BEAMER

Advancing the Standard

Electron and Laser Beam Lithography Software

Optimum productivity, quality and innovation by advanced data preparation for electron and laser beam lithography

GenISys

www.genisys-gmbh.com

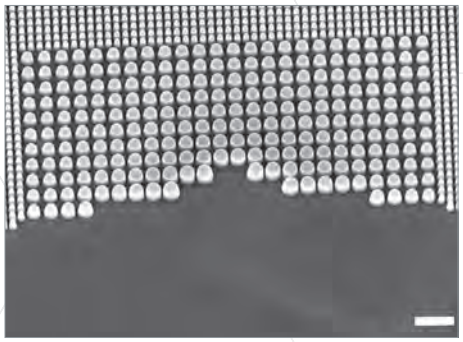
BEAMER

Electron and Laser Beam Lithography Software

High-resolution and high-throughput electron beam lithography is severely impacted by electron scattering, process effects, and tool artifacts resulting in non-ideal pattern transfer. Although the electron beam tool is a highly sophisticated and expensive printer, the pattern data needs to be optimized to significantly reduce the effects of various error sources such as beam positioning between shapes, filling shapes with "shots" on a discrete grid, field position dependent aberrations, stitching between fields, the spread of energy by electron scattering (proximity) and process effects.

BEAMER is the most comprehensive lithography software for optimum electron and laser beam exposure:

- Support for all major electron and laser beam exposure systems
- Superior machine-specific fracturing of complex curved layouts
- Optimized field and shot placement
- Writing order control and advanced writing strategies
- Library of comprehensive layout processing functions
- Support for all major layout formats
- Integrated layout editor
- Built-in viewer for immediate inspection, verification, and measurement of patterns
- Powerful proximity and process effect correction technology
- Electron beam simulation of absorbed energy and resist contours



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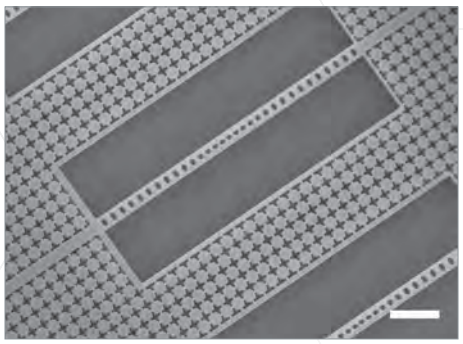
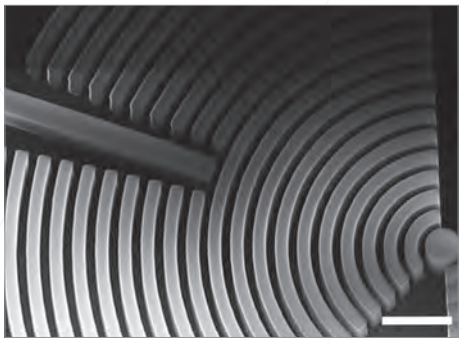
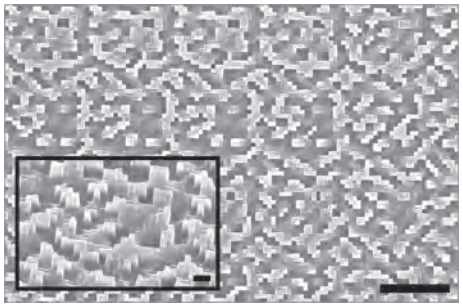
(Scale bar 500 nm)



Center for Nanoscale Science and Technology – USA
(Scale bar 2 µm)



AMO GmbH – Germany
(Scale bar 1 µm)



Bush Clover – Japan
(Scale bar 6 µm / 1.5 µm)

