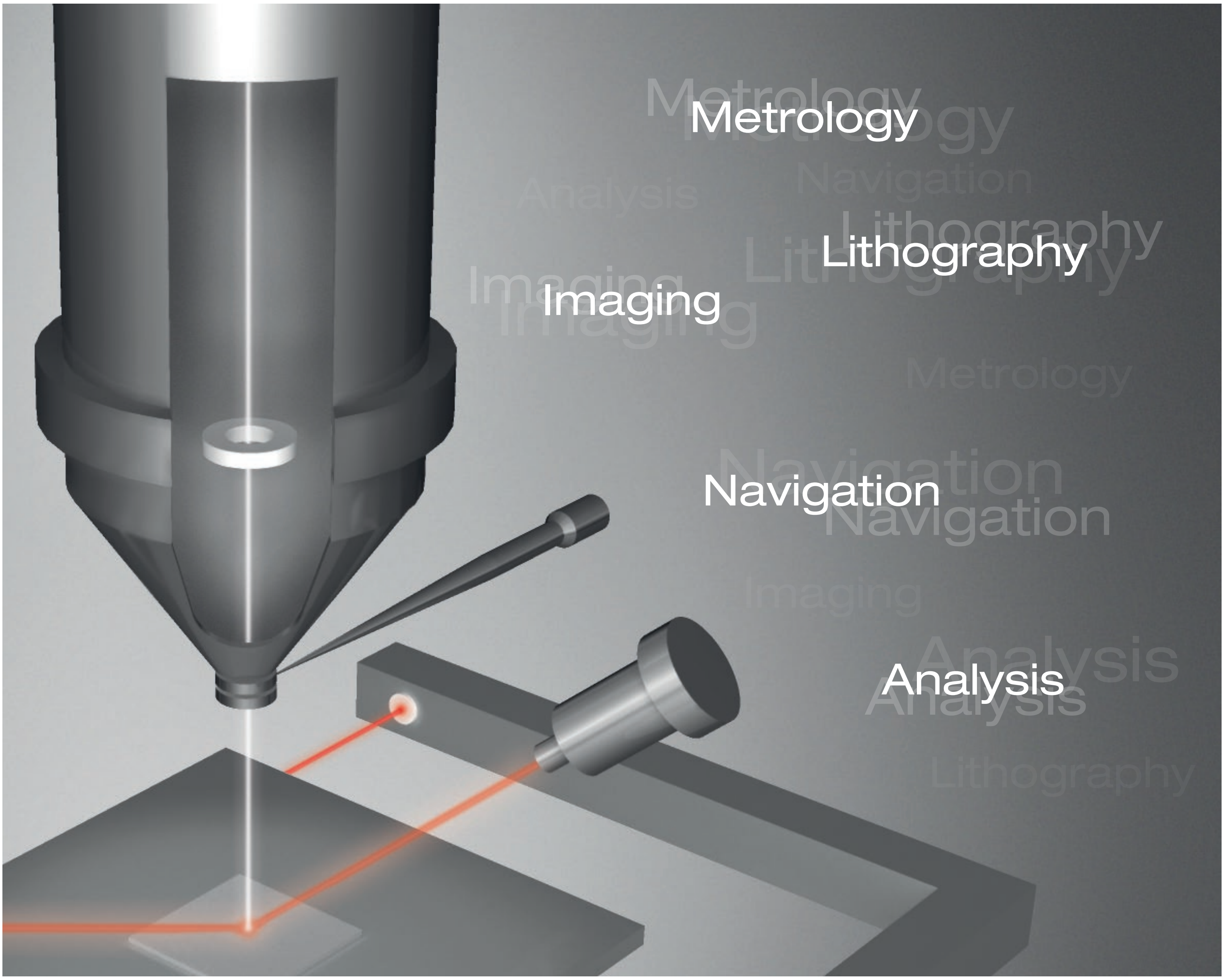


Raith Nanofabrication and SEM Instrument Technologies

Access to SEM applications that require stability, stage precision and automation

