module's versatile job handling capabilities ensure high process efficiency, superior prediction accuracy and on-the-spot decision making.



EUV Mask Solutions

ZEISS solutions supporting the EUV mask infrastructure



Ready for EUV!

Extreme ultraviolet (EUV) lithography today is deployed to high-volume chip manufacturing. EUV masks are significantly more complex than their predecessors in DUV lithography. Their manufacturing complexity and value is increasing accordingly. This also means that the economic pressure not to lose masks during the manufacturing process is soaring. In the following we present the broad range of solutions ZEISS is offering to ensure defect-free manufacturing of EUV Masks.

AIMS® EUV

A key enabler is the actinic mask qualification system AIMS® EUV, which fully addresses the industry requirements for EUV defectivity review. The AIMS® EUV platform is capable to provide a full understanding of the EUV imaging process and allows for mask qualification applications based on the employment of proven aerial image technology. Automation in image analysis and data processing can be enhanced employing the AIMS® EUV AutoAnalysis software package.

MeRiT® LE

MeRiT® LE is particularly focusing on EUV repairs. It features a decreased minimum repair size and improved edge placement accuracy to address the increased number and complexity of pattern defects on high-end photomasks.

PRT

The Particle Removal System removes even the smallest particle from photomasks, blanks and EUV pellicles. The system picks particles out of very small features such as EUV contact holes.

ForTune EUV

ForTune EUV optimizes EUV masks by improving the wafer overlay based on mask registration or wafer intra-field overlay input. The newly developed system enables mask tuning for EUV masks with standard mask backside coating (e.g. 70 nm TaB) by femtosecond-laser processing.

PROVE® neXT

The latest PROVE® generation enables the measurement of EUV mask with superior repeatability and accuracy. With its best in class resolution it is the tool of choice to localize EUV – Blank defects with highest precision. Powerful and fast DB – mode measurement schemes support extensive sampling as needed for the calibration of state of the art multibeam writers.

Product Information

Version 2.1

ZEISS Atlas 5

Master Your Multi-scale Challenge

Master Your Multi-scale Challenge

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› The Advantages
› The Applications
› The System
› Technology and Details
› Service

Atlas 5 makes your life easier: create comprehensive multi-scale, multi-modal images with a sample-centric correlative environment.

Atlas 5 is the powerful yet intuitive hardware and software package that extends the capacity of your ZEISS scanning electron microscopes (SEM) and focused ion beam SEMs (FIB-SEM). Use its efficient navigation and correlation of images from any source. Take full advantage of high throughput and automated large area imaging. Unique workflows help you to gain a deeper understanding of your sample.

Its modular structure lets you tailor Atlas 5 to your everyday needs in materials or life sciences research. Extend your possibilities even further with modules e.g. for nanopatterning or array tomography.

Discover highlights of Atlas 5.

Simpler. More Intelligent. More Integrated.

Acquire Nanoscale EM Images Easier and Faster than Ever Before

Acquire large sets of 2D or 3D nanoscale electron microscope (EM) images for hours, or even days, without operator supervision. Capitalize on Atlas 5's high throughput: automatic acquisition leaves you free to focus on results. Collect single images over thousands of samples, or cover large areas with mosaics comprised of thousands of adjacent images. Atlas 5 streamlines automatic image acquisition, using advanced preset and customizable protocols to produce consistent and reproducible results.

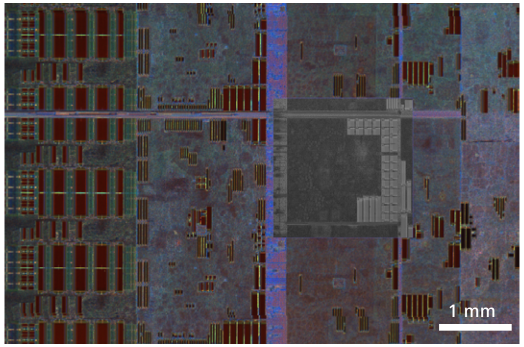
Correlate Images in Multiple Dimensions from Multiple Sources

Atlas 5's correlative workspace makes it easy to bring together images from multiple sources: zoom in from the full macroscopic view of your sample down to nanoscale details. Atlas 5 is the efficient way to analyze and correlate images from multiple sources – a powerful data hub that works with images from SEM, FIB-SEM, X-ray microscopes, light microscopes and any optical images, even from your digital camera. Its sample-centric workspace lets you build a seamless multi-modal, multi-scale picture of your sample. Use it to guide further investigations and target additional acquisitions.

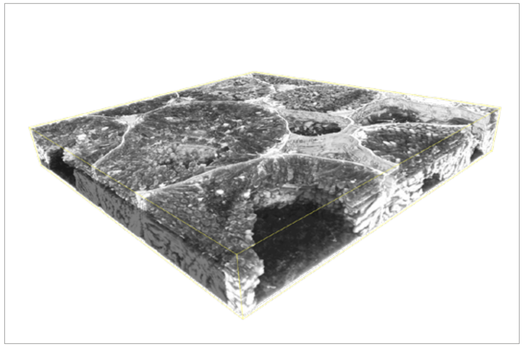
Understand Your Sample by Creating Unique Workflows

Understand your sample fully in both 2D and 3D. Atlas 5 employs a novel graphical user interface concept that makes it easy to investigate all your samples. Design a workflow tailored precisely to the complexity of your experiment, no matter whether it's a simple one-step task or a compound experiment. A sophisticated workflow environment guides you all the way from the setup for automated acquisition to post-processing and customized exports, and right on through to analysis.

Easy-to-use, workflow-oriented GUI (graphical user interface) for automated imaging.



Light microscope and SEM images of an integrated circuit are merged in the Atlas 5 correlative workspace.



3D visualization of root nodules from serial sections acquired automatically using Atlas 5 Array Tomography. Sample: courtesy of J. Sherrier, J. Caplan and S. Modla, University of Delaware, US.

Your Insight into the Technology Behind It

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Maximize Productivity – Acquire Nanoscale Images Easier and Faster than Ever Before

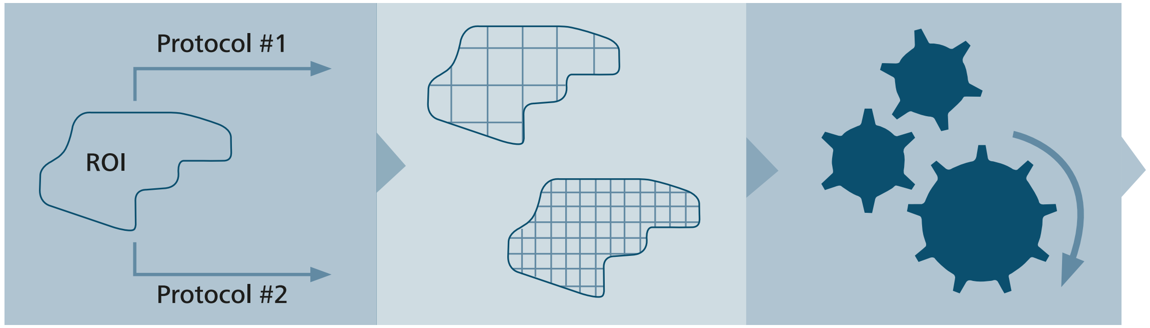
Automated 2D and 3D image acquisition lets you maximize productivity and ensure maximum use of your microscope, too. The xROI (exact region of interest) tools define the area you want imaged so you will save time as predefined protocols scan only your designated regions of interest. Atlas 5 allows you to put sophisticated imaging protocols in place to control your acquisitions. That means you will get consistent, reproducible results with built-in recordkeeping for future reference. You can develop protocols to manage ideal imaging conditions efficiently across resolutions, sample types and multiple users in an imaging facility.

Choose from the entire range of detectors and set imaging parameters to suit your sample and specific application needs. Now you can take full advantage of a new automated workflow that's tailored especially to STEM applications over multiple grids. Atlas 5 assesses whether an area can be covered by a single image or will have to be acquired as a mosaic of many images. Advanced autofocus and auto-stigmation keep the images sharp over even the longest acquisitions, and can be tuned to work reliably on the most challenging samples.

