



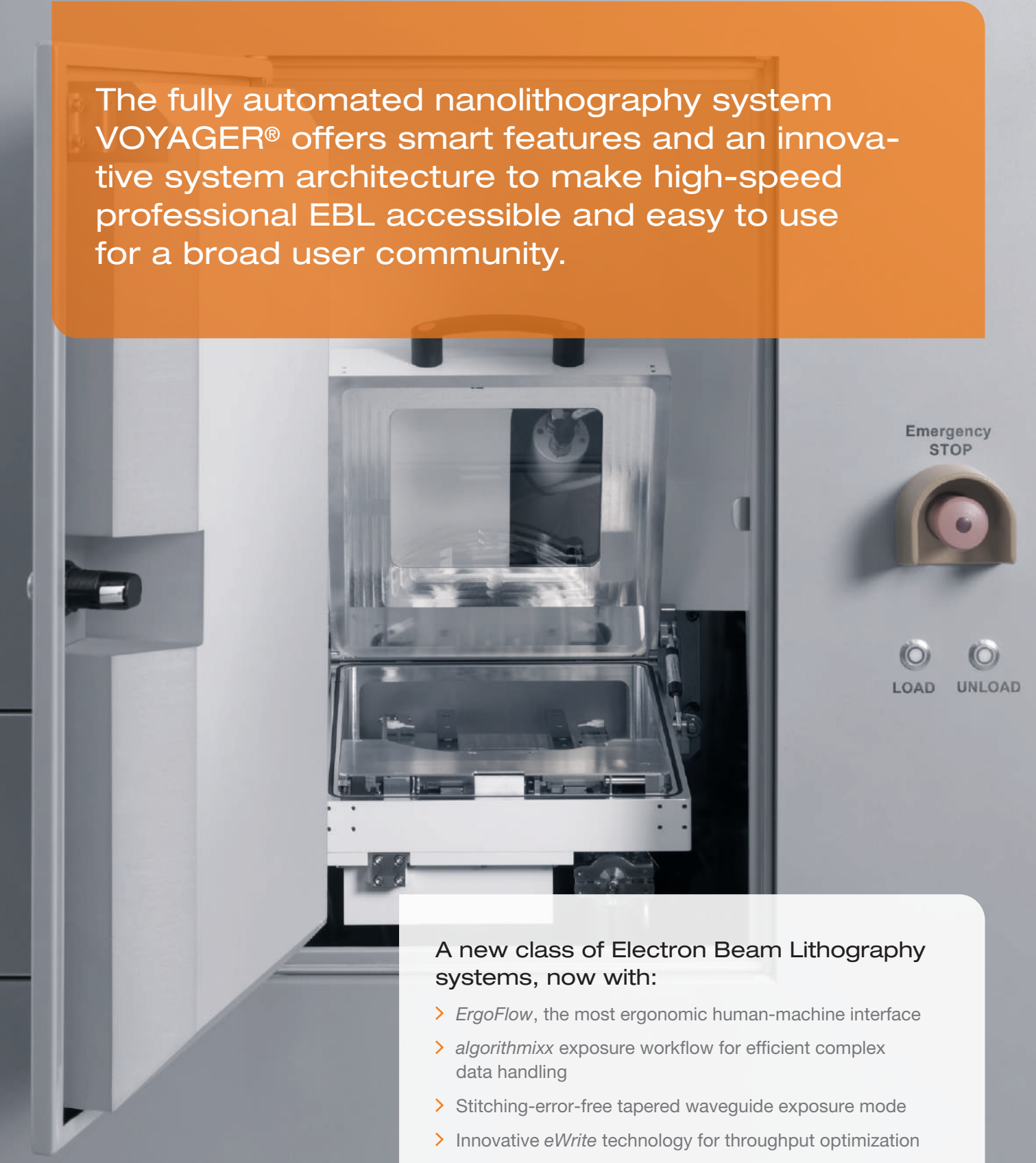
VOYAGER

EBL results at the push of a button

Fully automated high performance e-beam writer with innovative architecture for shortest time to result

DEDICATED ELECTRON BEAM LITHOGRAPHY

RAITH
NANOFABRICATION



The fully automated nanolithography system VOYAGER® offers smart features and an innovative system architecture to make high-speed professional EBL accessible and easy to use for a broad user community.