Productivity, Quality & Innovation

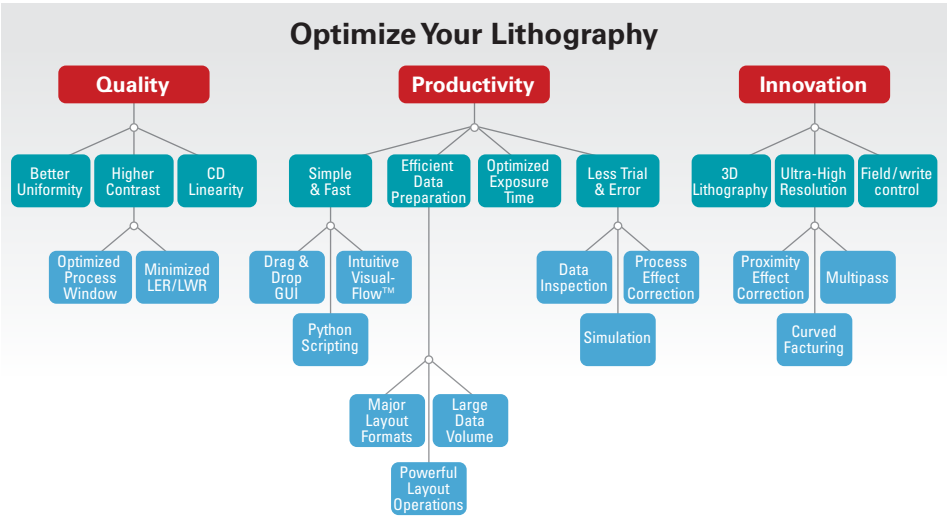
BEAMER offers reliable and highly powerful processing of large and complex layout data. It gives the user a large array of functions for extracting, combining and modifying the layout for an optimum exposure. Interfaces for all major electron and laser beam exposure tools are developed in close cooperation with machine vendors and are continuously optimized for the best exposure results, thereby extending the limits of these systems by advanced data preparation. Examples of these optimizations include fracturing for a significant reduction in shot placement artifacts, automated floating field to avoid/reduce field placement and stitching issues, user controlled field placement, and enhanced multi pass strategies. The user can quickly visualize and optimize the exposure process, including field and shot position. Applying techniques such as "bulk & sleeve" or "coarse & fine" combined with proximity effect correction PEC), high resolution with smooth edges can be easily and effectively achieved, leading to increased throughput.

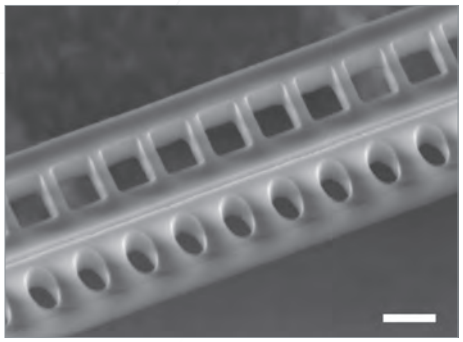
Strong collaborations with leading nanofabrication centers around the world drive rapid enhancements to our software, and provide the most advanced, efficient and effective capabilities to our users.

PEC is essential for improving the exposure quality by automatically adjusting exposure doses for optimum CD (critical dimension) uniformity and contrast. Additionally PEC eliminates the need to experimentally adjust the exposure dose for each layout thereby increasing productivity and process reproducibility. Performing traditional "Trial & Error" optimizations is very expensive and time consuming.

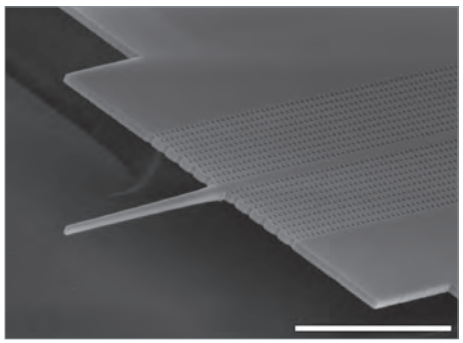
Advanced techniques available include: "model-based undersize-overdose" enabling ultra-high resolution in difficult scenarios, 3D PEC for three dimensional resist profiles in single and multi-layer resists, and full process calibration with simulation for quick development of new innovative solutions.

BEAMER is designed for the industrial user focused on productivity and the academic researcher looking for flexibility and high resolution.