Acquire Images in Multiple Sessions on Multiple Instruments

Atlas 5 supports multiple sessions, giving you the flexibility you need to image your sample whenever and wherever you wish. You can image a sample on the same microscope at various times when beam time is available, or move your sample to different microscopes as required. Survey a sample in your SEM, then move it to your ZEISS Crossbeam to perform FIB-SEM 3D data collection at precise locations based on the SEM imagery. You can do all of this as a single project in Atlas 5.

Acquisition Workflow

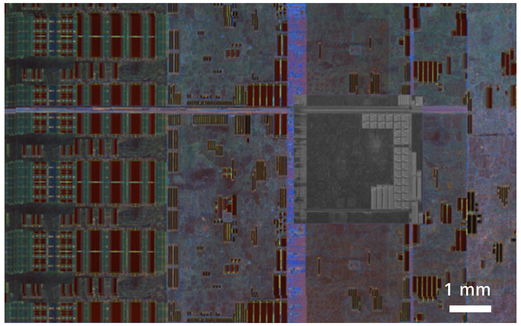


1. Focus on results with intelligent protocols and xROI.

2. Develop and apply imaging protocols for overview and high resolution imaging.

3. Automatic Acquisition

Set up your experiment and acquire your imagery in three steps. Atlas 5 automatically acquires mosaics and images over the regions you draw based on the protocol you select.



Light optical images and automatically acquired high resolution SEM images on selected regions. Fossiliferous carbonate sandstone sample. Sample: courtesy of D. Schumann, Fibics Incorporated, Canada.

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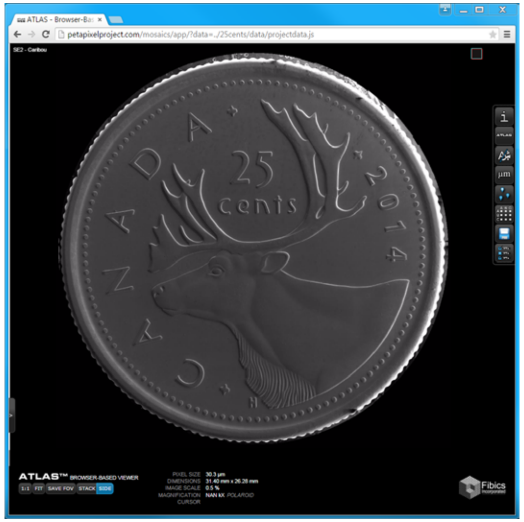
Correlate Images in Multiple Dimensions from Multiple Sources

Atlas 5 provides a sample-centric correlative workspace where you can bring together 2D images and 3D volume data from multiple instruments. Built as a state-of-the-art tool for managing large amounts of 2D and 3D images in one spot, Atlas 5 lets you import and align data from light, X-ray, electron and FIB-SEM microscopes to produce a single, consistent picture of your sample. Now you can see correlations between features visible in the different sources, visualize across multiple scales and guide further investigation and acquisition. Your EM images can guide you to places in the sample for further analytical analysis in both 2D and 3D (as EDS or 3D EBSD). In addition, take advantage of ZEISS Shuttle & Find to correlate with your ZEISS light microscopes: Atlas 5 keeps it simple.

Acquire Nanoscale EM Images Easier and Faster than Ever Before

Atlas 5 gives you a quick solution for generating and processing huge amounts of data. As demand increases for analyzing large sample areas or thousands of sites at nanometer resolution, you can visualize more than a terabyte of images in a single project. Atlas 5 includes powerful, efficient tools to correct, export and share the large amounts of data you collect. Flexible export options let you access data as acquired, or produce down-sampled, cropped, corrected image exports for other purposes. You can even export massive mosaics to its Browser-Based Viewer so that anyone with a standard web browser can view your entire dataset at full resolution. And you can do all of this at the microscope or at your desk.

Automatic acquisition of multi-scale SEM images. Serial sections of optical nerve tissue. Sample: courtesy of J. Lichtman, Molecular and Cellular Biology, Harvard University, US.



Export to explore a 25 gigapixel SEM image of this coin online

Your Insight into the Technology Behind It

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Correlate with X-ray Microscopy to Precisely Target Sub-Surface Sites in FIB-SEM

Atlas 5’s correlative workspace lets you correlate X-ray microscopy volume scans from your ZEISS X-ray microscope with surface features visible in your FIB-SEM. Use the X-ray data to virtually localize sub-surface features in 3D to precisely target FIB sites at features of interest – even if the features are not visible on the sample surface. Then navigate to those regions with confidence using your ZEISS FIB-SEM. Launch the Atlas 5 3D Tomography module to collect the highest resolution volume images of the exact features of interest you have identified. This significantly amplifies the efficiency of FIB-SEM tasks.

Resolution in 3D with Your FIB-SEM

Profit from accurate and reproducible results by reaching below 10 nm isotropic voxel size in 3D with your FIB-SEM. The Atlas 5 3D Tomography Module's powerful sample-tracking technology automatically corrects the sample drift while also measuring slice thickness with true accuracy. Collect precise 3D data automatically with consistent slice thickness over long acquisitions. Meanwhile robust autofocus and auto-stigmation algorithms keep all of your images sharp.

X-ray Tomography
Locate ROI

ZEISS Atlas 5
Register, navigate and drive FIB-SEM to ROI

FIB-SEM Tomography
Efficiently re-locate ROI

Expand Your Possibilities

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Get Better Results, Faster

At the microscope or at your desk, you have the tools you need to get better results in less operator time for all your demanding applications.

- Automated stitching tools let you pull tile-based acquisitions into seamless single images that can be more than a terapixel in size. You have complete control of the results and benefit from the automatic corrections.
- Apply batch stitching to previously acquired mosaics while still using the system to acquire new images.
- Image correction tools let you fix imaging irregularities in individual images or across entire mosaics.
- You can process information from multiple channels, detectors or sources into composite images.
- Flexible export options give you access to the exact pixel data as acquired, or produce down-sampled, cropped, corrected image exports or movies for other purposes.
- Export to the Browser-Based Viewer and anyone with a standard web browser can view your entire dataset at full resolution.
- Stitching, correction and export tools can be applied to datasets from previous versions of Atlas.

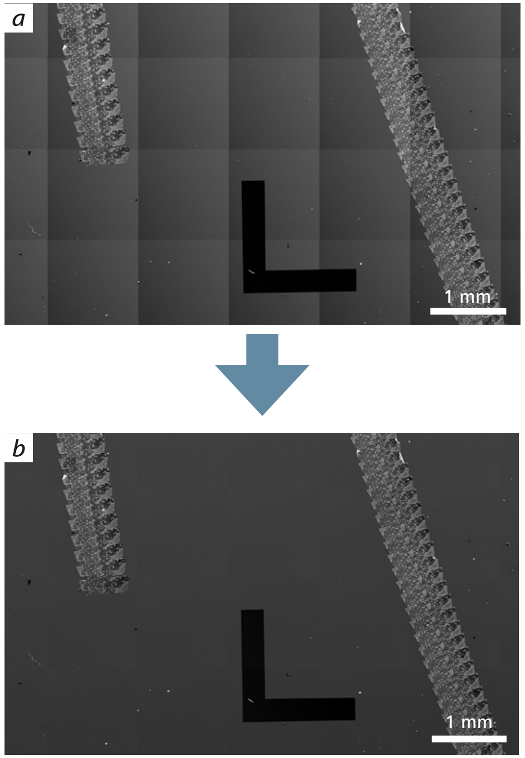
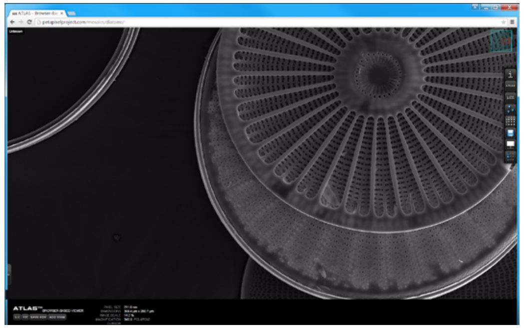
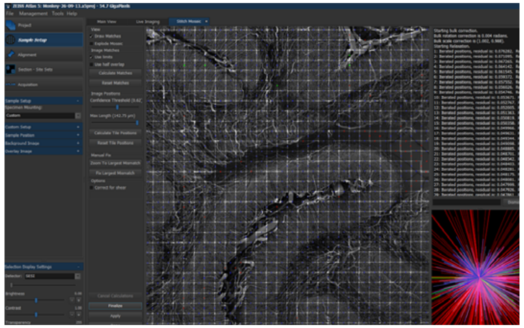


Image correction tools allow you to correct for imaging artifacts a) before and b) after.



