The SEM/FIB Workbench

Lithography stage:

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

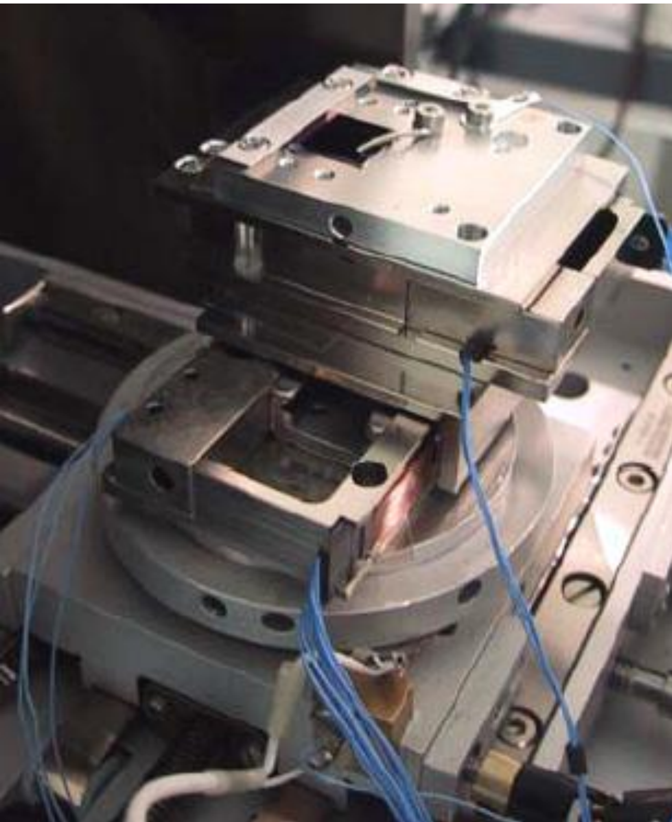
The task:

- 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.

The solution:

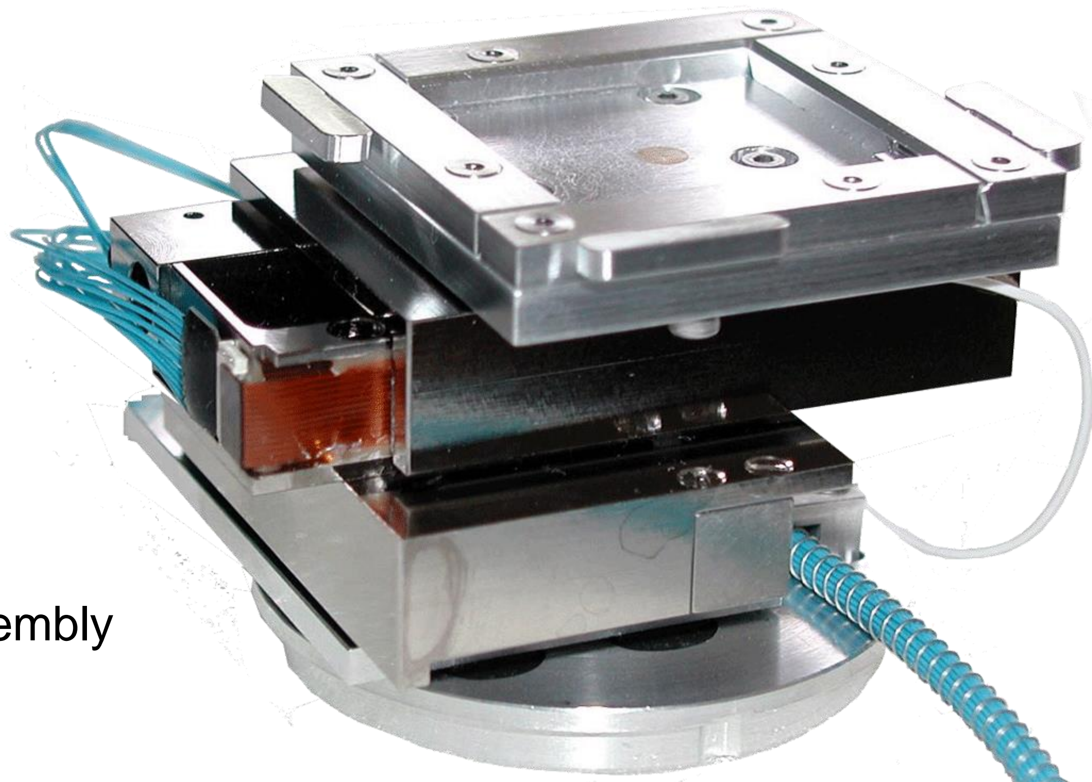
- The Nanorobotics XY-stages from Klocke Nanotechnik are small enough for an assembly onto every existing SEM/FIB sample stage
- They offer sub-Nanometer resolution in movement
- They offer sub-micron stitching accuracy
- Their hardware and software is fully compatible to the Nanorobotics manipulator 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.

