



Product Information  
Version 2.4

## **ZEISS MultiSEM Research Partner Program**

The World's Fastest Scanning Electron Microscopes



# Revolutionize the Speed of Electron Microscopy with ZEISS

- › **In Brief**

- › The Advantages

- › The Applications

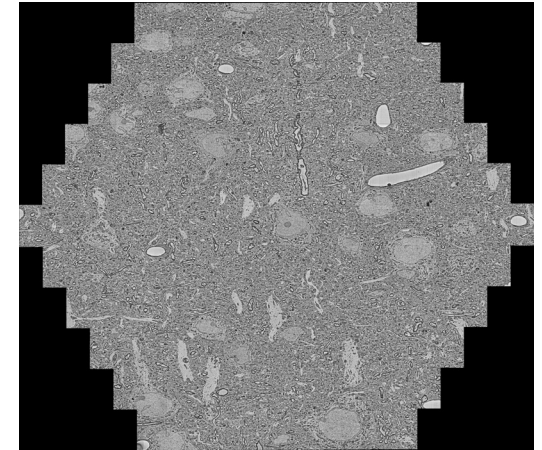
- › The System

- › Technology and Details

Unleash the speed of this unique scanning electron microscope and start thinking about new dimensions. Now, at last, you can image huge samples at nanometer resolution, driven by the unrivalled acquisition speed of MultiSEM.

MultiSEM is designed for continuous, reliable 24/7 operation. Simply set up your high-throughput data acquisition workflow. Then get on with your day while MultiSEM takes high contrast images all by itself – no supervision needed.

MultiSEM uses ZEN imaging software, so you can control this powerful microscope in an intuitive yet flexible way. Automated tuning routines make sure you achieve the best high resolution data.



*Mouse brain section, image acquired using ZEISS MultiSEM 506 with 91 beams and at 4 nm pixel size. The hexagonal field of view (FoV) is 165  $\mu\text{m}$  wide. Sample: courtesy of J. Lichtman, Harvard University, Cambridge, MA, USA*

## Research Partner Program

ZEISS offers you access to a groundbreaking technology for a rapidly developing application space. The ZEISS MultiSEM Research Partner Program is meant for early adopters who want to profit from the opportunities of new technologies and become members of a worldwide growing community. In close relationship with you we will work as partners at the forefront of science. By providing individual application support and a Premium Service concept, we help you to explore new territory. Are you ready to take the next step?

# Simpler. More Intelligent. More Integrated.

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## Highest-ever Acquisition Speed at Nanometer Resolution

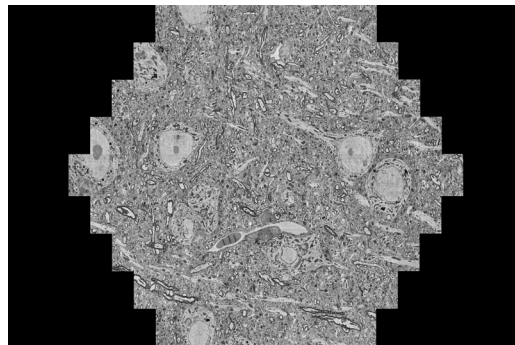
Multiple electron beams working in parallel give you unprecedented gross imaging speed. Acquiring an area of  $1 \text{ mm}^2$  at  $4 \text{ nm}$  pixel size takes only a few minutes of imaging time. The unrivaled imaging speed of more than  $1 \text{ TB}$  per hour enables imaging of large volumes ( $> 1 \text{ mm}^3$ ) at nanometer resolution. Optimized detectors collect the secondary electron signals very efficiently, providing you with high contrast images at low noise levels.

## Electron Microscopy of Huge Samples

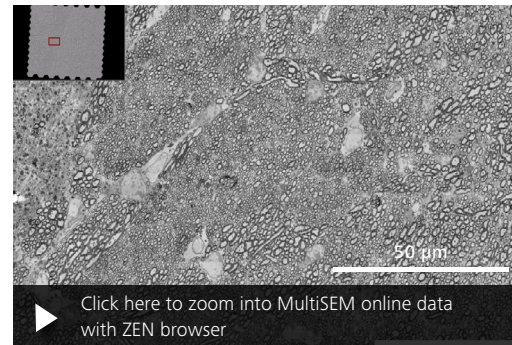
MultiSEM is built for continuous 24/7 operation and equipped with a sample holder covering an area of  $10 \text{ cm} \times 10 \text{ cm}$ . That means you no longer have to sacrifice sample size for nanometer resolution. You can finally image the entire sample and discover everything you need to answer your scientific questions. With automated acquisition protocols to enable large area imaging, you will get the detailed full picture, without losing the macroscopic context.

