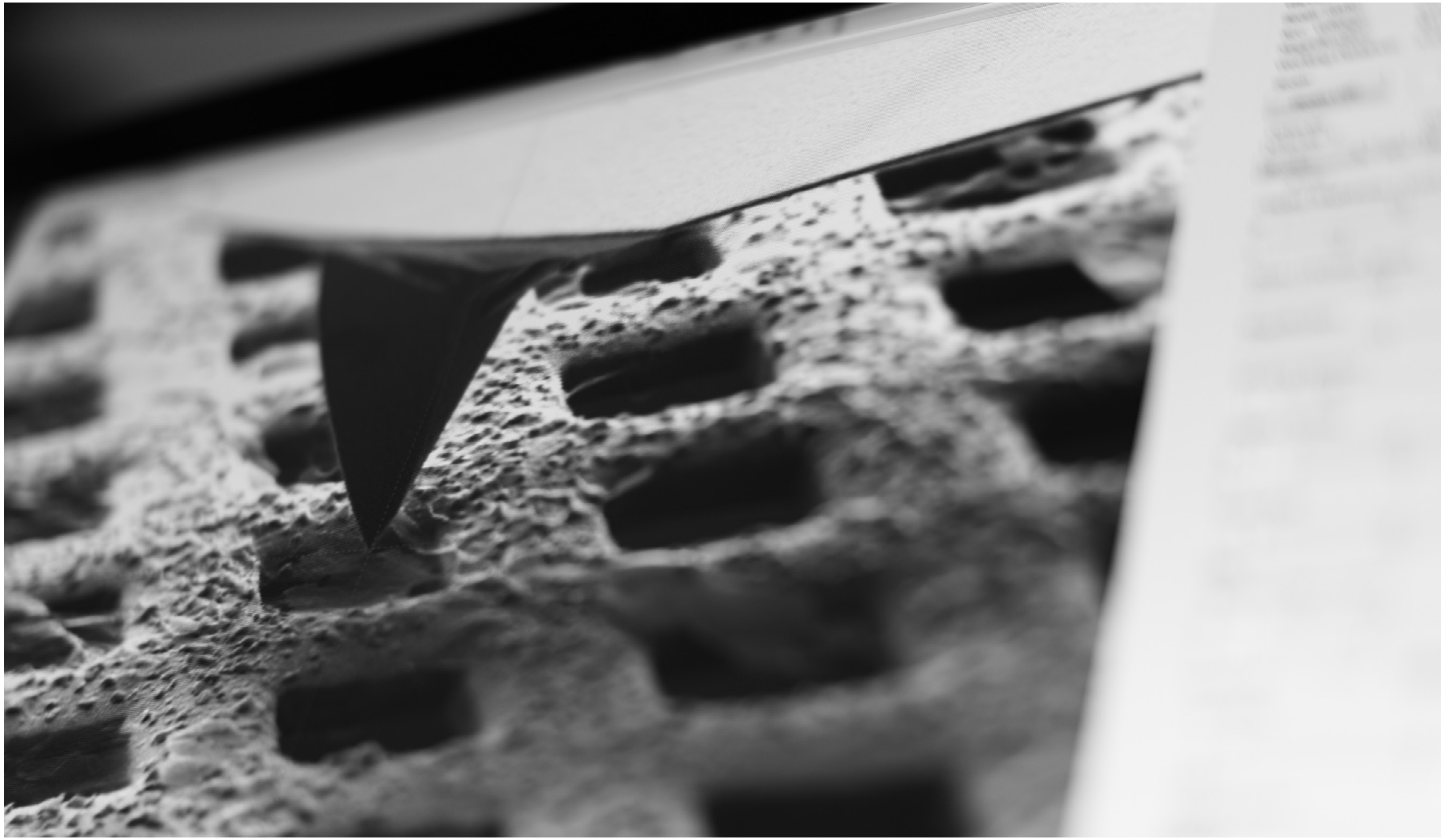


Product Information

Version 1.0

ZEISS Integrated Atomic Force Microscope

Your Only True *in situ* AFM Solution for FE-SEMs and FIB-SEMs

Your Only True *in situ* AFM Solution for FE-SEMs and FIB-SEMs

› **In Brief**
› The Advantages
› The Applications
› The System
› Technology and Details
› Service

Get the best of both worlds in a single instrument: combine atomic force microscopy (AFM) with your ZEISS scanning electron microscope (SEM) or focused ion beam-SEM (FIB-SEM). Put AFM performance to work in visualizing 3D topography down to atomic level while measuring a wide range of physical properties. At the same time, you have the advantage of ZEISS Gemini electron optics, tailored to deliver the best results in image quality and sample flexibility. What’s more, in-chamber integration allows simultaneous AFM and SEM imaging. Measure precise regions of interest right then and there, without the hassle of transferring samples between separate devices.

It's the only SEM-integrated AFM that can perform all commercially available scanning probe microscopy (SPM) modes (IP protected excluded).

Animation

Simpler. More Intelligent. More Integrated.

SEM and AFM:
The Best of Both Worlds in One

Uniting SEM with AFM brings you a unique advantage: your ZEISS SEM or FIB-SEM, together with its integrated AFM, lets you learn about the mechanical, electrical, chemical and magnetic properties of your sample's surface, all in the same instrument. The AFM performs calibrated sub-nanometer 3D topography and gives you access to material properties. Use it in any standard or electrical scanning probe microscopy (SPM) mode to capitalize on the SEM's higher sensitivity and resolution.

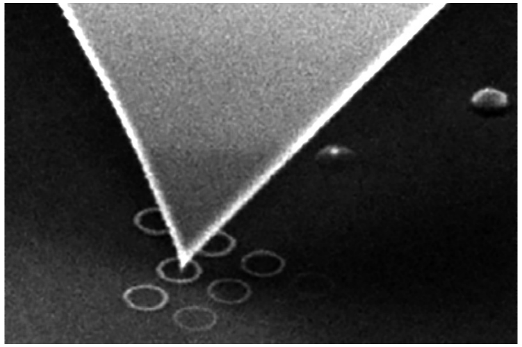
Increase Productivity and Versatility

The integrated AFM offers you another unique advantage by exchanging samples and tips through an airlock. You'll enjoy the simplicity and speed this brings to your investigations while also keeping your SEM chamber clean. ZEISS is the only provider that enables you to operate the AFM on the optical lever principle, thus giving you access to almost all commercial cantilevers—no active probes required.

