Micro production systems

... in ultimate precision

Klocke Nanotechnik

Pascalstr. 17
Aachen, Germany

One of 279 members in a

Microtechnology Network

Modular Nanorobotics

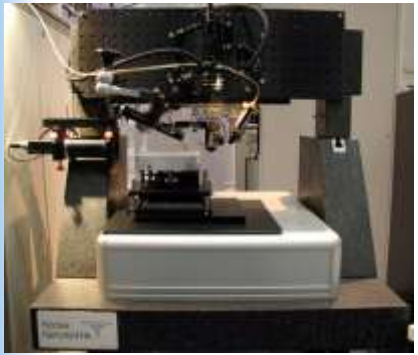
Configuration instead of Development

Pool of more than 200 Nanorobotics Components

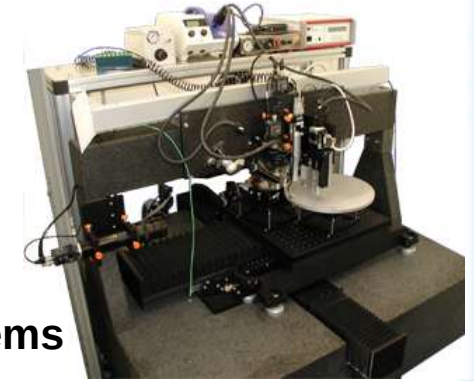
Configuration to individual machines

µ-Assembly, µ-Tensile-Machine, 3D-Nanofinger, SPM-Lithographer, ... **The SEM/FIB Workbench**