NANOFABRICATION/SEM

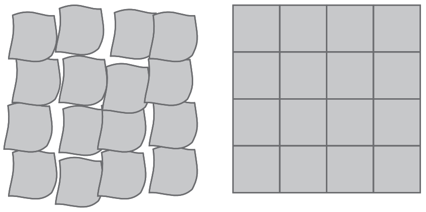
RAITH
NANOFABRICATION

Large-Area High-Resolution Imaging

Challenge of High-Resolution SEM Imaging

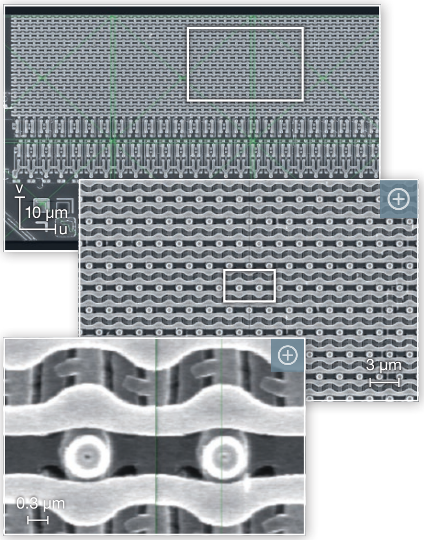
Acquiring SEM images that contain nanometer size information but that span up to cm^2-large samples is a common challenge. When this challenge is addressed using conventional SEM stage precision, software solutions for stitching tens of thousands of images into large mosaics often produce only distorted images.

The Raith systems are different: **By reversing the functionality of a professional electron beam lithography tool, the sample surface is not exposed; instead, existing nanostructures are seamlessly imaged using the extreme placement accuracy of the tool infrastructure.** Users can benefit e. g. from the "on-board" Laser Interferometer controlled Stage technology, related write field alignment functionality, and drift correction algorithms. These features deliver ultra-precise and fully automated image acquisition for generating highly accurate and undistorted "land maps" of large samples with highest resolution and stitching accuracy in the 10 nm range – and in 2D and in 3D in case several (sequentially deprocessed) layers are involved.

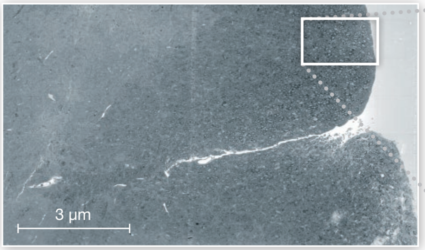


Reverse engineering and connectomics

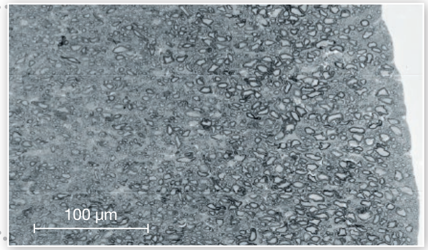
Chip makers are not the only users to rely on Raith technology for reverse engineering applications and identification of counterfeiting or parasitic chips. Also nanobiologists can use all these features to reveal the brain circuitry in connectomics. Here, analysis of the connectivity of neurons is the driver for (3D) brain mapping.



Right: large-area high-resolution mosaic image of an electrical device/chip. No software corrections have been applied; both the overview and the image zooms clearly show the difference in image stitching quality in comparison with a conventional SEM. Here, the stitching accuracy is of the order 10 nm. Green lines indicate the image overlap (~1µm) at the image acquisition boarders, which have intentionally been chosen to be very "generous".



*a) Image of the entire cross-section of a mouse spinal cord. This is the most accurate large-area high-resolution map of neuronal tissue directly acquired by an SEM instrument. This image contains 4.5*1010 pixels, whose locations are known to the high accuracy afforded by laser interferometry thus potentially supporting connectomics.*

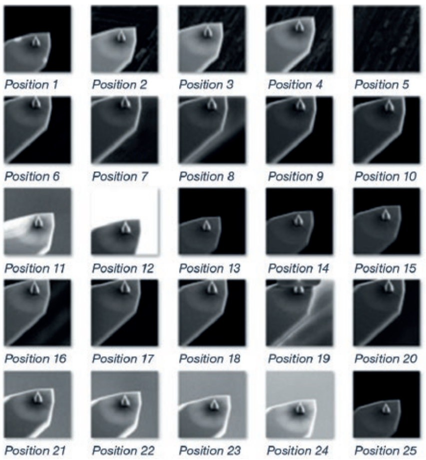


b) By using the Laser Interferometer Stage and a calibrated 100 µm field of view, SEM images of a large-area of this mouse spinal cord can be accurately stitched together. These near perfect images were NOT processed for error correction.

a) and b) Christine A. Brantner, et al., George Washington University

Qualitative process control

Even if ultra-precise positioning accuracy is not required, the Raith nanofabrication tool platforms provide automated routines for qualitative process control which are extremely easy to set up. Applying straightforward step and repeat, images at predefined positions can be automatically acquired, stored, and recalled in mosaic format or alternative specific arrangements e. g. for qualitative comparison with a reference (see set of images with AFM tips).