The mechanical setup:



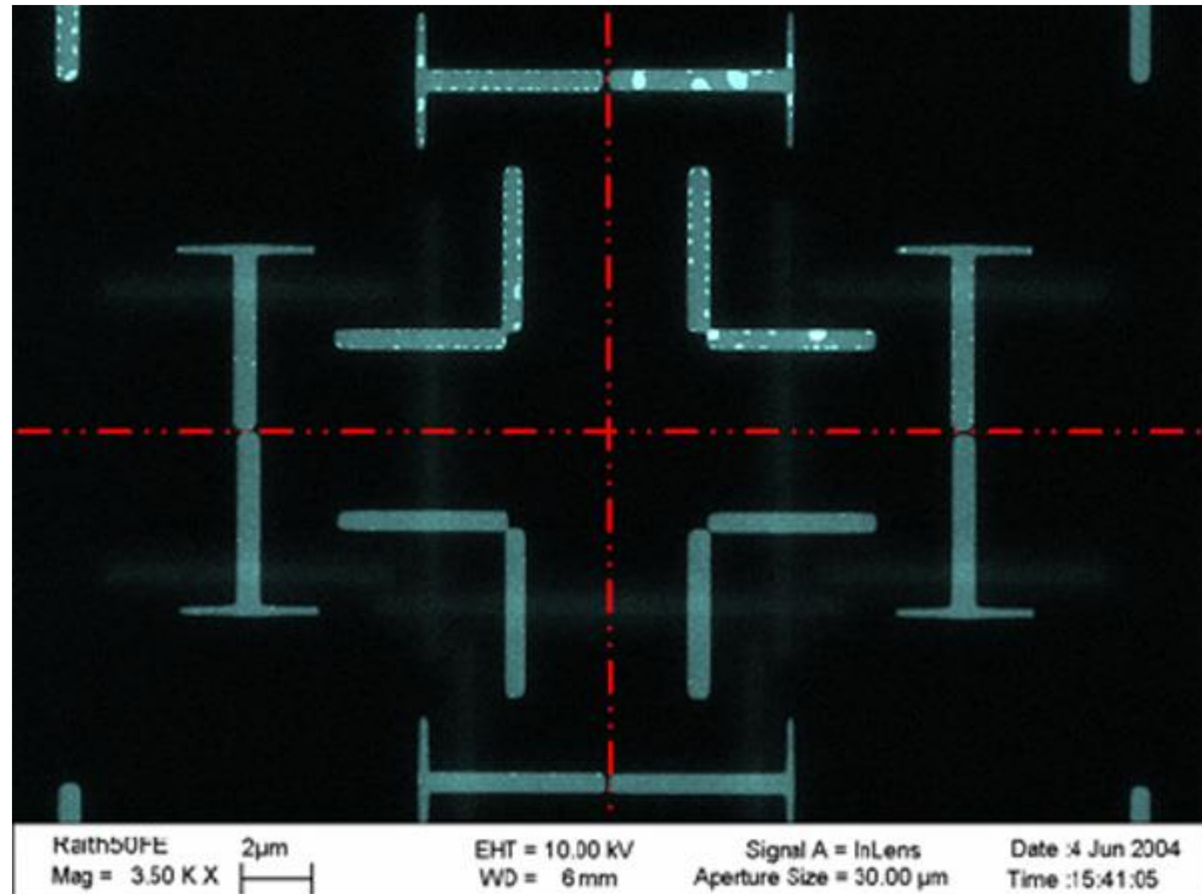
XY-Stage assembly on an existing SEM-stage

XY-Stage with customer specific sample holder



Stitching Accuracy:

- 4 fields were written by e-beam 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.



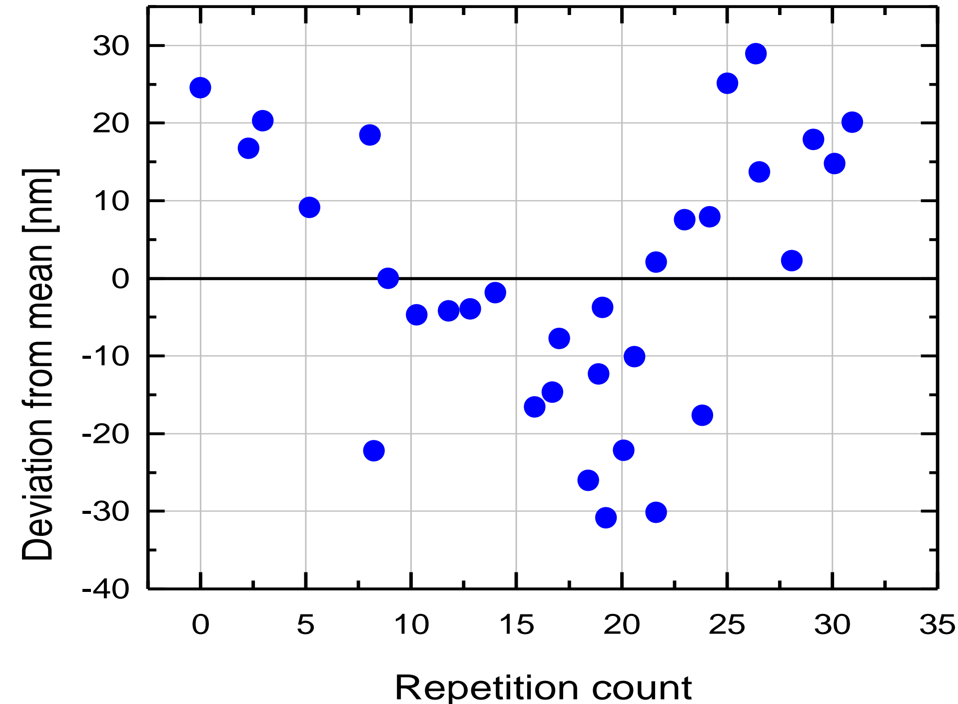
Typical hardware specifications:

