

Electron Beam Technology



## **PIONEER** Two

Best of both worlds: Direct write and direct view

Ultra High Resolution Electron Beam Lithography and  
Scanning Electron Microscope Imaging

MULTI TECHNIQUE ELECTRON BEAM LITHOGRAPHY

**RAITH**  
NANOFABRICATION



PIONEER Two – Defining a new and unique class of affordable professional Electron Beam Lithography (EBL) systems for both nanofabrication and SEM based analytics

**Best ingredients for unrivalled EBL and SEM performance:**

- › Smallest beam size in the world within a professional EBL system (< 1.6 nm)
- › Sub-8 nm nanolithography performance (guaranteed)
- › Optimum mark recognition capabilities and SEM analysis by up to 5 different detectors
- › Highest-precision Laser Interferometer Controlled Stage with integrated rotation and tilt functionality (for uncompromised analytical SEM inspection)

# PIONEER Two – The perfect EBL-SEM hybrid

## Combining state-of-the-art nanolithography and analytical SEM imaging in a single tool

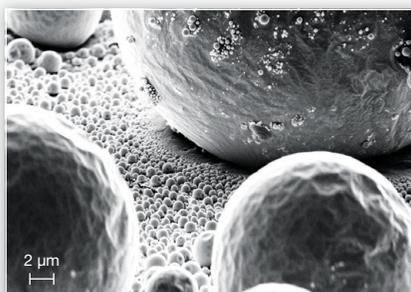
The new PIONEER™ Two complements Raith’s portfolio of thermal field emission (TFE) technology-based Electron Beam Lithography (EBL) tools. It yields very competitive specs and features – one of them being the smallest beam size within a professional EBL system in the world.

PIONEER Two has been designed as an uncompromising and affordable EBL system – and it comes with a modern SEM on-board. PIONEER Two closes the gap between SEM pattern generator combinations – probably from multiple vendors – and dedicated throughput oriented EBL systems.

Versatility, robustness and user-friendliness make PIONEER Two suitable for university institutes and other academic R&D institutions seeking not only to “print” and re-inspect their nanostructures, but also want to access an analytical tool with capabilities for chemical and structural analysis in material or life sciences.

### Versatility

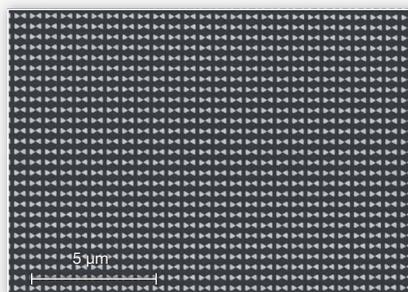
PIONEER Two is the ideal solution for all universities and scientists with equal requirements for both an EBL system and an analytical Scanning Electron Microscope (SEM). The system stands for almost unlimited bandwidth of nanolithography, imaging and analytical applications. Conceptually, PIONEER Two defines a new and unique class of instruments and is the first true EBL-SEM hybrid available. PIONEER Two integrates all highest-performance ingredients for professional EBL and SEM into a single complete turnkey system.



SEM image of a (tilted) ultra-high-resolution SEM sample

### Integration

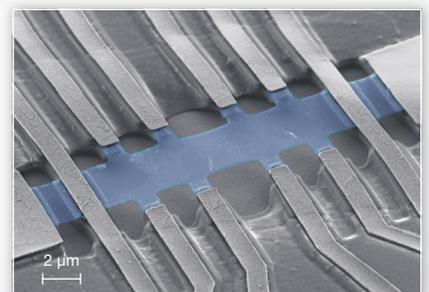
PIONEER Two is a compact, fully integrated turnkey system with a small footprint and state-of-the-art guaranteed nanolithography performance. The unique integration of a highest-precision Laser Interferometer Controlled Stage and thorough electron optical calibrations are essential for ultimate pattern placement accuracy of larger areas that exceed a typical SEM field of view.



Array of bowtie antennas with 25 nm gap; Amit Zeidler, Technion, Haifa, Israel

### Modularity

PIONEER Two is a configurable platform designed to match specific application needs. Customizable and field-upgradable at any time, PIONEER Two can be equipped with a variety of hardware and software options in order to optimize performance or adapt to changing research trends in future, even long after the initial system purchase.



Freestanding multi-terminal graphene device; M. Kühne et al., MPI Stuttgart, Germany