Integration in Nanorobotics systems

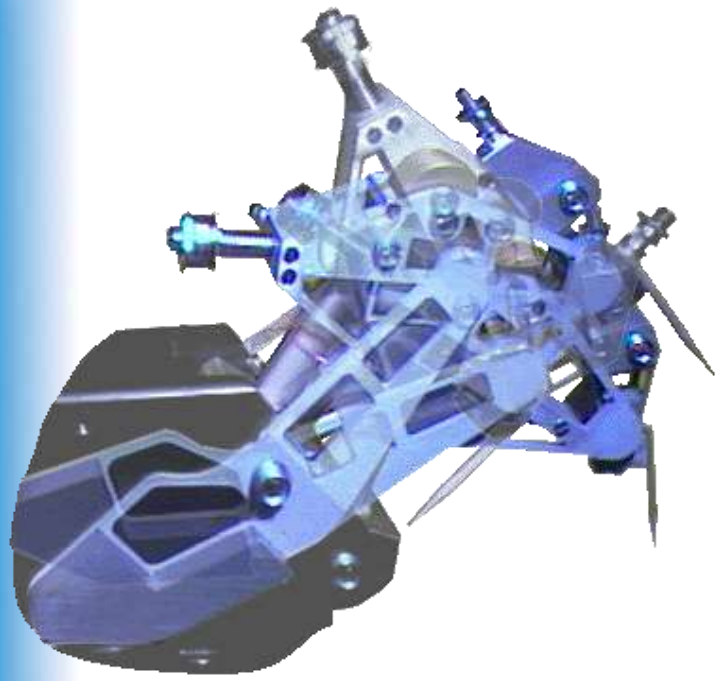


Universal Testing Benches

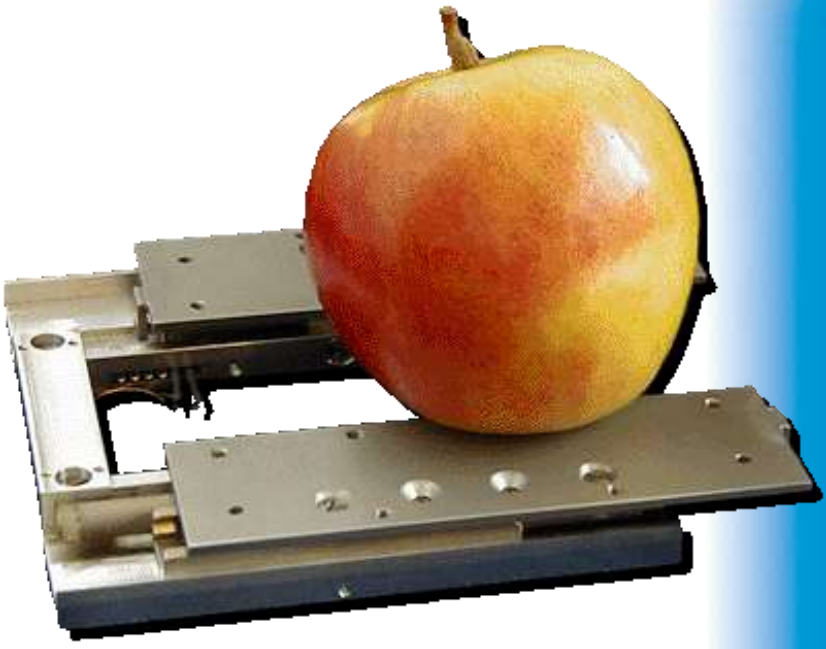


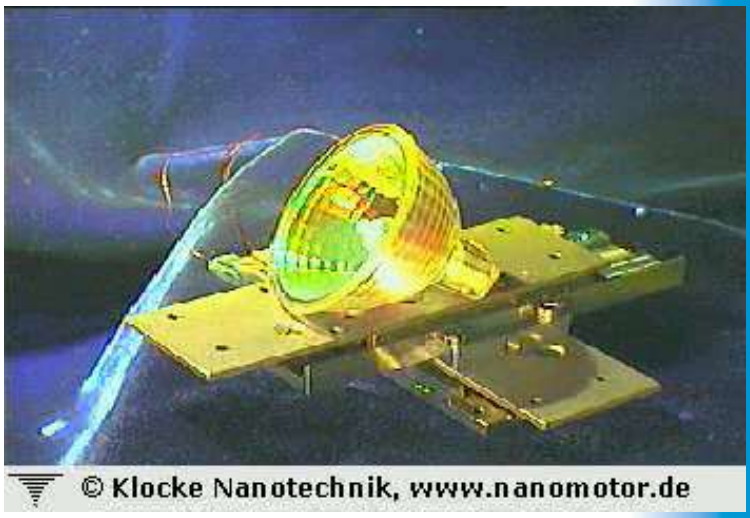
Micro Production Systems

Nanorobotics



5 - 50 mm stroke
Loads up to 2 Kg
1 nm resolution
No backlash





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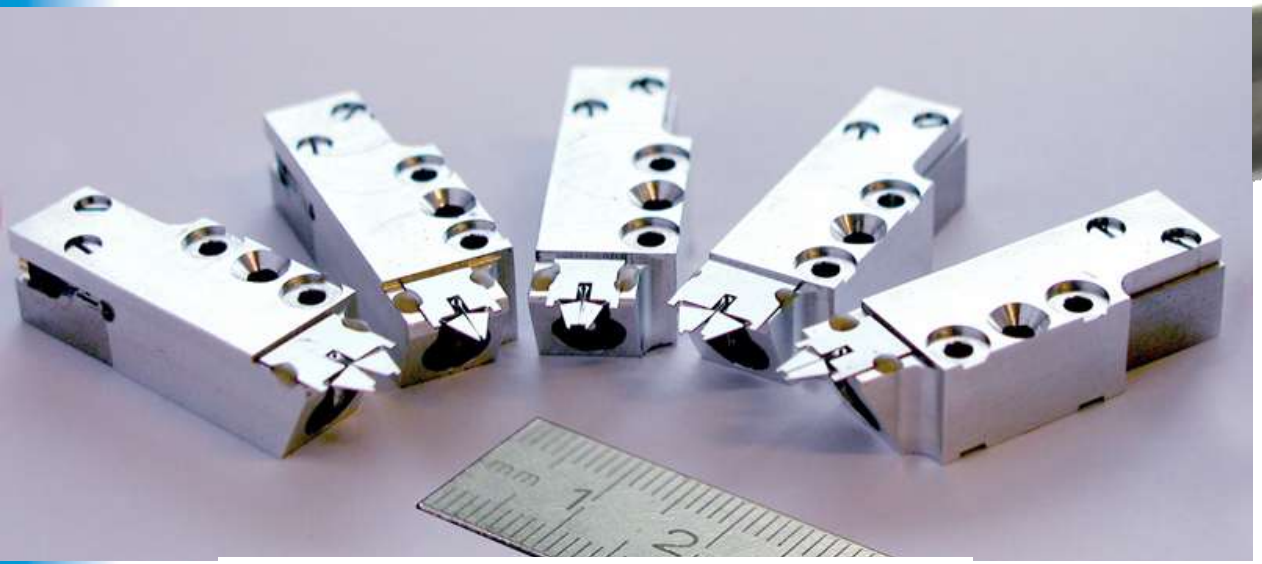
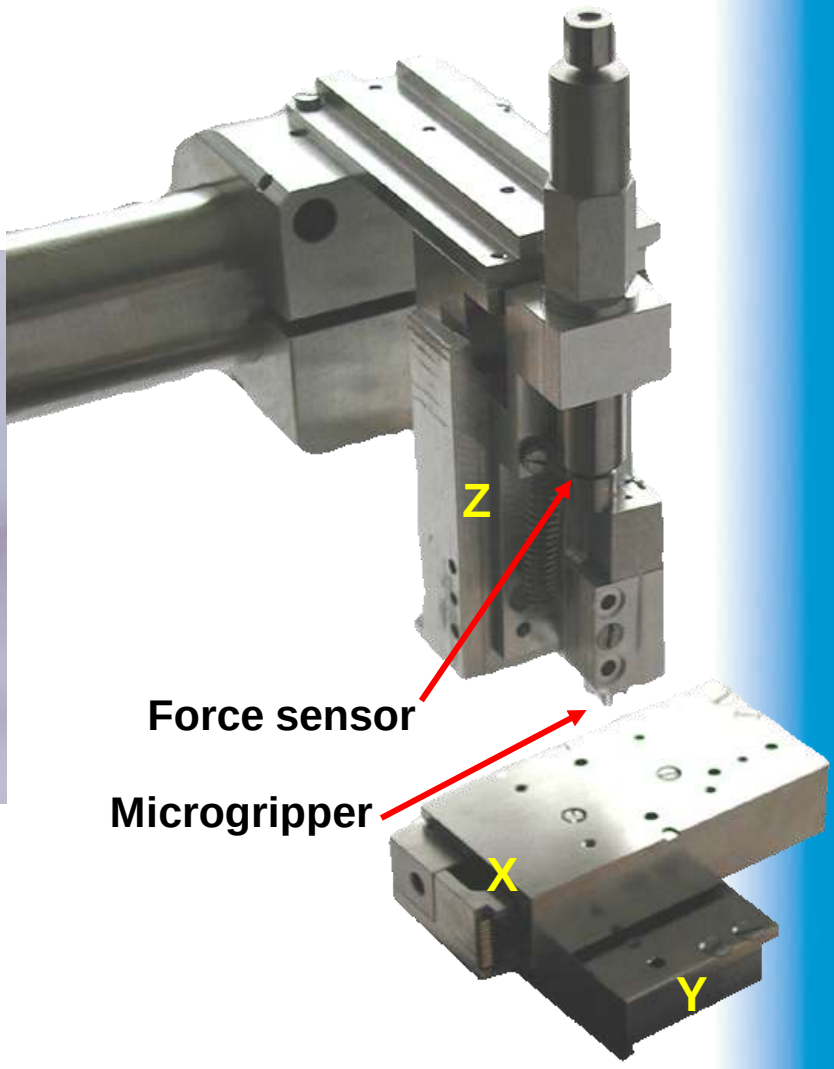
Microassembly-Module

with < 1 nm resolution



Microgripper with 1 nm resolution

and different tip shapes



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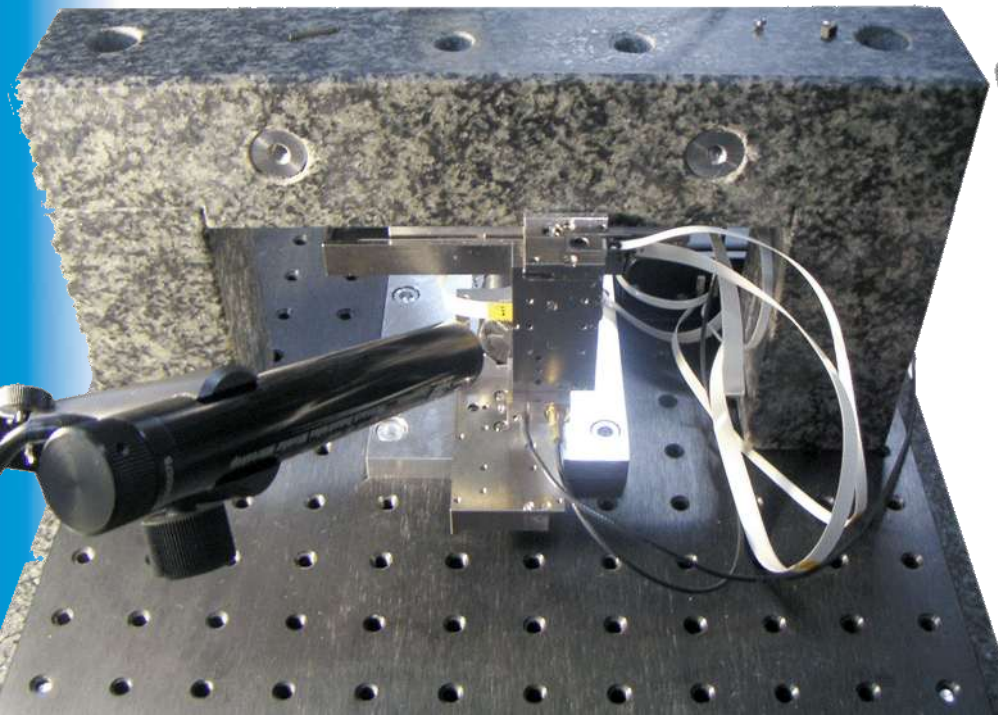
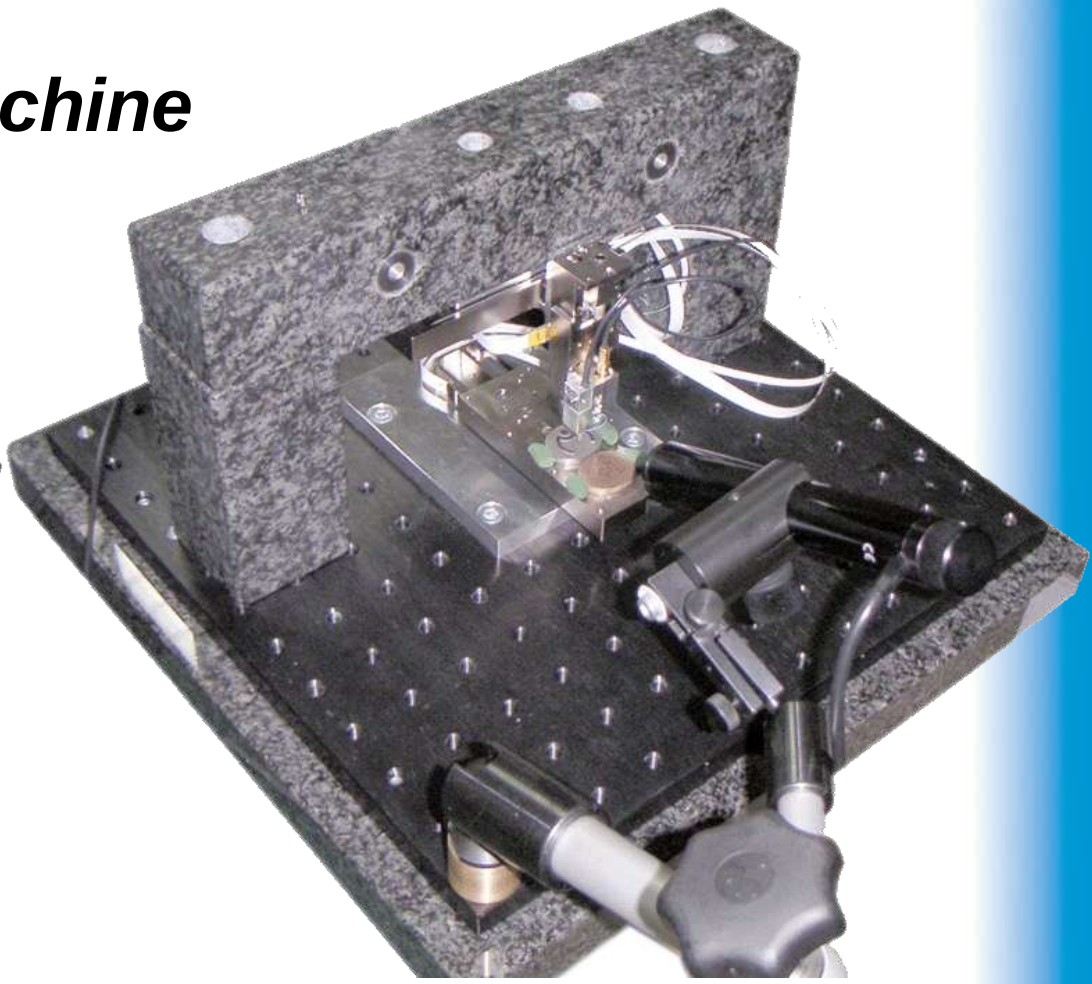
3D-Nanofinger ®