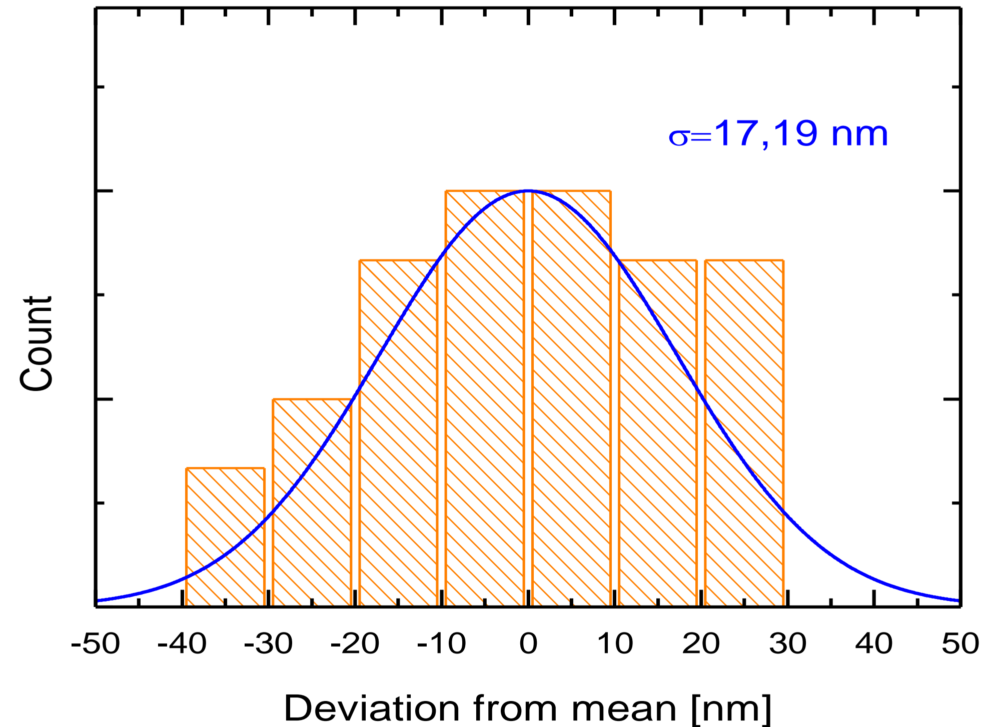
- 20 x 20 mm^2 travel range (optional 30 x 30 mm^2 or 50 x 30 mm^2)
- High vacuum compatible
- Encoder system, resolution 2 nm
- High vacuum feedthrough and cable set for SEM operation
- Network controller with Ethernet communication
- Power supply and sub-rack housing
- Universal lithography sample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

Lithography stage

of a typical setup, these are not guaranteed values.

1 axis repeatability





1 Axis repeatability test:
Deviation after 40mm of travel.

Lithography stage

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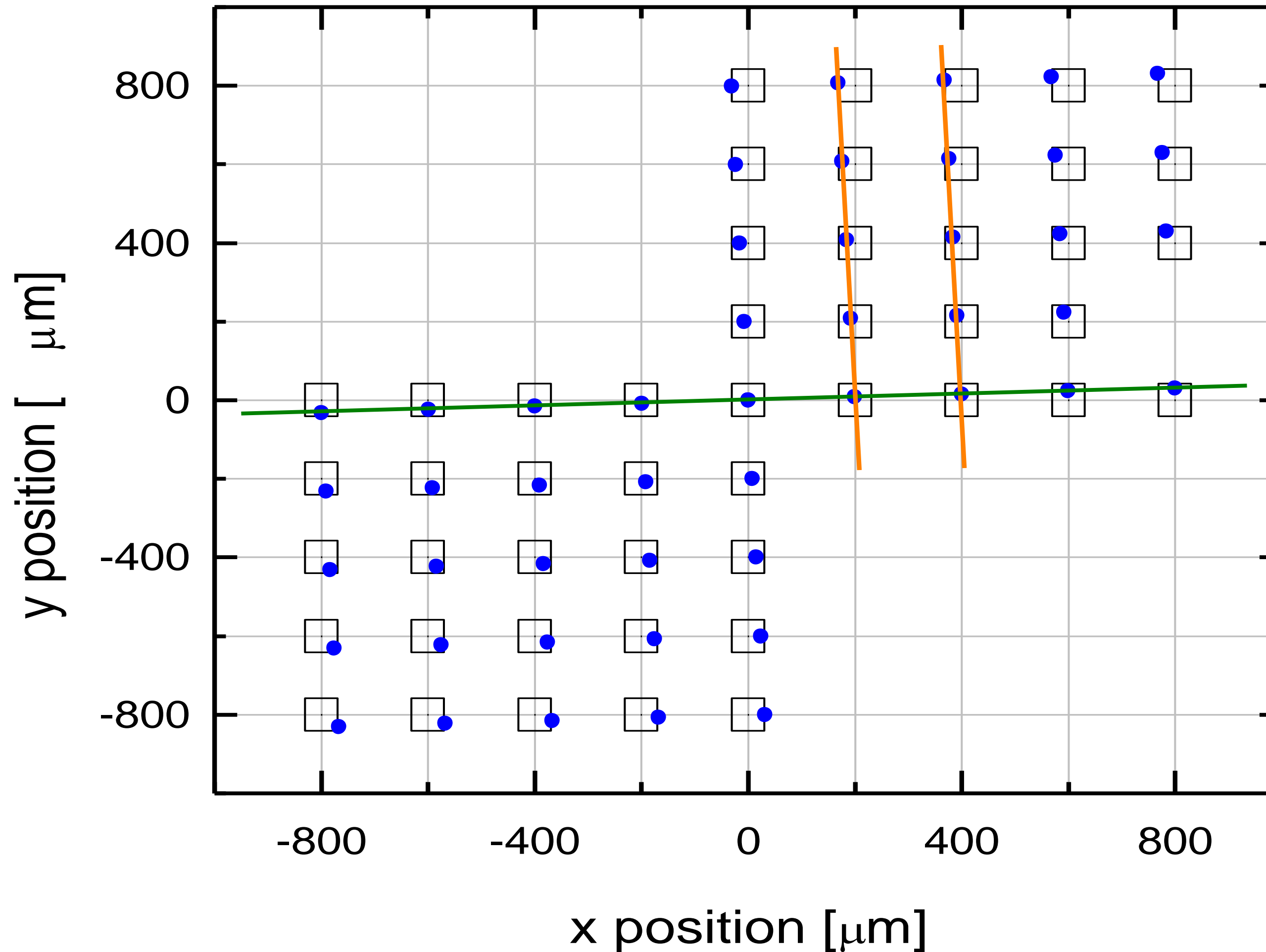
X-Y positioning