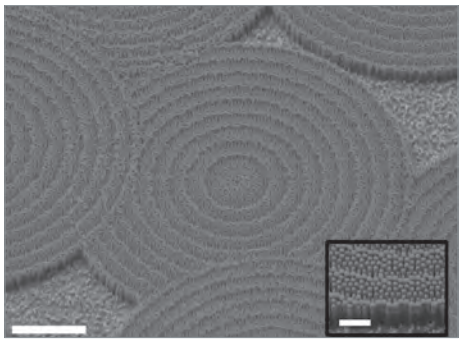




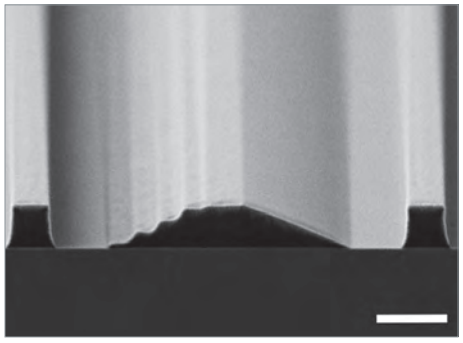
Center for Nanoscale Science and Technology (NIST) – USA
(Scale bar 200 nm)



C2N – France
(Scale bar 10 µm)



University of Southampton – UK
(Scale bar 8 µm / 2 µm)



Paul Scherrer Institute – Switzerland
(Scale bar 1 µm)

The **VisualFLOW™** user interface allows fast process flow creation by simple drag & drop to connect functional modules, providing increased productivity and efficiency.

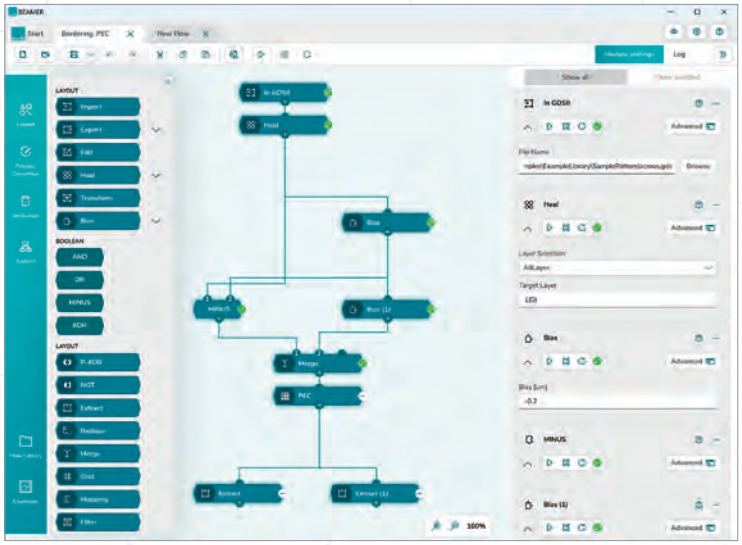
A comprehensive library of modules is available for building powerful flows. User Libraries allow storage and easy re-use of common blocks of modules for often-used functions.

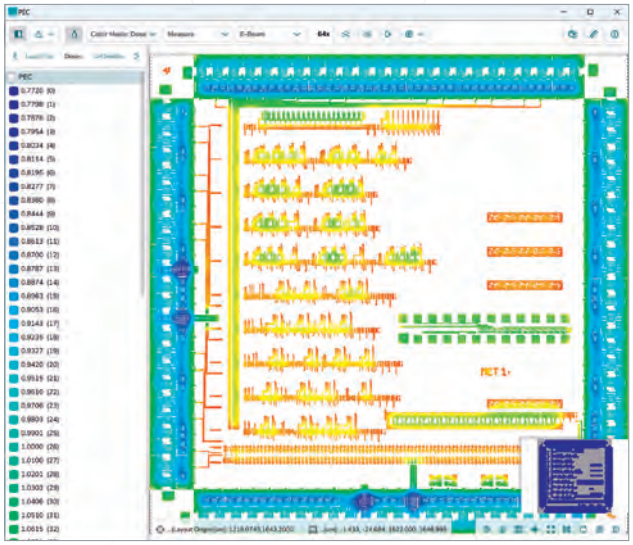
The integrated **VIEWER** provides layout inspection at all stages, allowing comparison of layouts in multi-view mode, measurement functions, metrology support, writing field placement, dose assignment, and shot placement. **VIEWER** is also available as a stand-alone software package.

