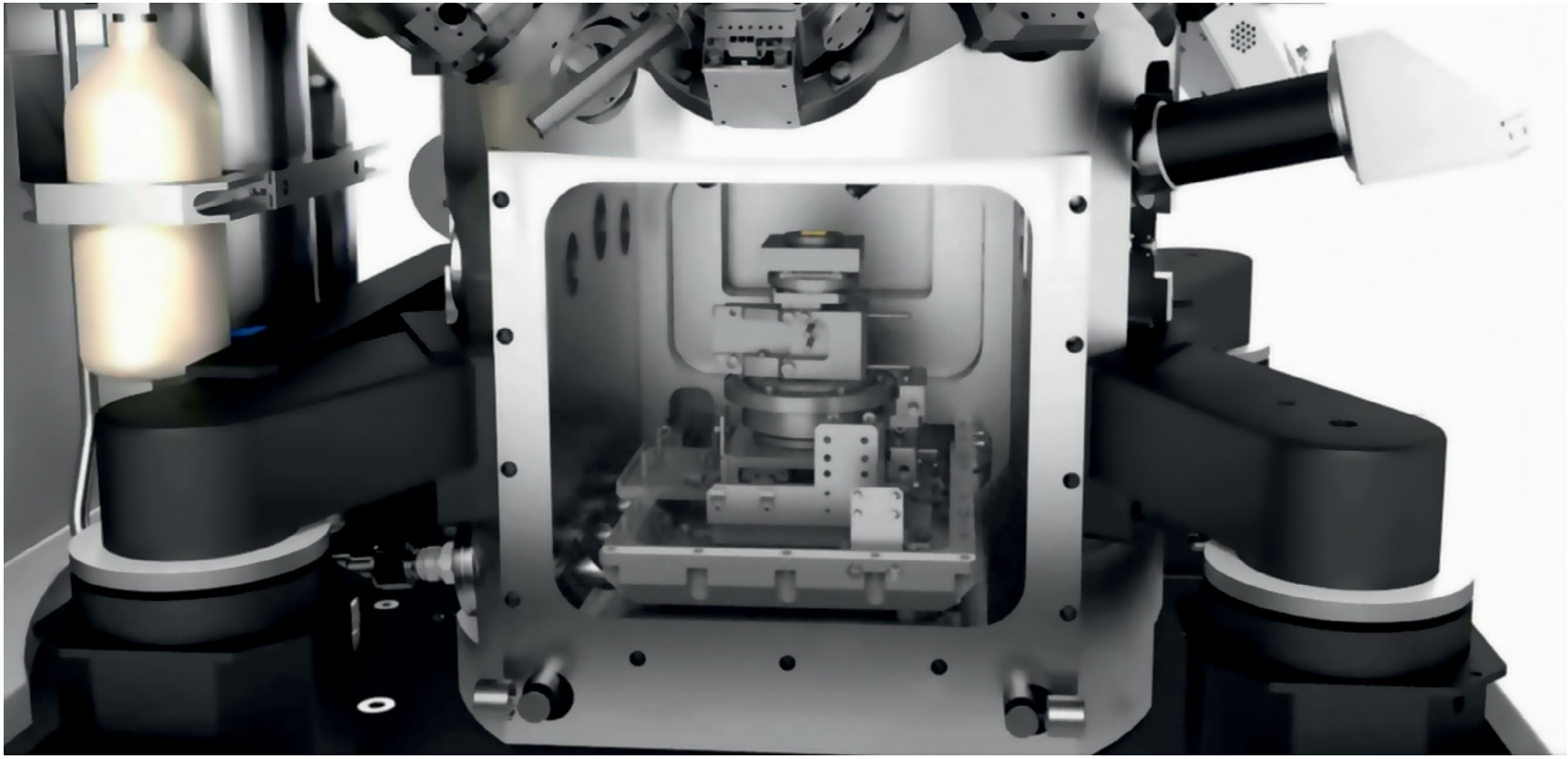


Product Information

Interactive PDF

INTERNET-LINK

VIDEO/ANIMATION

Release 1.0

ORION NanoFab

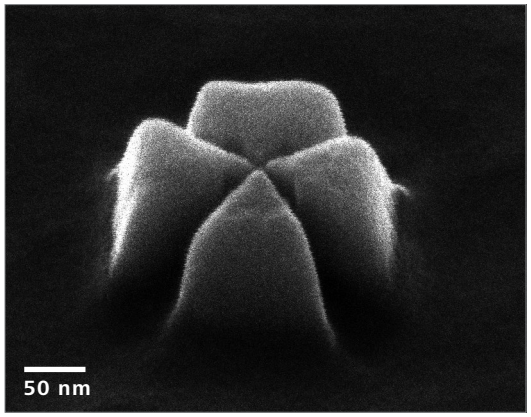
Three Ion Beams for Total Flexibility in Sub-10 nm Fabrication

ZEISS

We make it visible.

ORION NanoFab: One System with Three Ion Beams

Fabricate sub-10 nm nanostructures with speed and precision with your ORION NanoFab. Use its neon beam to machine nanostructures at great speed and achieve high throughput. Use the helium beam to create delicate sub-10 nm structures that demand extremely high machining fidelity. Equip your ORION NanoFab with the optional gallium FIB column and it becomes one of a kind: the only system in the world that covers the complete range of micromachining to nanomachining applications using gallium, neon and helium ion beams integrated in a single instrument.



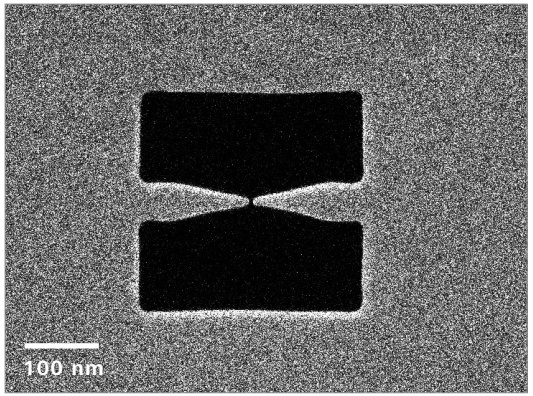
Plasmonic double bow tie structure fabricated in 100 nm thick gold film on glass with gallium, neon, and helium ions.