# PIONEER Two – Much more than a SEM-pattern generator combo

## Advanced lithography architecture inside

### Unique stage and column technology

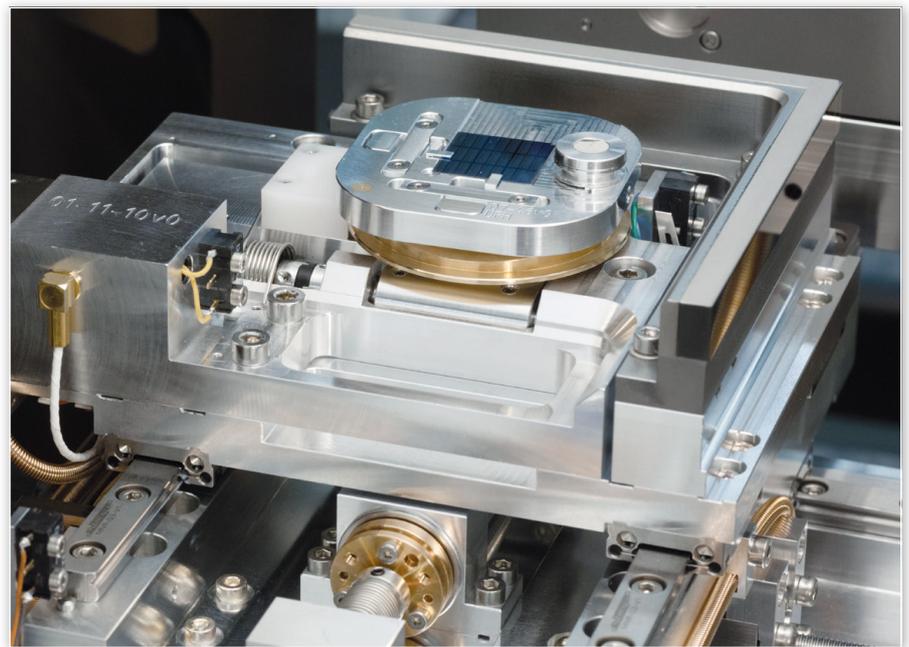
For more than two decades, Laser Interferometer Controlled Stages have belonged to the proprietary core technology of Raith nanolithography system solutions, shaping a professional EBL system and enabling both large-area nanofabrication and image acquisition with highest accuracy. Modified Gemini column technology stands for reliable ultra-high resolution nanopatterning and SEM imaging with crisp contrast and ultimate surface sensitivity.

### Ultra-high resolution using TFE technology

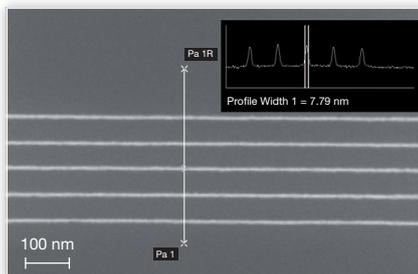
PIONEER Two comprises cutting-edge thermal field emission (TFE)-based (Gemini) electron optical column technology, featuring the smallest beam size in the world within a professional EBL system (< 1.6 nm beam size). Unprecedented low-kV performance, highest beam current densities and lowest distortions paired with excellent long-term stability ensure efficient, stable and high-precision nanopatterning.

### Highest precision and accuracy with a Laser Interferometer Controlled Stage

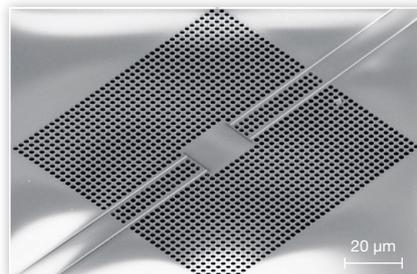
Unlike SEM-pattern generator combos, PIONEER Two comprises an integrated Laser Interferometer Controlled Stage that delivers positioning and pattern placement accuracies in the nm range. From nanolithography to SEM imaging, Raith delivers a fully integrated solution for automated large-area applications on samples from ~mm<sup>2</sup> up to 2 inches with highest precision. The PIONEER Two Laser Interferometer Controlled Stage is the only one in the world which offers an integrated rotation/tilt functionality fully compatible with all available sample holders.



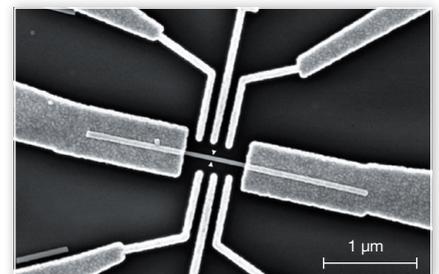
*PIONEER Two Laser Interferometer Controlled Stage as a MUST HAVE ingredient for a professional EBL system*



*< 8 nm lines exposed in HSQ resist at 20 keV*



*Tunnel junction thermometers surrounded by a 2D photonic crystal;  
Tero Isotalo, University of Jyväskylä, Finland*



*Tunable InAs/InP single-electron transistor;  
S. Roddaro, NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy*

# PIONEER Two – SEM analytics “on board”

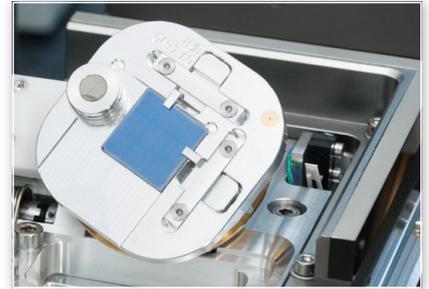
## Identifying and aligning to a nanostructure

### Detector capabilities for mark recognition, imaging and analytical sample information

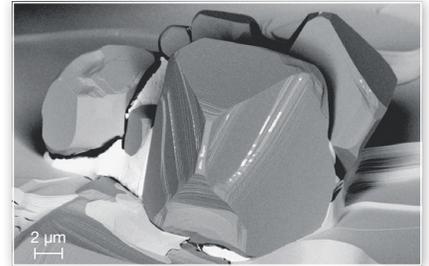
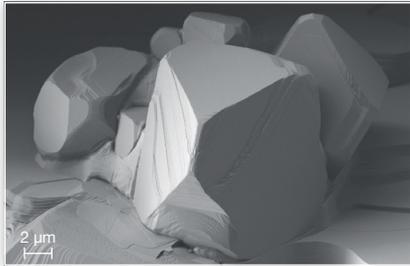
For most flexible operations with a large application bandwidth, PIONEER Two can be equipped with a variety of secondary and back-scattered electron detectors in many different configurations – whether for specific beam calibration, optimum mark recognition or purely analytical tasks.