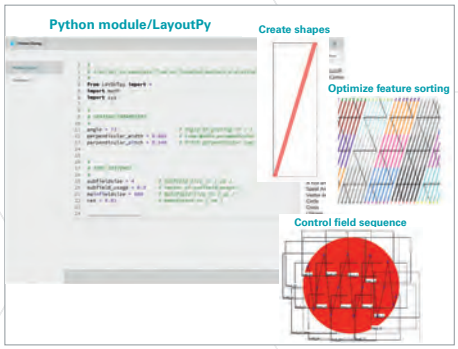
BEAMER imports and exports all major layout and machine formats, without size limitations. The integrated *Layout Editor* allows the creation and editing of layouts. We pursue close collaborations with machine vendors to ensure the best exposures and to implement the most sophisticated machine features. Advanced features include fracturing of complex curvilinear shapes, optimal fracturing of complex curved layouts, flexible control of field placement and shot placement, writing order definition and control, compensation for tool artifacts by intelligent multi-pass, and powerful data compaction.

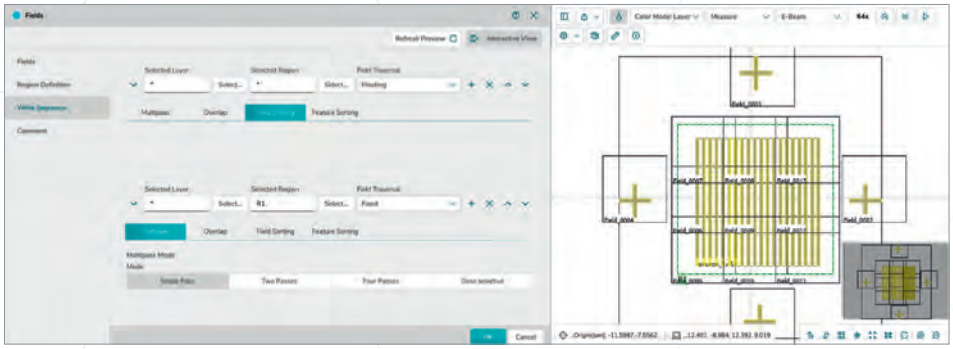
BEAMER provides innovative tools for PEC and advanced process correction for nanoscale electron beam lithography. It offers a robust 2D PEC complemented by model-based shape, and rule-based corner correction, as well as 3D correction for both single and multi-layer resist profiles. The flexible Point Spread Function (PSF) calculated by **TRACER**, can extend to correcting substrate, resist, and other process effects. *Rule-OPC* allows angle, size, or density dependent biasing and placement of resolution enhancement features for laser beam lithography, and mask making in general.

BEAMER integrates electron beam simulation, allowing for verification and optimization via modeling of the corrected layout. The modeling includes beam positioning for the major electron beam systems. The combination of *Metrology* for comparing simulated with experimental data, along with the *Optimizer*, facilitates the adjustment of model PSF parameters to perform basic process effect correction. The **TRACER** software package, in combination with **BEAMER**, allows full process calibration and correction, including not only exposure effects, but also development, process and metrology effects.









BEAMER Major Features

Layout Import/Export
- Layouts of all major formats, without size limitation (GDSII, CIF, DXF, LTXT, OASIS, BMP, DWG)
- Electron and laser beam machine formats (Raith, JEOL, Elionix, Crestec, ADVANTEST, MEBES, Heidelberg)

Advanced Fracturing
- Support of all major machine formats
- Optimized for arbitrary shapes
- Curved fracturing
- Correction for shot positioning
- Beam Step Size (BSS) fracturing
- Field position control (tiled, floating, manual)
- Multi-pass exposure
- Writing order control

Integrated Layout Editor
- Create new layouts
- Edit layout within flow

VIEWER
- Integrated detachable global viewer
- Multi-view
- Feature Measurements
- Shot and field placement view
- Write order and field visualization
- Dose assignment

Layout and Boolean Operation
- Healing, Biasing, Sizing, Merge, Tone reversal (NOT)
- *AND, OR, XOR, P-XOR, MINUS*
- Extract layer, datatype, cell, region
- Scale, Shift, Rotation, Mirror
- Filter geometries by width, height, area, angle, and relative dose
- Grid adjustment
- Mapping layout layers and datatypes
- Pre-fracture
- Cell Replace
- Hierarchy Flatten or Build