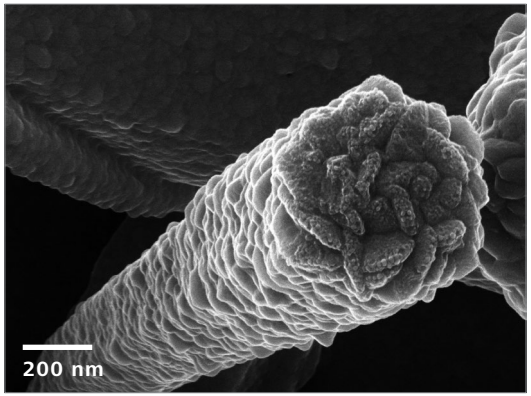
ORION NanoFab: Simpler. More intelligent. More integrated.

Fast machining of sub-10 nm structures
Creating nanostructures with feature size smaller than 10 nm is not possible with traditional gallium FIB. Using neon and helium ion beams in ORION NanoFab, you can make delicate sub-10 nm structures that demand extremely high machining fidelity with speed and ease. Whether your application is material removal using sputtering, gas induced etching or deposition or lithography, ORION NanoFab excels in sub-10 nm fabrication.

Three beams in one instrument
Seamlessly switch between gallium, neon and helium beams with ORION NanoFab. Use optional gallium FIB to remove massive material. Take advantage of the powerful yet gentle neon beam for precision nanomachining with speed. Use the helium beam to fabricate delicate sub-10 nm structures that demand extremely high machining fidelity. Avoid deposit contamination using neon and helium ion beams.

High resolution imaging
Take advantage of the high resolution performance of your ORION NanoFab: with imaging resolution of 0.5 nm, ORION NanoFab generates high resolution images of your sample in the same instrument that you used for fabrication. ORION NanoFab especially excels in imaging non-conductive samples due to charge compensation technology. Gain new insight from images with a 5 to 10 times greater depth of field compared to images acquired with FE-SEMs.





Your Insight into the Technology Behind It

Gas Field Ion Source Technology takes material removal to a new level

A finely sharpened needle is made even sharper through a proprietary process. Individual atoms are stripped away from the source until an atomic pyramid is created with just three atoms at the very end of the source tip – a configuration called the trimer. This repeatable process can be accomplished in-situ. Once the trimer is formed, the tip is maintained under high vacuum and cryogenic temperatures with helium or neon gas flowing over it. A high voltage is applied to the needle to produce an extremely high electric field at its apex. The helium or neon atoms are attracted to the energized tip where they are ionized. With ionization happening in the vicinity of a single atom, the resulting ion beam appears to be emanating from a region that is less than an angstrom in size. This produces an extremely bright beam that can be focused to an extraordinarily small probe size.

Advanced column for ultra-accurate beam focus

This GFIS source is combined with an advanced electrostatic ion column that focuses the beam with sub-nanometer precision. Much like an SEM, the beam is rastered across the sample pixel by pixel for imaging. For nanofabrication, the beam can be controlled to execute an user selected pattern with prescribed dosages.

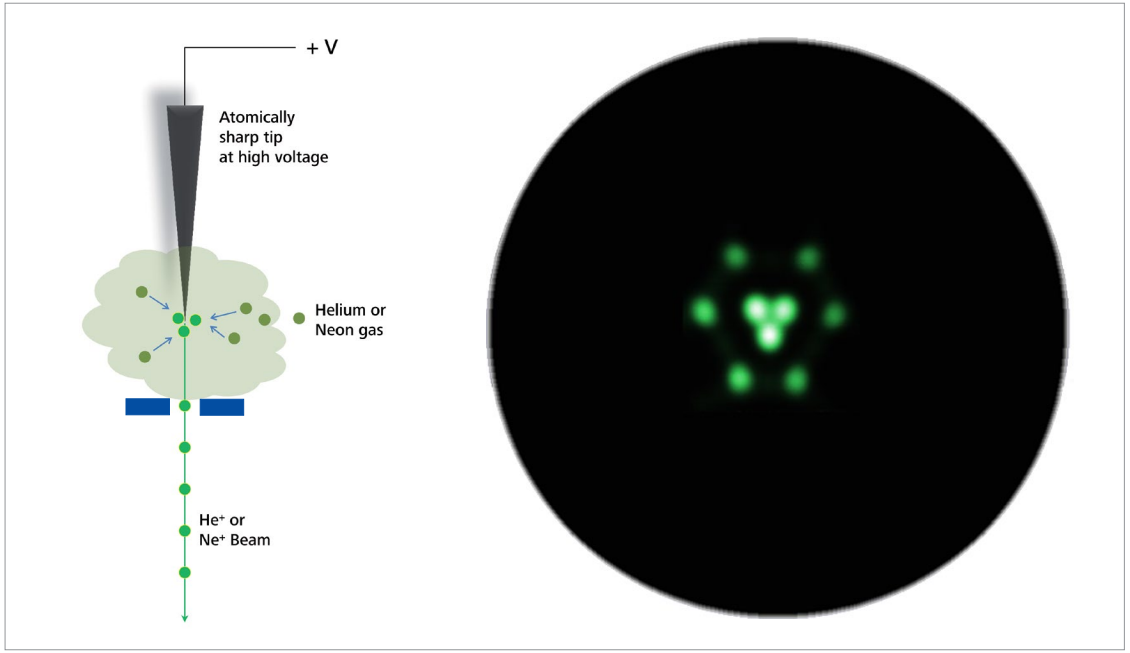
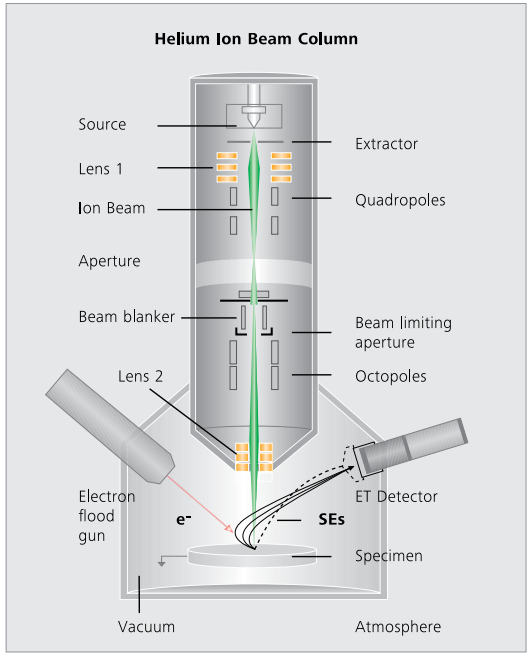