Share your data online at full resolution with the Browser-Based Viewer.



Stitch the largest mosaics into seamless single images with advanced automatic stitching tools.

Expand Your Possibilities

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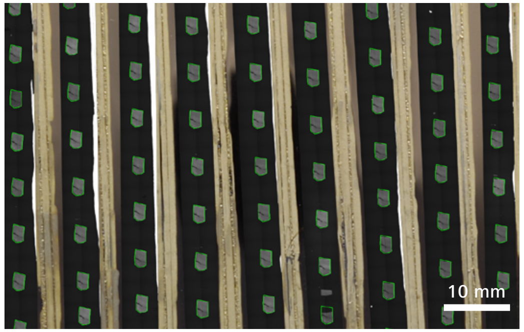
Array Tomography Module: The Fast and Efficient Solution for Imaging Your Serial Sections

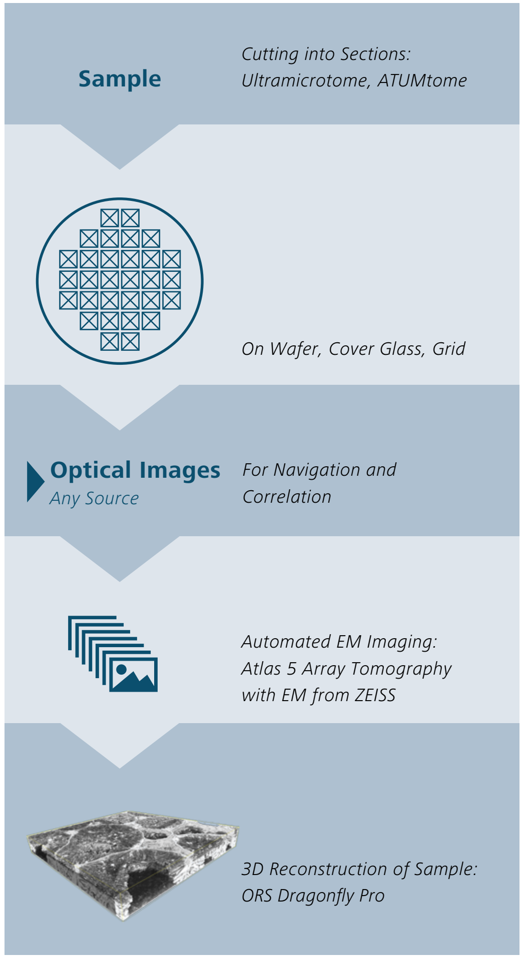
The Array Tomography Module lets you set up, acquire and export electron microscopical image stacks of serial sections quickly and efficiently. This software module is a highly productive tool for automated imaging of biological serial sections to enable 3D visualization of large volumes:

- Work with light microscope data for correlative workflows. Import datasets of light optical images acquired with ZEISS ZEN Correlative Array Tomography, our unique software module that lets you acquire LM images of serial sections. It’s designed to detect and mark the outlines of your sections automatically, then transfer them as regions of interest for further image acquisition at nanometer resolution in the SEM, using Atlas 5. In this way you will be maximizing your correlative experiment.
- It's the quick and efficient way to identify your sections and, optionally, sites of interest across ranges of sections.
- Section identification can be automated with image correlation tools specifically developed for hundreds of automatically prepared serial sections, prepared by an ATUMtome.
- Automatically acquire image sets of sections or sites using built-in protocols specifically tailored to life science applications – no operator supervision required.
- Export image stacks efficiently at full resolution or cropped and down-sampled for equally efficient 3D reconstruction in tools such as ORS Dragonfly Pro software.



Identify serial sections quickly and perform an easy setup for automated array tomography applications.

Array Tomography Workflow



Sample

Cutting into Sections: Ultramicrotome, ATUMtome

On Wafer, Cover Glass, Grid

Optical Images
Any Source

For Navigation and Correlation

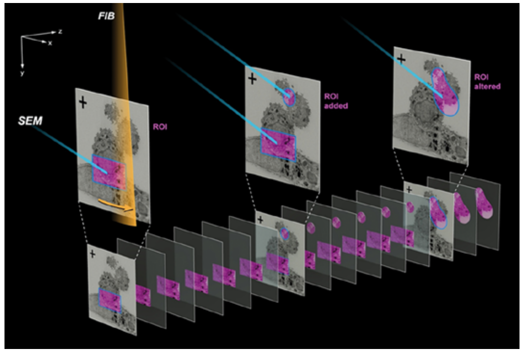
Automated EM Imaging: Atlas 5 Array Tomography with EM from ZEISS

3D Reconstruction of Sample: ORS Dragonfly Pro

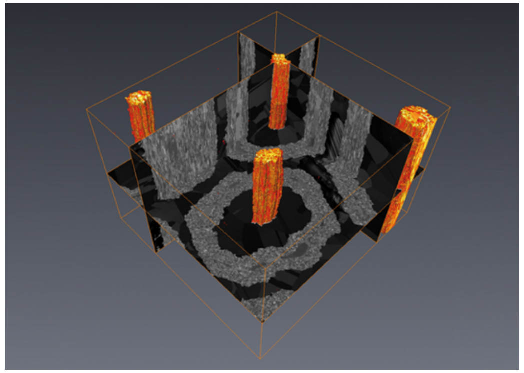
Expand Your Possibilities

**3D Tomography Module:
Maximum Throughput for Your FIB-SEM Nanotomography Applications**

Automatically create 3D data stacks up to several thousand images per stack. The 3D Tomography module allows you to analyze sample volume from thousands to millions of cubic micrometers with nanometer resolution in all three dimensions. Intelligent software algorithms reduce the amount of data and the time needed for 3D volume acquisition. Drift correction, auto-stigmation, autofocus and dynamic 3D tracking algorithms give you fast and reliable automation. Adaptive 3D tracking of both the FIB and SEM beam results in homogeneous slice thickness of a nanotomogram throughout the entire acquisition process, yielding optimized results. Use high resolution xROIs combined with periodic Key Frame overview images of your sample's entire cross-section, enabling collection of simultaneous multi-resolution datasets. Carry out high resolution milling and imaging simultaneously, and without requiring time-intensive stage movement.



Automated FIB-SEM Nanotomography: Acquire simultaneous multi-resolution datasets using xROI and Key Frames. Courtesy of: K. Narayan and S. Subramaniam, National Cancer Institute, National Institutes of Health, Bethesda, MD, USA.



Still image of a volume rendering of a niobium tin multi-filament superconducting cable in a copper matrix, derived from a three-dimensional dataset of approximately ten billion 10 × 10 × 10 nm voxels.

Expand Your Possibilities

Analytics Module:
Add Comprehensive Elemental and Crystallographic Information in 3D
3D FIB-SEM experiments let you investigate the internal structure of samples after slicing and imaging the sample's surface on a nanoscale. Profit from Atlas 5' unique capability to precisely track the slice thickness in the nanometer range. Atlas 5' unique capability to track the slice thickness precisely in the nanometer range is a distinct advantage. You can add information about elemental composition or crystallography to your experiment by using EDS (energy dispersive x-ray spectroscopy) or EBSD (electron backscatter diffraction). The EDS or EBSD maps can be acquired at a different set of beam parameters thus assuring ideal conditions for the chosen analytic technique without sacrificing resolution during the imaging. Just consider the benefits of having these analytical methods fully integrated into your 3D workflow.