## Another First: Electron Microscopy with ZEN Imaging Software

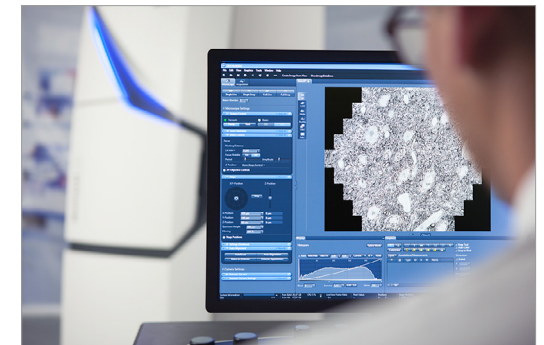
By introducing ZEN to MultiSEM, we bring the standard software for ZEISS light microscopes to the world of electron microscopy. ZEN lets you control MultiSEM in a straightforward, intuitive way. Smart auto-tuning routines support you as you capture optimal images with high resolution and quality. You quickly and easily set up even complex automated acquisition procedures, adapted and tuned to your sample imaging. ZEN for MultiSEM also masters the high speed required for continuous, parallel image recording. An open application programming interface (API) is provided for flexible and fast application development.



Mouse brain section ( $50 \text{ nm}$  thick) image acquired in  $1.3 \text{ s}$  with a MultiSEM 505 covering a hexagonal field of view of  $108 \mu\text{m} \times 94 \mu\text{m}$ . Sample: courtesy of J. Lichtman, Harvard University, Cambridge, MA, USA



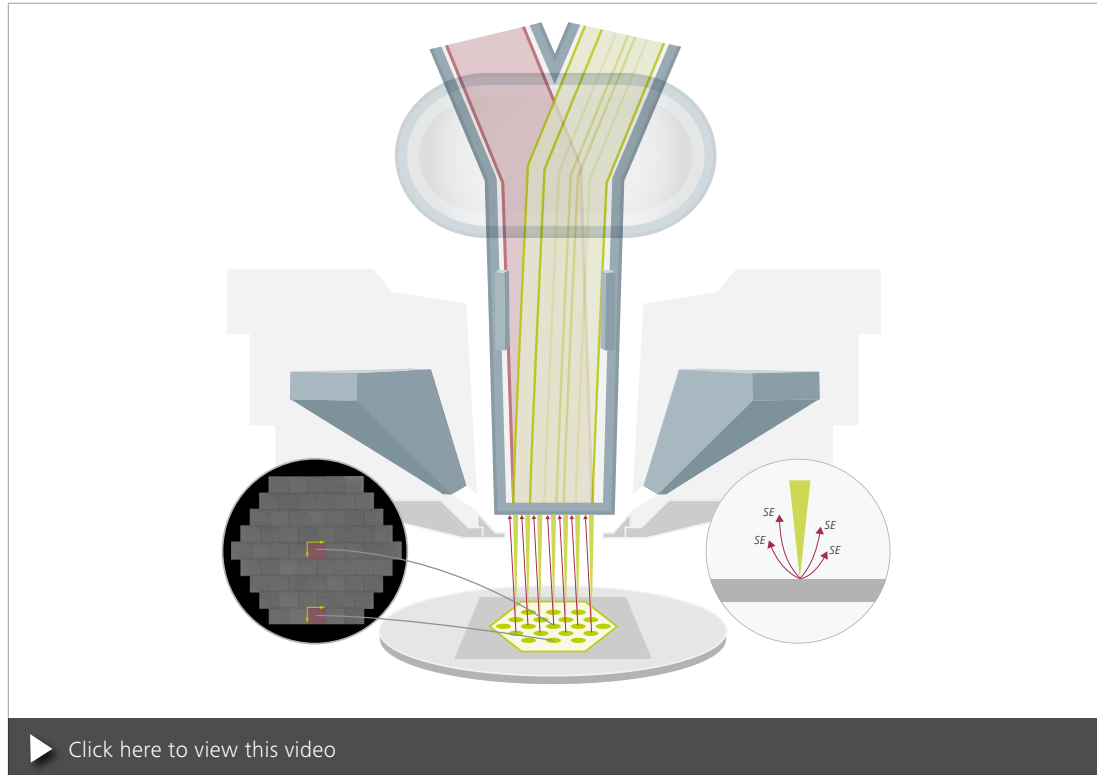
Mouse brain section, automated image acquisition of  $1 \text{ mm}^2$  at  $4 \text{ nm}$  pixel size totaling  $100 \text{ GB}$  of data. Sample: courtesy of J. Lichtman, Harvard University, Cambridge, MA, USA