A new instrument between Profilometer and Coordinate Measuring Machine





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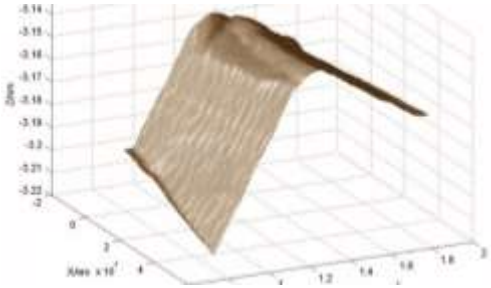
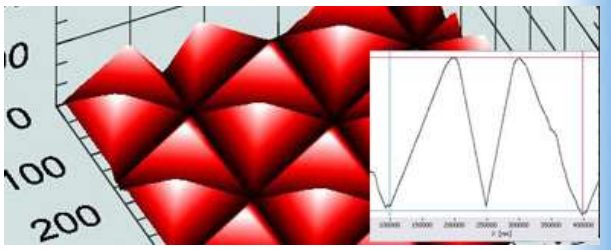
3D-Nanofinger®

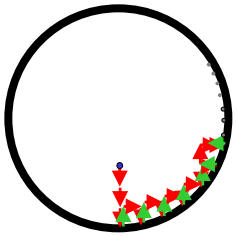
•3D Topography

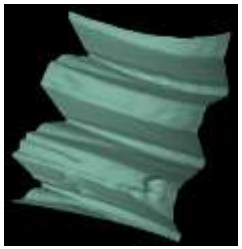


•Dimensions

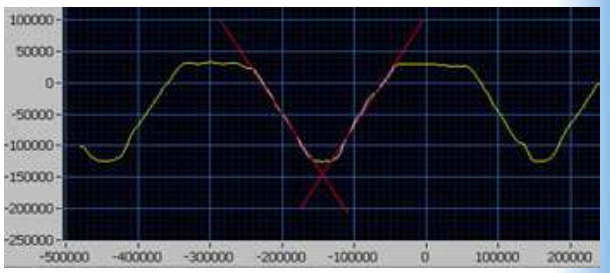


• Contours



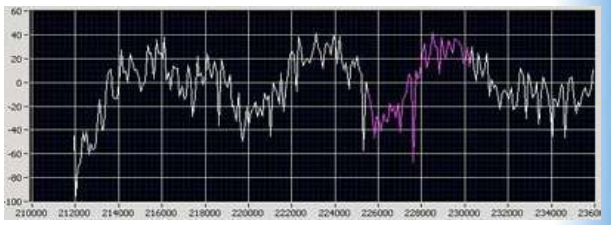


• Angles



- **Stroke:**
  Up to 50 mm in XY and 20 mm in Z
- **Resolution of movement: 1 nm**
  Sensor resolution: 0.5 nm
  Smallest structure size: < 100 nm
- **Automation**

• Roughness



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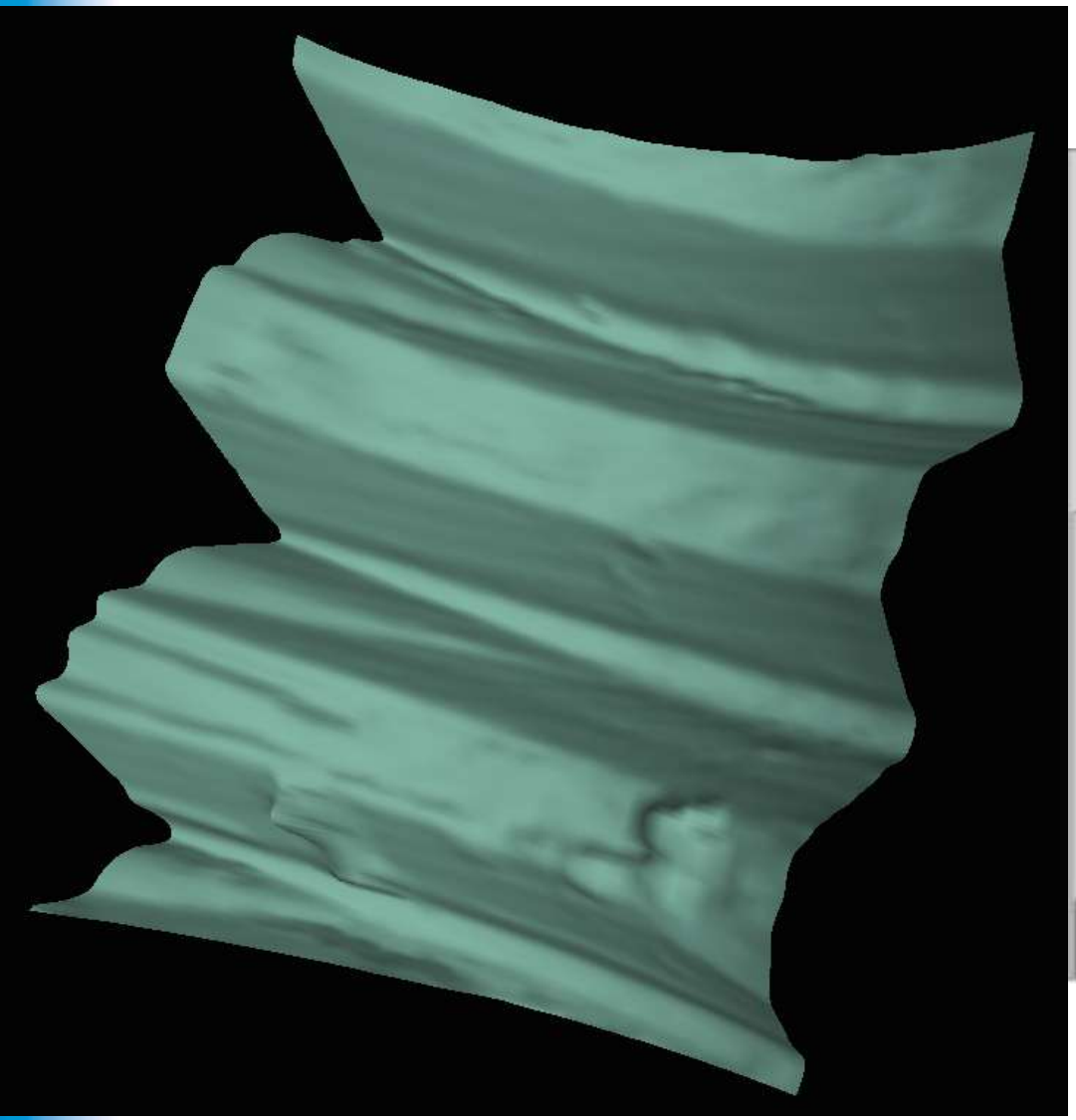
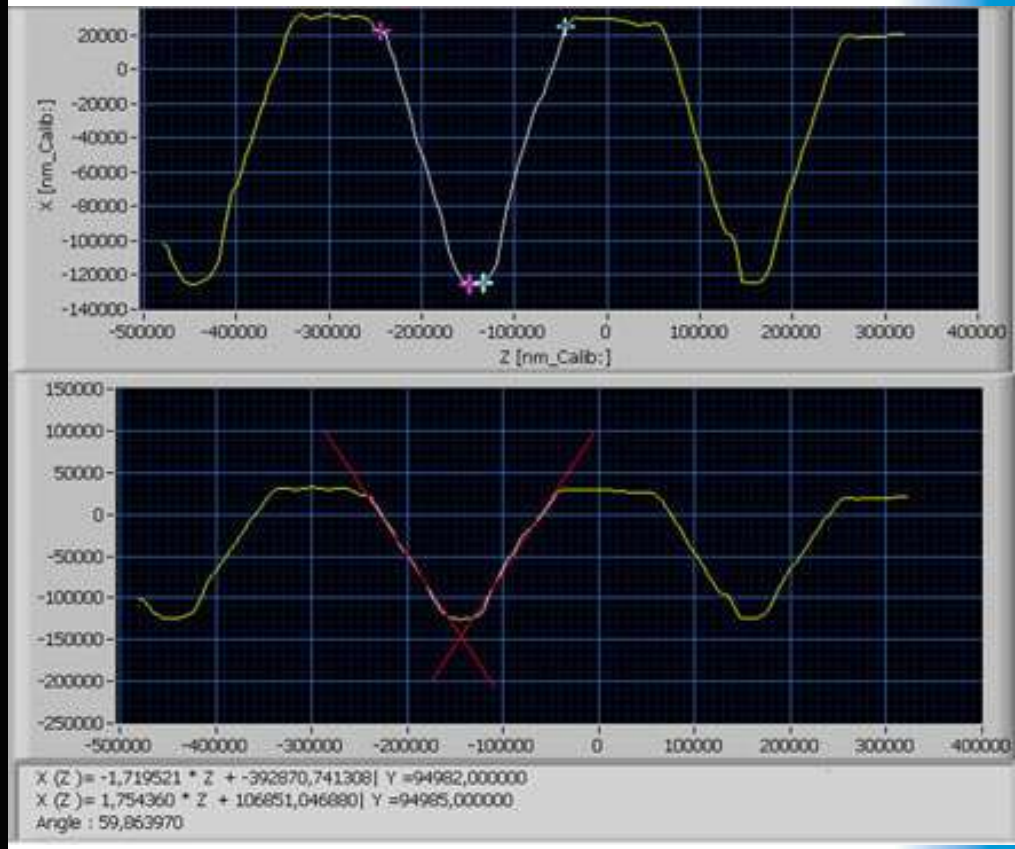
1 Example