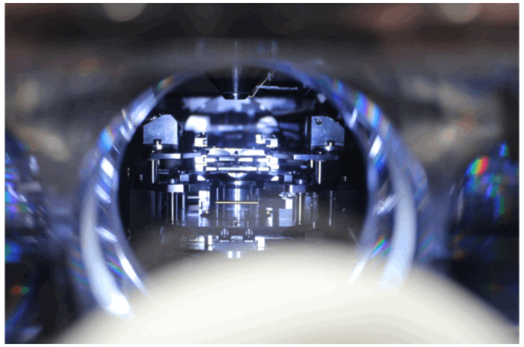
Switching between different stage types is simple, fast and easy, courtesy of the contamination-free storage vacuum chamber and its door module concept.

Working with AFM Made Easy

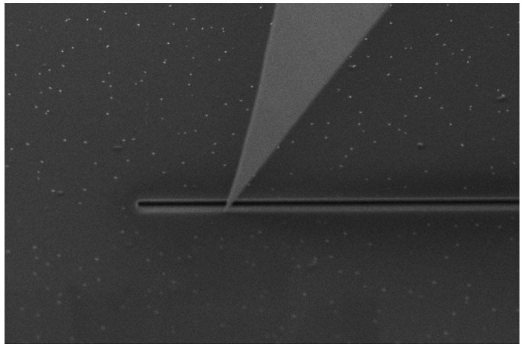
Simply find your region of interest (ROI) and position the AFM tip. The SEM's zoom capabilities make it easy to navigate your AFM tip directly to the ROI. Having a single software interface for the SEM and AFM helps you align the cantilever automatically, without vacuum break. Image your sample with the SEM or measure it simultaneously with the AFM. The optical design of ZEISS field emission SEMs gives you the distinct advantage of Gemini optics: Gemini guarantees superb image quality and fast time-to-image, especially with magnetic samples. You can prepare or modify your samples and tips *in situ* with the FIB-SEM.



Calibrated sub-nanometer 3D topography: the cantilever is navigated to the ROI, structures generated by ZEISS ORION NanoFab, SEM image. (Image, field of view: 14.5 µm).



Sample and tip exchange through airlock.



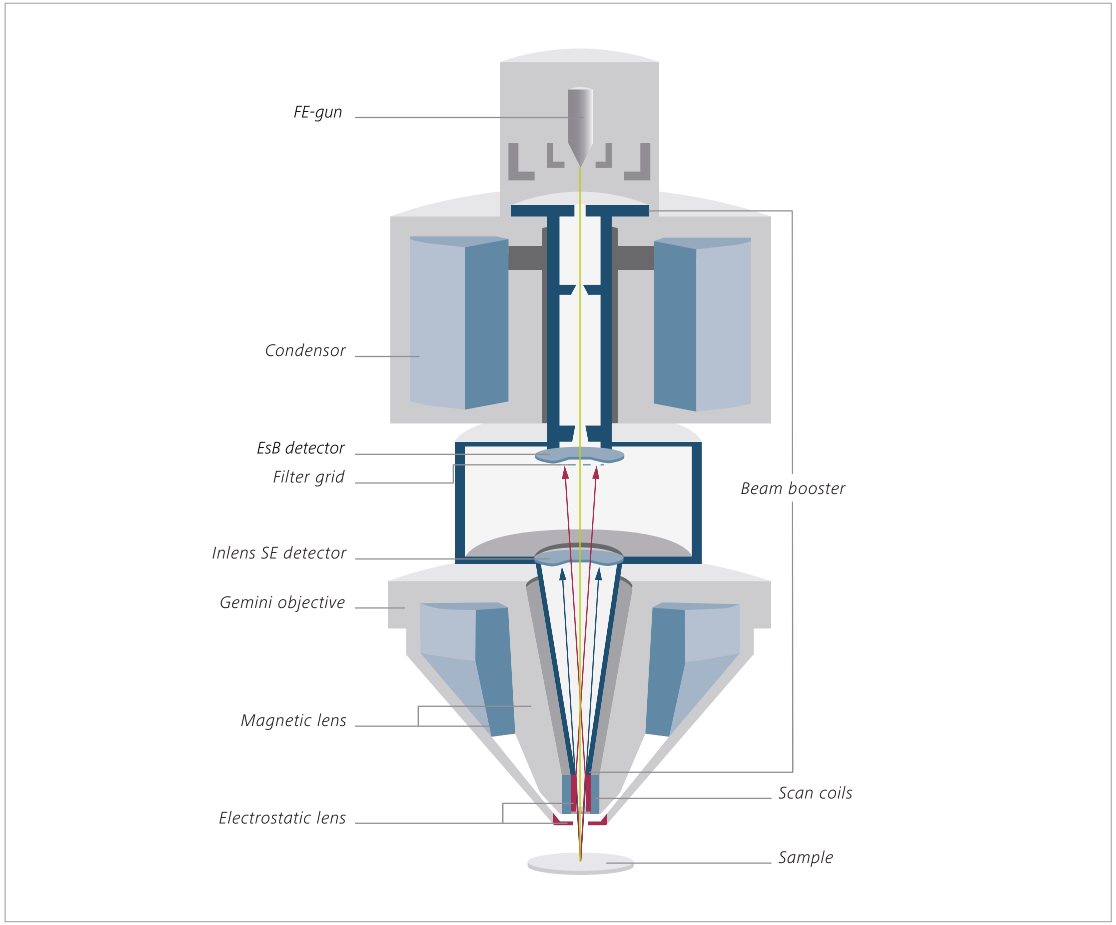
Simple workflow, thanks to SEM-guided positioning of AFM tip to region of interest. (Image, field of view: 3 µm).

Your Insight into the Technology Behind It

Combine the Advantages of ZEISS Gemini Optics with *in situ* AFM

ZEISS FE-SEMs and FIB-SEMs are based on more than 20 years of experience in Gemini technology—proven optical design for superb image quality, detection efficiency and sample flexibility.

- 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 Inlens detection concept ensures efficient signal detection by detecting secondary electrons (SE) and backscattered electrons (BSE) in parallel, thus minimizing time-to-image.
- Gemini beam booster technology guarantees small probe sizes and high signal-to-noise ratios.