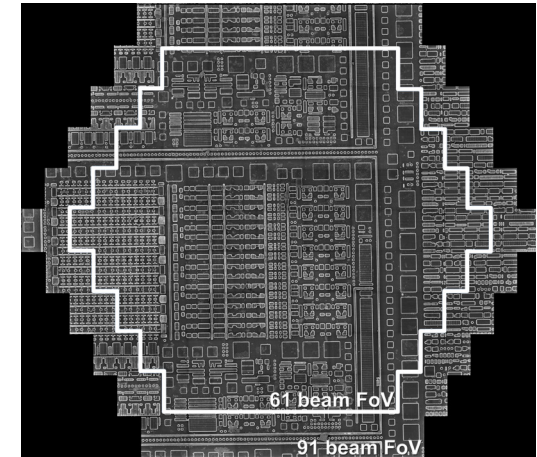
ZEN imaging software is used to control the MultiSEM.

# Your Insight into the Technology Behind It

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MultiSEM achieves high imaging speed by employing multiple electron beams and detectors in parallel. The key to this approach is a finely tuned detection path (red) collecting a large yield of secondary electrons used for imaging with a multiple detector array. Each beam carries out a synchronized scanning routine at one sample position, resulting in a single sub-image. The electron beams are arranged in a well-characterized hexagonal pattern. By merging all sub-images together, the final, full image is formed. A parallel computer setup is used for fast data recording ensuring high total imaging speed. Image acquisition and workflow control are fully separated in the MultiSEM system to guarantee full performance.



Two MultiSEM versions are currently available. MultiSEM 505 with 61 beams in parallel offers high acquisition speed at top resolution while MultiSEM 506 with 91 beams provides an even higher imaging throughput by covering a larger area per single scan pass. MultiSEM 505 provides a data rate of up to 1 TB per hour, whereas MultiSEM 506 offers a data rate of up to 1.5 TB per hour.

The image above (graphics processor chip) shows the fields of view of the two MultiSEM versions – MultiSEM 506 covers a 50% larger area with just a single scan pass.

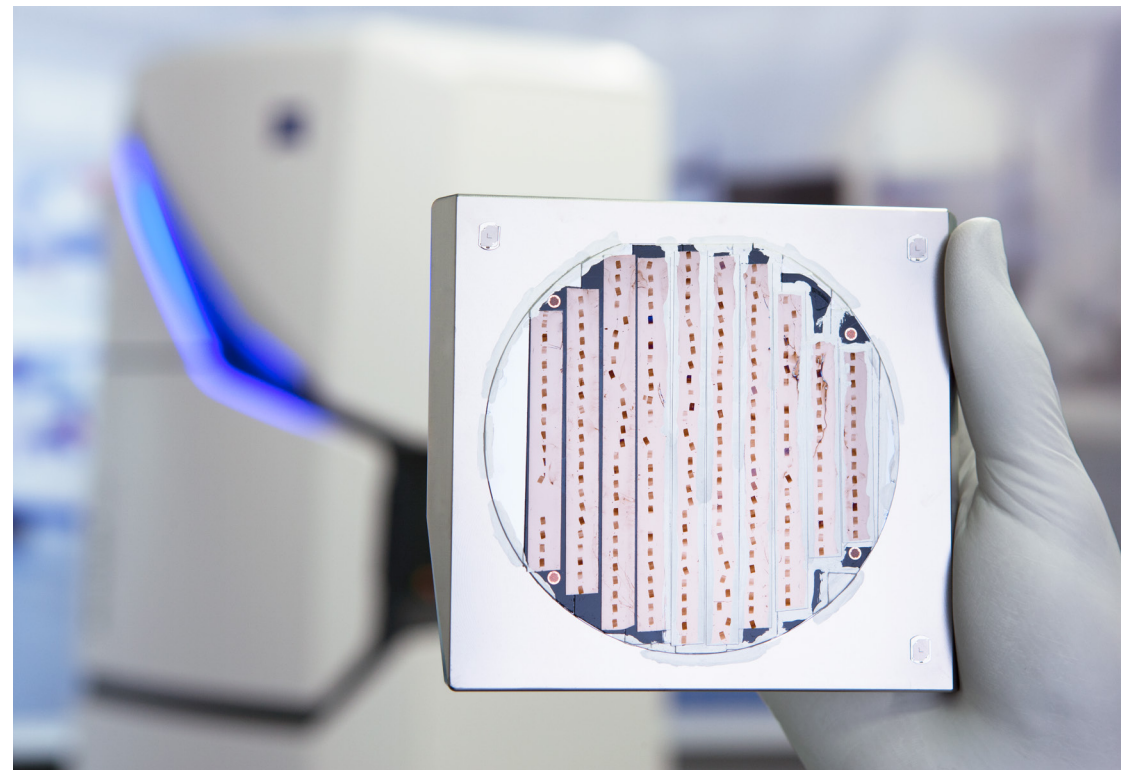
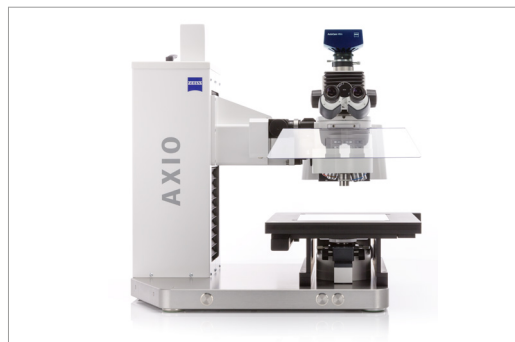
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## Your Complementary Workflow Solution for Acquisition of Serial Sections