Measurements in small holes



Internal screw thread with 1.4 mm diameter



Linescan to determine the winding angle

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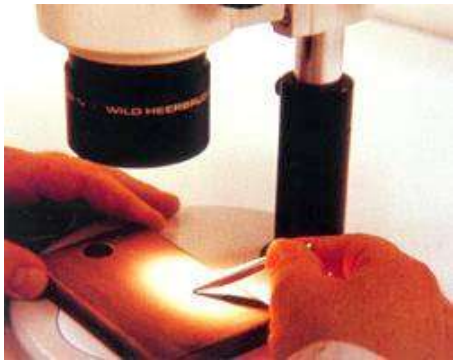
The SEM-FIB Workbench

Handling in SEM/FIB, as easy as at a Light microscope:



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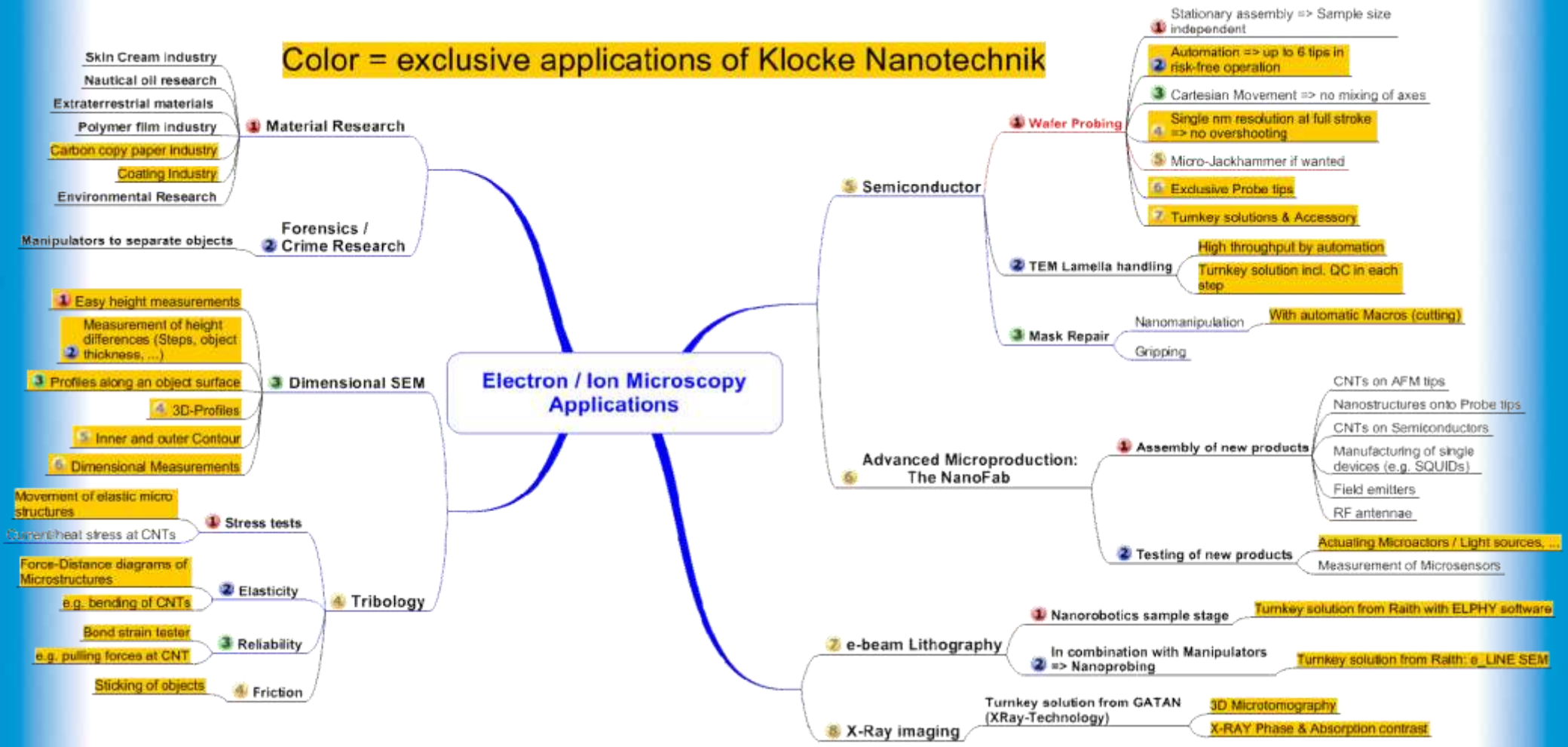
The SEM-FIB Workbench