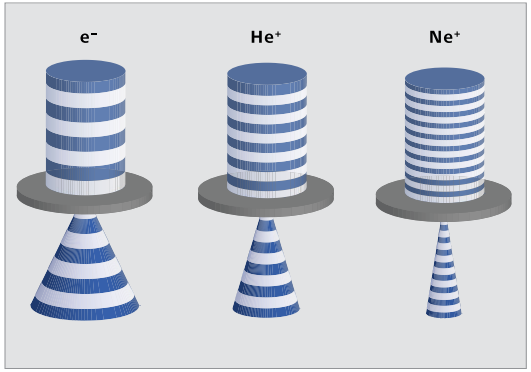
Image of the atoms at the end of the source tip emitting helium ions.



Your Insight into the Technology Behind It

Minimize diffraction

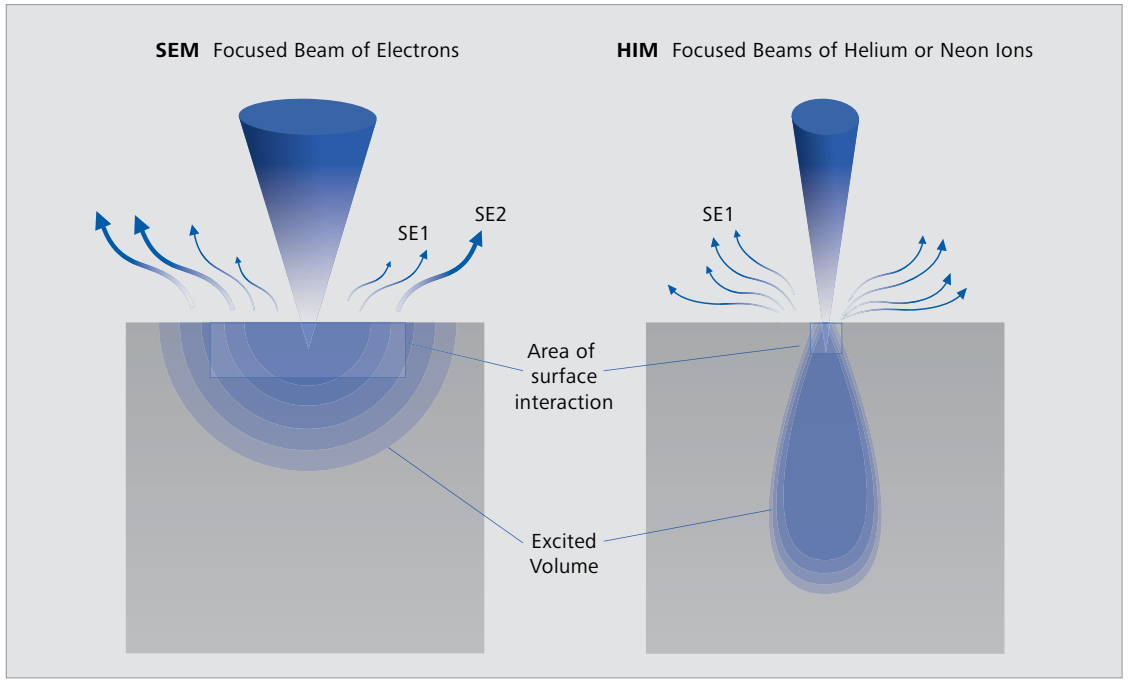
Helium ions are about 7,000 times heavier than electrons and neon ions are 40,000 times heavier than electrons. Because of this, helium or neon ion beam exhibits very little diffraction when passed through an aperture or across an edge. Diffraction is a significant problem for an SEM where the diffraction effect limits its ultimate spot size. Since the helium or neon ion beam is not affected by diffraction, it can be focused to a very small spot size.



The helium and neon ions have a DeBroglie wavelength that is much smaller than an electron beam resulting in much less diffraction.

Localized beam-sample interaction for higher resolution images

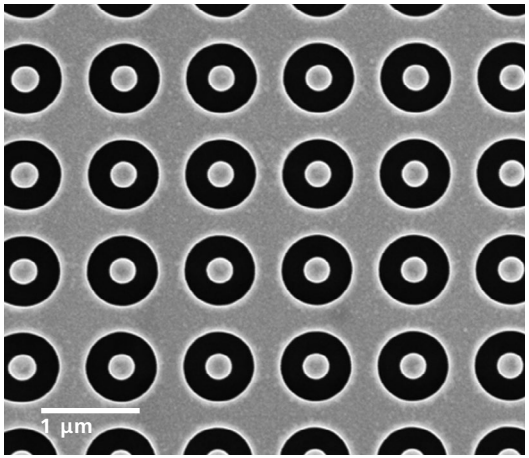
When electron beam strikes a surface, it is subjected to a beam scattering effect due to interaction with the surrounding material causing the emission of secondary electrons from an area that is somewhat larger than the size of the beam itself. The smaller the area of surface interaction, the higher will be the ultimate image resolution. When the helium or neon ion beams strike the sample with its larger and heavier particles, the particles do not scatter near the surface. This translates into a smaller area of surface interaction and much higher resolution images for the helium ion microscope.