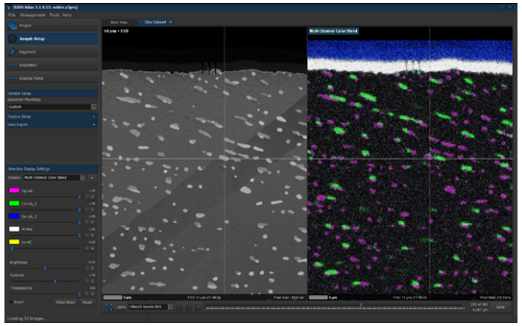
Use Atlas 5' Analytics Module on FIB-SEMs to:

- enable high resolution 3D SEM imaging and 3D EDS/EBSD mapping, in the order of hundrets of maps and thousands of images, using two different sets of SEM or EDS/EBSD conditions that are optimized for each task
- tailor the spatial increments for images and maps independently of each other
- set up the best landing energies using a user-friendly workflow, which will then switch automatically between imaging and EDS or EBSD analysis
- increase throughput and save data storage by defining and deciding where and how to investigate specific sites with EDS or EBSD, because image and map resolutions, as well as z spacing of the slices, are independent.
- visualize simultaneous views of SEM images and processed elemental or crystallographic maps.

For 3D segmentation and volume reconstruction ZEISS recommends an advanced analysis and visualization software solution, ORS Dragonfly Pro Advanced. Spatial and elemental information can be observed as two individual datasets or they can be flexibly merged to give the most effective understanding, well beyond the limits of single datasets.

Use Atlas 5' Analytics Module on SEMs to:

- integrate 2D EDS mappings into your workflow
- select regions of interest (ROI) for 2D EDS mappings
- automatically acquire multiple selected ROIs



User interface showing results done with Atlas 5 Analytics module. Lead-free solder in SEM mode (left) and corresponding information from EDS (right).

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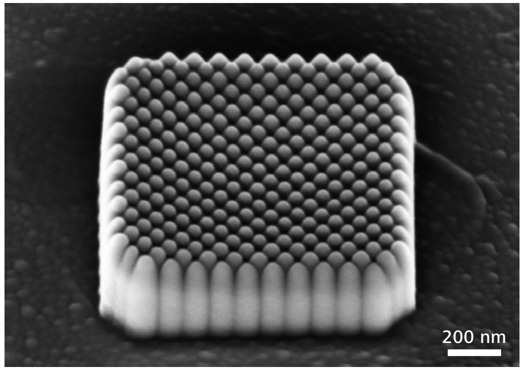
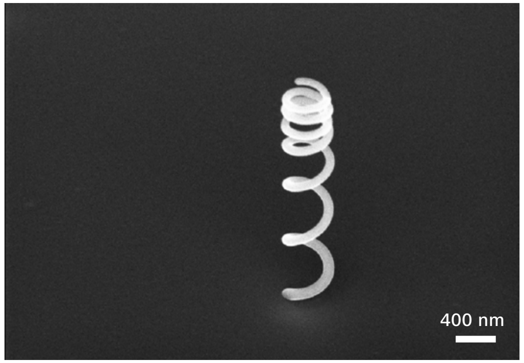
Advanced NanoPatterning & Visualization Engine (NPVE Advanced) Module
Simple to learn yet extremely powerful, the NPVE Advanced module is your solution of choice for a wide range of nanopatterning applications. It’s easy to use, allowing even novice users to begin solving complex problems in nanoprototyping quickly – with or without gas chemistry. As an add-on to your ZEISS FIB-SEM, the NPVE Advanced module enables rapid prototyping of structures from nanometers to millimeters in size. The module provides not only precise simultaneous control of your beam(s) for patterning, but also patterning parameters with real-time visualization of the patterning operation from the perspective of each beam. Advanced Operation Recipes make it simple to control all patterning parameters and sequences for each shape, giving you complete control of your beam(s). This includes Fastmill, a special scanning strategy that allows you to prepare FIB cross-sections faster and more efficiently, saving up to 40% milling time. A suite of tools such as Advanced Set Operations, the Array Builder and Digital Lab Book allow you to design and execute experiments to optimize your results quickly.

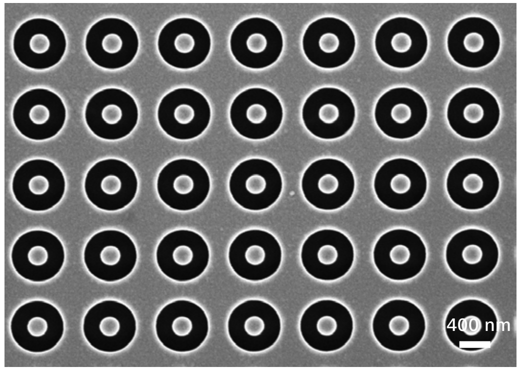


A 1 um × 1 um square of pillars has been formed from silicon oxide using Electron Beam Deposition with a 45° patterning angle, chosen to have the pillars just contacting.

A FIB grayscale rendering of the Lincoln Memorial is patterned into silicon with the FIB beam. An unmodified photograph was used as the data source. Pattering time: 10 minutes.



FIB deposition has been used to form a 3D 'wire', 120 nm in diameter, in the shape of a coil 600 nm in diameter.



In this array of annular shapes, each shape is 650 nm in diameter, with a 1 µm spacing (pitch) between the shapes.

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Tailored Precisely to Your Applications

Typical Applications, Typical Samples	Task	ZEISS Atlas 5 Offers
Large Area Imaging	■ Image large areas of the sample surface at high resolutions as efficiently as possible for sample characterization or to gather statistics on infrequent features.	Automated acquisition, exact regions of interest (xROIs) and protocol-based imaging all come together in Atlas 5's correlative workspace. Save on setup time with easy-to-use software and execute unattended overnight runs to image large samples. Powerful correction and stitching tools let you export seamless results to the scientific community. Automated STEM imaging of samples on TEM grids. Create overviews of all samples in a STEM holder, select xROI for nm resolution STEM imaging.
Multi-instrument Workflows	■ Manage acquisitions across multiple instruments or at different times to optimize equipment use. ■ Use light microscopical data to guide further correlative EM imaging tasks.	Session-based imaging lets you survey your sample in your SEM, then move to your FIB-SEM to perform 3D data collection at precise locations based on the SEM imagery, all in the same Atlas 5 project.
Imaging Facility Management	■ Enable inexperienced instrument users to get excellent and consistent results.	Configurable protocols and precise auto-focus and auto-stigmation algorithms let expert users set up recipes that novice users can use to get excellent results without extensive SEM training.
High Resolution Tomography	■ Remove material with the FIB while imaging with the SEM to produce volume data with nanometer resolution voxels.	With the Atlas 5 3D Tomography module, collect FIB-SEM tomography data at high resolution and throughput. Auto-tracking and tuning produce datasets of excellent quality from automated acquisitions over hours or days without operator supervision.
Multi-scale Characterization	■ Use X-ray microscopy data over mm scales to precisely target sites for FIB-SEM analysis over µm scales to upscale characteristics from your high resolution data. ■ Use 3D data from your ZEISS confocal microscope to target sites for FIB-SEM analysis.	Correlate your Versa XRM data with SEM and light microscope images in Atlas 5 to specify and perform FIB-SEM tomography. Use your X-ray tomography or laser scanning microscope 3D data as a subsurface road map for your sample and gather the precise FIB-SEM volumes you need to characterize your sample properly.

Tailored Precisely to Your Applications

Typical Applications, Typical Samples	Task	ZEISS Atlas 5 Offers
Nanopatterning	■ Pattern the sample surface with the ion or electron beam, with or without the use of gases to assist etching or deposition. Fabricate nano-devices or directly modify circuits or structures.	Create and control complex patterns with extensive geometric and beam control tools using the Atlas 5 Advanced NanoPatterning and Visualization Engine (NPVE Advanced). Intelligent recipes give you precise control of beam and gas parameters for consistent milling and deposition results. Observe FIB operations live with the SEM or visualize details from the perspective of either beam while patterning.
Analytics, EDS, EBSD	■ Go beyond the information revealed by SEM images by integrating 3D EDS or 3D EBSD analysis into your high resolution tomography acquisitions. ■ Select sites for 2D EDS based on available images.	With Atlas 5 Analytics module, you can integrate EDS and EBSD acquisitions using Oxford Instruments detectors and cameras for your high resolution 3D tomography experiment to gather precise elemental or crystallographic information correlated with your high resolution image data. Independent EDS/EBSD and imaging energies as well as spatial resolutions maximize quality and flexibility. Choose sites for 2D EDS mappings based on LM or EM images and acquire EDS maps automatically. Import and display results into Atlas 5 for further correlative analysis.