A new class of Electron Beam Lithography systems, now with:

- › *ErgoFlow*, the most ergonomic human-machine interface
- › *algorithmixx* exposure workflow for efficient complex data handling
- › Stitching-error-free tapered waveguide exposure mode
- › Innovative *eWrite* technology for throughput optimization
- › Small footprint and attractive cost of ownership

VOYAGER – The highly ergonomic EBL system

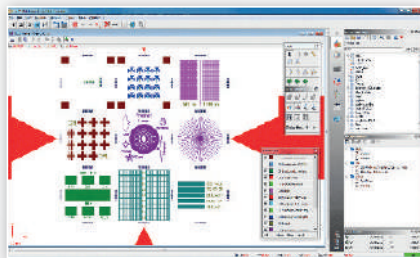
Straightforward access to highest quality EBL with quick sample turnaround

VOYAGER is the perfect solution wherever straightforward access to electron beam lithography is needed for multi-user facilities. Its high degree of automation allows you to focus on your application while it is still meeting all criteria of a highest-quality electron beam lithography system. VOYAGER is thus suitable for a broad bandwidth of applications in both academic and industrial environments.

Ergonomics

VOYAGER simplifies access to professional lithography

VOYAGER is an uncompromised yet affordable high-speed electron beam lithography system, especially useful for multi-user facilities with a need for utmost efficiency. Its latest highly ergonomic human-machine interface *ErgoFlow* ensures quick sample turnaround. With the help of this new smart workflow, professional lithography becomes accessible to everyone – regardless of the level of expertise. *ErgoFlow* complements the standard Raith Nanosuite, which still offers highest flexibility for parameter fine-tuning.

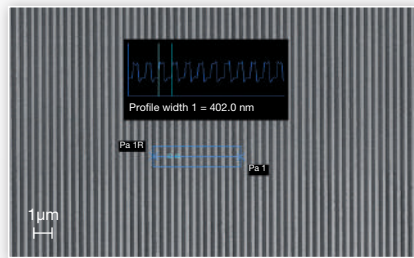


Screenshot of the widely used Nanosuite software

Automation

VOYAGER delivers shortest time to result

The variety of VOYAGER's new workflows and functionalities caters for EBL results at the push of a button. The new *ErgoFlow* software and hardware environment takes conventional EBL system automation a step further. VOYAGER takes care of all system adjustments and calibrations fully automatically, replacing manual user intervention. *eWrite* technology for automatic real-time on-the-fly beam corrections and automatic aperture changers are the answers to throughput optimization.



High-density grating exposed in shortest time:
< 2 h/cm² in ZEP520A

Unique solutions

VOYAGER provides smart features for application perfection

Not only does VOYAGER cover a broad bandwidth of applications, it also comes with smart and innovative software and hardware modules for advancing specific applications in photonics, optics, and optoelectronics. Moving-stage- and algorithmic-patterning-based technologies open up new opportunities. Relying on these, productivity can be significantly enhanced and device quality can be perfected.



Multiple mm-length tapered waveguide array
R. Schmits, TNO Delft

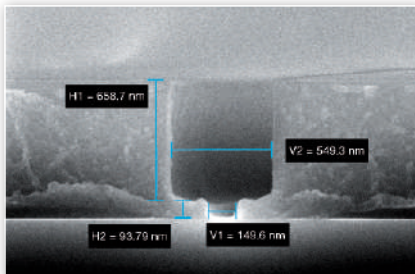
Professional lithography with highest precision

VOYAGER brings applications to perfection

With its innovative system architecture combined with ultra-comprehensive and widely used EBL software, the Raith Nanosuite, VOYAGER supports the entire bandwidth of advanced applications in both industrial and academic environments.

High-frequency device fabrication

High-electron-mobility transistors (HEMT) require ultra-precise overlay accuracy provided by highly accurate mark recognition schemes. VOYAGER offers a choice of adaptive and ultra-flexible alignment strategies, where marks of any material, geometry and position can be used. Evaluation schemes based on e.g. 2D-FFT mark recognition algorithms support the evaluation of alignment mark information obtained by VOYAGER's SE- and BSE-detectors, which deliver crisp contrast.