Expand your possibilites

NanoPatterning and Visualization Engine

Orion NanoFab features an integrated hardware and software control system: the NanoPatterning and Visualization Engine (NPVE) incorporates a dedicated 16 bit scan generator for each NanoFab column and dual signal acquisition hardware supporting real-time advanced patterning and visualization. Completely control the beam by a GUI that allows you to create a range of fully editable shapes including rectangles, trapezoids, polygons, lines, polylines, ellipses and spots.
You can then vector-fill these shapes while maintaining full control over dose variation and patterning parameters including patterning direction, spacing, dwell, refresh and scan strategy.



Fabricate ultra-fine structures with gas injection system

Extend the nanofabrication capabilities of your ORION NanoFab with the optional gas injection system. By combining a targeted delivery of chemically active species with a sub-nm ion probe you will be able to deposit and etch ultra-fine structures. Thanks to a higher secondary electron yield, the helium and neon beams provide faster etching and deposition rates as well as higher purity films compared to gallium beam deposits.

Perform elemental analysis

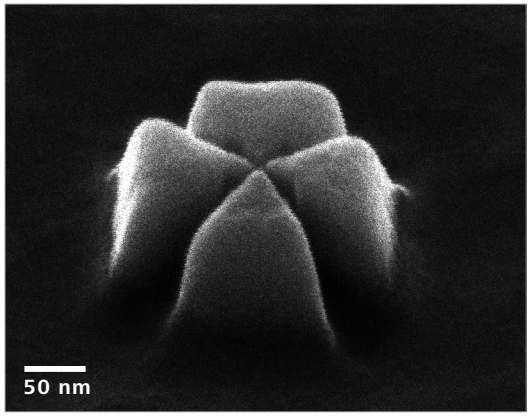
Enhance the analytical capabilities of your ORION NanoFab with the optional X-Ray Exciter column and your choice of EDX detectors. With this option, you evaluate your nanofabricated devices immediately by both imaging and elemental analysis.

Tailored Precisely to Your Applications

Typical applications	Task	**ORION NanoFab provides**
DNA sequencing	Make sub-10 nm pores in multilayered thin films for molecular detection and sequencing.	■ ORION NanoFab offers material removal at a very fine rate allowing you to make nanopores in films in a single step.
Photonics/Plasmonics	Create smaller structures with fidelity reaching sub-10 nm without gallium contamination of the sample.	■ ORION NanoFab offers fabrication of structures that are too small to be made with gallium based traditional FIB systems.
Lithography	Electron beam lithography suffers from “proximity effect“ as the patterns become dense and small.	■ ORION NanoFab offers lithography without any proximity effect.
Graphene	Make nanoribbons with sub-10 nm width in sensitive material.	■ ORION NanoFab enables precision cutting of delicate samples such as graphene.
Ion Beam Induced Deposition	Deposit high quality conductive and insulating material.	■ ORION NanoFab enables the deposition of material without gallium implantation and the consequential changes to physical properties.

ORION NanoFab at Work

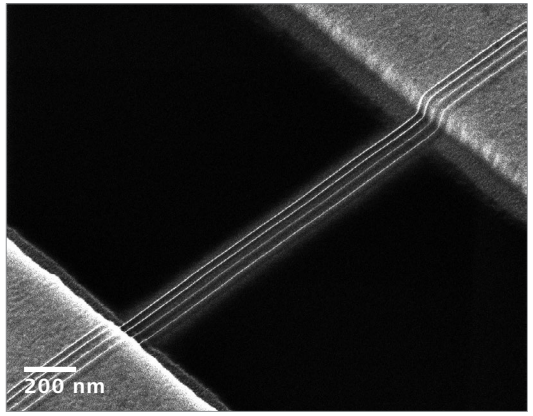
Sub-10 nm Nanofabrication



A plasmonic antenna fabricated in single step in 100 nm thick freestanding gold film using helium ions. The gap beween the two tips is 4 nm.

ORION NanoFab is ideal to make sub-10 nm structures by sputtering. Much smaller structures with better accuracy can be made than what is possible using a gallium FIB.

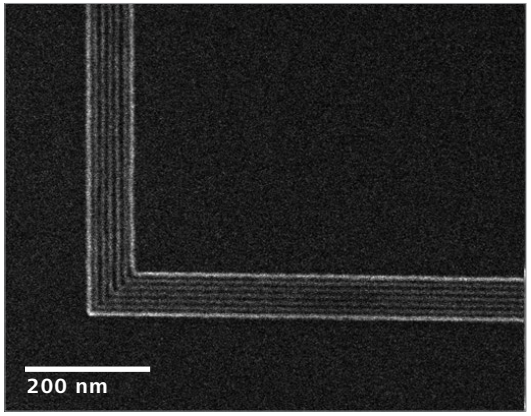
Circuit Analysis



10 nm metal lines direct deposited with helium with resistivity of < 200 µohm.cm.

ORION NanoFab is ideal for making cuts and conductive connections in semiconductor circuit analysis applications.