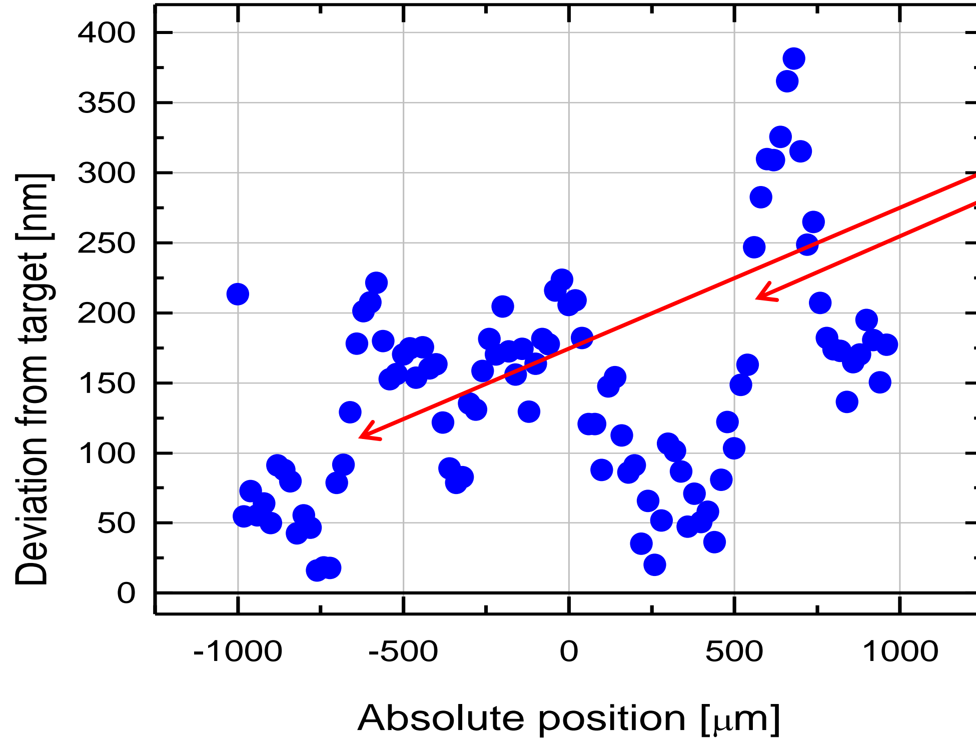


Sample correction angle

of a typical setup, these are not guaranteed values.