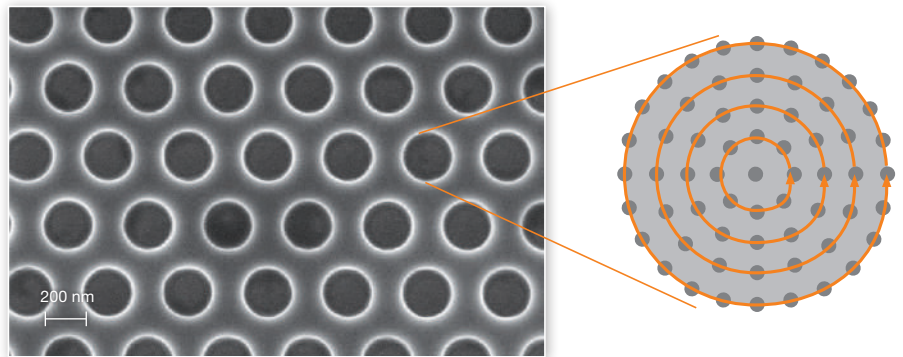
High-frequency device (HEMT) fabrication required for THz-technology

Coarse/fine split exposure – mode switch within seconds

VOYAGER offers a fully automated “split exposure” mode which can switch between specific exposure parameter sets required for e.g. coarse or fine structures in the design. Parameters for these high-throughput or high-resolution modes can be changed in seconds from a predefined exposure mode library without the need for long stabilization times. This efficiently helps to minimize exposure time.

FLEXposure – directional exposure modes for photonic crystal fabrication with optimum fidelity

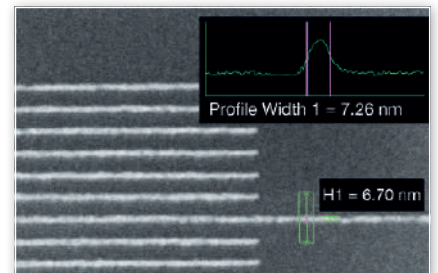
Perfect pitch and, most importantly, perfect roundness of circles in a photonic crystal make all the difference in photonic device quality. With *FLEXposure*, a set of multiple different and specific directional shape-filling modes within the Raith Nanosuite, VOYAGER ensures optimum pattern-fidelity and enables fabrication of highest-quality-factor photonic crystals.



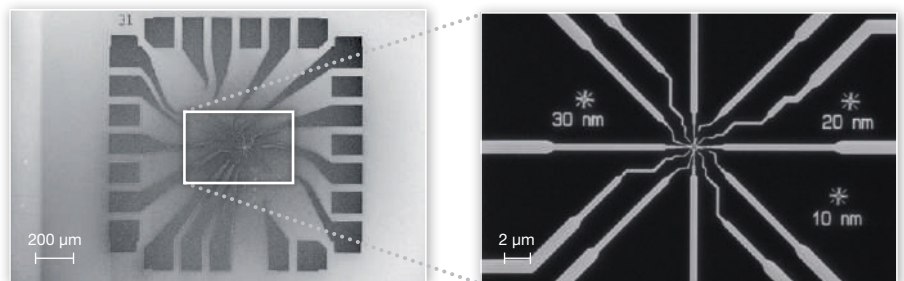
Perfect circles using “concentric outwards” filling mode

Ultra-high resolution

VOYAGER's highest-resolution electron optical column delivers minimum feature sizes in the single-digit nm regime.



Sub-8 nm lines exposed in HSQ; non-coated resist image using VOYAGER



Automatic switch between high-throughput mode and high-resolution mode for coarse and fine structures

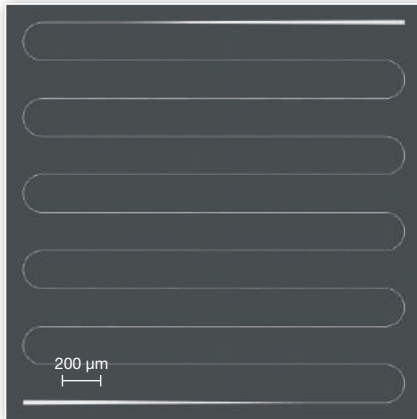
VOYAGER offers unique solutions

Innovative technologies for photonic, optical, and optoelectronic applications

VOYAGER comes with dedicated and unique features that achieve perfection for highest-quality devices by using stitching-error-free, 3D-, and formula-based writing modes