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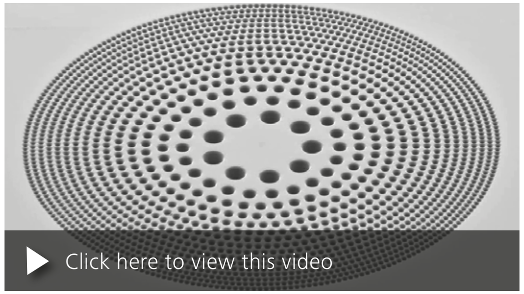
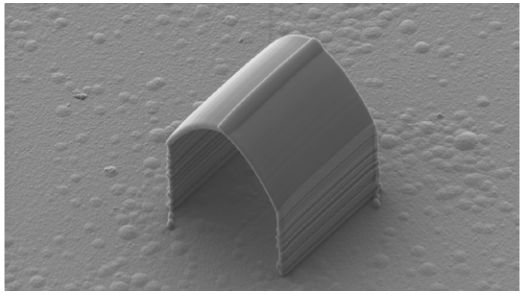
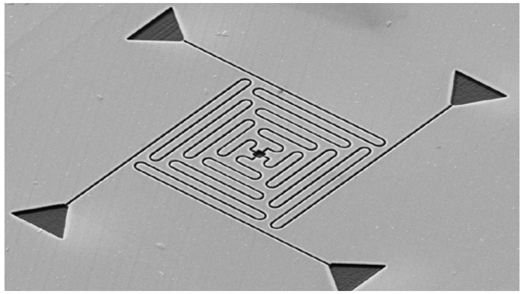
Nanopatterning



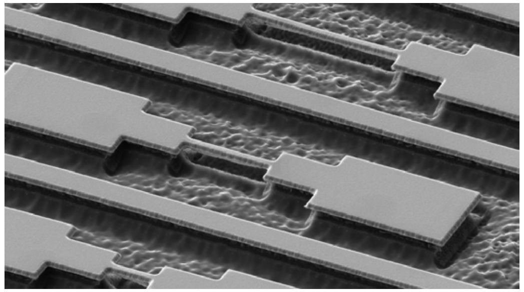
A sieve-style zone plate was nanofabricated using ZEISS Crossbeam and Atlas 5 NPVE Advanced. Atlas 5 acquired it as a single 32k × 24k pixel image and produced the movie.



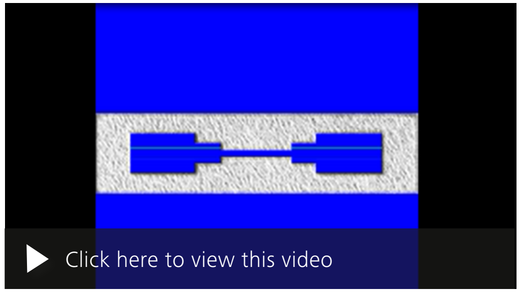
A 3D structure has been formed using NPVE Advanced and FIB deposition, field of view 14 µm.



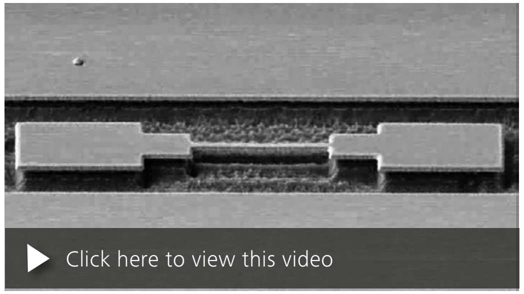
20 nm wide nano-channels in various configurations up to 20 µm in length are patterned with NPVE Advanced, field of view 59 µm.



Metal nanobridges on silicon, fabricated with Atlas 5 NPVE Advanced, SEM image.



Metal nanobridges on silicon, fabricated with Atlas 5 NPVE Advanced, from FIB perspective.



Metal nanobridges on silicon, fabricated with Atlas 5 NPVE Advanced, from SEM perspective.

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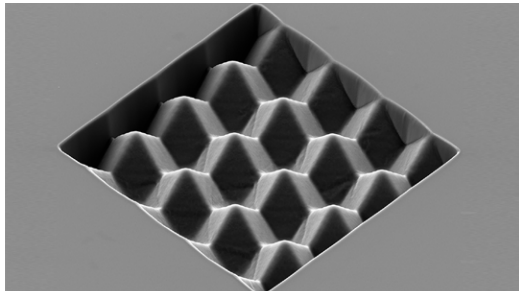
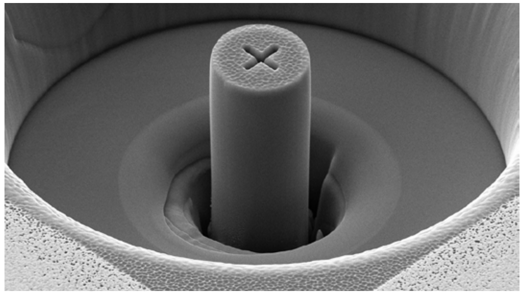
Nanopatterning

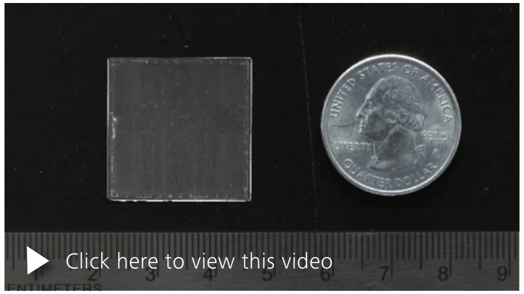


A three dimensional structure has been milled into a silicon wafer using the Atlas 5 NPVE Advanced module 3D-Profiler tool, field of view 30 µm.

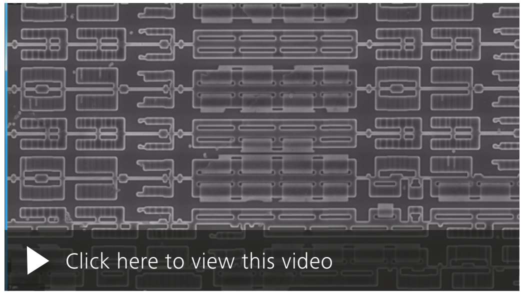


A parallel-sided cylinder with a central alignment mark is fabricated 'top-down' on ZEISS Crossbeam using Atlas 5 NPVE Advanced, field of view 40 µm.

Large Area Imaging

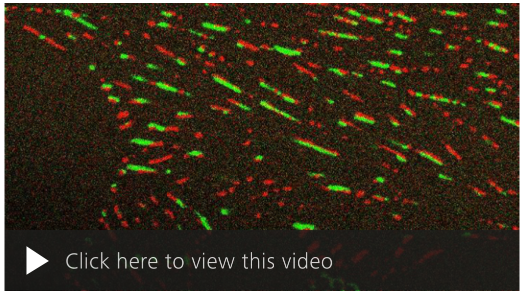


25 mm × 25 mm large area of a computer chip was acquired automatically in 24 hours, resulting in a 1/2 Tera Pixel dataset.



Deprocessed integrated circuit, acquired in 10 hours for a total of more than 90 gigabytes of image data with Atlas 5.