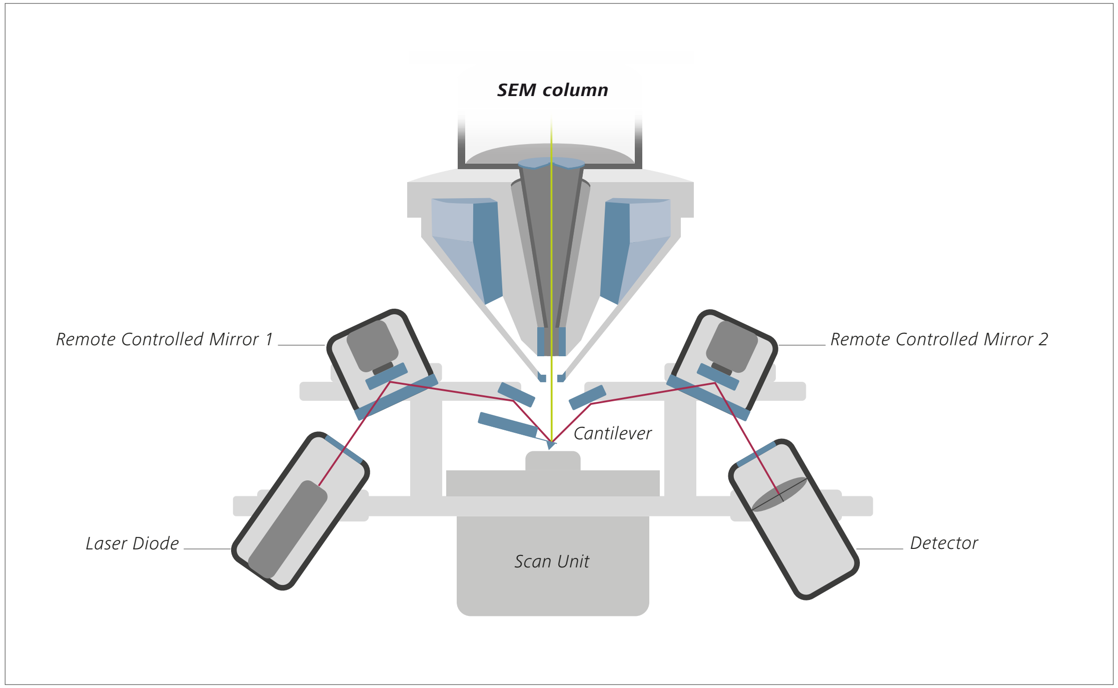


Gemini technology: Schematic cross-section of Gemini optical column.

Your Insight into the Technology Behind It

Laser Deflection AFM
The integrated AFM is a high resolution, sample scanning system that scans a volume of 25 µm × 25 µm × 5 µm and a maximum sample size of 10 mm. The design allows a minimum working distance of 5 mm, which delivers excellent SEM performance.

An AFM image is generated by moving a fine tip mechanically across the sample. Physical topography, charge density, magnetic field and other surface properties interact with the tip to deflect the cantilever. This deflection is first measured by focusing a laser on the back of the cantilever and then reflected to a position detector. The ZEISS integrated AFM's laser-based readout of the cantilever deflection lets you use any type of commercial cantilever, thus supporting all SPM modes. You can change the cantilever and alignment of the laser path without breaking the vacuum. Use the sample and cantilever holders for advanced AFM modes to provide four electrical slide contacts. They will connect to electronic equipment such as lock-in amplifiers or allow electrical measurement on active devices such as semiconductors or energy storage devices.



Schematic setup of AFM design.

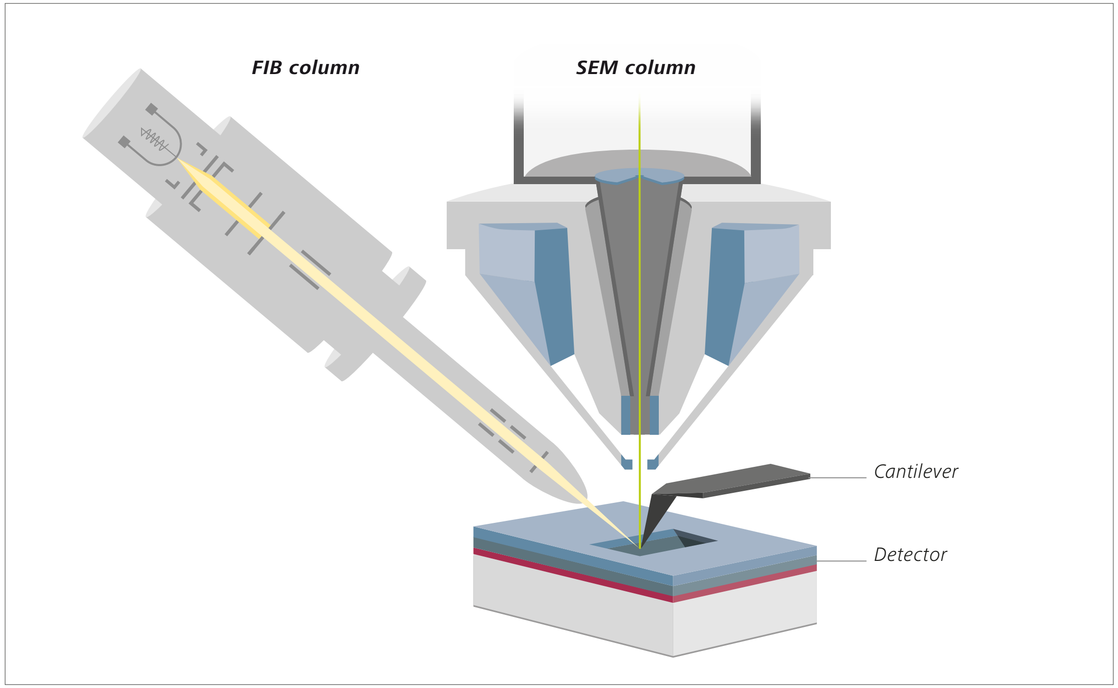
Your Insight into the Technology Behind It

Benefit from *in situ* AFM

Position SEM, AFM and area of interest with respect to each other by the 7-axis stage of the integrated AFM. The stage is part of the main door of the SEM. The integrated AFM always comes with the stage exchange option: a table with a vacuum chamber that prevents contamination, when the stage is not in use, and a lifting unit. Safely change from the SEM to AFM stage or vice versa.

In combination with a ZEISS FIB-SEM, align the AFM tip with the FIB e-beam in the coincidence point, rotate around it with an angle of about 75° and position the sample surface perpendicular to the e-beam or the FIB.