Low-loss tapered waveguides with stitching-error avoidance

Using *traxx*, the stitching-error-free writing mode based on Raith's unique fixed beam moving stage (FBMS) technology, VOYAGER can fabricate cm-long and seamless waveguides with smallest line edge roughness (LER) – now also with tapers. As a result, waveguides with highest performance and lowest attenuation can be manufactured.

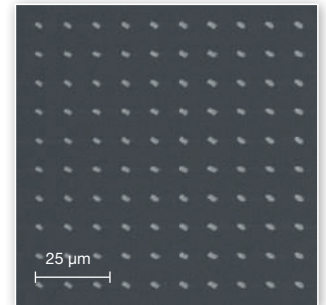


Stitching-error-free high-performance tapered waveguides, several mm in length

Large-area metalens nanofabrication

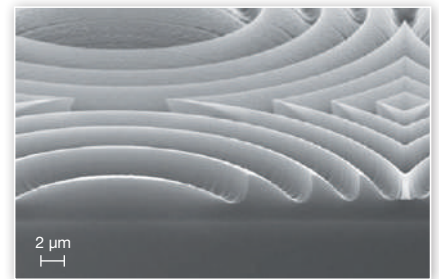
Corresponding GDSII designs for large metalens patterns can contain millions, if not billions, of individual unique shapes. This may lead to several 100 MB or even TB of design data, which cannot be efficiently handled by a standard EBL control system – if at all! VOYAGER's new exposure workflow *algorithmixx*, based on Raith's unique formula-based patterning (FBP) technology, circumvents generation of flat GDSII design data and instead delivers pattern generator data using scripts. This avoids both preparation of unmanageably large GDSII files and elaborate data processing overhead.

Large-area metalens-like pattern, generated using algorithmixx, based on Raith's formula-based patterning (FBP) technology



Innovative greyscale lithography capabilities

VOYAGER offers simple and straightforward 3D data format import into Raith Nanosuite for greyscale lithography applications. Resist contrast curve data and even subsequent specific process-technology-related properties can be convoluted with 3D greyscale data during import in order to achieve equidistant z-steps in resist, or even in the substrate, after specific process technology steps.

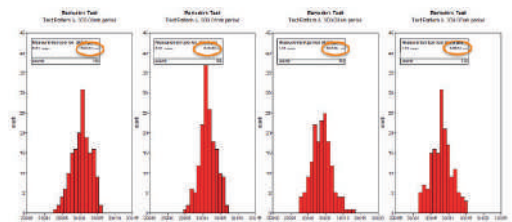
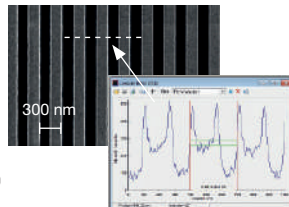
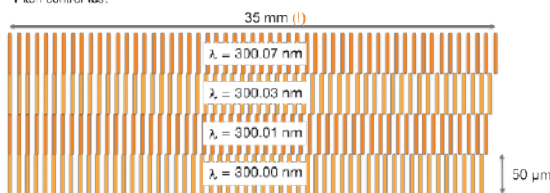


3D lithography: Fresnel lens

Ultimate sub-nm-pitch tuning for large-area gratings

Electron beam lithography is the method of choice for manufacturing highly advanced large-area gratings for AR/VR applications or DFB laser gratings for the tight wavelength separation specifications required by current and upcoming telecom standards. Relying on *periodixx*, based on Raith's proprietary modulated beam moving stage (MBMS) technology, VOYAGER sets new standards and pushes the boundaries of Electron Beam Lithography with finest pitch tuning capabilities in the 10 pm regime.

Pitch control test:



Pitch control verification of 0.01 nm in stitching-error-free gratings 35 nm length using VOYAGER's MBMS technology. Here, VOYAGER's onboard SEM imaging and metrology capabilities have been exploited for evaluation.