Applications



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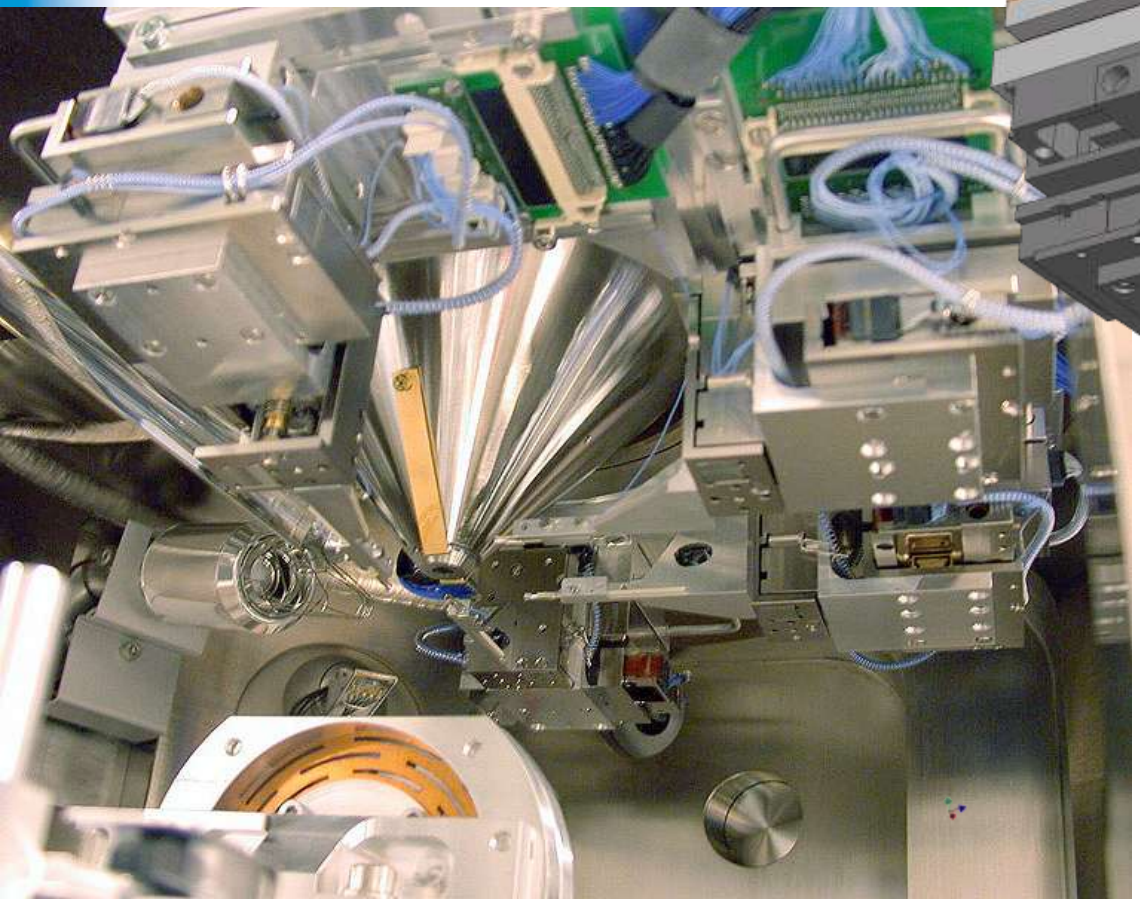
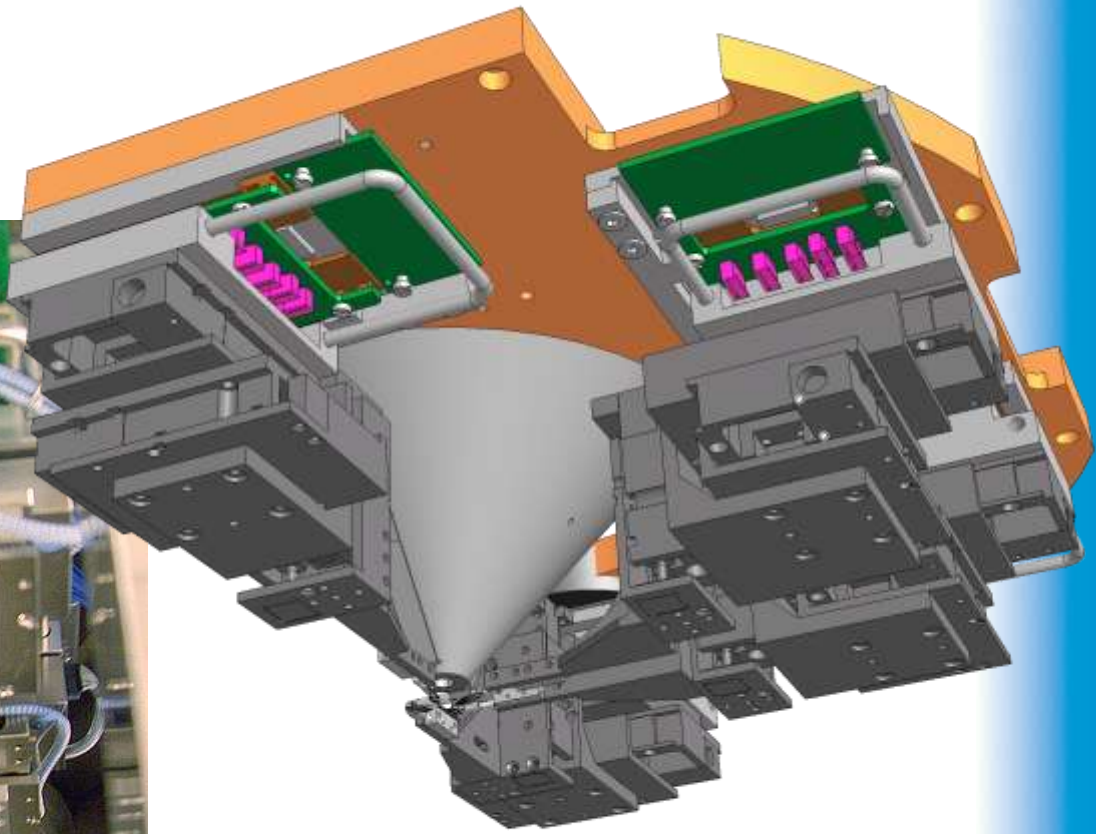
4 Nanorobotics Manipulators

Typical SEM-Integration





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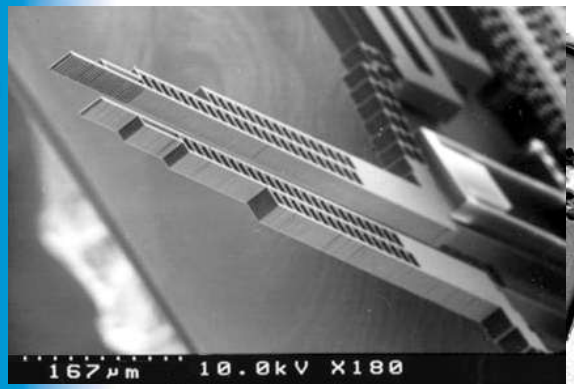
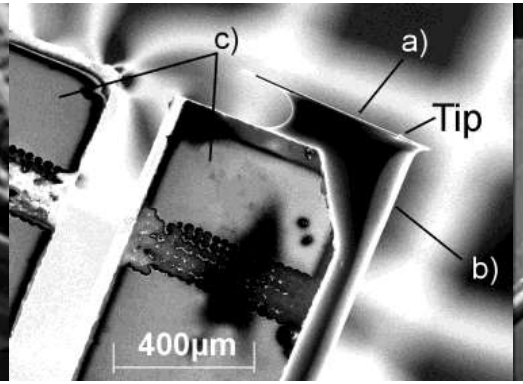
Proof of precision:

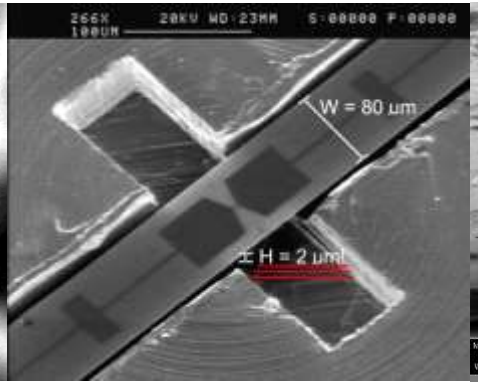
The in-SEM “NanoFab”

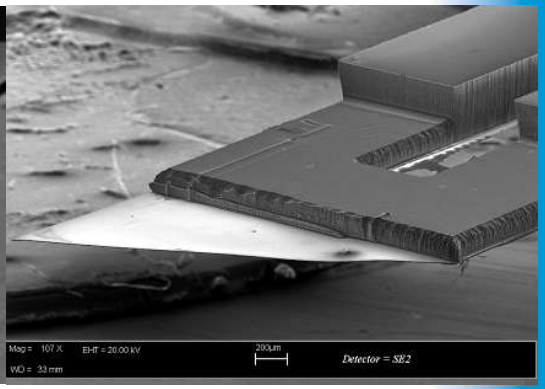
Automatic microassembly of smallest components

- Production of Carbon Nanotube transistors
- AFM tips sharpened by CNTs
- Production of GHz antennas …