Operate SEM and AFM from a single user interface with the AFM's software. Perform user-designed advanced measurement routines and automated measurement routines for the reproducible acquisition of comparable data sets.



Exchange stage with integrated AFM (top). SEM, FIB and AFM in coincidence point (bottom).

Tailored Precisely to Your Applications

Typical Applications, Typical Samples	Task	ZEISS Integrated AFM Offers
SEM and AFM		
Navigation and experiment set up	Navigate ROIs. Find ROIs on your sample with the SEM easily and perform AFM investigations.	The ability to navigate your sample with the SEM and identify the ROI. Position your AFM tip and perform easy, reliable AFM investigations.
Measure sub-nanometer topography	Determine sub-nanometer topographical features.	Imaging and measuring of e.g. atomic layers, nanoparticles, nanorods, nanostructures surfaces and Helium-Ion-Beam-structured silicon with sub-nanometer resolution.
Analyze surface properties of a surface mount device (SMD)	Characterize electrical properties.	Kelvin Force Probe Microscopy (KPFM). Identify topography, surface potential differences with SE and BSE images in the SEM, examine topographical and electrical properties with KPFM by AFM.
Characterize graphene	Investigate material properties, e.g. rupture toughness and e-modulus.	Nano-indentation. Manipulate graphene and other 2D materials with the AFM tip. Image topographical features of a single atomic layer in AC mode (tapping mode or intermittent contact mode). Obtain force curves by recording z-travel and force applied to the cantilever.
FIB-SEM and AFM		
Semiconductor, energy storage	Characterize heterogenic structures *in situ*. Investigate organic solar cells.	FIB milling to open the surface for AFM investigation. KPFM localizes the interface on which the main potential drop occurs. Combine topography and work function data in a 3D-AFM image. Find the potential distribution along organic solar cells.

ZEISS Integrated AFM at Work

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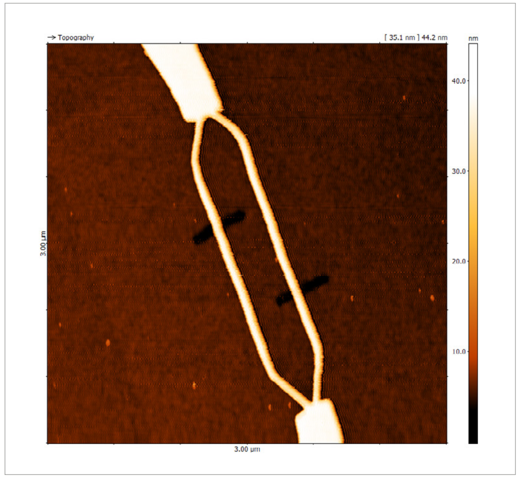
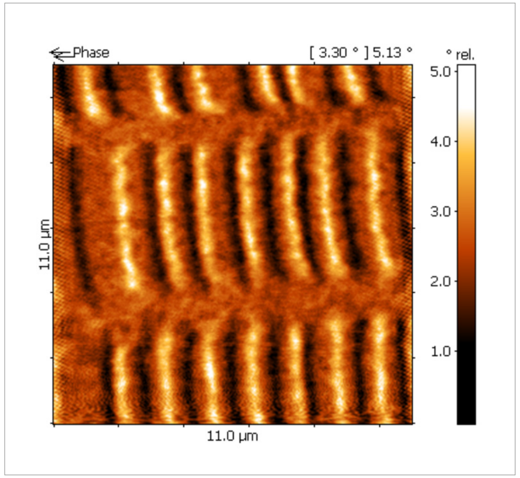
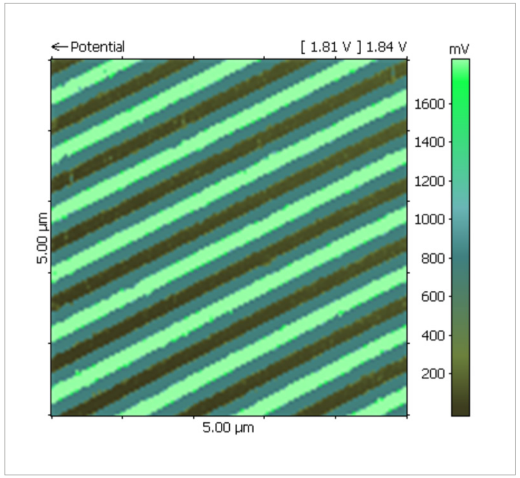
Surface Analysis



FIB modified metallic nano-scaled structure.



Analysis of surface properties: magnetic forces on a hard drive.



Investigation of the chemical surface potential by Kelvin Force Probe Microscopy (KFPM): work function of a multilayer condenser.

Navigate to the precise area of interest to measure surface properties

One great advantage of combining AFM and SEM is the ability to direct the AFM tip precisely to the area of interest and observe every action by the SEM.

The AFM lets you measure the topography of the sample with sub-nanometer resolution. And analyze surface properties such as the magnetic force on the sample surface, the chemical surface potential by Kelvin Force Probe Microscopy (KPFM), the conductivity of the surface—and many others.

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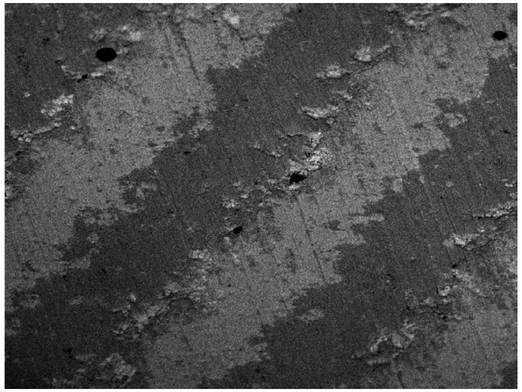
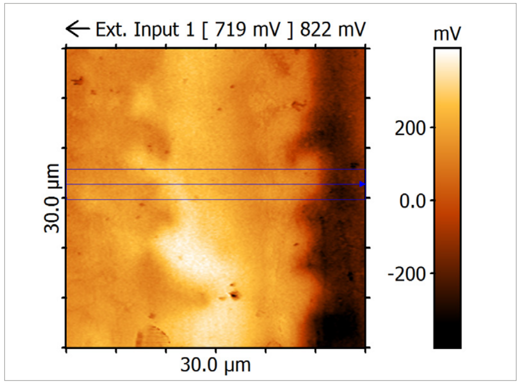
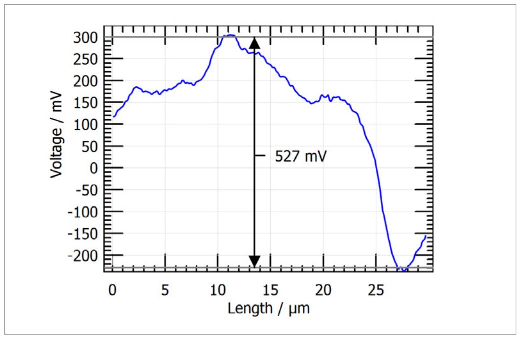
ZEISS Integrated AFM at Work