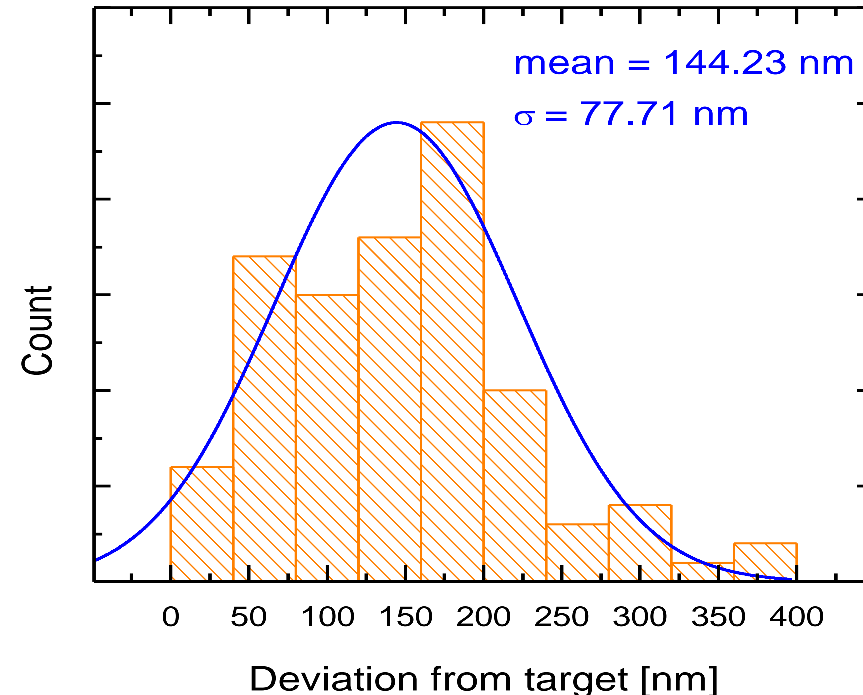
Lithography stage

Absolute positioning accuracy



Tescan Mira SEM: Effect of degaus + refocus

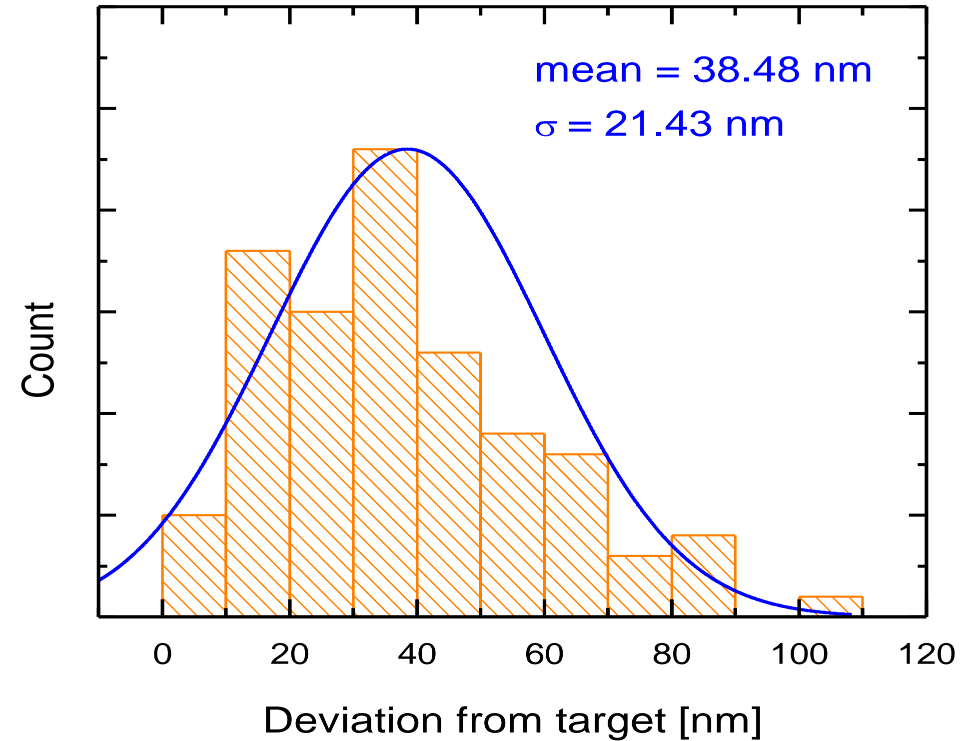
2 Axis absolute positioning test:
Deviations at 2 mm of travel.

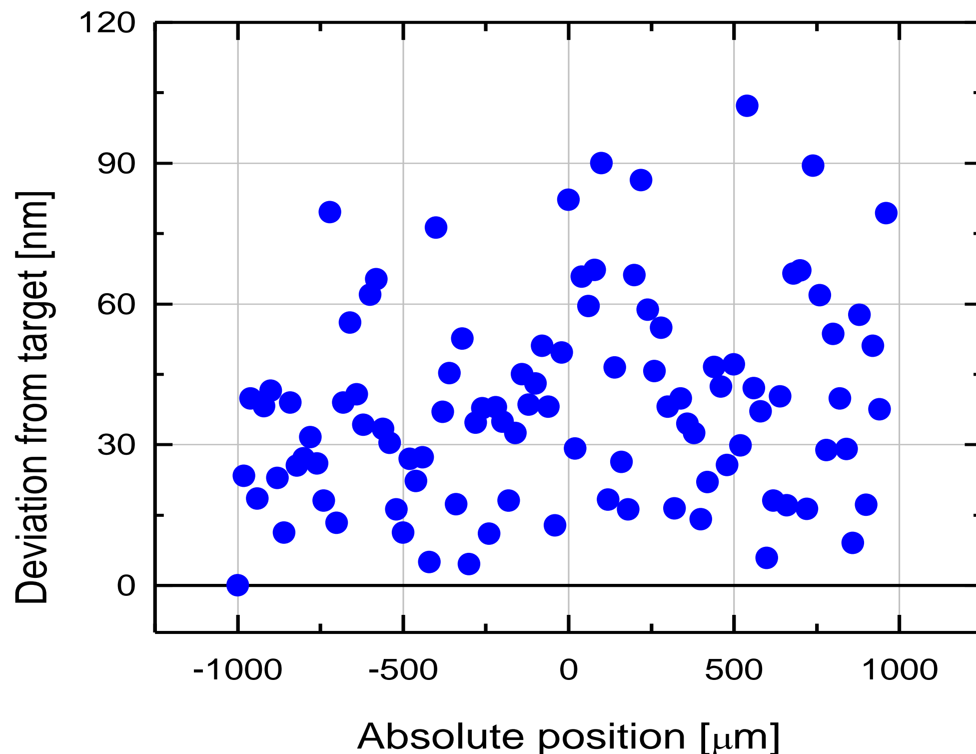


Lithography stage

of a typical setup, these are not guaranteed values.