Up to 1000 serial sections can be collected in one day by the ATUMtome, an automated tape collecting ultramicrotome. Subsequently, the tape with sections is mounted on a silicon wafer and can be imaged with a ZEISS light microscope using ZEN imaging software and Shuttle & Find.

By taking a light microscope overview image you can plan your experiment and navigate easily on your sample within the MultiSEM using the same ZEN software user interface. For planning and setting-up the acquisition workflow only one graphical user interface is needed. Automated section detection supports you in identifying and targeting your regions of interest in a very efficient way.



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## Automated Section Detection

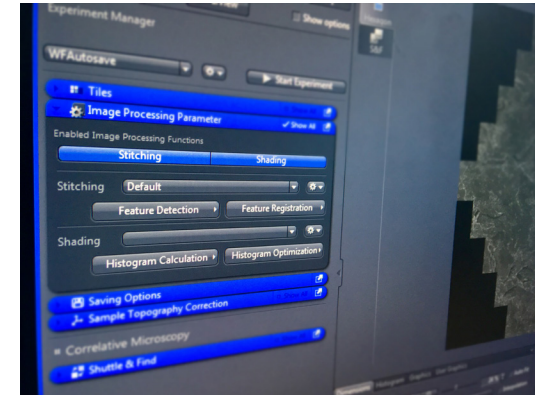
ZEN for MultiSEM employs a section detection algorithm that saves you hours of manual labor. By template matching all sections are labeled automatically and can be defined as regions of interest for the experiment setup. Selected sub-regions can be transferred from one section to all others by just one mouse click.

## Intelligent Retake Manager

ZEN for MultiSEM features a unique and intelligent data management system to ensure data completeness. Assess your data quality by using the high resolution viewer. If required, the smart retake manager supports you in setting up the follow-up experiment. Retake images are seamlessly added to the existing data set.

## Image Processing and Online Analysis

The high-performance image acquisition pipeline of MultiSEM provides processing tools that run in the background during data acquisition. A flexible user interface supports image stitching for a wide range of samples.