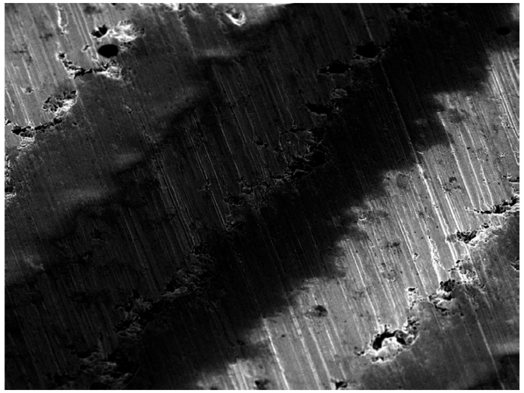
Material Contrast

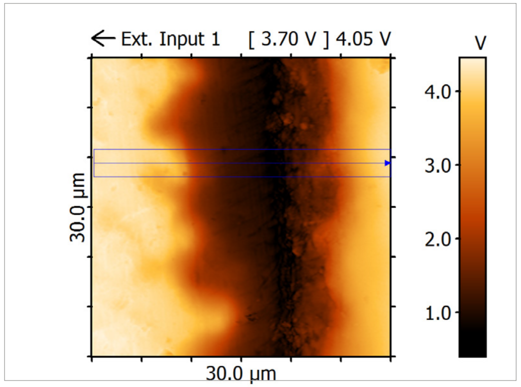


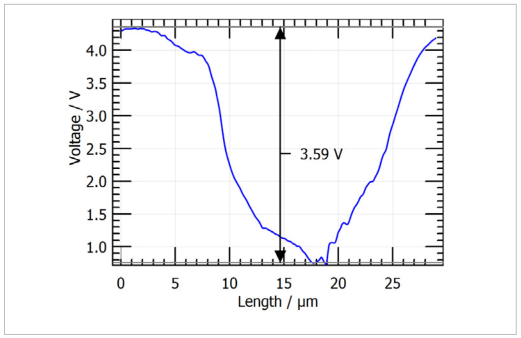




Electrical Properties





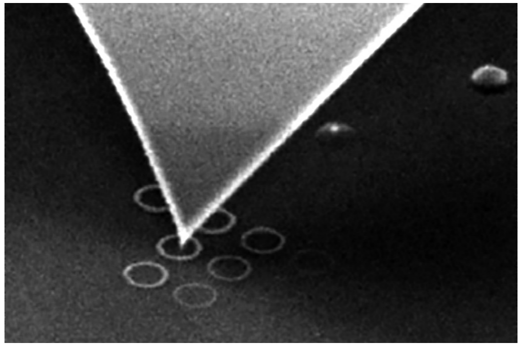


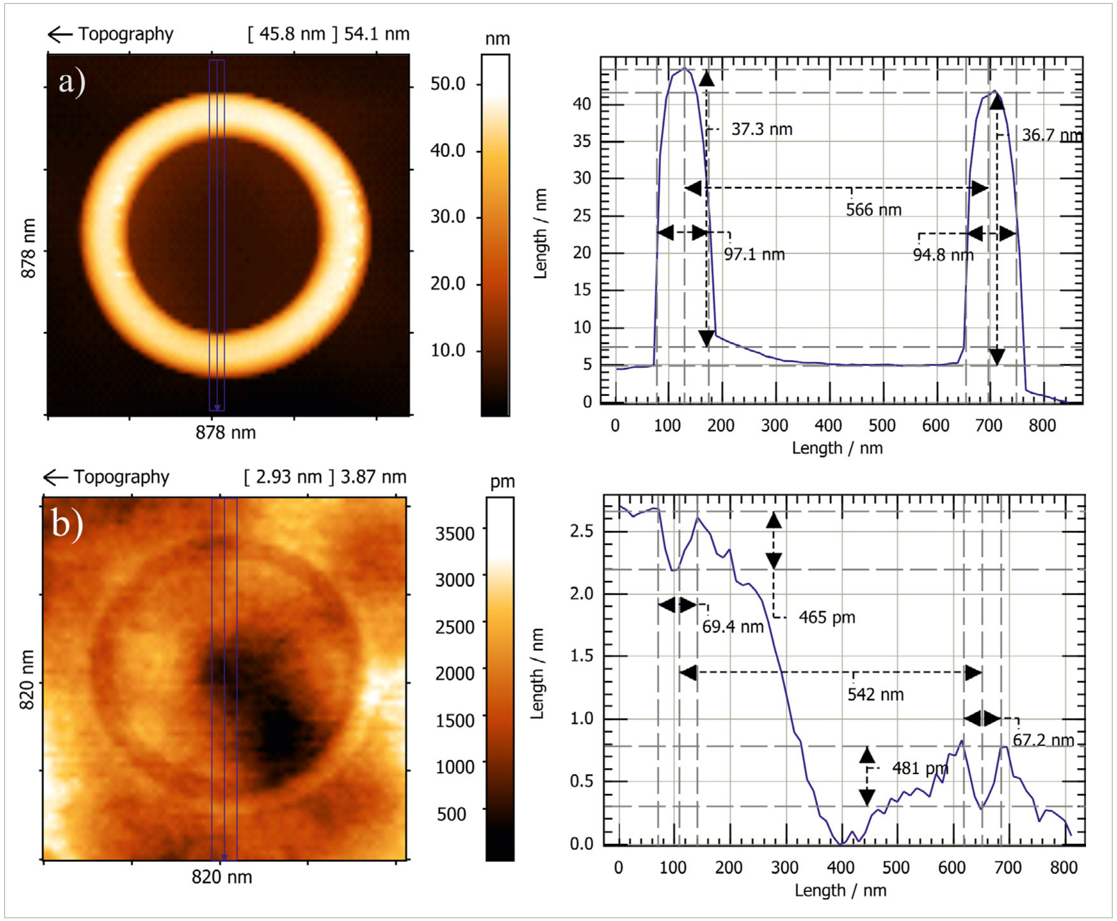
Characterize Electrical Properties Quantitatively

Use the SEM to investigate the potential distribution along the layer structure of an SMD (surface mount device) capacitor or of a 4.5 V battery. Then examine the topographical and electrical properties by AFM Kelvin Probe Force Microscopy (KPFM): Apply a voltage to generate a topographical effect in the secondary electron image (top left). Identify material and potential differences in the backscatter electron image (top right). Observe contrast changes after voltage inversion. Characterize the surface potential that you observe in the SEM images quantitatively with KPFM (center) and measure potential differences (bottom).