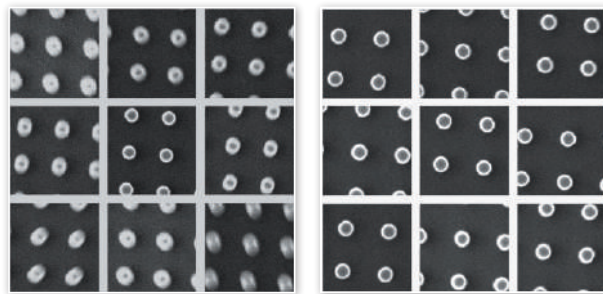
More than a standard

Smart technology bricks for improved performance

VOYAGER is the first system that incorporates Raith *eWrite* technology. *eWrite* combines dedicated EBL electron optics with latest innovations in pattern generator design that automate system calibrations and batch fabrication. Enhanced detector performance improves mark recognition precision and adds both SEM imaging and metrology functionality.

Raith's innovative proprietary *eWrite* technology simplifies data preparation

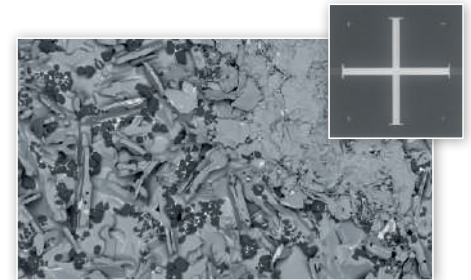
VOYAGER's carefully designed, well-harmonized pattern generator and electron optical column technology ensure efficient e-beam writing with straightforward automatic routines. The 20-bit FPGA-based pattern generator delivers highest beam placement accuracy in a large writing field of 500 μm , while off-axis beam shape, focus, and deflector corrections are automatically calibrated and subsequently corrected on the fly during the exposure – across the entire writefield and using only a single-stage beam deflection system! Unlike conventional EBL systems, VOYAGER does not need subfield handling. This does not only eliminate related overhead times, but also significantly simplifies design considerations and related beam deflection strategies.



Comparison of the center and corner images of a 500 μm field size. The left image shows a pattern without dynamic stigmator and focus, the right one the same pattern with active on-the-fly stigmator and focus correction.

Shadow-free and ultra-fast mark detection with BSE detector

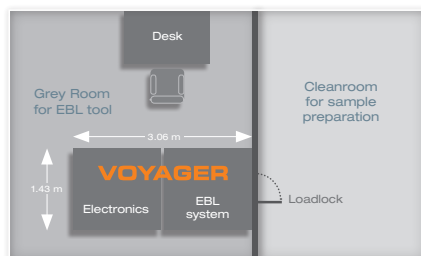
VOYAGER offers dedicated electron detectors with highest efficiency and sensitivity (25 ns), providing crisp material contrast for sophisticated and fast mark recognition schemes.



BSE imaging on ceramic BiCaCoO with strong material contrast – useful for superb mark recognition

Moderate clean room costs

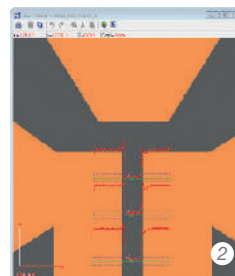
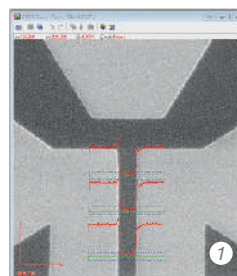
With its environmentally tolerant shield, VOYAGER complies with much less strict specifications for the clean room than usual. Furthermore, VOYAGER's small footprint only takes very few m^2 of lab floor space, and the optional "through-the-wall" loading setup even allows you to keep the system in the grey room, thus saving precious cleanroom space.



