

Discover Nano-Scale Creation at Your Fingertips.



RAITH

**Solutions for Advanced
Nanofabrication and E-Beam
Lithography**

zeiss.com/microscopy/nanomaterials



Seeing beyond

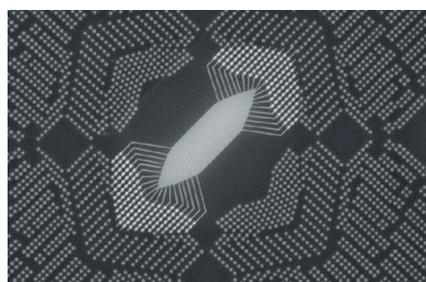
Your Technology Enabler for Nanolithography and Nanofabrication

Perform advanced imaging and lithography using systems specifically tailored for nanofabrication and rapid prototyping. Discover what the joint expertise in nano-scale electron and ion microscopy and nanofabrication instrumentation can offer you.

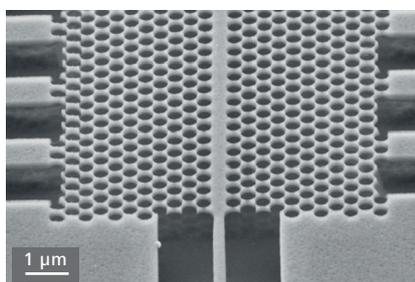
Field emission scanning electron microscopes¹ and focused ion beam SEMs² from ZEISS, such as ZEISS GeminiSEM or ZEISS Crossbeam, combined with RAITH ELPHY nanofabrication upgrade kits offer efficient and flexible solutions for electron and ion beam lithography³.

Create precise nanometer-scaled objects easily and reliably: Benefit from the combination of the unique properties of the ZEISS Gemini electron optics that comes with every ZEISS FE-SEM and FIB-SEM, and the RAITH ELPHY pattern generators. In one instrument, you can obtain high-resolution images, even at low kV, analyze your structures, or perform micromanipulation. Researchers and engineers in academic and industrial laboratories will drive materials design for electronics, energy, systems for diagnostics, environmental control of natural resources, electrical engineering, photonics, optoelectronics, plasmonics, nanobiotechnology, MEMS, or quantum technology.

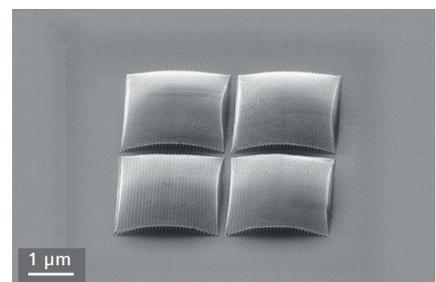
¹ FE-SEM; ² FIB-SEM; ³ EBL, IBL



CMOS decoder circuit, aligned e-beam pattern with CMOS Metal 5 vias. Image courtesy of Kuk-Hwan Kim, EECS, University of Michigan, USA



Photonic crystal structure in membrane (underetched). Image courtesy of William Whelan-Curtin, University of St. Andrews, UK



Step-and-Flash Imprint Lithography (S-FIL) imprint of a "motheye" lens; mold fabricated by 3D-FIB lithography. Image courtesy of J. Kettle, Cardiff University, UK

About RAITH

RAITH is the global market and technology leader for maskless nanofabrication and characterization systems and solutions, enabling customers in industrial and scientific settings to drive innovation and device production all around the world.

With a broad range of technologies and many years of experience, RAITH enables a wide variety of applications of the digital future – including connectivity, mobility, green energy, and healthcare. The unique combination of high-precision writing and imaging tools creates efficient solutions for research and industry.

RAITH

www.raith.com

Solutions for Nanofabrication and Lithography

from ZEISS and RAITH

Explore different lithography solutions combining ZEISS FE-SEMs or FIB-SEMs with RAITH ELPHY pattern generators to serve various applications, stability performance, and budget requirements.

Universal solution for single-field lithography



ZEISS GeminiSEM or ZEISS Crossbeam with RAITH ELPHY Quantum attachment is your universal, flexible solution for small or single-field lithography applications. ELPHY Quantum consists of an advanced PCI board-based, noise-protected, and deglitched scan generator electronics. The entire lithography workflow – from CAD layout and processing, control of exposure parameters and automation to remote control of the microscope – is integrated into a single user interface: the RAITH NanoSuite.

The ZEISS Gemini electron optics along with high-precision electron deflection system provide a well-focused and stable spot beam with excellent beam placement, exposure stability within the field, and pattern fidelity.