Flow Control Modules
- Parametrized loops with IF, SELECT, and FILTER operations
- Script for starting command line application from flow
- Optimizer for parameter fitting

Proximity and Process Correction

2D Dose PEC
- Fast and robust edge equalization technique
- Excellent dimension control by optimized dose on feature edges
- Fracturing based on absorbed energy distribution
- Perfect symmetry and stability for arbitrary shapes
- Process correction (e.g. lateral development, loading)

Shape Correction
- Model-based shape correction of short and mid-range effects
- Combination with long-range correction with dose modulation
- Model based contrast enhancement ("undersize – overdose")

3D PEC
- Correction for defined resist thickness at any layout position (resist profile) for single layer resist (e.g. 3D gratings, 3D holograms, angled sidewalls, lenses)
- Correction for critical dimensions (CD) for each layer for a multi layer resist (e.g. T-gate structures)
- Additional compensation for substrate topography or material variation

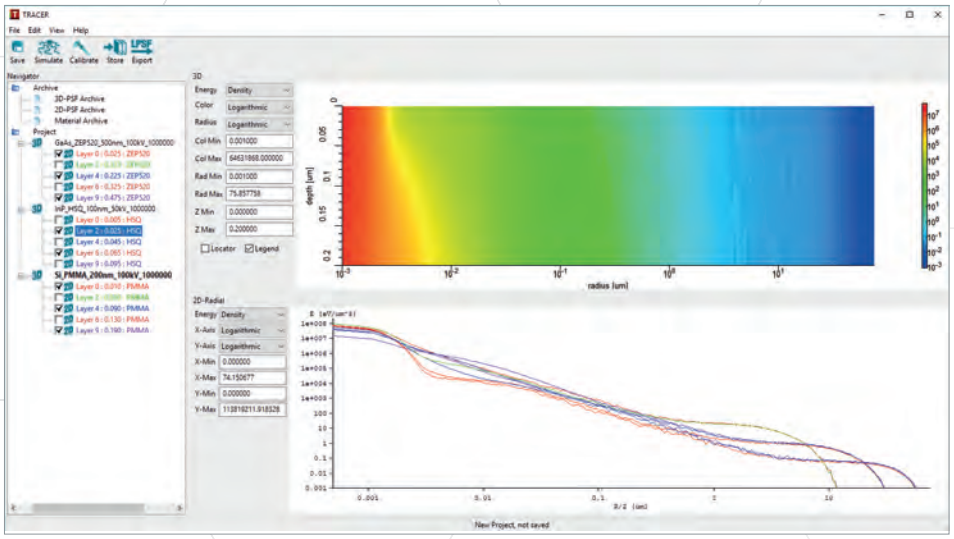
Laser beam Lithography Correction
- 3D Gray Tone Lithography
- OPC for resolution and linearity enhancement

Corner PEC
- Corner sharpening correction
- Dose PEC combined with rule based correction for edges, inner and outer corners.

Flexible PSF and Process Modeling
- PSF from Monte Carlo simulation or experimental table
- Visualization and fit of PSF function
- Apply full PSF data or Gaussian approximation
- Process loading, shot size dependent blur, fogging effect

Electron beam Modeling
- 2D intensity image, 2D resist contour at multiple thresholds
- 1D/2D image viewing and analysis
- Multi- and matrix-view for automated runs
- Metrology for automated measurement and comparison to experiment
- 3D resist simulation can be performed with the LAB software package

TRACER

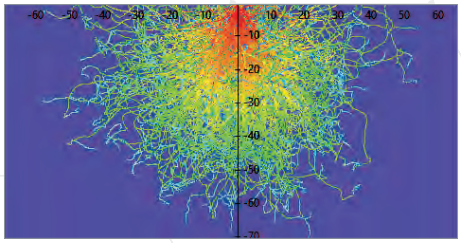


Fast, Easy and Accurate PSF Simulation and Visualization

Manage, Maintain and Archive all PSFs with a seamless interface with BEAMER and LAB