Lithography

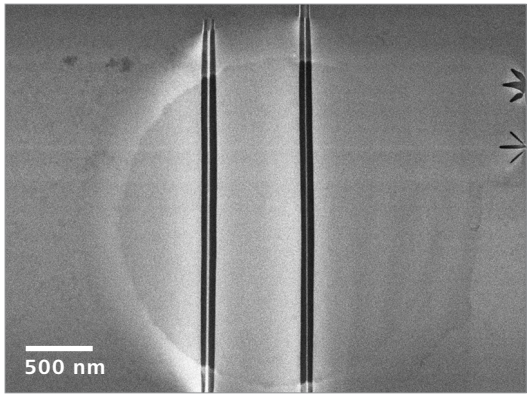


6 nm nested lines in HSQ fabricated by helium ion lithography.
Courtesy of: HP Labs

ORION NanoFab is ideal for lithography as photo-resist can be exposed without proximity effects using helium and neon beams resulting in smaller and more uniform features than what is possible using electron beam lithography.

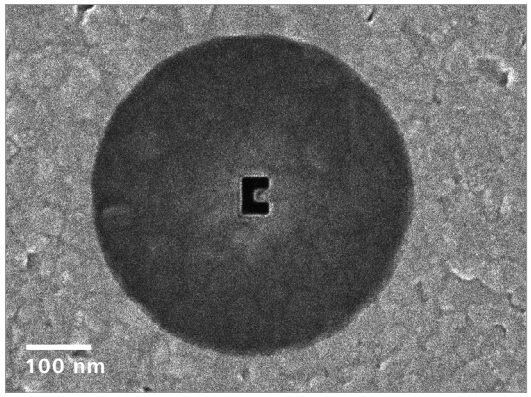
ORION NanoFab at Work

Beam used for fabrication: Helium
Beam used for imaging: Helium



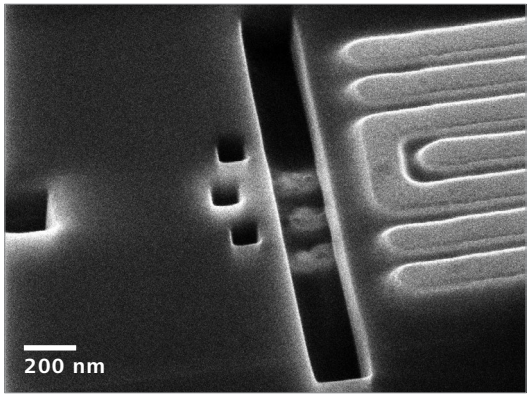
20 nm (left) and 10 nm (right) suspended nano-ribbons in graphene created by helium ion milling.
Courtesy of: Dan Pickard, National University of Singapore

Beam used for fabrication: Helium
Beam used for imaging: Helium



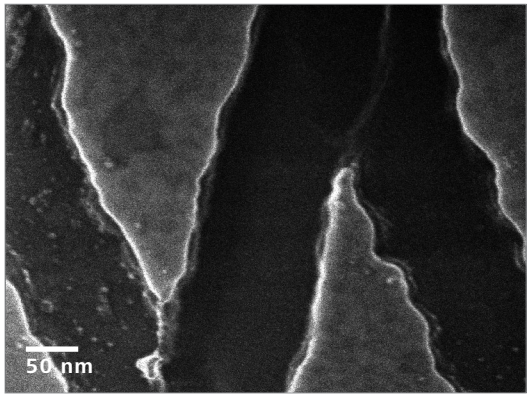
C-aperture in an aluminum film was made by helium beam. A machining acuity of 5 nm is obtained for the corners of the apertures.

Beam used for fabrication: Neon
Beam used for imaging: Helium



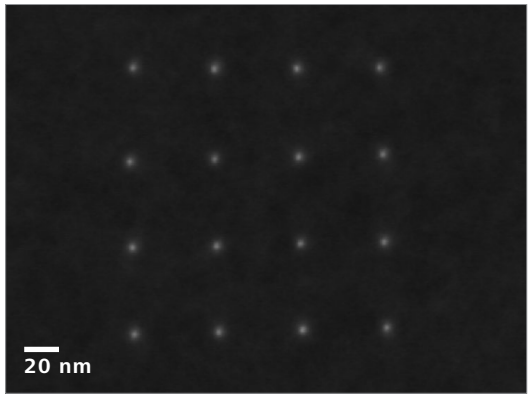
Rectangular hole milled through approximately 300 nm of dielectric with neon beam to expose buried copper lines in a semiconductor chip.

Beam used for fabrication: Helium
Beam used for imaging: Helium



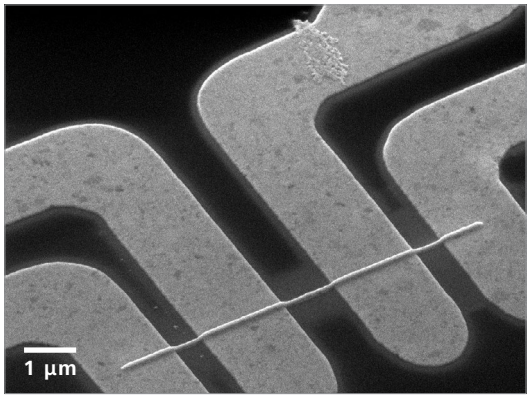
Gold islands patterned on glass by helium ion beam for a surface enhanced raman spectroscopy (SERS) device.

Beam used for fabrication: Helium
Beam used for imaging: Electron



Scanning transmission electron micrograph of an array of 4 nm diameter nanopores drilled through a 30 nm silicon nitride membrane. Pores were drilled in about 1 second each.
Courtesy of: Adam Hall, JSNN

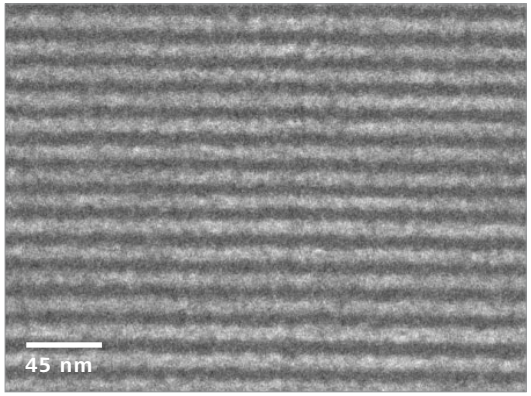
Beam used for fabrication: Neon
Beam used for imaging: Helium



100 nm wide tungsten wire deposited using neon beam on a test structure.