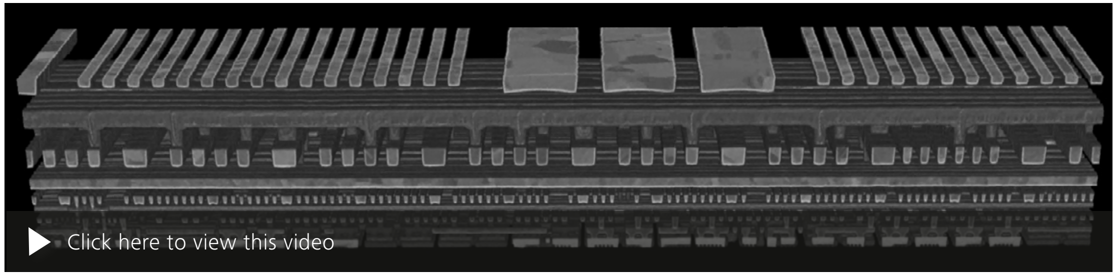
3D EDS Analytics



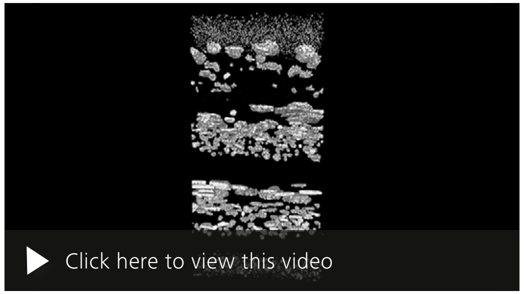
3D tomogram of lead-free solder using ZEISS Crossbeam. 3D Nanotomography data of a lead-free solder containing Cu and Ag particles in an Sn matrix. SEM images (top) and EDS maps (bottom) were acquired at the same sample site at 1.8 kV and 6 kV, respectively, using a ZEISS FIB-SEM and Atlas 5 Analytics. Courtesy of: M. Cantoni, EPFL Lausanne, Switzerland.

ZEISS Atlas 5 at Work

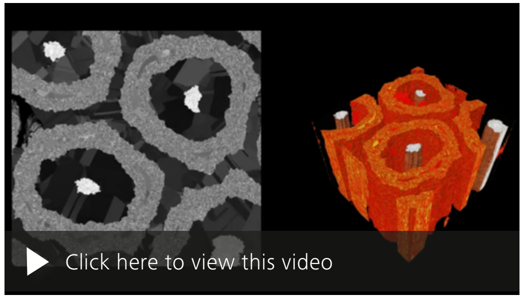
High Resolution Tomography



A portion of a 22 nm Intel Tri-Gate integrated circuit, acquired with 5 nm voxels with Atlas 5. Sample: courtesy of UBM TechInsights.



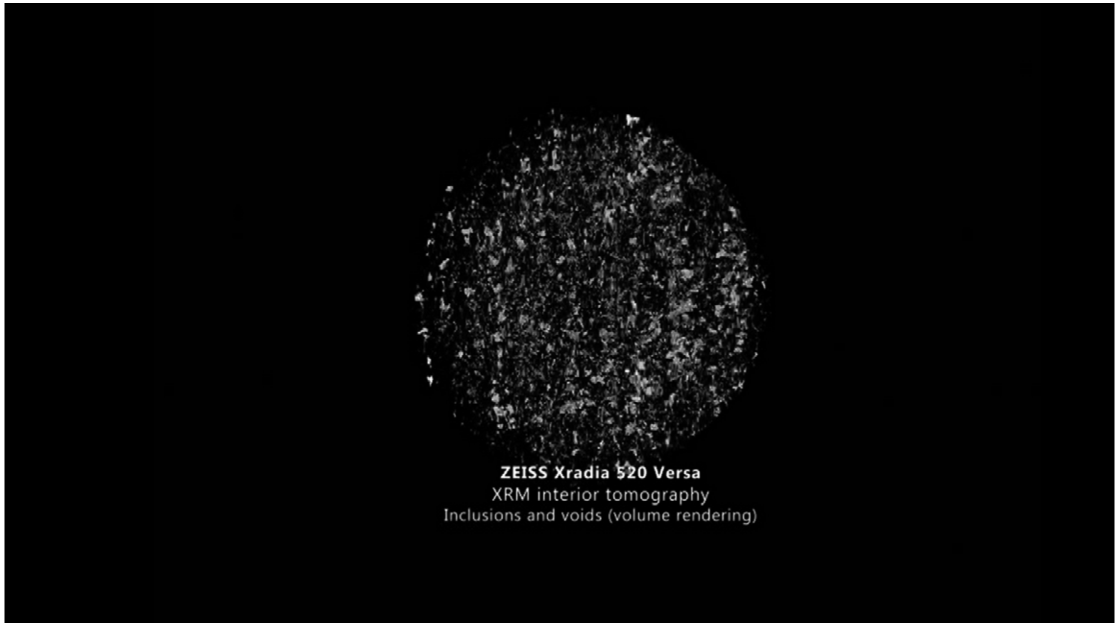
A 20 µm high sample of the nanocrystalline layers of silver salts that make up typical "ISO 400" color film. This volume reconstruction was rendered using commercially available software from an image stack acquired in an automated overnight data run with Atlas 5. Sample: courtesy of Fibics Incorporated, Canada.



A data stack of images (left) and a volume rendering (right) of a Nb_3Sn multifilament superconducting cable in a copper matrix, derived from a three-dimensional dataset of approximately ten billion 10 × 10 × 10 nm voxels, acquired with Atlas 5. Sample: courtesy of M. Cantoni, EPFL, Switzerland.

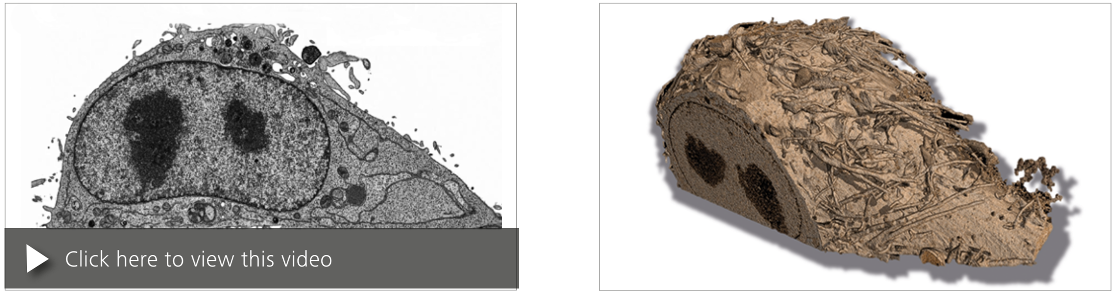
ZEISS Atlas 5 at Work

Multi-scale Characterization



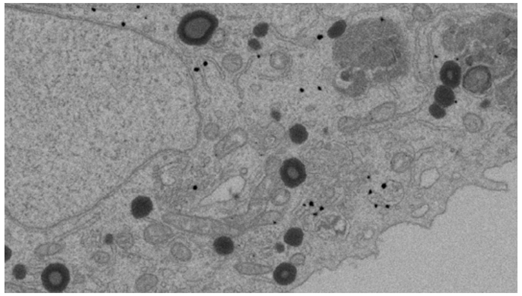
Look below the surface of your sample, using X-ray tomography to drive your ZEISS FIB-SEM. In this ZEISS Atlas 5 project, 2D SEM images and 3D X-ray tomograms of a polished aluminum alloy sample were correlated to identify sub-surface precipitates and voids of interest. The ZEISS Atlas 5 3D Tomography module was then used to acquire high resolution 3D FIB-SEM tomography data on a targeted feature of interest. The project contains over 40 GB of data acquired over two days on three different instruments. Sample: courtesy of N. Chawla and S. Singh, School for Engineering of Matter, Transport, and Energy (SEMTE), Arizona State University, USA.

ZEISS Atlas 5 at Work

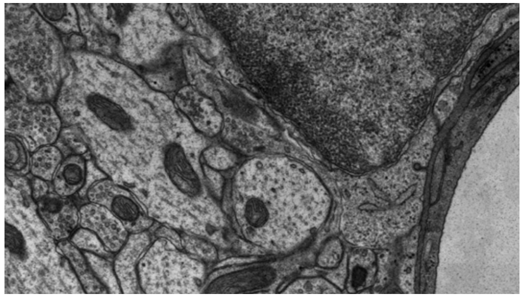


Individual cells grown in a cell culture, chemically-fixed and resin-embedded. One unique feature of ZEISS Crossbeam is its ability to deliver a constant low section thickness along with a detection principle that allows it to image ultrastructural details at high resolution without suffering from the charging artifacts that occur when investigating resin-embedded samples. The sections in this experiment have a slice thickness of 16 µm; 1400 sections are shown in the video on the left. The 3D visualization (right) was done with ORS dragonfly software. Courtesy of: A. Steyer & Y. Schwab, EMBL Heidelberg, Germany. (Field of view 44 µm x 28 µm).