# Tailored Precisely to Your Applications

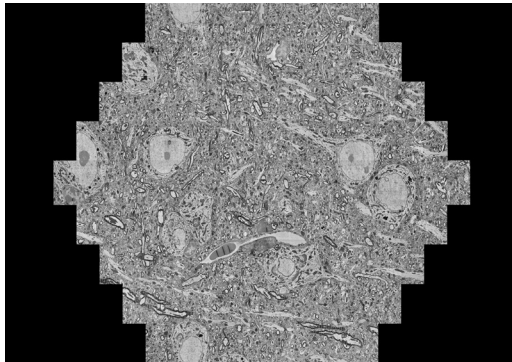
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Typical Applications, Typical Samples	Task	ZEISS MultiSEM Offers
Stained Serial Sections of Brain Tissue	Capture large images of sections for subsequent 3D reconstruction needed for analysis in connectomics	Highest throughput electron microscopy at high resolution
Ultrathin Sections from Cultured Cells or Tissue Cultures	Screen through large sets of samples with different treatments and compare the results.	Larger regions of interest (ROI) in less time and for complete experimental trials, statistics become more reliable
Reverse engineering, Computer Chips, Patterned Silicon Wafers	Examine large areas with nanometer-sized structures	Imaging of entire chip surfaces in reasonable time frames
Analysis of Polished Rock Samples	Examine large sample surface areas to evaluate natural resources	Better quantitative assessment, larger ROIs, better statistics
Characterization of critical battery components	Analysis of large sample areas to quantify aging processes in batteries	Real, large-area quantitative assessment, delivering significant statistically relevant data
Resin-embedded bone samples	Analysis of cell distribution patterns on the etched surface of bulk bone samples	Retrieving contextual information about small features of interest at a macroscopic scale

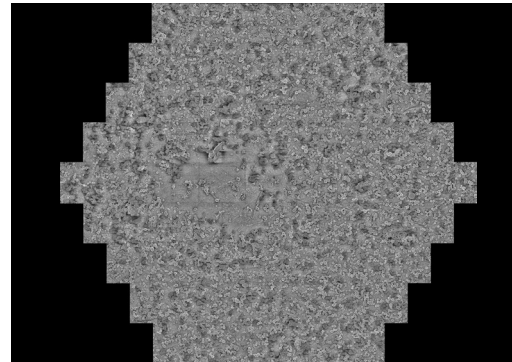
# ZEISS MultiSEM at Work

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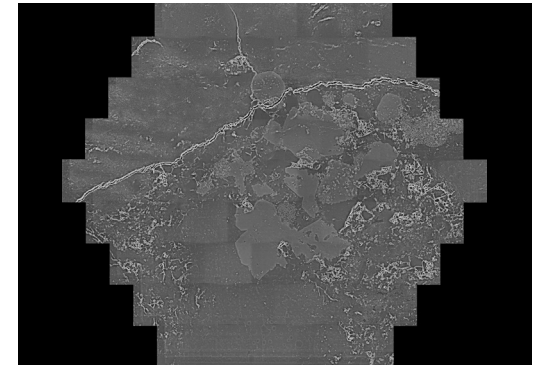
▶ [Click here to zoom into MultiSEM online data with ZEN browser](#)



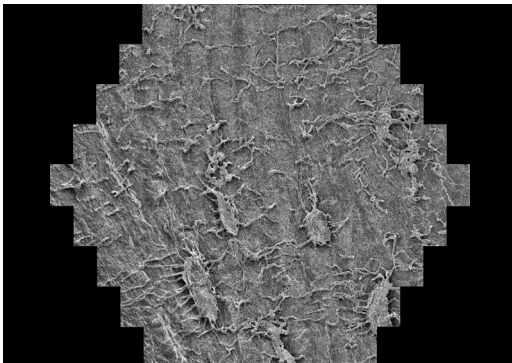
Mouse brain, 50 nm thick section. Image acquired with MultiSEM 505 covering a hexagonal field of view of  $108\ \mu\text{m} \times 94\ \mu\text{m}$  at 4 nm pixel size. Sample: courtesy of J. Lichtman, Harvard University, Cambridge, MA, USA.



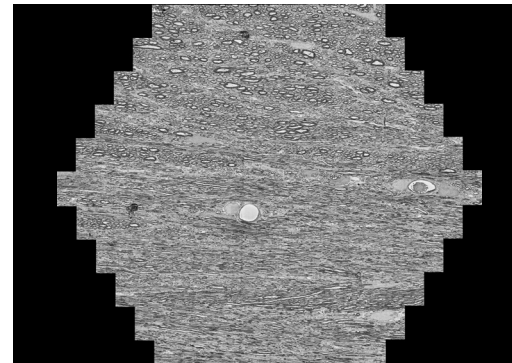
Separator foil of a cycled battery with precipitates from the anode side. Image acquired with MultiSEM 505 at low landing energy of 1 keV and 4 nm pixel size, covering a field of view of  $108\ \mu\text{m} \times 94\ \mu\text{m}$ . Sample: courtesy of U. Golla-Schindler and T. Bernthaler, Hochschule Aalen, Aalen, Germany.