ZEISS Integrated AFM at Work

Nanopatterning

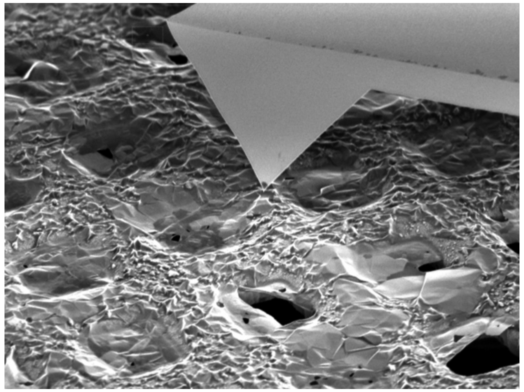




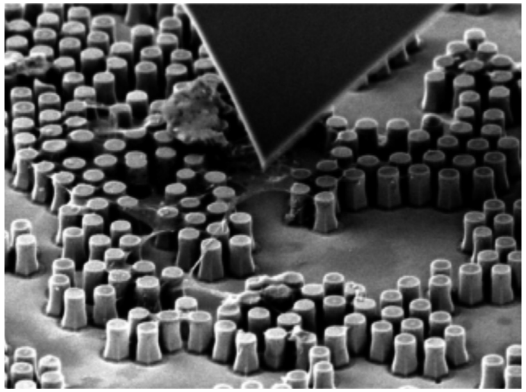
An array of ring nanostructures produced with the helium ion beam of ZEISS ORION NanoFab was studied using ZEISS FE-SEM with the AFM option. The AFM cantilever is navigated to the vicinity of the ROI (left, SEM image, field of view: 14.5 µm). Dimensional analysis of rings written with 1 nC / µm² (in a), top) and 0.1 nC / µm² (in b), bottom) helium ion dose, respectively. Sample courtesy of N. Anspach and F. Hitzel, Semilab Germany GmbH, Germany.

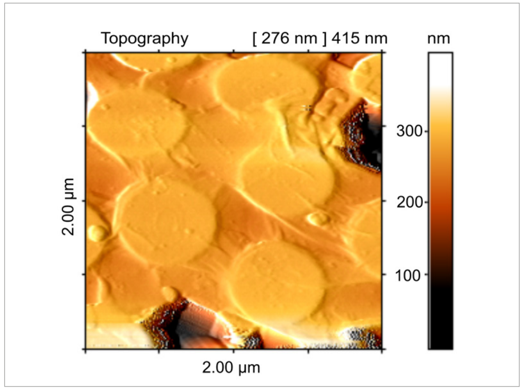
ZEISS Integrated AFM at Work

Graphene

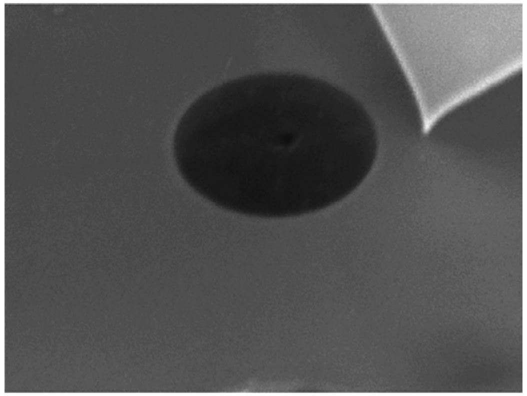


Observe wrinkles and foldings in the nanometer range on a graphene membrane that encompasses a few layers of graphene (Image, field of view: 40 µm).

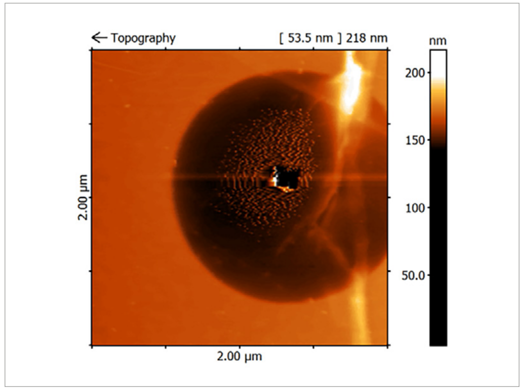


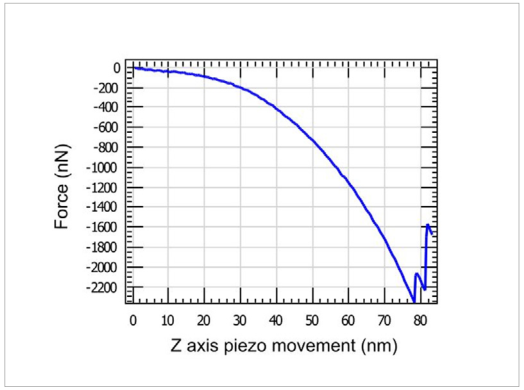


Graphene on nano pillars, SEM image, field of view 10 µm (left), AFM topography map (right). Sample courtesy of: S. Christiansen, Helmholtz Zentrum, Berlin, Germany



Punctured graphene membrane: in AC mode (tapping mode or intermittent contact mode), you can image the topographical features of a single atomic layer—without any damage (Image, field of view: around 7 µm).