One of the strengths of the ELPHY Quantum is its simple and flexible overlay functionality, which allows nanostructures such as carbon nanotubes, nanowires, nanojunctions, nanodevices, or graphene flakes to be connected to large contact pads for the measurement of various physical properties.

Versatile solution for complex designs and dense patterns



ZEISS GeminiSEM or ZEISS Crossbeam with RAITH ELPHY Plus is a versatile lithography solution for both EBL and IBL for large-field and multiple-field applications. The Digital Signal Processor (DSP) technology and RAITH's unsurpassed software user interface make this pattern generator the ideal complement to the state-of-the-art ZEISS FE-SEMs with Gemini optics or the FIB-SEM with the high-performance Ion-sculptor FIB column. Faster exposure, best signal quality, improved long-term stability and performance, and higher pattern fidelity are ideal for high area pattern density applications, and step-and-repeat applications with alignment markers.

The combination of high-resolution nanostructures and large area exposures in a single run – e.g., for contacting nanostructures to the macroscopic world – is a very common application. ELPHY's split exposure functionality can switch between lowest beam currents for high-resolution nanostructure patterning and high beam currents for large area exposures in a fully automated exposure sequence.

Solution for sequential beam lithography and automatic end-point detection

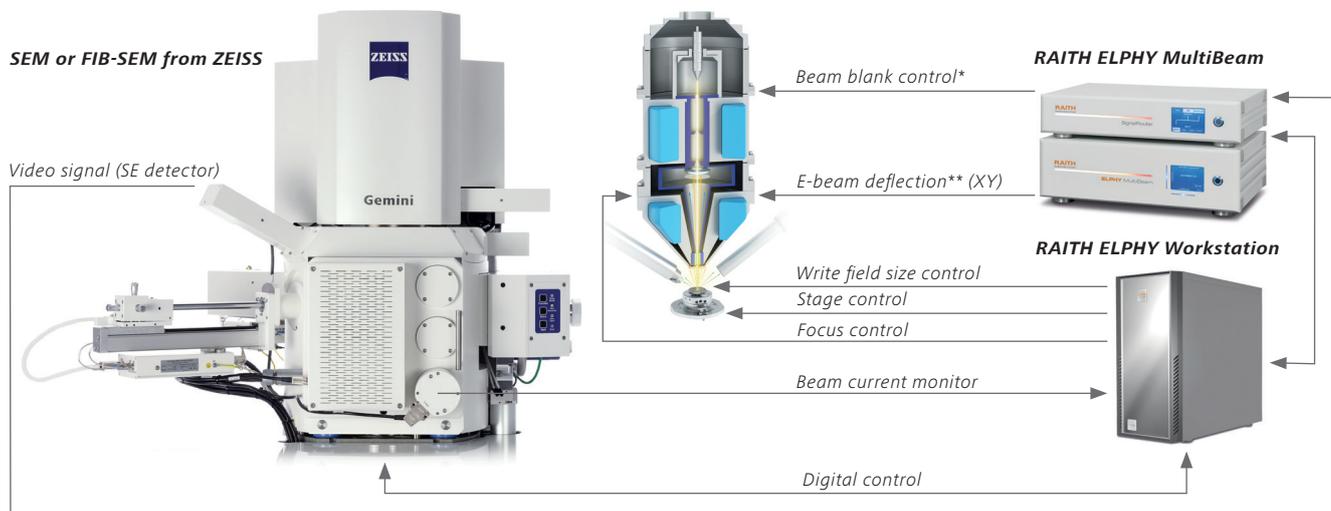


ZEISS GeminiSEM or ZEISS Crossbeam with RAITH ELPHY MultiBeam sets new standards for advanced functionality in SEM and FIB-SEM nanolithography solutions. The ELPHY MultiBeam combines advanced EBL performance with the latest technology in three-dimensional ion-beam-based nanofabrication techniques to perform complex automated tasks and end-point detection.

ELPHY MultiBeam provides all the functionality for nanopatterning techniques in a single tool for Focused Ion Beam Nanofabrication, Etching and Deposition, Electron Beam Lithography, and Gas-Assisted Focused Electron Beam Induced Processing (FEBIP). Based on DSP technology, developed for high-end FIB-SEM tools, it offers unrivalled signal quality with differential outputs and an additional signal router.

Patterning-on-image functionality allows new nanostructures to be inserted into existing features on your sample without the need for alignment routines. Combined sequential EBL and IBL can be executed with highest precision for EBL-IBL mix-and-match applications.