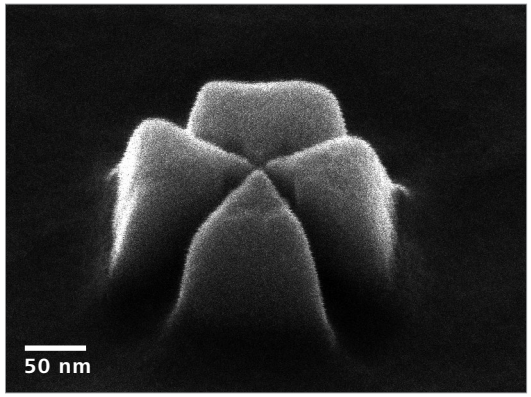
ORION NanoFab at Work

Beam used for fabrication: Helium
Beam used for imaging: Helium



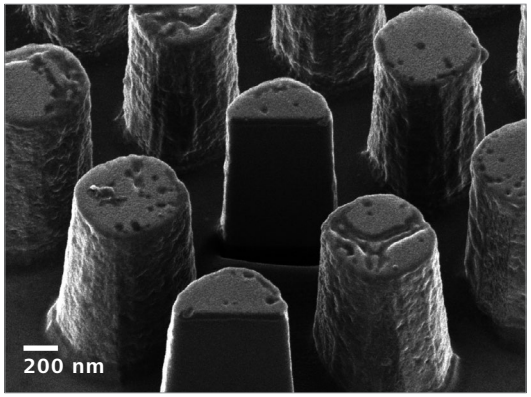
7 nm wide lines patterned in HSQ at a 15 nm pitch using helium ion lithography. The line width is independent of the pitch of the lines - no proximity effect was observed. Courtesy of: TU Delft

Beam used for fabrication: Gallium, Neon, Helium
Beam used for imaging: Helium



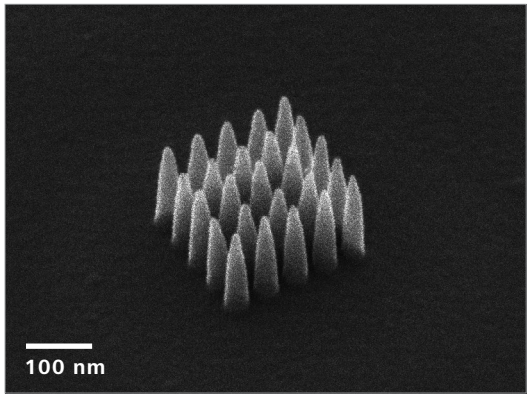
An isolated plasmonic double bow tie structure fabricated in 100 nm thick gold film on glass. Gallium beam was massive material removal outside the bow tie region and neon/helium were used for creating sub-10 nm gaps between the four tips.

Beam used for fabrication: Neon
Beam used for imaging: Helium



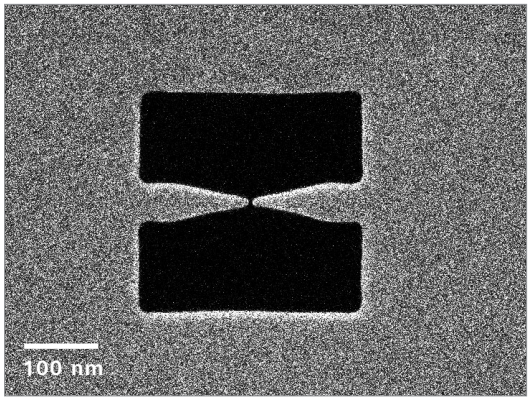
Aluminum posts cut by neon ion beam.

Beam used for fabrication: Helium
Beam used for imaging: Helium



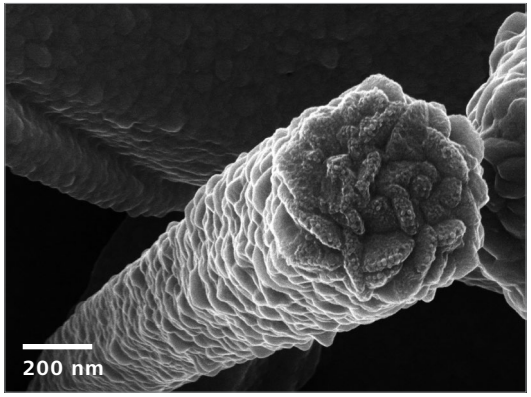
Array of platinum nano-pillars created by helium ion beam induced deposition. 35 nm diameter of pillars and tight array pitch (50 nm) is an example of the depostion capability.

Beam used for fabrication: Helium
Beam used for imaging: Helium



A plasmonic antenna fabricated in single step in 100 nm thick freestanding gold film using helium ions. The gap beween the two tips is 4 nm.
Courtesy of: Nestor Zaluzec, Argonne National Lab

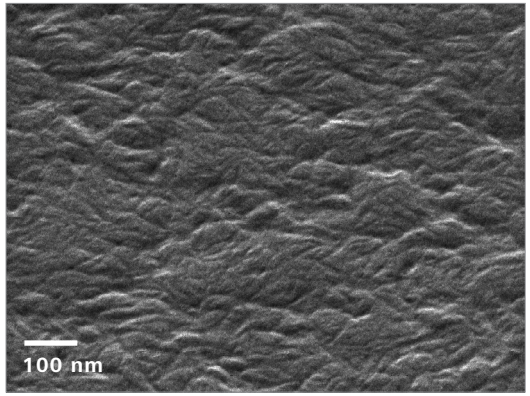
Beam used for imaging: Helium



Hollow palladium nanorods for catalysis research.