Caenorhabditis elegans is a model organism for molecular biologists. This dataset of images taken from C. elegans shows how the design of ZEISS Crossbeam and the automated workflow of Atlas 5 allow the microscope to run in a stable manner over several weeks, acquiring 10,000 sections. Atlas 5 automatically acquires the datasets with automated routines for focus and correction of astigmatism included during the run. Images were taken with ZEISS Crossbeam and Atlas 5.



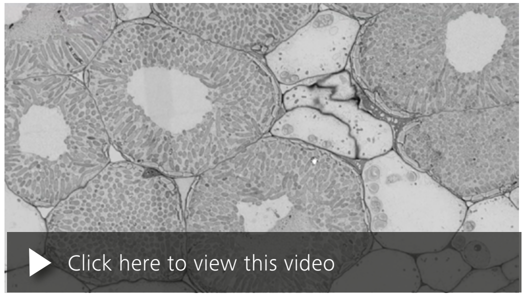
HepG2 is an immortalized cell line consisting of human liver carcinoma cells, derived from the liver tissue of a patient who had a well-differentiated hepatocellular carcinoma. These HepG2 cells were not treated with any heavy metals except uranium acetate and were then labeled with endosomal antibodies. This mild preparation visualizes regions of special interest—the endosomes—while the tissue shows very low contrast in all other regions. The gold particles are clearly visible. Imaging with the Inlens EsB detector visualizes the immunolabeling together with ultrastructural details, thus taking full advantage of having greater contrast and more detail as a result of the detection capabilities of Gemini optics. Images were taken with ZEISS Crossbeam and Atlas 5. (Field of view 27.5 µm)



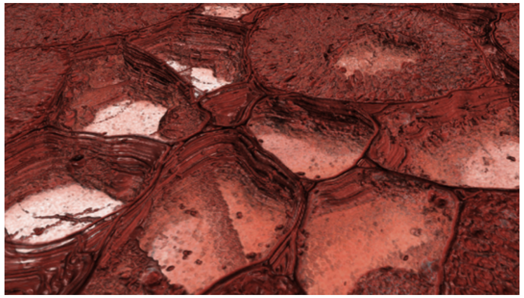
Chemically-fixed and osmium-stained ultrathin section of mouse brain, investigated in transmission mode with the STEM detector. This image provides ultrastructural details close to TEM resolution, enabling details such as coated vesicles (arrow) to be visualized. (Field of view 55 µm x 45 µm).

ZEISS Atlas 5 at Work

3 cm diameter corrosion cast of circulatory system of the monkey brain. Mosaic of over 1000 images stitched and exported to Browser-Based Viewer.



Unterstand the symbiotic relationship of plants and bacteria in root nodules by visualizing the distribution bacteria in 3D. Images were taken with Atlas 5 Array Tomography.



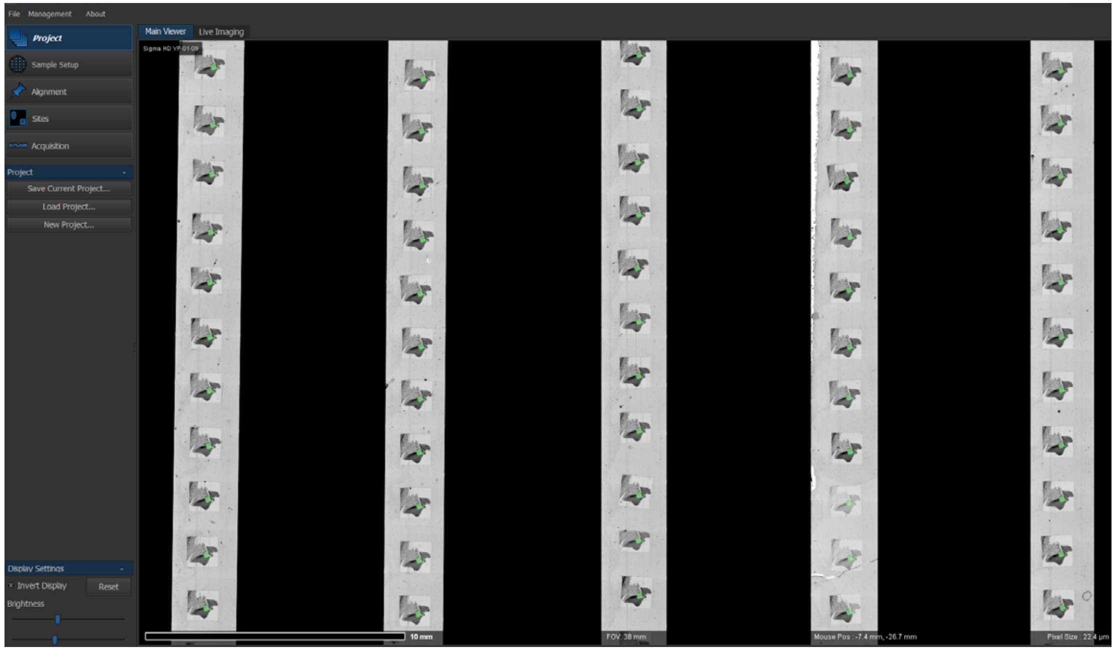
The SEM image data stack from serial sections acquired automatically using Atlas 5 Array Tomography can be computed into a 3D model. Root nodules. Sample: courtesy of J. Sherrier, J. Caplan and S. Modla, University of Delaware, USA.

ZEISS Atlas 5 at Work

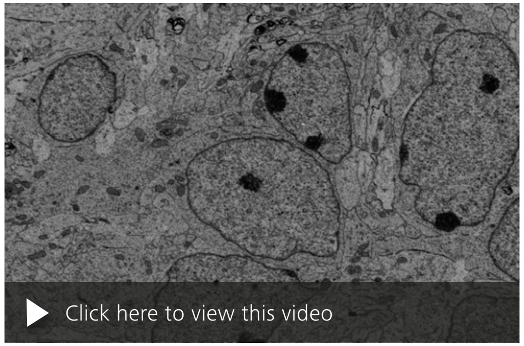
Acquire Serial Sections with Array Tomography

Choose specific areas within an ultrathin section and then image with multiple user-defined resolutions based on predefined imaging protocols. Apply image corrections automatically on selected images or across series of serial sections.

Use an automated and intuitive workflow to acquire image data from hundreds of sections on a carrier. This datastack can then be computed into a 3D model.



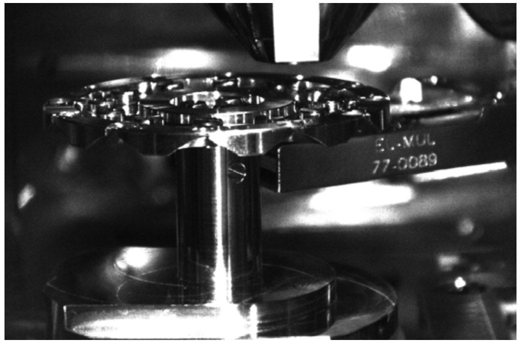
Serial ultrathin sections of a mouse brain prepared on a wafer with an automated tape collecting ultramicrotome. Sample: courtesy of J. Lichtman, Harvard University, USA.



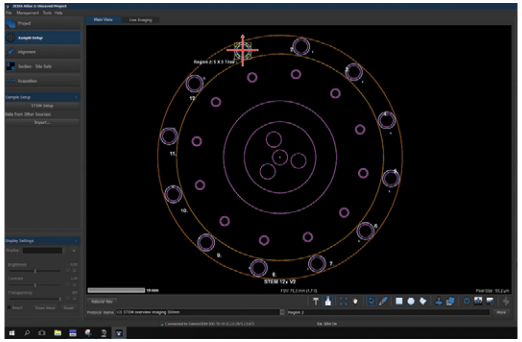
This animation shows a visualization of a selected area on an ultrathin section. It can be used for 3D reconstruction with commercially available software.