Relative positioning accuracy



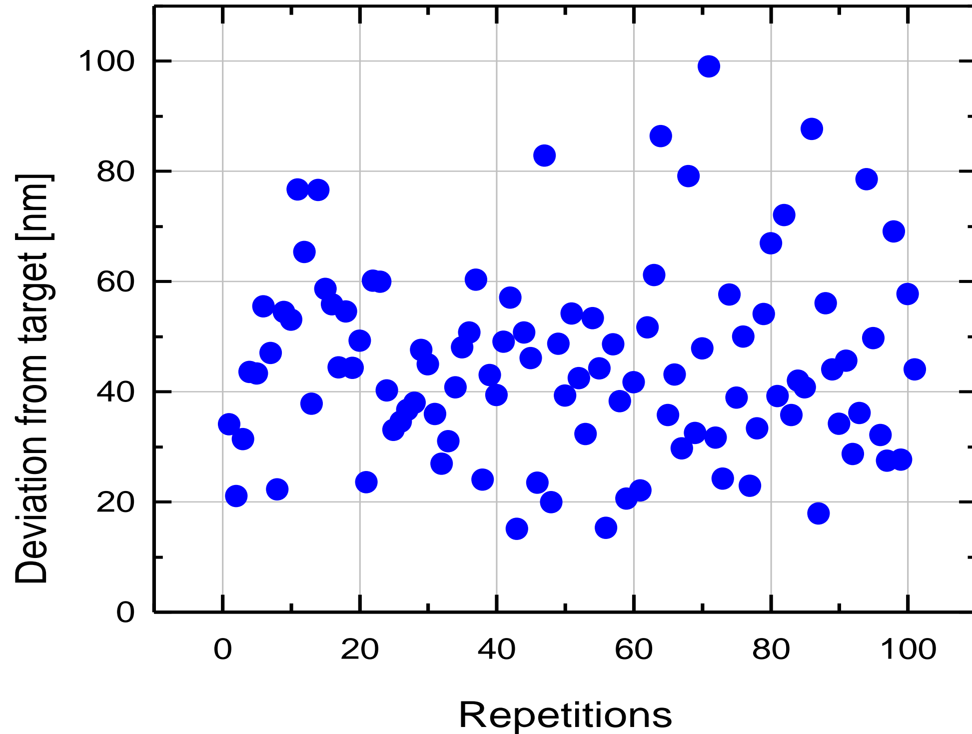


2 Axis absolute positioning test:
Deviations at 2 mm of travel, 20µm per step.

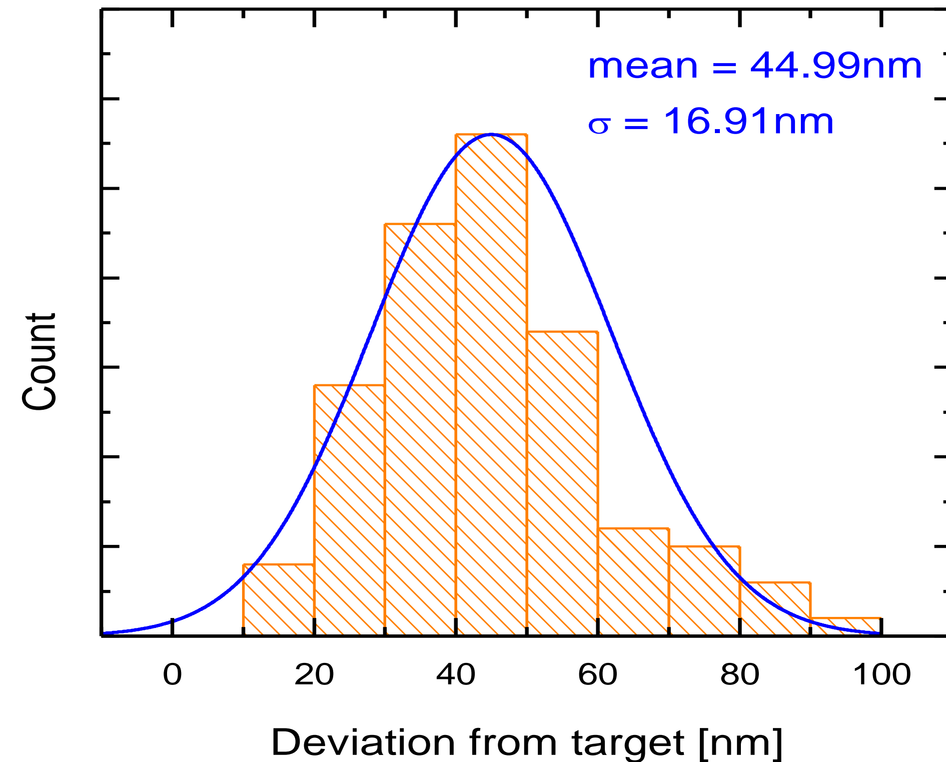
Lithography stage

of a typical setup, these are not guaranteed values.