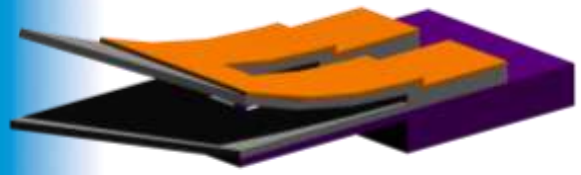


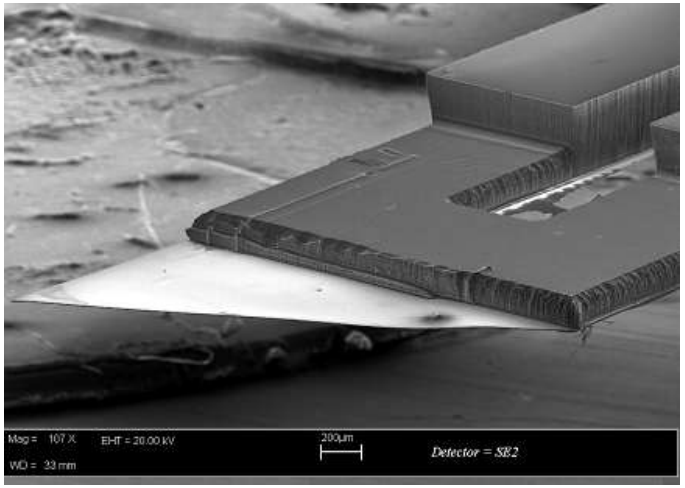
The “NanoFab” from Klocke Nanotechnik in a network of partners:

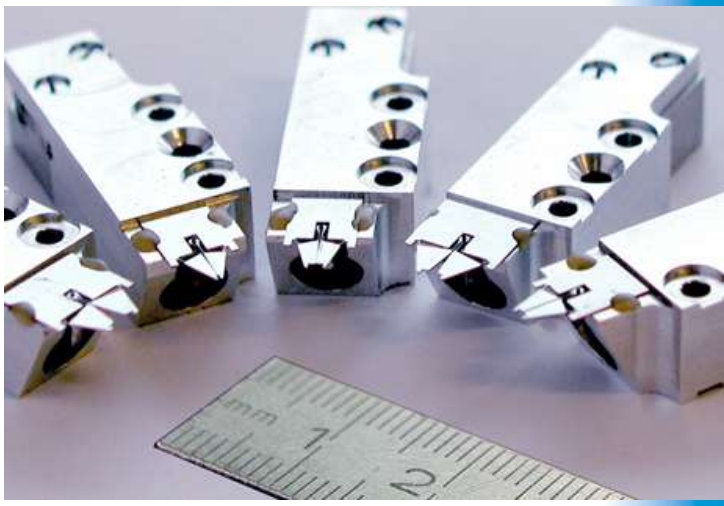
NanoHand · OFFIS · Nascatec Nanoscale Technologies GmbH · EMPA Materials Science & Technology · Institut for Mikro- og Nanoteknologi · ST · csem · VDI|VDE|IT · FUTUREtec Gesellschaft für angewandte Informatik mbH · EurExcel · TESCAN · EPFL École Polytechnique Fédérale de Lausanne · Klocke Nanotechnik

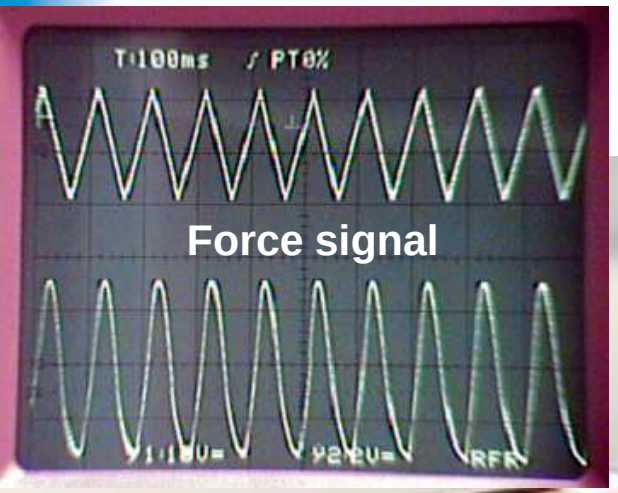
The “NanoFab” in your SEM

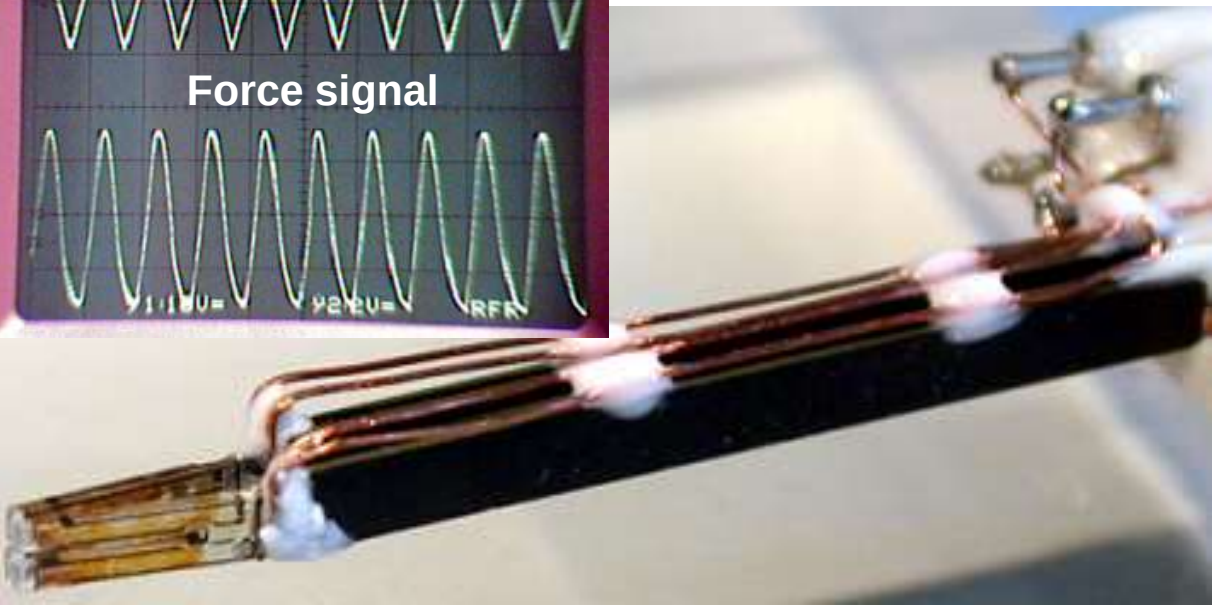
… including several different Microgripper series