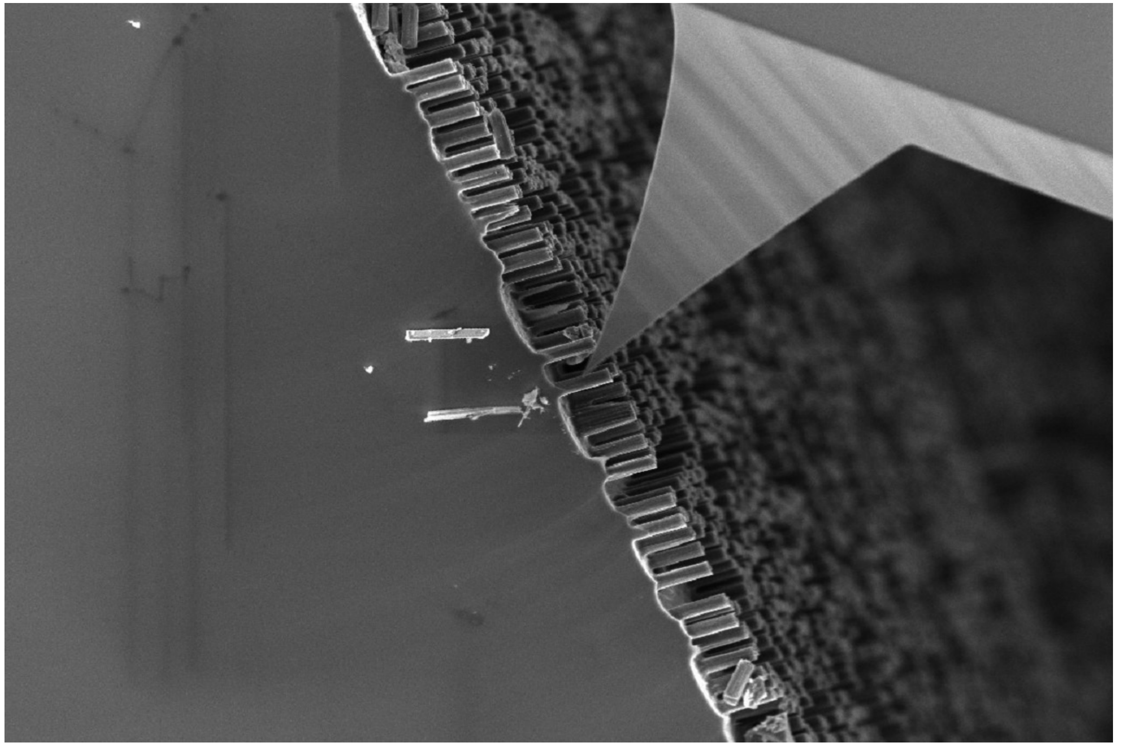




Punctured graphene membrane after indent: characterize mechanical properties of the membrane or use the AFM as a nano-indenter (left). Obtain indentation curves by recording z-travel and force applied to the cantilever. This enables you to calculate mechanical properties such as rupture toughness and e-modulus (right).

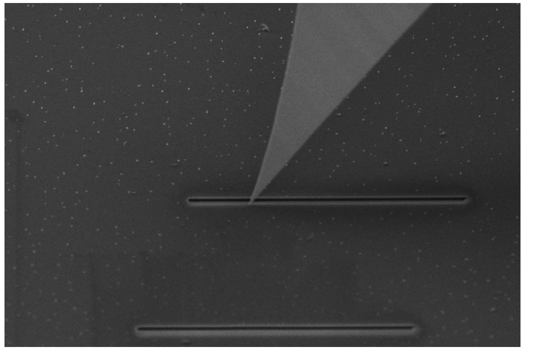
ZEISS Integrated AFM at Work

Semiconductors



Determination of doping profile of a single Helium ion beam prepared nanorod. Courtesy of: S. Christiansen, Max Planck Institute for the Science of Light, Erlangen, field of view 25 µm.

Energy Storage

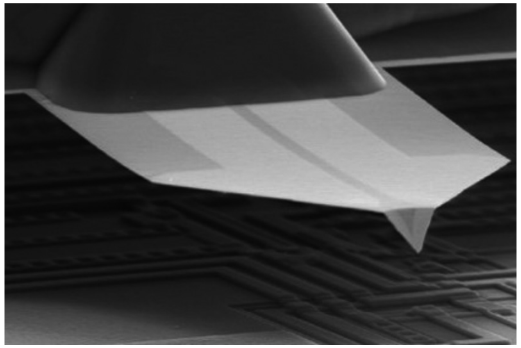


AFM tip imaging FIB prepared bevel structure to determine sub surface layer properties, field of view 30 µm.

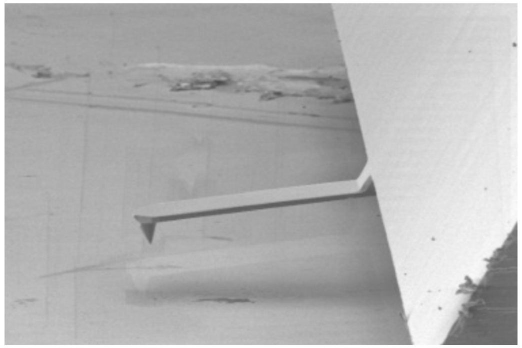
Your Flexible Choice of Components

Benefit from Having Access To All SPM Modes At Hand
The optical lever design has become the gold standard in more than 90% of all laboratory-based SPM systems. As a result, an enormous number of cantilever types (SPM tips) based on this technology are now commercially available This guarantees the highest standards in quality, quantity and availability: no other cantilever technology, including piezo active cantilevers, can match it.

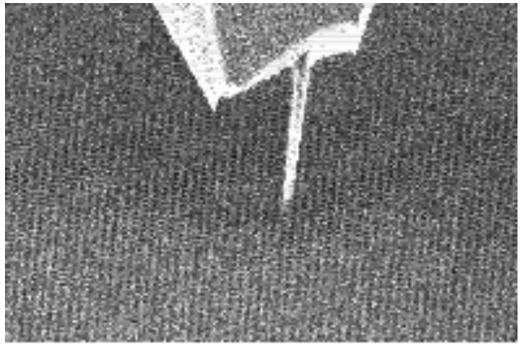
The integration of ZEISS AFM into SEMs ensures you can exploit the full compatibility of all available SPM modes—without compromising any method. That makes it the one and only 'true' *in situ* solution.



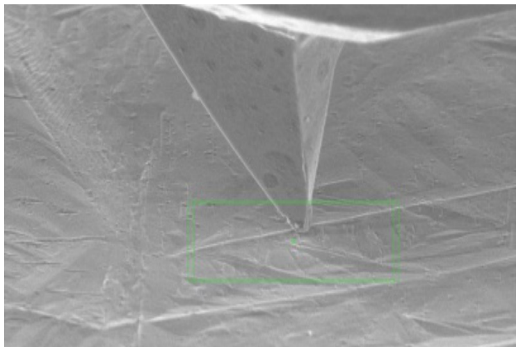
Advanced cantilevers, e.g. for scanning thermal microscopy. Image courtesy of: Kelvin Nanotechnology Ltd.