Series of SEM images for process control, acquired in fully automated step&repeat manner. Andrzej Sierakowski, et al., ITE Warsaw

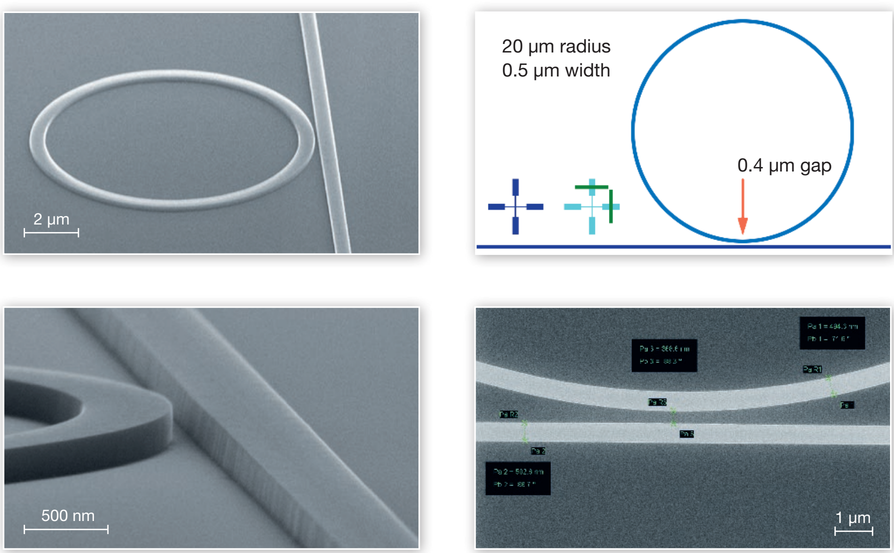
Automated SEM Metrology

Linewidth, placement, distance and statistics

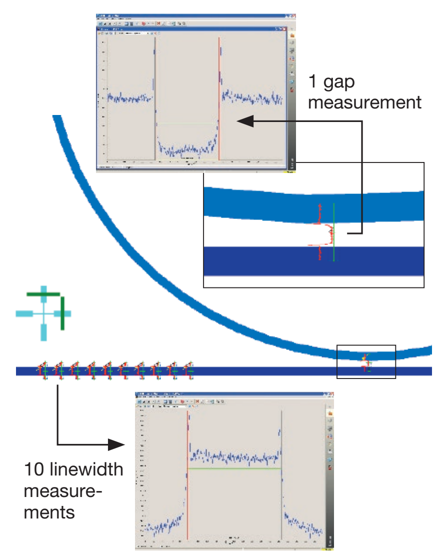
Nanolithography and nanofabrication are one thing, dimension check another. Given that nanostructures are still shrinking, nanometrology is becoming increasingly important for verifying a nanofabrication process.

Automated process control is increasingly finding its way into NON semiconductor fab-like environments such as Nanofabrication Centers or Quality Control, with the goal of stabilizing processes. Precise and reliable measurement of nm-sized features using automated user-independent recipes with process feedback will increase yield and device performance. Statistical data are automatically generated.

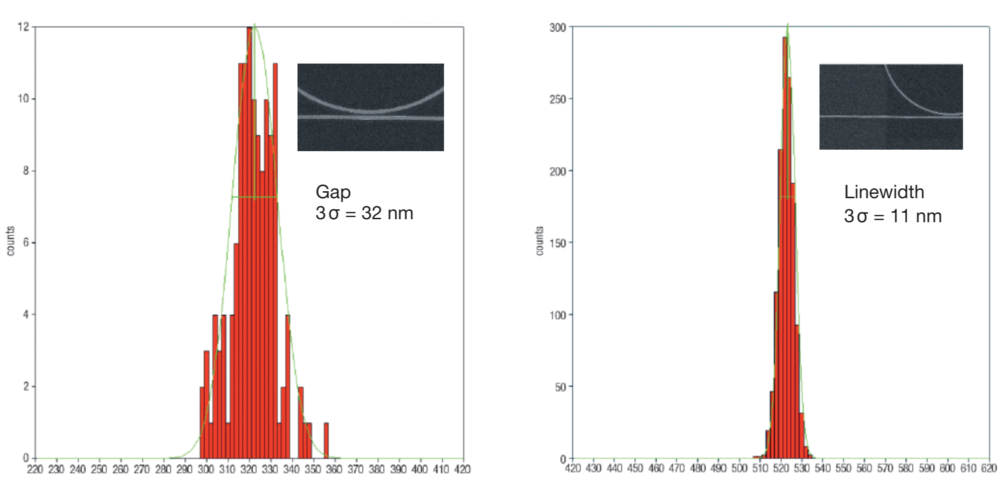
Raith provides this in all its turnkey systems, which can be operated in a "CD-SEM like" manner. Efficient and fully automated nanometrology operations and statistical evaluations thereof are available, as well as measurement algorithms such as: linewidth, placement, pitch and distance. All these nanometrology operations can be seamlessly integrated in the GDSII design, overlaid with real SEM images and executed from the position list. Data acquisition and processing takes place fully automatically in the background. (Statistical) results can be displayed in the GUI, specifically recalled individually, and exported later in standard formats if required.