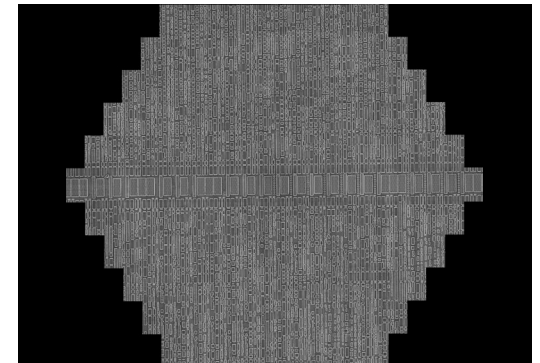
High maturity shale rock sample with broad ion beam milled surface. Image acquired with MultiSEM 505 at 4 nm pixel size, field of view is  $108\ \mu\text{m} \times 94\ \mu\text{m}$ . Sample: courtesy of L. Hathon, University of Houston, Houston, TX, USA.



Femoral neck sample, PMMA embedded, surface-polished and selectively etched to carve out osteocytes, hidden within the bone matrix before. Image acquired with MultiSEM 505 at 12 nm pixel size, field of view is  $135\ \mu\text{m} \times 117\ \mu\text{m}$ . Sample: courtesy of M. Knothe Tate, University of New South Wales, Australia, and Ulf Knothe, Cleveland, OH, USA.



Mouse brain, 50 nm thick section. Image acquired with MultiSEM 506 covering a hexagonal field of view of  $165\ \mu\text{m} \times 143\ \mu\text{m}$  at 4 nm pixel size. Sample: courtesy of J. Lichtman, Harvard University, Cambridge, MA, USA.



65 nm technology node graphics processor integrated circuit, stripped to its silicon substrate with HF acid etching. Image acquired with MultiSEM 506 at 4 nm pixel size, covering a hexagonal field of view of  $165\ \mu\text{m} \times 143\ \mu\text{m}$ .

# Your Flexible Choice of Components

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Accessory	Function	Technical Details
Airlock	Enables quick, manual specimen transfer ( $\leq 5$ min) into chamber. Use of airlock minimizes contamination and maximizes sample throughput	Consists of <ul style="list-style-type: none"> <li>■ Airlock chamber with integrated control window &amp; panel</li> <li>■ Removable sample transfer rod</li> <li>■ Control integrated in ZEN software</li> </ul>
Chamber Plasma Cleaner	For cleaning the MultiSEM chamber. Reduction of contamination by hydrocarbons results in improved image quality and resolution	Generation of reactive gas-phase radicals removing unwanted contaminants. Consists of <ul style="list-style-type: none"> <li>■ Plasma Cleaner Evactron Zephyr</li> <li>■ Adapter kit for MultiSEM chamber</li> <li>■ Control integrated in ZEN software</li> </ul>
Sample Plasma Cleaner	For cleaning and etching the sample in the airlock. Reduction of sample surface contamination results in improved image quality and resolution	Generation of reactive gas-phase radicals removing unwanted contaminants. Requires airlock. Consists of <ul style="list-style-type: none"> <li>■ Plasma Cleaner Evactron Zephyr</li> <li>■ Multiport for MultiSEM airlock</li> <li>■ Adapter Kit for Multiport</li> <li>■ Control integrated in ZEN software</li> </ul>
Standard Sample Holder	Flat surface holder for flexible sample mounting ( $\leq 100 \times 100$ mm <sup>2</sup> )	Including L-marker fiducials for Shuttle & Find functionality
Multi-Purpose Sample Holder	For mounting standard sized EM stubs and silicon wafer chips. Additional space for flexible sample mounting (ca. $50 \times 50$ mm <sup>2</sup> )	Including L-marker fiducials for Shuttle & Find functionality, dedicated slots for standard sized EM stubs ( $6 \times 12.7$ mm, $3 \times 25.4$ mm, $2 \times 32.0$ mm), $6 \times$ silicon wafer chips ( $10 \times 10$ mm)
Multi-Purpose Sample Holder for Life Sciences	For mounting standard sized EM stubs, TEM grids and ITO cover slips. Additional space for flexible sample mounting (ca. $45 \times 35$ mm <sup>2</sup> )	Including L-marker fiducials for Shuttle & Find functionality, dedicated slots for standard sized EM stubs ( $6 \times 12.7$ mm, $2 \times 25.4$ mm, $1 \times 32.0$ mm), $6 \times$ silicon wafer chips ( $10 \times 10$ mm), $8 \times$ TEM grids and $2 \times$ cover slips
Adapter Plate for ZEISS Light Microscope	For mounting MultiSEM sample holders directly onto light microscope stage	Suitable for ZEISS Axio Imager Vario