Repeated relative positioning accuracy



2 Axis absolute positioning test:
Deviations at 500 um of repeated 100 times.



Lithography stage

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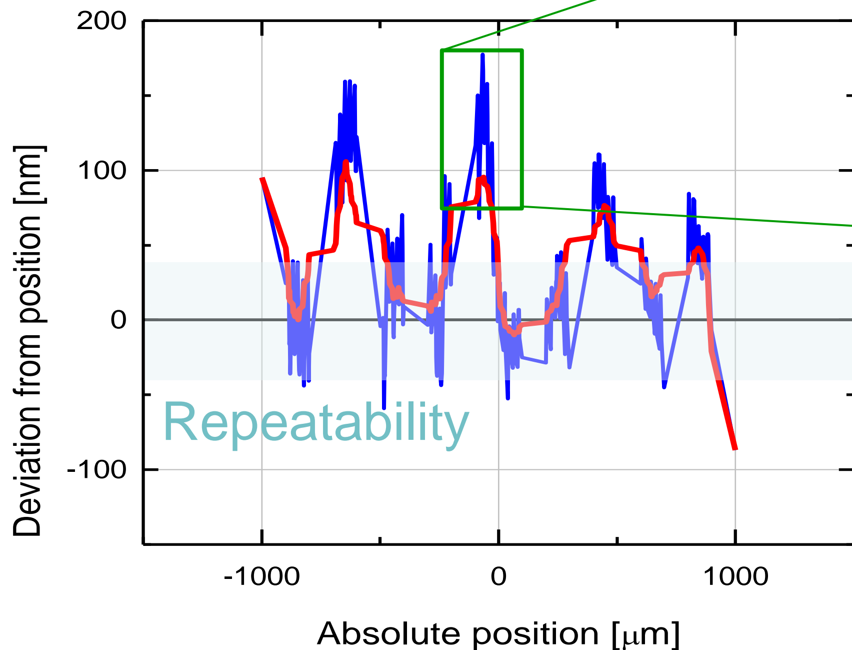
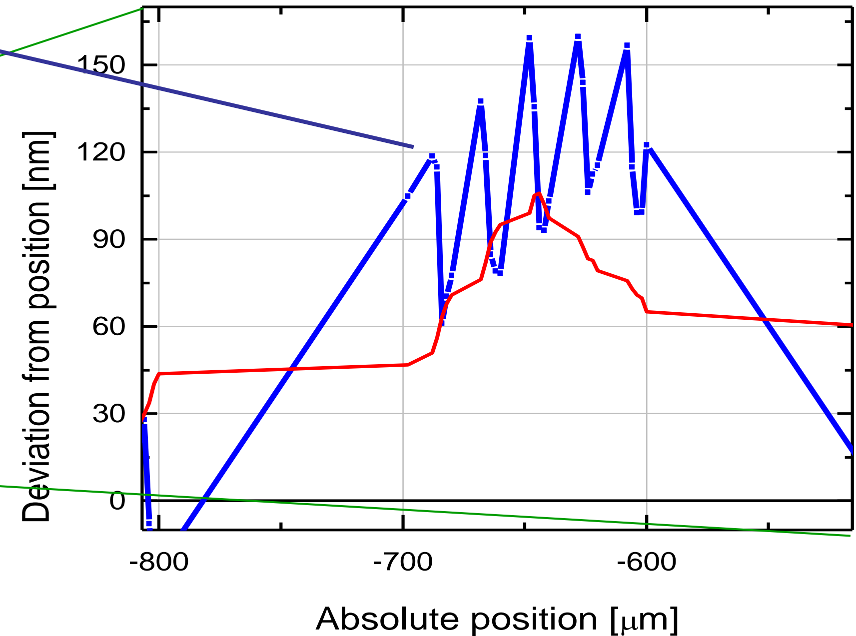
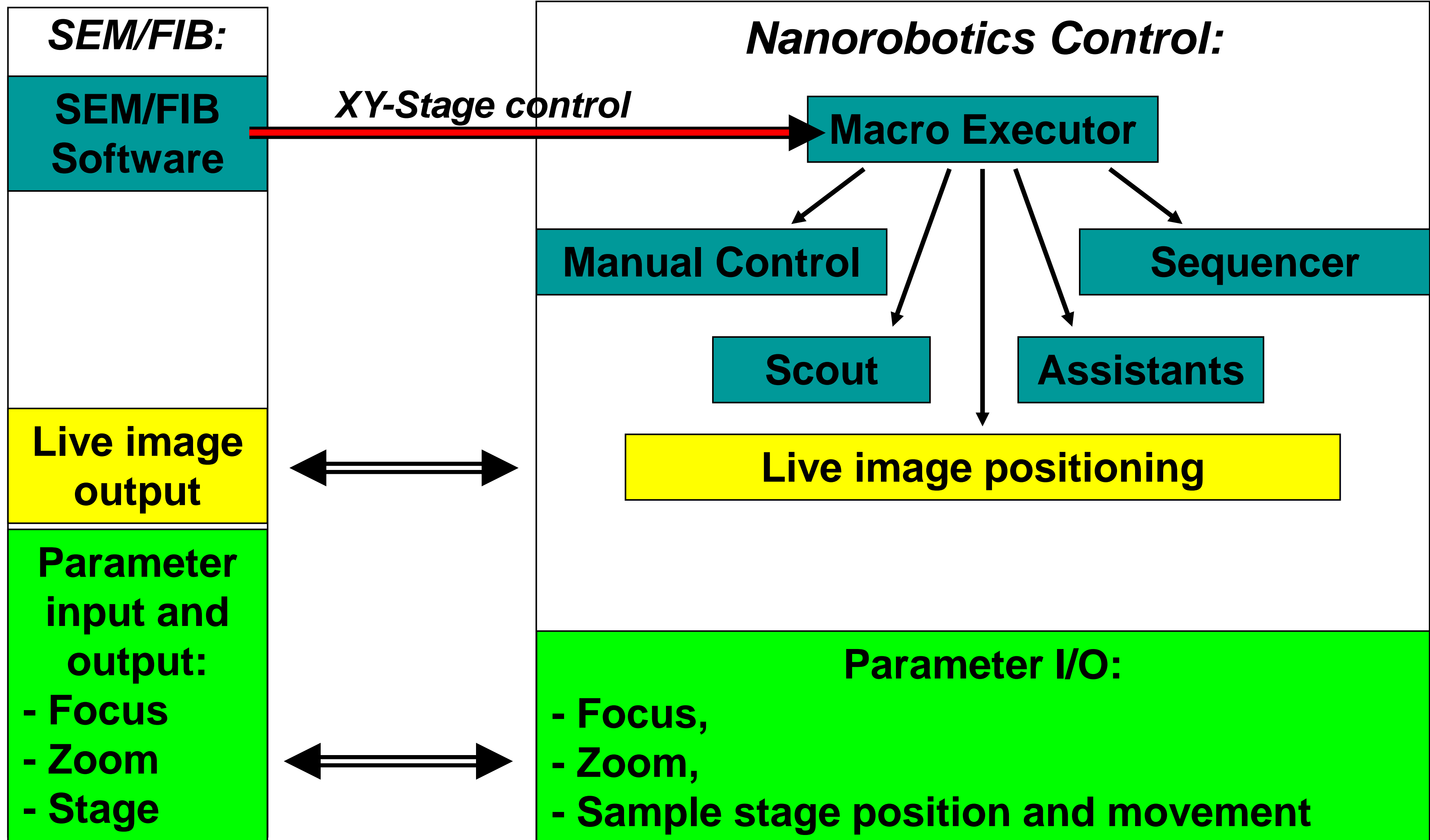
Improvements