Your Insight into the Technology Behind It



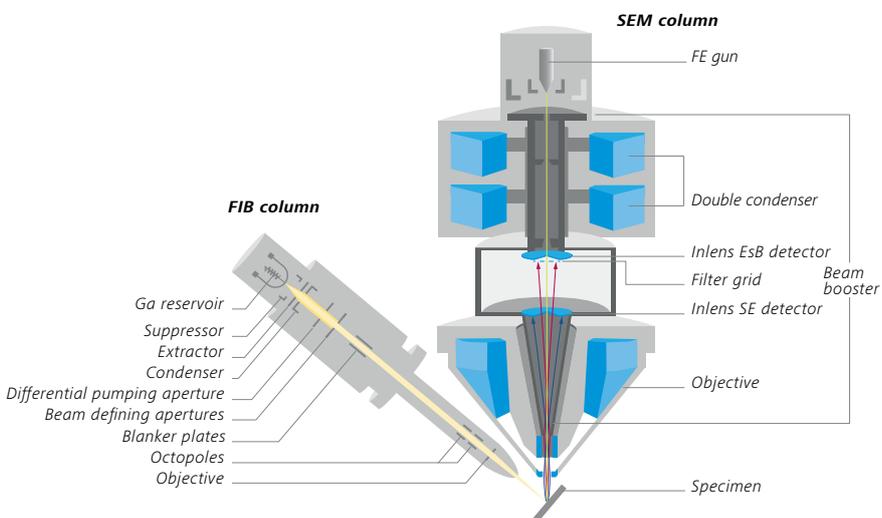
Processes for advanced nanofabrication and patterning are controlled by the ELPHY MultiBeam and its interface to a ZEISS FE-SEM with a Gemini electron optical column or a ZEISS FIB-SEM with an Ion-sculptor FIB.

* Electrostatic Beam Blanker required for SEM column ** Analog external scan interface required for SEM / FIB-SEM

The 30 kV Gemini electron optics provides the best technology for state-of-the-art lithography performance with linewidth features in resists down to sub-10 nm where linewidths below 5 nm have been demonstrated in high-resolution resist. The high beam current stability of the Gemini is essential for lithography and enables reproducible results. Finally, the stable center-to-periphery field uniformity and minimal geometric-field distortion provide a solid foundation for the highest pattern fidelity. Such column stability has been demonstrated for both small and very large fields of view. While these features together ensure that Gemini-based systems are the best choice for nanolithography applications, the ELPHY attachments unlock the full potential of nanolithography and nanofabrication without compromising high-resolution imaging and vast analytical versatility. The state-of-the-art ZEISS Ion-sculptor FIB column provides high performance over a

wide current range up to 100 nA. Its high stability and level of automation ensure that all demanding long-term patterning applications meet today's and tomorrow's expectations for research and industrial applications. Of particular importance is the high-definition focusing with excellent beam profiles, beam current stability over long time periods, automatic