ZEISS Atlas 5 at Work

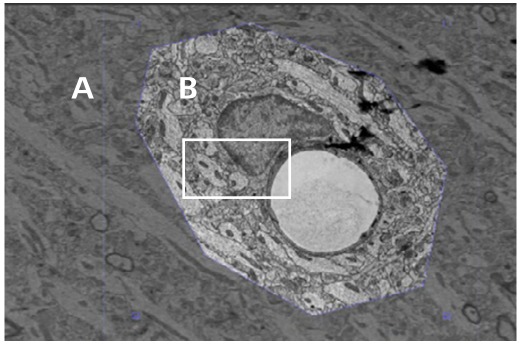
Automated STEM Imaging



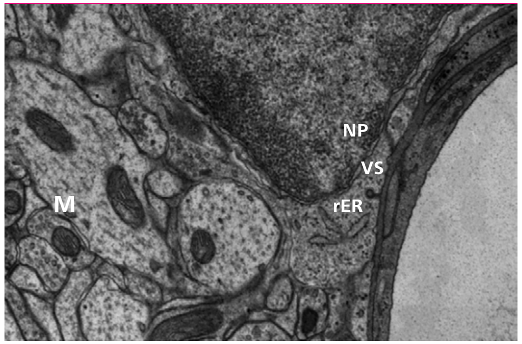
Mount your STEM sample holder for 12 TEM grids into the SEM. Place your STEM detector beneath one of the TEM grids.



Start your new STEM project and easily navigate between samples.



Start imaging with a low resolution overview (A). Follow on by selecting xROIs and image with a higher resolution (B). Sample mouse brain, multi-scale STEM image.



Get the final results from highly resolved image data by zooming into your selected xROIs: Detail of mouse brain, zooming in from region B (left):The inset shows a zoom into the highlighted rectangle depicting cellular structures like vesicles with surrounding coatomer (VS), rough endoplasmatic reticulum (rER), nuclear pore (NP) and cristae of mitochondria (M).

Automated STEM Imaging

With Atlas 5 you are now able to accelerate your STEM detection. STEM holder and software are aligned perfectly to each other.

Workflow

- Prepare your sample as you normally do for TEM grids.
- Fix your TEM grids in the multiple STEM grid holder.
- Mount the STEM grid holder into the SEM.
- Set-up your STEM experiment and start.
- Locate the single TEM grids automatically, then image the sample as defined.

Your Flexible Choice of Components

ZEISS Atlas 5 Comes with Multiple Offerings
Get to know ZEISS Atlas 5's modules, their features and their configurability: Extend the capacity of your ZEISS SEM and FIB-SEM with Atlas 5 as an option. Benefit from advanced capabilities of further modules and learn how they are combined.

	SEM	FIB-SEM	Offline
Atlas 5	○	○	○
Array Tomography	○	○	○
3D Tomography	×	○	○
NPVE Advanced	×	○	○
Analytics	*	**	×

○ option
× not configurable
* available for FE-SEMs
** available for Crossbeam 550

ZEISS Atlas 5: Modular Software Structure

ZEISS Atlas 5 Modular Structure	
Atlas 5	Workflow oriented high throughput acquisition platform. Fusion of images from multiple instruments, detectors and sessions in one correlative workspace. Import several image file types (BMP, JPG, TIF, CZI, TXM), flexible layered arrangement of images. Protocol based automated 2D acquisition. Large framestore up to 32k × 32k, 100ns, 8bit/16bit, 2 channels. xROI imaging (exact regions of interest). Manual stitching of 2D mosaics. Advanced Image Correction (gradient corrections, radial correction, per channel corrections), Advanced Automatic Stitching, Export to Movie, Export to Browser-Based Viewer for web-enabled collaborative data exchange, Optimize protocols per acquisition. Export multi-channel data by channel or as blends. Integrated image review in a guided review workflow. Efficient review of acquired 2D SEM data and automated reacquisition of problematic images.
Array Tomography	Tools for array tomography setup: Clone Tool for section definition, Snap Section tool for automated section definition, Site Management functions for efficient sub-site definition across sections. Image stack viewer and image stack export options, Batch Stitching
3D Tomography	3D FIB-SEM acquisition engine with automated sample preparation, exact region of interest (xROI) volume imaging, advanced sample tracking, adaptive slice thickness tracking, predictive drift correction and auto-tuning. Image stack viewer with FIB-SEM stack alignment, cropping and image stack export.
Analytics	Add 3D EDS/3D EBSD analytics to high resolution FIB-SEM tomography acquisition. Specify imaging and mapping conditions independently, including landing energy, dwell time and spatial resolution in all three dimensions. Advanced acquisition engine automatically switches between analysis and imaging conditions during acquisition. Flexible visualization allows simultaneous views of SEM images and processed elemental maps. On FE-SEMs, integrate 2D EDS mappings into your workflow, select regions of interest (ROI) for 2D EDS mappings and automatically acquire multiple selected analytical ROIs.
Advanced NanoPatterning & Visualization Engine (NPVE Advanced)	Advanced control over patterning geometry and parameters. Simultaneous beam control with full patterning and imaging support for ion and electron beams. Operation recipes for smart control of beam and GIS parameters for consistent milling and deposition control over the widest range of conditions. Set operations, 3D profiles and array builder tools to optimize design of experiments. Include Fastmill, a special scanning strategy that allows you to prepare FIB cross-sections faster and more efficient; save up to 40% milling time.

Atlas 5 modules require Atlas 5. Optional Analytics Module requires ZEISS Oxford Instruments hardware and software package. Analytics Module on FIB-SEM requires Atlas 5 3D Tomography.

Technical Specifications

Function	Headline
Image Characteristics	Continuously selectable up to 32k × 32k (50k × 40k on ZEISS Crossbeam family). Save image data as 8 or 16 bit TIFF files. Sample any available detector and record two detector signals simultaneously.
Dwell Time	Flexible, from 100 ns to >100 s per dwell point, continuously selectable for optimized imaging or patterning.
Autofocus & Auto-stigmation	Independent of FOV, image size and resolution, user tunable based on sample characteristics. Configurable to minimize impact on samples.
Exact Regions of Interest (xROIs)	Imaging in any shape: arbitrary polygonal, elliptical or rectangular regions, adjustable 'on the fly'. Direction of scan rotation adjustable to shape of site. Precise control of scanned image area.
Data Acquisition	Designed for automated acquisition of large field of view overview images and multi-image mosaics at multiple regions of interest. Sequential multi-job lists. Possible to resume and reacquire any desired region at any time, using the very same parameters. Predefined imaging protocols suitable for common sample types are provided.
Analytics	Offers advanced analytic capabilities embedded in an integrated correlative environment. Requires a specified package of Oxford Instruments components.
Correlative Approaches	Import of optical images for navigation, overlay and correlation of LM with EM data. Support for ZEISS Shuttle & Find correlative holders and for calibration is integrated. Import and correlate ZEISS 3D Laserscanning microscope datasets. Import and correlate ZEISS 3D X-ray microscope volumetric datasets.
Data Import/Export	Import 2D images from CZI, TIFF, JPG and BMP formats. Import ZEISS TXM 3D X-ray volumes. Import 3D image stacks from ZEISS Laser Scanning Microscopes. Export CZI, TIFF, JPG and MRC formats. Export at full resolution into CZI, raw format.

Atlas 5 is available as option or field upgrade for ZEISS C-SEMs, FE-SEMs and FIB-SEMs. The retrofit must be performed by a service engineer who is authorized by ZEISS Microscopy.

Count on Service in the True Sense of the Word

Because the ZEISS microscope system is one of your most important tools, we make sure it is always ready to perform. What's more, we'll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified ZEISS specialists who will support you long beyond the purchase of your system. Our aim is to enable you to experience those special moments that inspire your work.

Repair. Maintain. Optimize.
Attain maximum uptime with your microscope. A ZEISS Protect Service Agreement lets you budget for operating costs, all the while reducing costly downtime and achieving the best results through the improved performance of your system. Choose from service agreements designed to give you a range of options and control levels. We'll work with you to select the service program that addresses your system needs and usage requirements, in line with your organization's standard practices.

Our service on-demand also brings you distinct advantages. ZEISS service staff will analyze issues at hand and resolve them – whether using remote maintenance software or working on site.

Enhance Your Microscope System.
Your ZEISS microscope system is designed for a variety of updates: open interfaces allow you to maintain a high technological level at all times. As a result you'll work more efficiently now, while extending the productive lifetime of your microscope as new update possibilities come on stream.

Profit from the optimized performance of your microscope system with services from ZEISS – now and for years to come.

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