Beyond the standard, PIONEER Two offers additional patented high-efficiency detectors for collecting:

- topographical information (ET-SE)
- compositional information, material contrast (EsB, AsB)
- surface information (inlens SE)
- crystallographic information (AsB)
- chemical/stoichiometric information or elemental mapping data (EDX)



*Raith's unique Laser Interferometer Controlled Stage with integrated compucentric rotation/tilt functionality for the entire sample holder to preserve full SEM functionality*

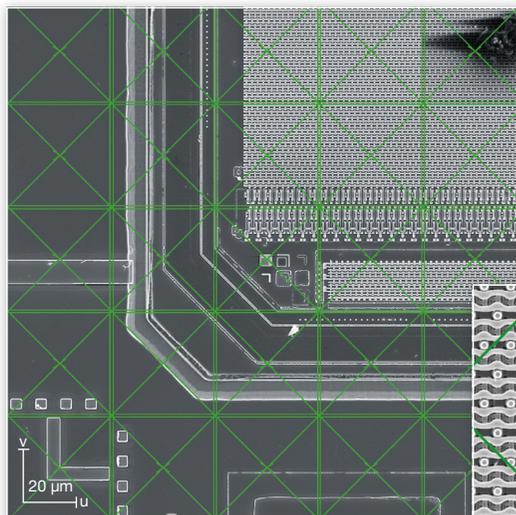


*SEM images of a  $\text{Bi}_2\text{Ca}_2\text{Co}$  compound imaged at 1.5 kV with 1) standard Everhart-Thornley secondary electron detector, 2) inlens secondary electron detector showing superior contrast and surface sensitivity, and 3) inlens backscattered electron detector with secondary electron suppression, showing distinct material contrast representing the different metal elements.*

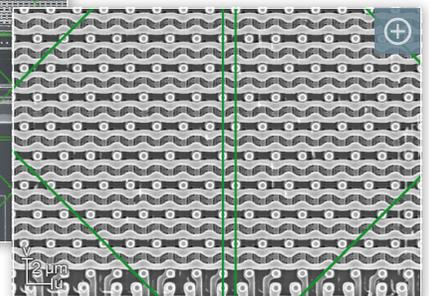
### Mosaic function for large-area image display

Using the Laser Interferometer Controlled Stage, mapping/tiling of (larger) sample areas exceeding a single field of view becomes feasible to nm precision by stitching SEM images together.

*5 by 5 SEM images (30 µm field of view each) of a DRAM device displayed using mosaic functionality*



*Zoom into image data at higher resolution showing the negligible stitching error indicated by the green vertical line.*



# PIONEER Two

## The perfect EBL-SEM hybrid

- State-of-the-art TFE-column technology featuring the smallest beam size in the world within a professional EBL system (< 1.6 nm) sub-8 nm nanolithography guaranteed
- Laser Interferometer Controlled Stage with modular integrated sample holder rotation and tilt functionality (thus preserving full SEM capabilities)
- Modularity, upgradability and best price/performance ratio for all research budgets: configurable system with application-specific options
- Various detectors available (ET-SE, inlens SE, inlens EsB, AsB, EDX, etc.) for optimum EBL mark registration, advanced SEM imaging and analytics
- Most comprehensive Raith NANOSUITE software with true multi-user management (no “user interference” thanks to user-specific system log-in and parameter file administration, users find “their system” as they have left it)
- Compact system architecture with small footprint

## Product specifications

Filament type	Schottky-TFE	Minimum feature size	≤ 8 nm
Beam energy	20 eV – 30 keV	Minimum grating periodicity	40 nm
Beam current	5 pA – 20 nA	Field stitching	≤ 50 nm (m+3σ)
Laser stage travel range	50 x 50 x 25 mm	Overlay accuracy (alignment)	≤ 50 nm (m+3σ)
Beam size	≤ 1.6 nm*		
Beam current drift	≤ 0.5 % /hour		
Writing speed	6 MHz (12 MHz)		

\* Following ASTM standard procedure described in Designation E986-97



### Support and service concept

Specifications and system performance are certainly driving decisions; however, there is more to be taken into consideration to ensure an efficient start and subsequent solid support over the instrument lifetime:

All site surveys with environmental measurements, support with resulting clean-room setup, both factory and on-site acceptances, on-site basic and advanced trainings are included. Moreover, free-of-charge application support infrastructure is available in all global time zones. Service concepts that are affordable for university environments complement these benefits.

## Sales

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