Optional split-room setup for VOYAGER

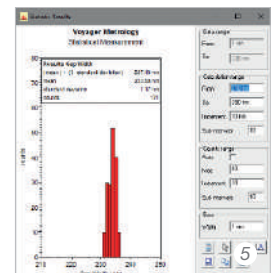
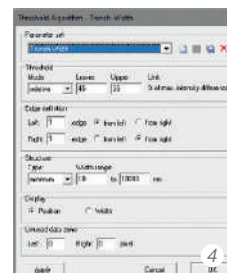
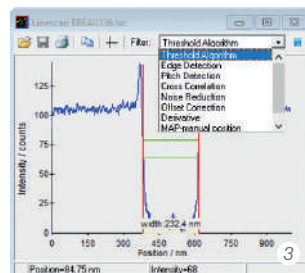
Automated SEM, metrology, and height mapping capabilities

Additionally, the VOYAGER platform with its height mapping system and its electron detectors not only enables automated SEM imaging, but also supports dedicated automated metrology measurements and process control workflows.



Raith Nanosuite's metrology and process control functionality features:

- 1 SEM image of gap
- 2 Corresponding GDSII design
- 3 SEM linescan with a variety of filters for gap width determination
- 4 Parametrization of specific metrology filter
- 5 Statistical evaluation of multiple linescan



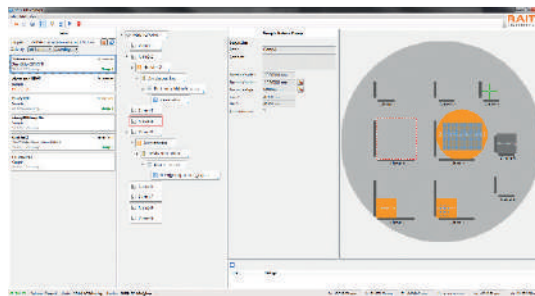
EBL results at the push of a button

VOYAGER enables quick sample turnaround

With *ErgoFlow*, VOYAGER offers an additional new and autonomous human-machine interface with fully automated workflows and easy-to-use GUIs, which are especially useful for multi-user facilities requiring highest efficiency with respect to job completion – regardless of the level of user expertise.

ErgoFlow – replacing manual by automatic workflows

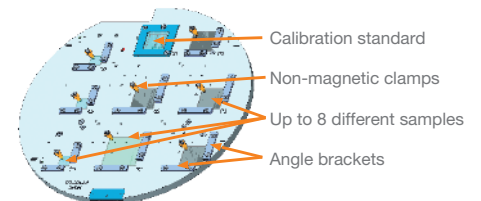
With the new alternative and complementary software environment and fully automated exposure workflow *ErgoFlow*, VOYAGER now defines a new class of fully automated lithography tools – ergonomic EBL systems. *ErgoFlow* represents the fast lane to EBL results at the push of a button for multiple operator environments – whether they involve multiple small samples or entire wafers. It comes with a high degree of user-friendliness and ergonomics, particularly for those who may have to master a handful of more complex apparatuses in their cleanrooms and want to focus on device qualification rather than its fabrication. The most widely used Raith Nanosuite still remains the standard interface for VOYAGER and offers the most advanced parameter fine-tuning cockpit for highest exposure flexibility.



ErgoFlow environment as efficient optional user interface

Simplified access to professional lithography

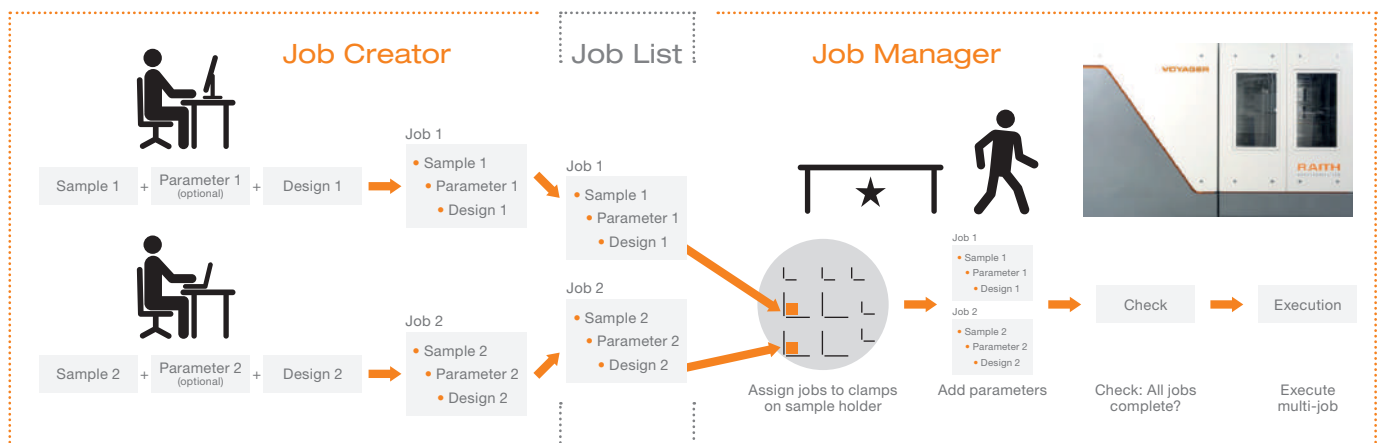
ErgoFlow was specifically developed to set up and sequence EBL jobs from multiple users – even on the same sample holder. This is especially useful in centralized facilities servicing many internal and external EBL users or customers.