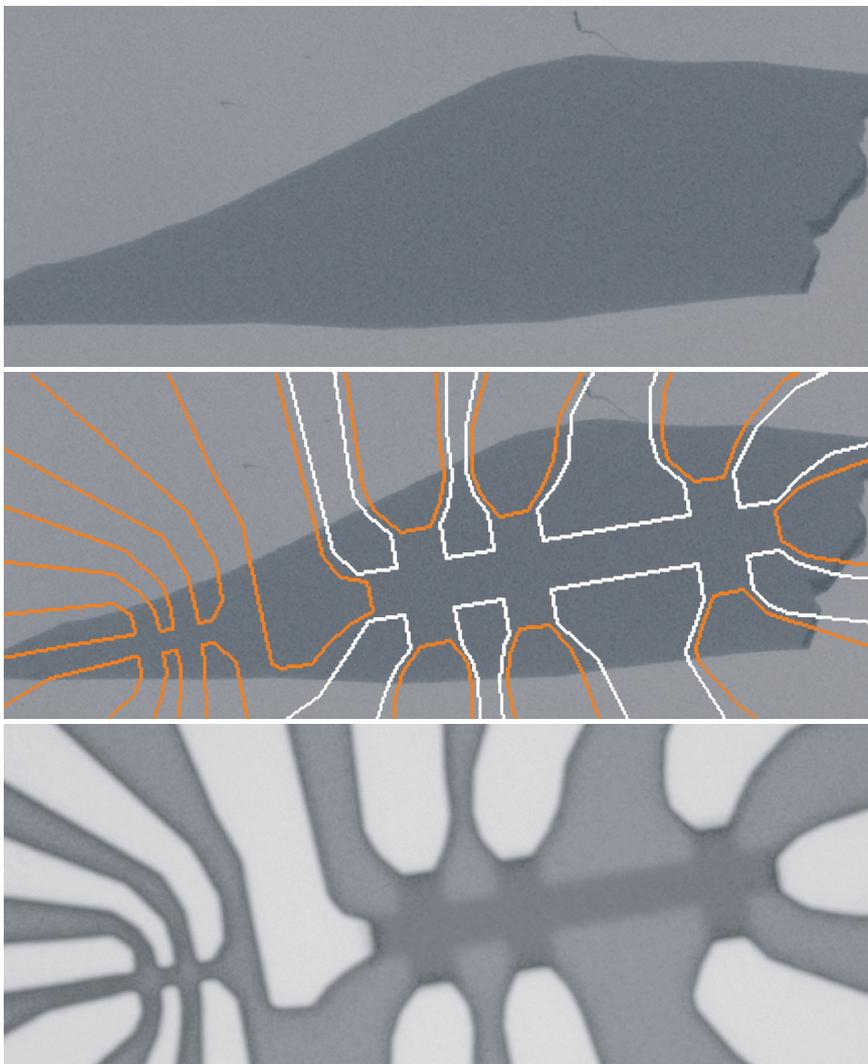
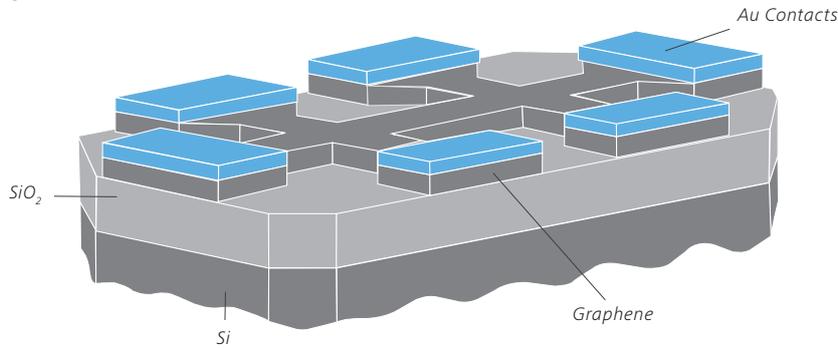
emission recovery, and automation. This enables various direct nanopatterning applications as well as hybrid EBL and IBL processes. Crossbeam equipped with a Gemini column, an Ion-sculptor FIB, and an ELPHY Multibeam offers the widest application window for diverse nanopatterning and nanolithography tasks as well as high resolution for 2D and 3D imaging and analysis.



ZEISS Crossbeam: FIB- and FE-SEM column arranged at an inclination angle of 54°.

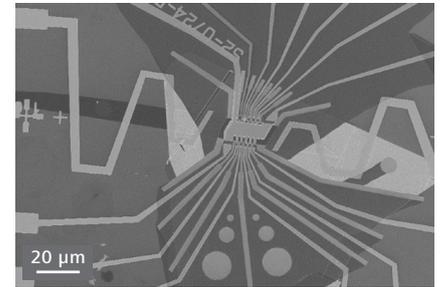
Applications

Graphene device fabrication

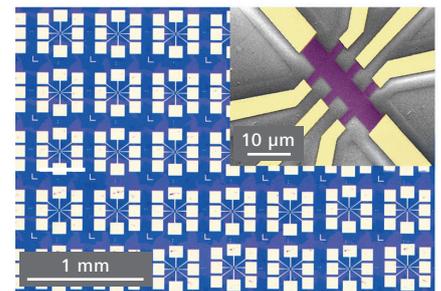


Top: SEM image of graphene flake, middle: GDSII-design overlay for mesa and contacts, bottom: mesa and contact formation. Image courtesy of Fred Schedin, Andre Geim et al., University of Manchester, UK

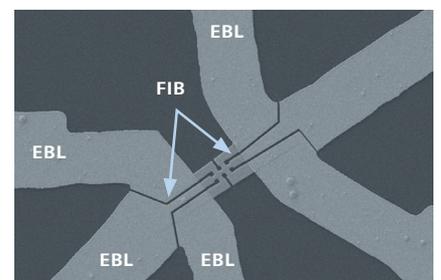
Nanoelectronics



Fabrication of high-mobility graphene device with accurate alignment of patterns in different EBL layers. Image courtesy of Zefei Wu, National graphene institute and department of physics and astronomy, University of Manchester, UK