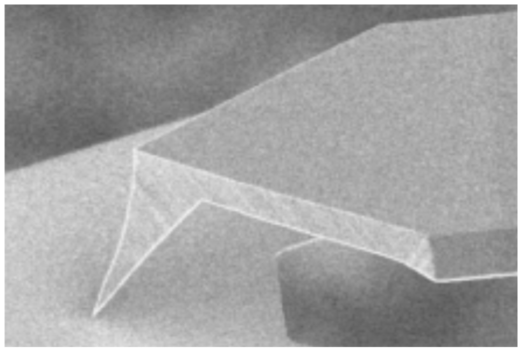
AC mode AFM tip for topography measurements.



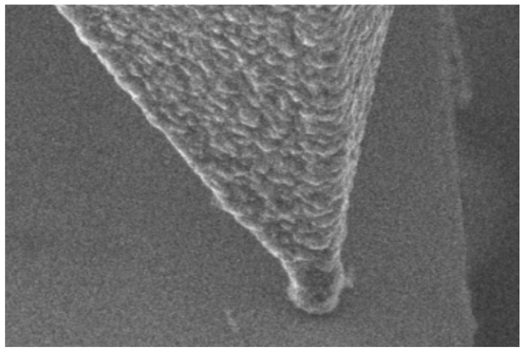
FIB sharpened AFM tip for high aspect ratio measurements.



Conductive AFM tip for KPFM measurements and EFM.



Special tip geometry to reach ROI on highly structures samples.

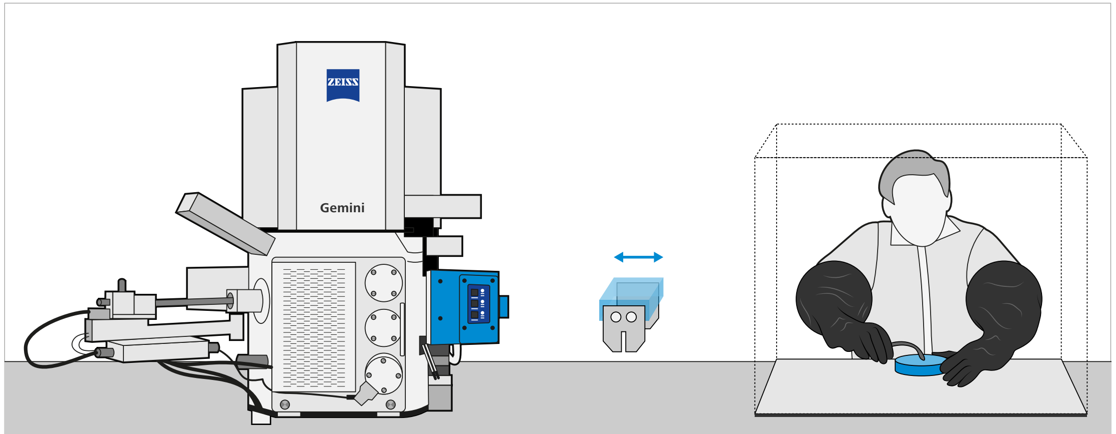


Conductive diamond tip for scanning spreading resistance measurements.

Your Flexible Choice of Components

Handle Air-sensitive Samples with Care
Protect a sample that should not be exposed to air by using the sample transfer shuttle to take it between the SEM and your facilities for sample storage and preparation, e.g. a glovebox. Since the shuttle is a small standalone container, you won't need an external power source or feed-throughs into the SEM chamber. An infrared remote control manages the opening and closing operation of the sample transfer shuttle.

The shuttle remains in the airlock. Only the sample is moved to the stage, thus no mechanical conflicts or performance degradation will occur during SEM investigation.



Transfer even your most sensitive specimens from the glovebox to the SEM without air exposure. Profit from vacuum or inert atmosphere within the shuttle that protects your sample.

Technical Specifications

AFM Specifications	
Type	High frequency sample scanner (tube)
Scan volume	9 µm × 9 µm × 1 µm or 25 µm × 25 µm × 5 µm
Maximum sample size	~10 mm × 10 mm
Resolution	Subatomic in all three dimensions
	Digital resolution <13 pm x/y, <1 pm in z
Stability	Designed for single atom resolution
Anchored™ Stage	AFM scanner, sample, and cantilever mechanically isolated
Tip to sample mechanical loop	~3 cm
Scan Modes	AFM contact and noncontact
	e.g.: STM, LFM, PFM, EFM, KFPM, MFM, SSRM
Supported cantilevers	All standard AFM cantilevers
Cantilever mounting	Mechanically clamped
Supported sensors in STM mode	Conductive cantilevers or etched STM tips
Laser / detector alignment	Automatic alignment after cantilever change

System Specifications	
Stage exchange	Vacuum storage and lift wagon included
Software	Single software interface for both SEM or FIB-SEM and AFM
	Use of SmartSEM in parallel possible
Data storage	Common for AFM and SEM images
Viewing angle for SEM	0° to 85° for SEM with a minimum working distance of 5 mm
Coincidence point for FIB-SEM	Lies at the cantilever tip.
	The design as a sample scanner allows combination measurements of all three techniques at exactly the same point in space and on the sample.
Accesibility of cantilever tip and sample	Accessible by FIB in 0° and 54° position
	In situ tip sharpening by FIB supported

ZEISS integrated AFM is available as a field upgrade for all ZEISS FE-SEMs and FIB-SEMs.
The retrofit must be performed by an authorized service engineer from Carl Zeiss Microscopy GmbH.

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.

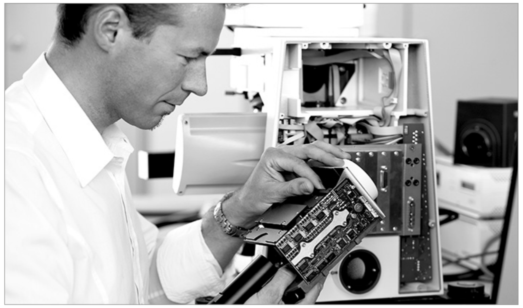
Repair. Maintain. Optimize.

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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