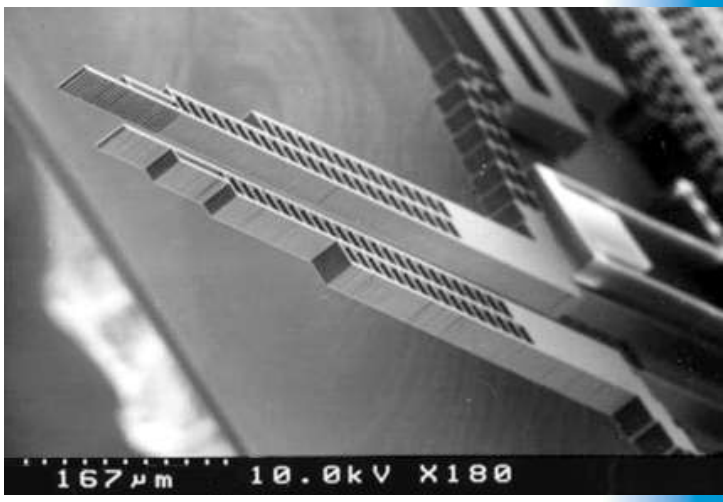












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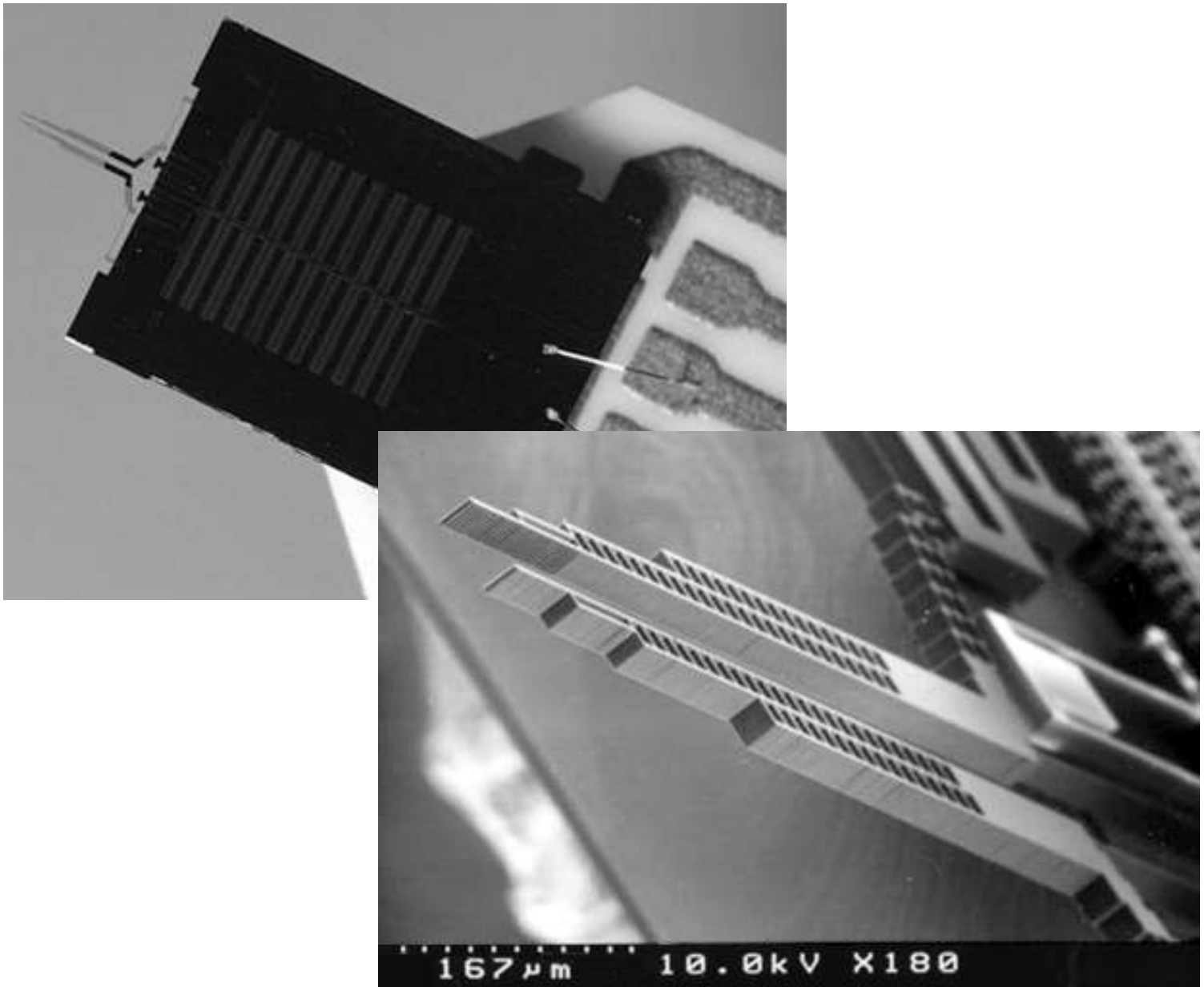
Electrostatic Gripper



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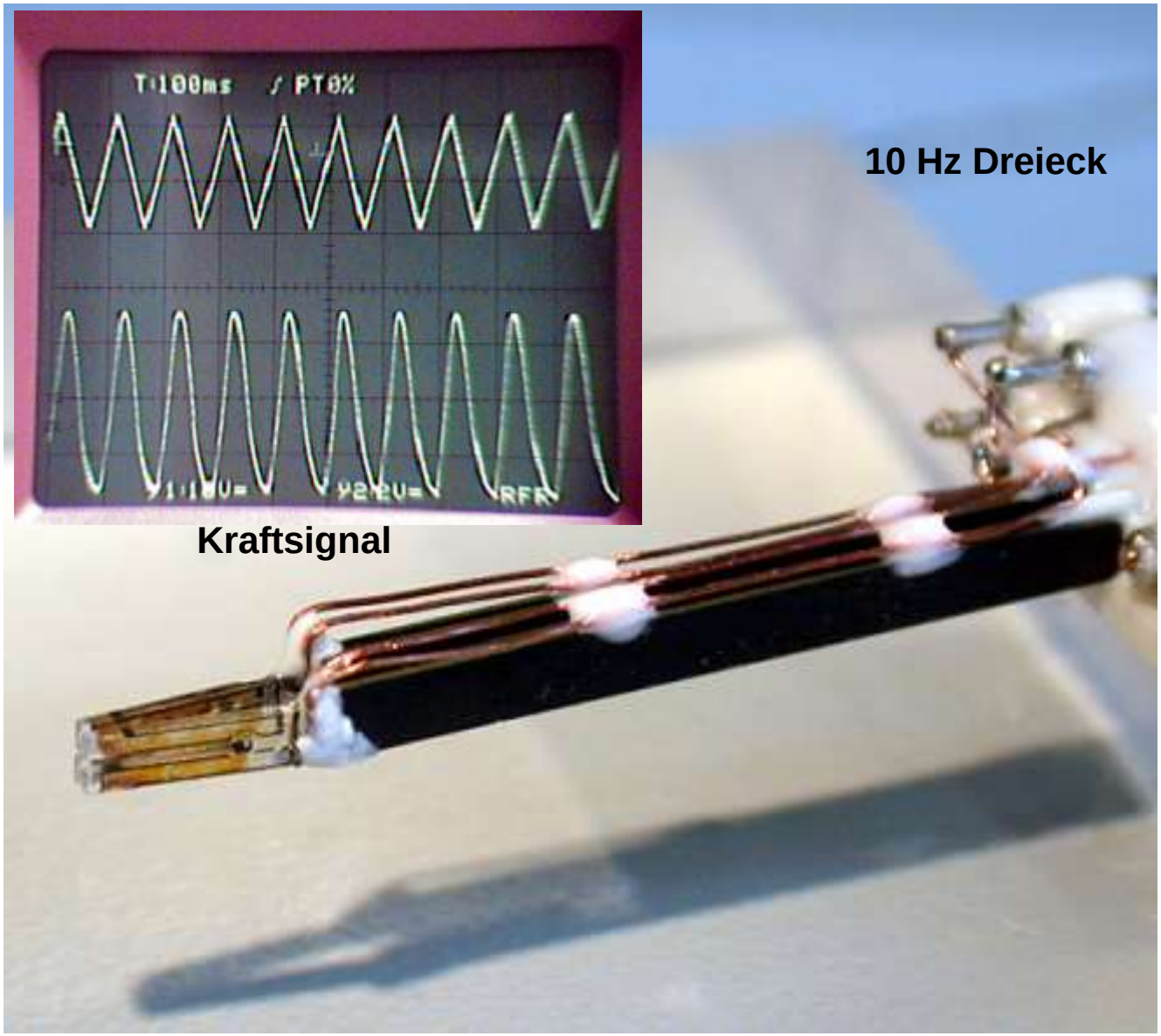
Force Feedback Gripper



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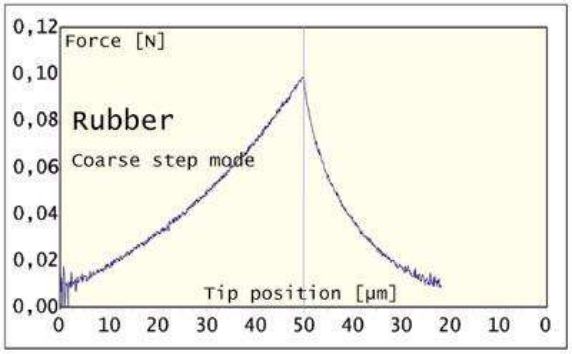
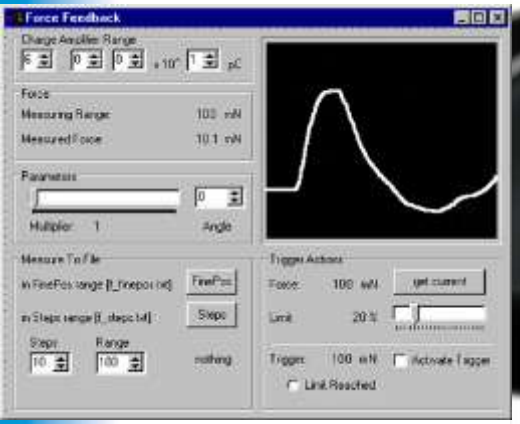
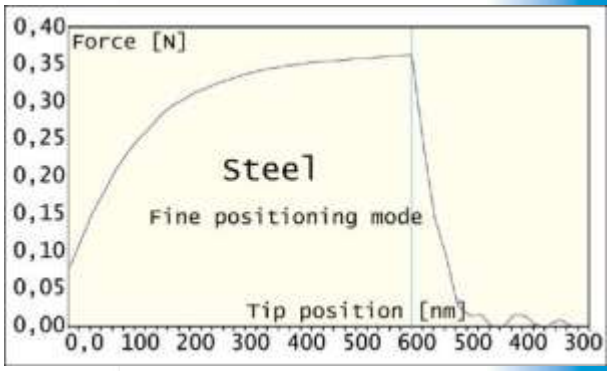
Force Measurement