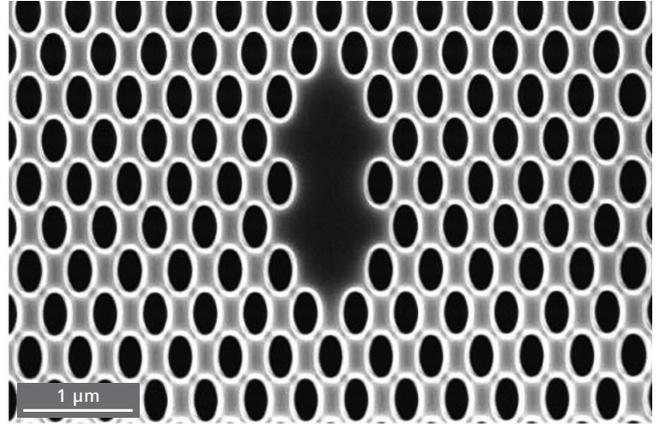
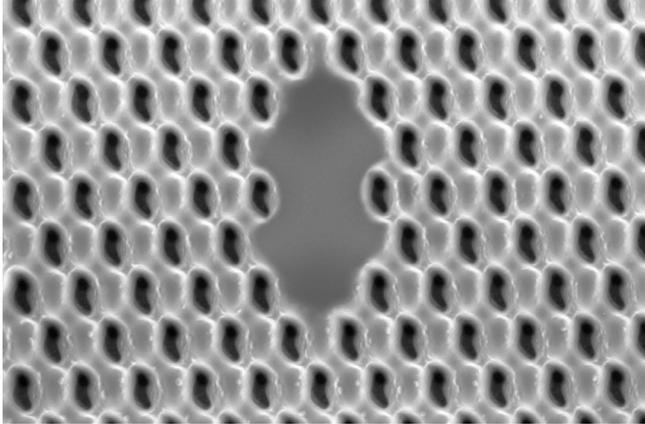
Optical image of 50 graphene Hall bars on SiO₂/Si to study high-mobility graphene. Inset: false-colour SEM image of a single Hall bar. Image courtesy of Center for Nanotechnology Innovation NEST, Italy



Combined EBL / FIB nanofabrication process of a (Nano) Hall bar (200-500 nm). First Cd₃As₂ nano plates and contacts were fabricated using EBL and metal deposition; in a second step, FIB was used to etch the samples into Hall bar geometry. Image courtesy of W. Wang et al., Fudan University, Shanghai, China

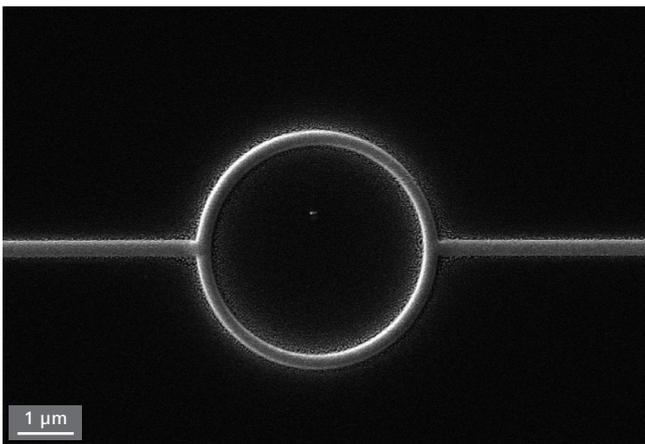
Applications

Photonics



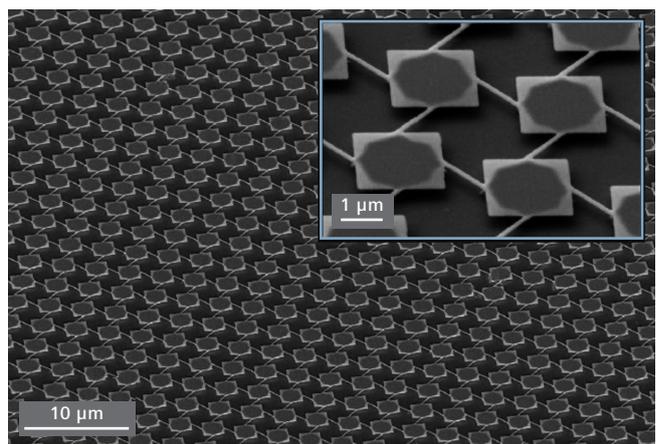
Photonic crystal fabricated in a direct milling process with a FIB-SEM (left) in the conventional way and (right) in highest quality using concentric elliptical patterning mode (outwards), drift correction schemes, and GDSII element loops as patterning attributes.