Error in data shown above, recently solved by improved Position Measurement System





Nanorobotics Control

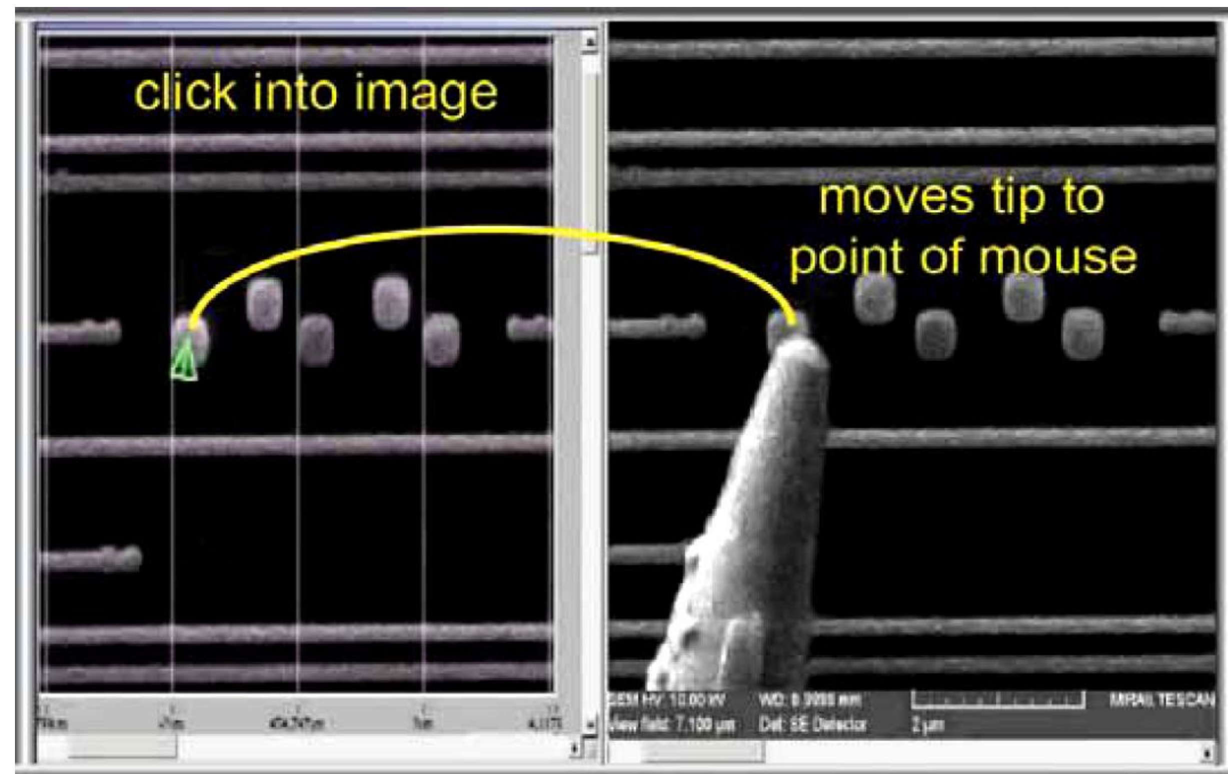


One common control system:

- 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**

Lithography stage

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, …