A Point Spread Function (PSF) is the essential input for any type of Proximity/Process Effect Correction (PEC) or electron beam simulation. It describes the deposited energy as a function of the distance from the incident beam. Alternatively, a PSF can be described as the convolution of the electron scattering beam size (or beam blur) and process effects, which can include collateral effects such as resist development and pattern transfer effects. The quality of a process effect correction (PEC) depends entirely on the knowledge of the PSF and process correction parameters such as base dose and process bias. As such, a necessary starting point is a Monte Carlo (MC) simulation of not only electrons backscattered from the substrate, but also fast secondary electrons from both the primary exposure and backscattering events.

TRACER offers an easy-to-use interface for defining the required parameters (material data, stack parameters, acceleration voltage), running the MC simulation, visualizing the 2D r-z simulation results (energy spread at different resist thicknesses), and extracting the 1D PSF which can then be used for PEC.

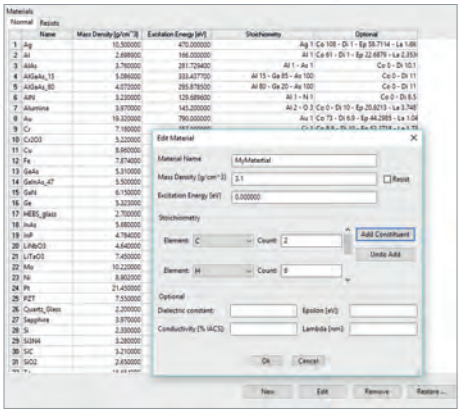


The comprehensive material database includes all standard materials and can easily be expanded with custom materials by defining their stoichiometry and mass density. Functionalities such as fitting to Gaussian functions, averaging, convolution of PSFs, determination of base dose factors between PSFs and powerful visualization enable the user to analyze, compare and optimize PSFs.

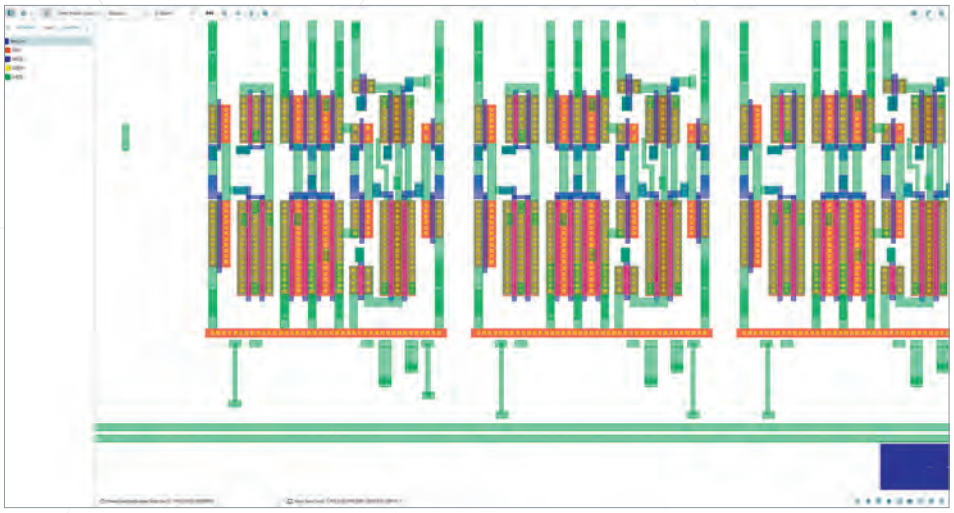
Furthermore, tool and process effects such as spot size, lateral development, resist diffusion and loading effects need to be quantified and corrected. **TRACER** has an easy-to-use *Calibration* feature which determines and corrects these effects using measured CD data (typically CD as a function of dose and layout density) obtained after processing of a calibration pattern. Process parameters such as base dose, process blur and process bias are rapidly computed and the display of calibration versus measured data allows the user to immediately verify the fit quality.