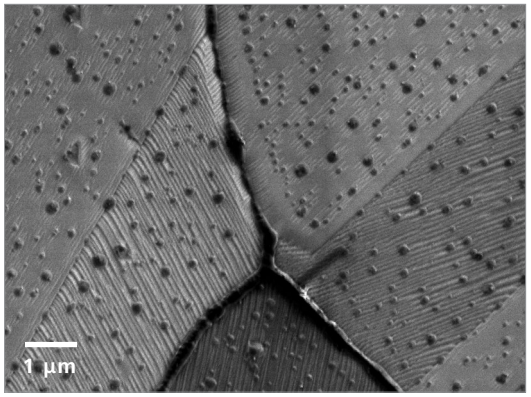
ORION NanoFab at Work

Beam used for imaging: Helium



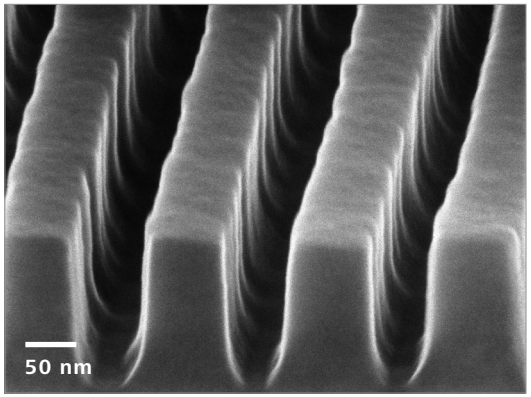
114 kX image of the surface of an organic photovoltaic material. The preservation of surface detail, even on low atomic weight materials, allows nano-scale study of surface morphology. Courtesy of: Konarka Technologies, Inc.

Beam used for imaging: Helium



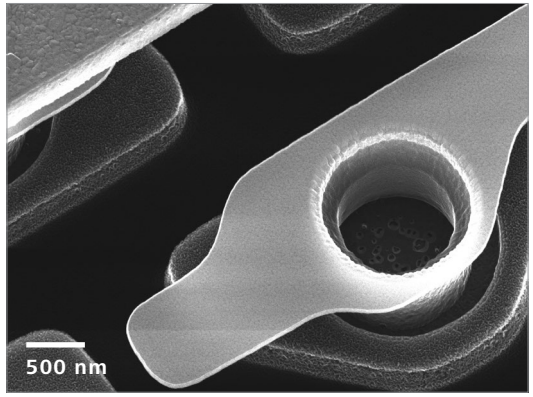
Surface of polycrystalline platinum showing grain boundaries. Note the channeling contrast between different grains.

Beam used for imaging: Helium



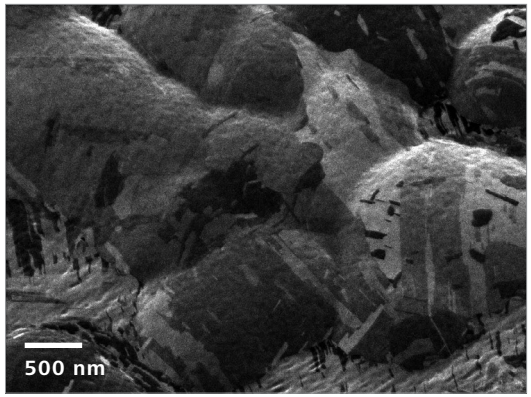
Patterned low-k dielectric lines illustrating edge roughness Courtesy of: National Institute of Advanced Industrial Science and Technology (AIST), Japan

Beam used for imaging: Helium



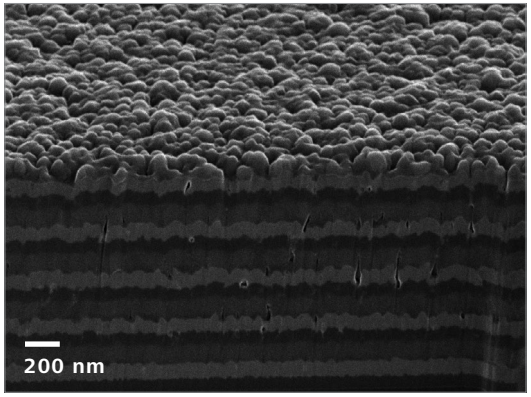
Deprocessed section of a digital micromirror device (DMD) on a Texas Instruments DLP® chip showing its MEMS components.

Beam used for imaging: Neon



Polycrystalline gold surface imaged with neon beam. Note the remarkable channeling contrast in the image.

Beam used for imaging: Helium



A multilayered sample consisting of tungsten, titanium and aluminum.

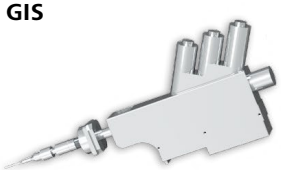
ORION NanoFab: Your Flexible Choice of Components

Options

Ga FIB column

State of the art gallium column for high rate ion milling

GIS



Single needle gas injection system (GIS) with up to three precursors

XRE

Electron beam column as X-Ray Exciter

EDX

State of the art EDX detector for material analysis

ORION NanoFab: Your Flexible Choice of Components

Choose the Right Beam for Your Job	Material	He	Ne	Ga
Circuit edit for 22 nm node and beyond	Silicon, dielectric	●	●	●
Fine plasmonic structures	Gold / Aluminium	●	●	
Antennas and apertures for electromagnetic devices	Metal films	●	●	●
Lithography at sub-10 nm scale	HSQ / PMMA	●	●	
Solid state nanopores for biosensors	Silicon nitride, metals films	●	●	
Device fabrication using graphene nanoribbons	Graphene	●		
Visualising organic porosity in shale	Shale	●		
Exposing and imaging shallow defects	Various	●	●	●
Surface imaging of nanopore structure	Coal	●		