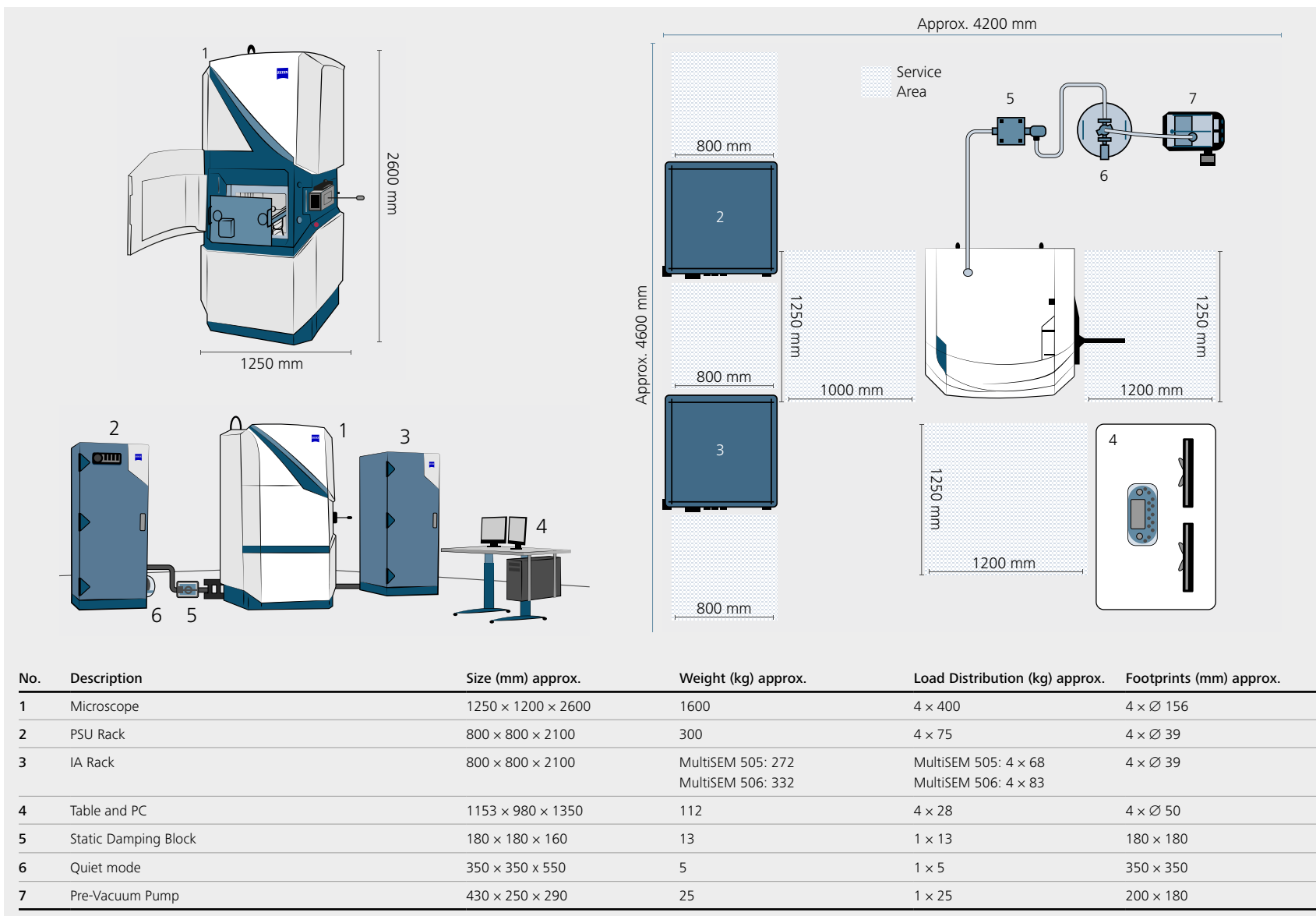
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Accessory	Function	Technical Details
<b>Workflow Add-ons</b>		
Light Microscope	Large area imaging (> 10 cm <sup>2</sup> ) for fast sample overview and region of interest selection. Sample positions can be accurately identified and relocated within MultiSEM	Recommended microscope is ZEISS Axio Imager.A2 Vario. ZEN software (blue edition) with Shuttle & Find licence required.
ATUMtome	Automated sectioning and section collection of resin-embedded biological tissue	Ultramicrotome based section collection robot from RMC Boeckeler. Up to 1000 sections per day with a typical sample thickness of 30 – 50 nm