The Multi-Sample Holder: max. 8 samples from up to 8 different users can be mounted and exposed sequentially in a fully automated process

Unattended batch processing on multiple sample holder – just a few mouse-clicks for multiple EBL job preparation and execution

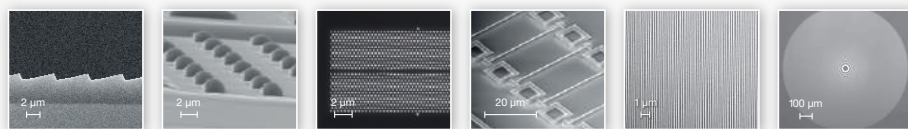
VOYAGER's *ErgoFlow* automatic exposure workflow includes two software elements. With its first element, the *Job Creator*, any user – regardless of expertise – can easily define an EBL job by loading a GDSII pattern and assigning this to a specific predefined sample from a database. With the help of the *Job Manager*, an experienced user then completes the job by assigning a suitable predefined exposure parameter set from a database and a position on the sample holder. If working on a multi-sample holder, up to 8 users can define their specific jobs on their own samples. The *Job Manager* then sequences and executes the entire multi-job from 1 to 8. Once the sample holder is loaded, all required EBL steps are performed fully automatically for each sample, from focussing and height levelling to writefield calibration. VOYAGER provides a unique sample leveling system on the stage, with no manual leveling or prealignment required whatsoever.



VOYAGER

Features at a glance

- *ErgoFlow* – New workflow as complement to widely used standard Raith Nanosuite
- *algorithmixx* – Innovative formula-based patterning strategy
- *FLEXposure* – Flexible directional shape-filling exposure modes
- *traxx* and *periodixx* – Stitching-error-free exposure modes based on moving-stage technology
- Stitching and overlay ≤ 20 nm
- Beam current stability $\leq \pm 0.2\%$ / h
- Guaranteed min. linewidth ≤ 8 nm (in resist)
- 0.5 mm (50 kV) and >1 mm (20 kV) write field size with dynamic beam corrections in real time
- 10 to 50 kV electron optical column, low energy consumption
- 150 mm full travel range laser interferometer stage (optional 100 mm)



Support and service worldwide

Sustainable long-term support channels

There is more to take into consideration than specifications and system performance only. Raith ensures optimal use over a whole system lifetime, with a team of professional trainers and a global support infrastructure from the market leader for Electron Beam Lithography.

High quality service worldwide

Wherever you are, a service engineer is always nearby. Raith has locally based engineers and spare parts in all major regions. Regular training is held at the factory to ensure consistent levels of expertise worldwide. VOYAGER is a modular system that can be field-upgraded later if your requirements change. This safeguards your long-term investment in the EBL system in combination with our unique long term full service and spare part availability guarantee.

Trainings

We help you benefit from your EBL system quickly with comprehensive onsite trainings included at every VOYAGER installation, free-of-charge site survey, and advanced facility check. In addition, our Service Centers provide application support. Our expert training courses help experienced customers reach the next level or retrain new colleagues.

User meetings

Raith organizes several yearly international user meetings and symposia where you can present your results, meet Raith experts, discuss the latest developments, and improve your knowledge.

Join the largest lithography user and support network in the field!

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05-2022

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