The SEM/FIB Workbench

lithe

Lithography stage:

Small ultra-precise Nanorobotics XY-stages for e-beam Lithography from Klocke Nanotechnik



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Task

The task:

- Standard SEM/FIB sample stages are not precise enough for stitching of generated patterns
- Laser stages allow absolute positioning of big samples with best accuracy, but they do not fit into standard SEM/FIB chambers and they are very expensive
- Small stages fitting onto existing SEM/FIB sample stages normally are not precise enough.



Solution

The solution:

- The Nanorobotics XY-stages from Klocke Nanotechnik are small enough for an assembly onto every existing SEM/FIB sample stage
- They offer sub-Nanometer resolution in movement
- They offer sub-micron stitching accuracy
- Their hardware and software is fully compatible to the Nanorobotics manipulator application packages from Klocke Nanotechnik
- The e-beam lithography application can be expanded later e.g. by a Nano-Probing, Nano-Cutting or Nano-Cleaning application package operating in the same control system.



Mechanical setup

The mechanical setup:



XY-Stage with customer specific sample holder



Klocke Nanotechnik 🐺

XY-Stage assembly on an existing SEM-stage

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Stitching Accuracy

Nanotechnik

Stitching Accuracy:

- 4 fields were written by ebeam lithography, one after another.
- In-between the XY-stage moved the sample field by field in XY.
- The stitching accuracy of this movement is below 1 micron, even on a movement range of 20 mm per axis.



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Properties

Typical hardware specifications:

- 20 x 20 mm² travel range (optional 30 x 30 mm² or 50 x 30 mm²)
- High vacuum compatible
- Encoder system, resolution 2 nm
- High vacuum feedthrough and cable set for SEM operation
- Network controller with Ethernet communication
- Power supply and sub-rack housing
- Universal lithography sample holder
- Typical sample size up to 20 x 20 mm²



of a typical setup, these are not guaranteed values.

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Relative positioning accuracy

mean = 38.48 nm

 $\sigma = 21.43 \text{ nm}$



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80

100

120

Lithography stage 10 20

40

60

Deviation from target [nm]

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Repeated relative positioning accuracy

of a typical setup, these are not guaranteed values.



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of a typical setup, these are not guaranteed values.

Improvements



Nanorobotics Control

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System Integration

One common control system:

- Expandable by Nanorobotics Manipulators, e.g. for Nano-Probing, Nano-Cutting or Nano-Cleaning
- Live Image Positioning for sample stage and manipulators, e.g.:

Move the tip by a simple mouse click in the Live Image Positioning Module



Left: Grabbed SEM/FIB image in NanoControl; Right: SEM/FIB live image with tip

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Products for this application:

• One Nanorobotics XY-stage from Klocke Nanotechnik including:

- System integration into a SEM/FIB chamber
- Cable set and electronics
- Upgrade for high accuracy lithography application
- Software module with remote access for external lithography software
- Macro Executor
- Software Assistant, e.g. for calibration
- Optional: Process Control Sequencer for automation
- Optional: Combination with the Nanoworkbench, incl. Application Packages like: Nano-Probing, SpotHeater, Nano-Cutting, Nano-Cleaning, 3D-Nanofinger[®], Force-Distance measurements, NanoFriction, ...