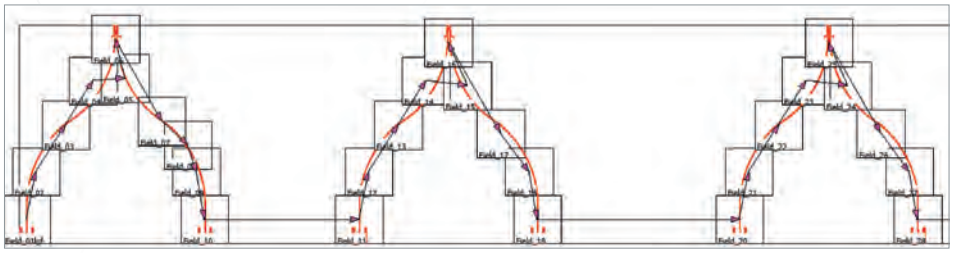
TRACER Major Features

- Monte Carlo simulator that computes the electron-solid interaction for optimal electron beam exposures, including beam blur
- Process calibration using experimental data
- Archive to maintain and manage all PSFs
- Visualization tool for PSF inspection
- Allows to combine electron-PSF and process-PSF into a single-effective-PSF, or to seperate out the process-contribution-PSF from an experimental-PSF
- Dose factor calculator between two PSF's
- Electron trajectory visualization (results can be exported for post-processing)



VIEWER





VIEWER is an ideal, ultrafast tool to inspect and compare layouts, that is included in **BEAMER**. On the input side, all major layouts (GDSII, OASIS, CIF, DXF) plus electron and laser beam machine formats are supported. Multiple layout files can be loaded to visualize them overlaid. The user has a multitude of viewing options and capabilities. **VIEWER** is also available as a stand-alone software package.

- Extensive color management (user defined palette, transparency and overlay colors, and mapping of colors to layers / datatypes, doses, cells, layouts)
- Hierarchy support (view of the hierarchy tree, selection of cells / layers to be displayed, drawing of features down to a user specified hierarchy depth)
- Metrology support (measure, pick, various snapping options such as snap to edge, snap to corner, snap orthogonal)
- Script generation for automation of metrology equipment and visualization of metrology results added into the layout
- For electron beam machine formats view deflection fields, beam shots, writing order, and stage traversal order

GenISys products share highly dedicated support, have flexible licensing and are available on various platforms operating systems.

Flexible licensing and platform support

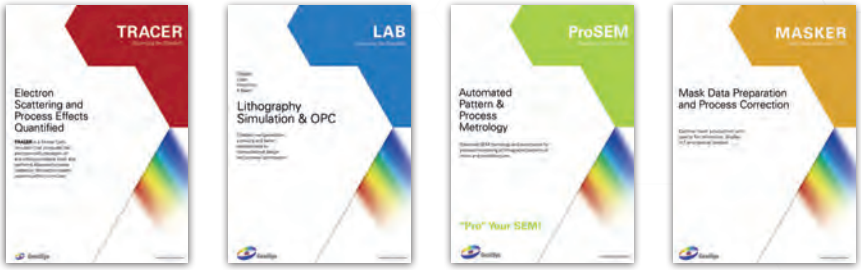
- USB license key for standalone dongle and network
- Flexible on off-the-shelf PCs (> 4 GB RAM recommended)
- Windows 11 64bit, Linux 64bit (RedHat 7+, Ubuntu 18.04+)
- Multithreaded processing

Maintenance and Support

- Technical Support Hotline (e-mail, screen sharing and phone)
- Frequent updates with new features, enhancements, performance improvements and bug fixes
- Regional trainings, technical workshops and user meetings
- 12 month maintenance service included in license price
- User feature requests are given high priority for future updates

For more details

BEAMER



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Based in Munich (Germany), with offices in Tokyo (Japan), and California (USA), **GenISys** develops, markets and supports flexible, high-performance software solutions for the optimization of micro and nanofabrication processes. Addressing the market for lithography and inspection, **GenISys** combines deep technical expertise in layout data processing, process modeling, correction and optimization with high caliber software engineering and a focus on ease of use.

GenISys products give researchers, manufacturers, and system suppliers unparalleled efficiency, ease of use and optimal value in research, development, and production of future nano-patterning technologies.

As a company focused on customer service, **GenISys** delivers fast, highly dedicated support for the application and development of the functionality needed to meet demanding customer requirements.