Left: SEM image of a ring resonator coupling device. Both the minimum line edge roughness (LER) along the entire waveguide as well as the accuracy and stability of the "coupling gap" (here 0.4 µm) are of crucial importance with respect to the device performance. Right: Corresponding GDSII design. First the waveguide is written using the unique FBMS exposure mode; then a marker is used for highly precise alignment relative to the waveguide before the ring is written. A conventional manual measurement for gap and LER can be applied, but is tedious and time consuming for a large number of devices (here 135 devices).



GDSII setup for automated nanometrology for both LER (10 linewidth measurements at different waveguide locations) and a single distance measurement for gap determination – all applied to 135 devices exposed at different places.



Results of automated statistical evaluation for gap and LER.

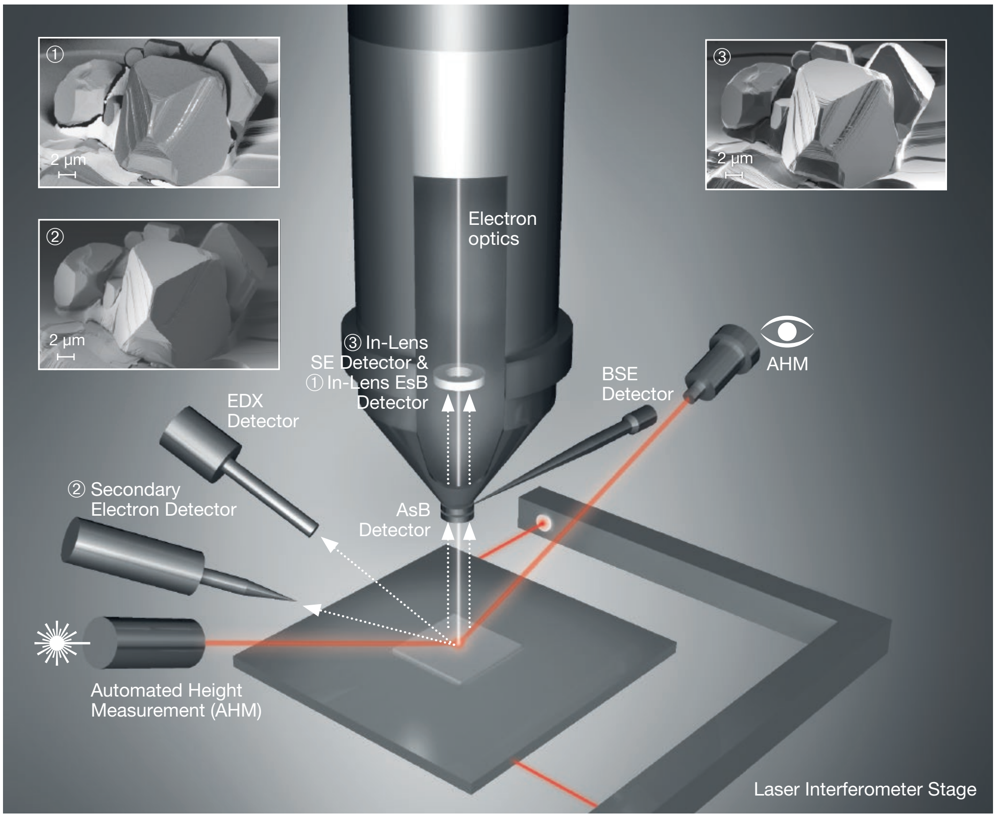
*All images on this page:
Linjie Zhou, Katsunari Okamoto, and S. J. Ben Yoo, et al., University of California Davis, and James Conway, et al., Stanford Nanofabrication Facility*

SEM Metrology

Variety of detectors – True large-area SEM

The Laser Interferometer Stage is an undeniably important ingredient of any professional nanolithography system. When reversing the functionality of an EBL tool from writing to imaging, it is also a critical component for accurately stitching SEM images over large areas because it allows the sample to be accurately positioned under the field of view (FOV). Moreover, it is used to map out errors in the FOV to a measurement accuracy of 1 nm.

Various detectors – whether secondary or backscattered detectors – help to achieve the best image contrast or to extract the optimum analytical information. Laser height measurement and corresponding automatic sample height adjustment to an accuracy of better than 1 µm ensures focus stability over an entire sample such as a large wafer, even if the sample is inclined or exhibits a strong curvature such as a wafer bow.



Comparison of Features Per Instrument

	EBL	FIB	SEM	Large-Area Imaging	Metrology	Probing	EDS
PIONEER Two	x		x	x	x		x
eLINE Plus	x		x	x	x	x	x
RAITH150 Two	x		x	x	x		x
CHIPSCANNER 150			x	x	x		x
CHIPSCANNER 100			x	x	x	x	x
CHIPSCANNER 50			x	x	x		x
ionLINE Plus		x				x	

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