Technical Specifications

Product Name	Description
ORION NanoFab	Scanning ion microscope
	Gas Field Ion Source (GFIS) and column including helium and neon source gas operation
	Advanced NanoPatterning and Visualization Engine (NPVE) for ORION NanoFab
	ET secondary electron detector
	Electron flood gun for charge compensation
	5 axis motorized stage
	Advanced workflow based user interface on 64 bit Windows 7® operating system
	Powervar Security Plus uninterruptible power supply
GFIS Column	Field of view: 900 µm - 100 nm @ 8 mm working distance
Helium Ion Beam	Resolution: 0.5 nm
	Beam energy: 10 - 35 kV
	Beam current: 0.1 to 100 pA*
Neon Ion Beam	Resolution: 1.9 nm
	Beam energy: 10 - 30 kV
	Beam current: 0.1 to 50 pA*
Chamber	Internal dimensions: 280 x 280 x 260 mm (L x W x H)
	Plasma cleaner
	80 mm loadlock
	Customizable access door
	6 line of sight ports for options
	Time to transport sample: 3 minutes
Sample Stage	Motorized 5 axis eucentric stage
	Order of stage stracking (bottom to top): tilt, y, x, rotate, z
	Stage travel: x = 50 mm, y = 50 mm, z = 8 mm
	Rotation: 0 - 360°
	Tilt: 0 - 56°
	Coincidence point for gallium FIB option is at 8 mm helium/neon beam working distance

* Beam current depends upon gas pressure, condenser lens setting and aperture. For ideal imaging and precision work, proposed beam current is between 0.1 and 0.5 pA.
For high current applications, proposed beam current could be as high as 100 pA for helium and 50 pA for neon.

Technical Specifications

Product Name	Description
Detector	Everhart Thornley Secondary Electron Detector
Source Cooling	Liquid nitrogen, on-board Dewar with computer controlled autofill
Vacuum System	Fully automatic, pneumatic column isolation valve
	Two 450 L/sec Mag-Lev turbomolecular pumps backed by oil-free and particle-free roughing pumps
	One 40 L/sec ion pump
	Ionization gauge for high vacuum measurement
	Pirani / Magnetron gauge for measurement of pressure in sample chamber
Camera	Camera for viewing sample position
Scan and Acquisition System	Image size: up to 4 k x 4 k pixels
	Dwell time: 100 ns - 100 ms
	64 k x 64 k DAC for beam positioning
	Auxiliary inputs for detectors
	External input for third party scan control
Charge Compensation	Low energy electron flood gun
	Line by line or frame by frame multiplexing
User Interface and Software	Advanced workflow based user interface on 64 bit Windows 7® operating system
NanoPatterning and Visualization Engine	16 bit Scan Generator module
	Dual Signal acquisition modules
	NanoPatterning and Visualization Engine Software
	Recipe builder
	Grayscale bitmap NanoPatterning
	Deflection lists
	Array builder
	Real time image processing & FFT
	Automated drift correction

Technical Specifications

Options	Description
Gallium FIB	Gallium Focused Ion Beam with Liquid Metal Ion Source (LMIS)
	Resolution: 3 nm @ 30 kV, 1 pA
	Beam energy: 1 - 30 kV
	Beam current: 1 pA - 100 nA
	Source life: 2000 µAh
Gas Injection System	Single needle gas injection system (GIS) with 3 precursor gases (W, PMCPS, XeF2) and 2 inert carrier gases
Transmission Detector	Detector for transmission ion microscopy
X-Ray Exciter (Available in future)	X-Ray Exciter column for enabling EDX analysis
SESI Detector (Available in future)	Secondary Electron and Secondary Ion (SESI) detector which replaces standard ET Detector (fits in the same port)

Count on Service in the True Sense of the Word

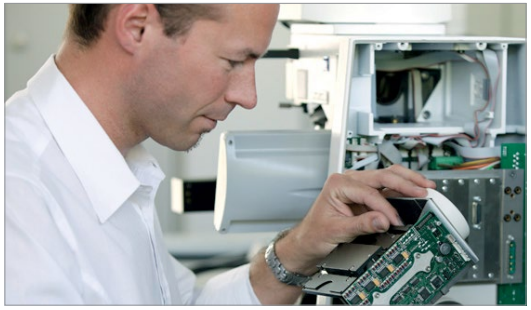
Because the Carl Zeiss microscope system is one of your most important tools, we make sure it is always ready to perform. What's more, we'll see to it that you are employing all the options that get the best from your microscope. You can choose from a range of service products, each delivered by highly qualified Carl 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.

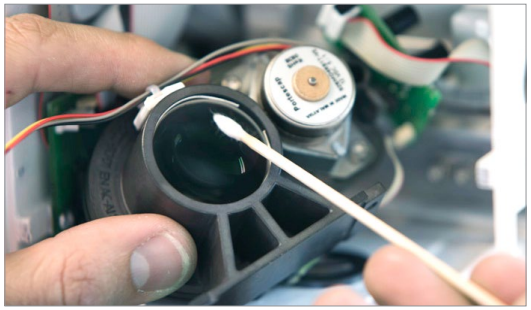
Repair. Maintain. Optimize.
Attain maximum uptime with your microscope. A Carl Zeiss maintenance contract lets you budget for operating costs, all the while avoiding costly downtime and achieving the best results through the improved performance of your system. Choose from service contracts designed 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 standard preventative maintenance and repair on demand contracts also bring you distinct advantages. Carl Zeiss service staff will analyze any problem at hand and resolve it – whether using remote maintenance software or working on site.

Enhance Your Microscope System
Your Carl 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.

Please note that our service products are always being adjusted to meet market needs and may be subject to change.





Profit from the optimized performance of your microscope system with a Carl Zeiss service contract – now and for years to come.

www.zeiss.com/microservice

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