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Electron Optics	MultiSEM 505	MultiSEM 506	
Resolution	Average resolution of all beams @ 1.0 kV, 1.5 kV, 3.0 kV	≤ 3.5 nm	
Resolution Uniformity	@ 1.0 kV, 1.5 kV, 3.0 kV and 12 μm pitch size	≤ ± 0.5 nm	≤ ± 1 nm
Landing Energy	Range	1.0 – 3.0 kV	
Beam Arrangement	Beam pattern	Hexagonal	
	Number of beams	61	91
	Pitch size (width of single beam image)	12 μm or 15 μm (optional)	
	Pitch uniformity	≤ ± 1 %	
Field of View (FoV)	Long axis of hexagon (12 μm pitch / 15 μm pitch)	108 μm / 135 μm	132 μm / 165 μm
Beam Current	Single beam	≥ 570 pA	
	Total current	≥ 35 nA	≥ 52 nA
	Uniformity	≤ ± 10 %	
Electron Source	Filament	Schottky emitter	
	Filament current stability	≤ 1 % per hour	
Beam Blanker	Electrostatic beam blanker		
Working Distance	1.4 mm		
Detection	Secondary electron projection optics with high-efficiency multi detection unit		
<b>Scanning</b>			
Scan Rate	Max. 20 MHz per beam, different discrete scan speeds are available		
Scan Mode	Step and scan		
Pixel Size	Range for complete stitching (at 12 μm pitch)	2 nm – 20 nm	
Scan Arrangement	Image tile consists of 61 Sub-Images arranged in a hexagonal pattern	Image tile consists of 91 Sub-Images arranged in a hexagonal pattern	Adjustable overlap of adjacent scan fields

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Stage and Specimen	MultiSEM 505	MultiSEM 506
Stage	Type:	Stepper Stage
	Usable travel range x/y/z:	100 / 100 / 30 mm
	Repeatability XY	≤± 3 μm
	Settling time	≤ 1.5 s
Specimen Requirements	Maximum size in XY	100 × 100 mm <sup>2</sup>
	Maximum height	≤ 30 mm
	Maximum flatness	≤ 500 nm / 100 μm (Peak-to-Peak)
	Maximum weight	≤ 0.2 kg
Specimen Exchange Time	with airlock	≤ 5 min
<b>Software</b>		
User Interface		ZEN for MultiSEM
Application Programming Interface (API)		provided for custom workflow development
Shuttle & Find Functionality		Reliable transfer of sample coordinates from different imaging modalities (e.g. light microscope or single-beam SEM)
Performance Monitoring		Check of all relevant system parameters such as vacuum pressures or optics alignment quality
Parallel Software Architecture		Distributed image acquisition
Data Base Support		provided for workflow and data management
Automated Alignment Functions		autofocus, auto-stigmation, detector equalization, etc.
<b>Image Acquisition Workflow</b>		
Graphical Experiment Setup		Image based region of interest selection
Automated Section Detection (Option)		Fast workflow setup for serial sections imaging
Interaction Requirement		Max. 1 hr/24 hrs dedicated user interaction for beam alignment & calibration

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Computer Hardware	MultiSEM 505	MultiSEM 506
Main Controller		≥ 4 core CPU (64 Bit), ≥ 32 GB DDR, ≥ 1 TB HD, min. 2 ports with 1 Gbit Ethernet
Main Controller Operating System		Windows® 7 (64 Bit)
Display		2 Monitors, 1920×1080 Pixel, 24"
Image Acquisition	8 PCs, in 19" Rack	12 PCs, in 19" Rack
Image Acquisition PC		≥ 4 core CPU (64 Bit), ≥ 32 GB DDR3, 1 Gbit ethernet, 10 Gbit ethernet to customer network
Data Transfer Rate to Customer Network		≥ 10 Gbit ethernet
<b>Vacuum System</b>		
Chamber Vacuum Pumps		Turbo molecular pump (≥ 280 l/s); oil-free Scroll Pump
Chamber Operating Pressure		≤ 1 × 10 <sup>-5</sup> mbar
Monitoring		Automatic monitoring of all relevant pressures



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