Quantum Phenomena



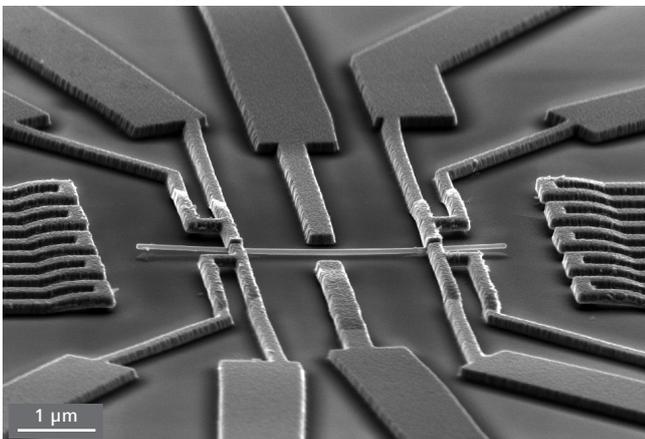
W-C superconducting ring fabricated via Pulsed Focused Ion Beam Induced Deposition (P-FIBID) using $W(CO)_6$ as precursor gas. Image courtesy of Nano-FabLab at IMDEA-Nanociencia, Spain

NEMS



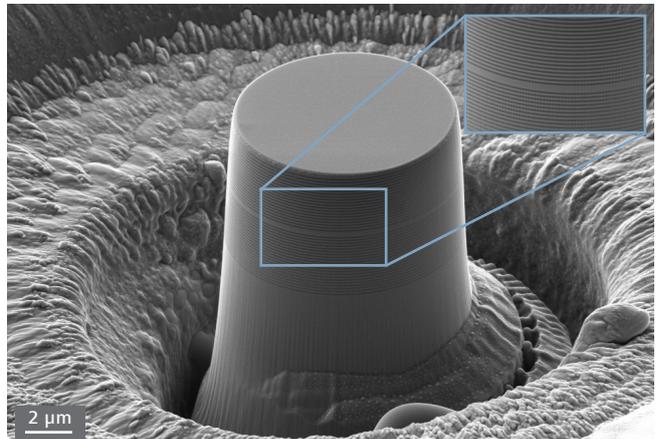
Fabrication of silicon nanowire mechanical resonators. Image courtesy of Xavier Borrísé Nogué, The Institute of Microelectronics of Barcelona IMB-CNM-CSIC, Spain

Nanocontacting



Fabrication of InAs/GaSb core-shell and InAs suspended nanowires. Image courtesy of Mirko Rocci, NEST Lab, Scuola Normale Superiore, Italy

Optical resonators



Prototyping of optical resonators. Sample courtesy of F. Pérez-Willard, Karlsruhe Institute of Technology, Germany

Configure Your ZEISS FE-SEM or FIB-SEM for EBL and Nanofabrication

Electron beam lithography is a sophisticated technique employed to design and fabricate devices, systems, and functional materials at the nanoscale. This miniaturization method enables the transfer of large-scale designs onto the surfaces of small-scale substrates, allowing for intricate and precise structures.

Electron and ion beam lithography is versatile and applicable across a wide range of scientific disciplines. It is particularly valuable for the development of nanophotonic devices, nanoplasmonics, advanced electronics in the semiconductor industry, and nanobiosensors, among other applications.

Applications

Nanocontacting/Nanoelectronics

Electrical Engineering

Quantum Technologies

Nanobiotechnology

Photonics/Optoelectronics

Microfluidics

MEMS/NEMS

Benefits of Gemini column

Ultra-high-resolution imaging capabilities

Excellent low kV performance and detection system

API enables remote access to system parameters and automation capabilities

High beam current stability of the Gemini suitable for long time exposures

High beam current density

Extremely low write-field distortion and stable exposure field uniformity from its center to periphery enable highest pattern placement accuracy and pattern fidelity

Configuration

ZEISS GeminiSEM 360 / 460, ZEISS Sigma 360 / 560, ZEISS Crossbeam 350 / 550

Electrostatic Beam Blanker plates for SEM column

Beam Blanker electronics





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