Haptic interface







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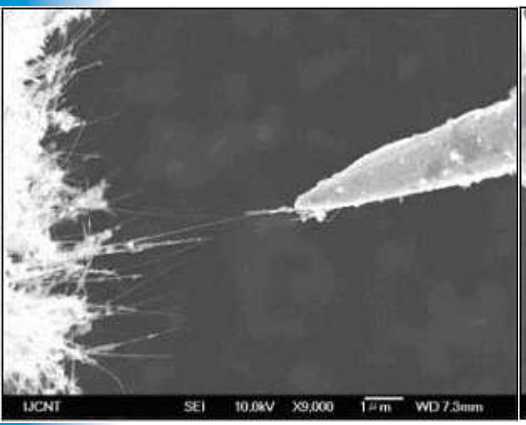
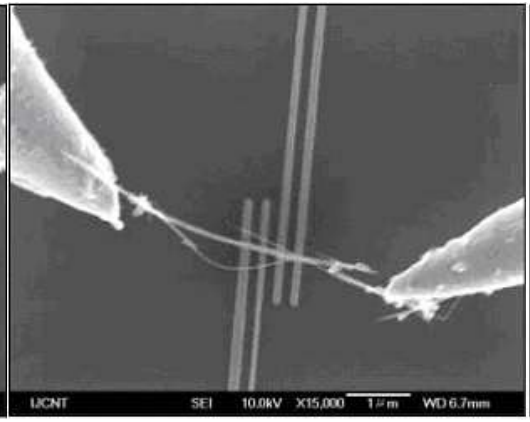
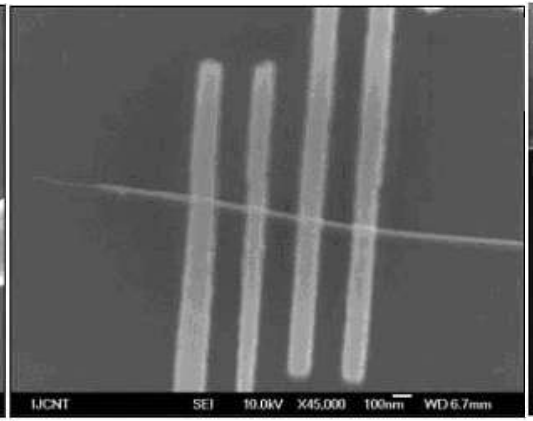
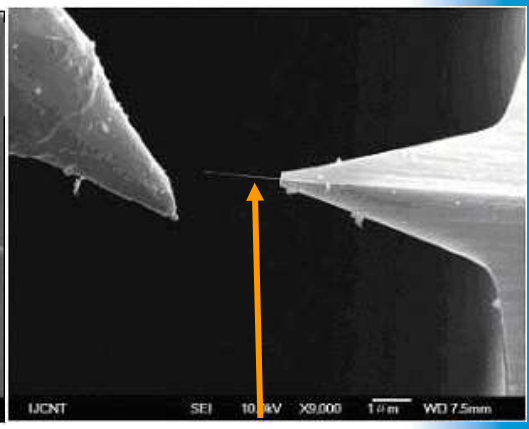
Nanoassembly of Carbon Nanotubes



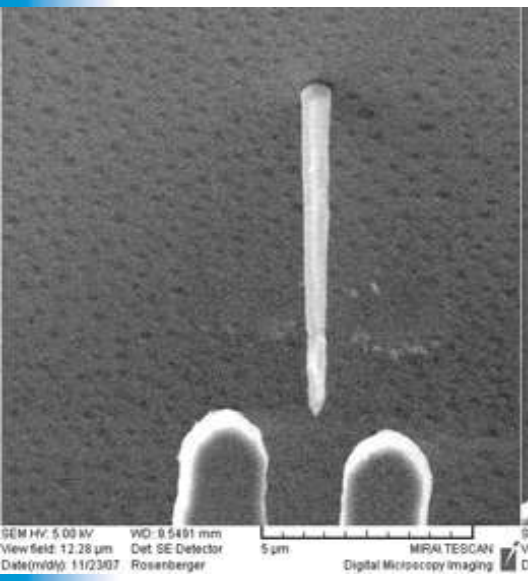


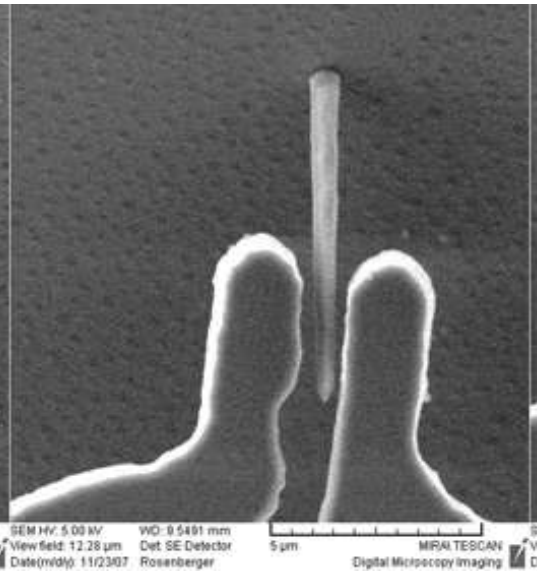


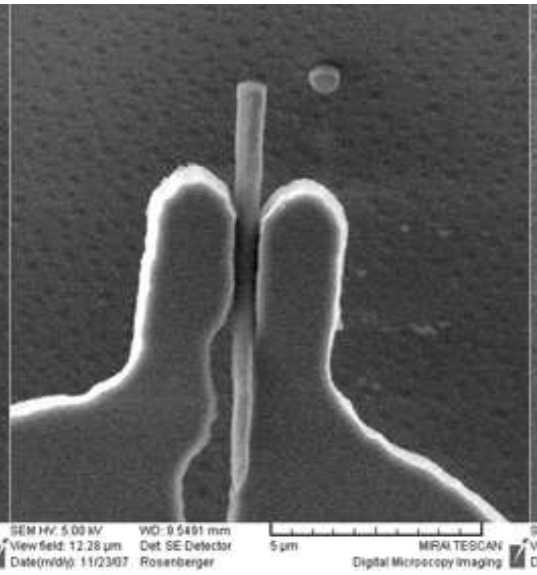
Handling & assembly of a CNT with 2 manipulators

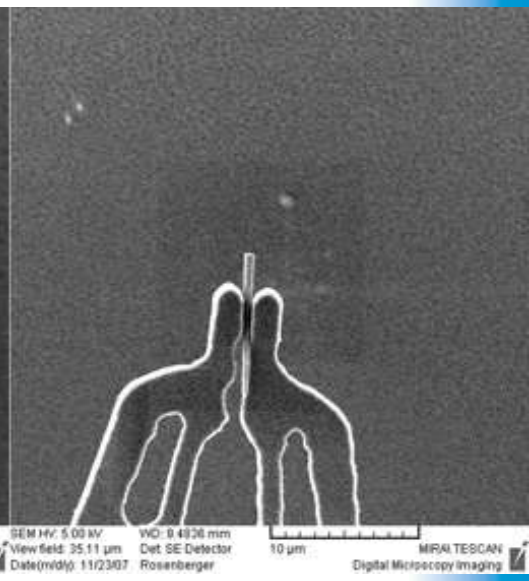


Assembly of a CNT at an AFM-Tip









Handling & assembly of a CNT with a microgripper

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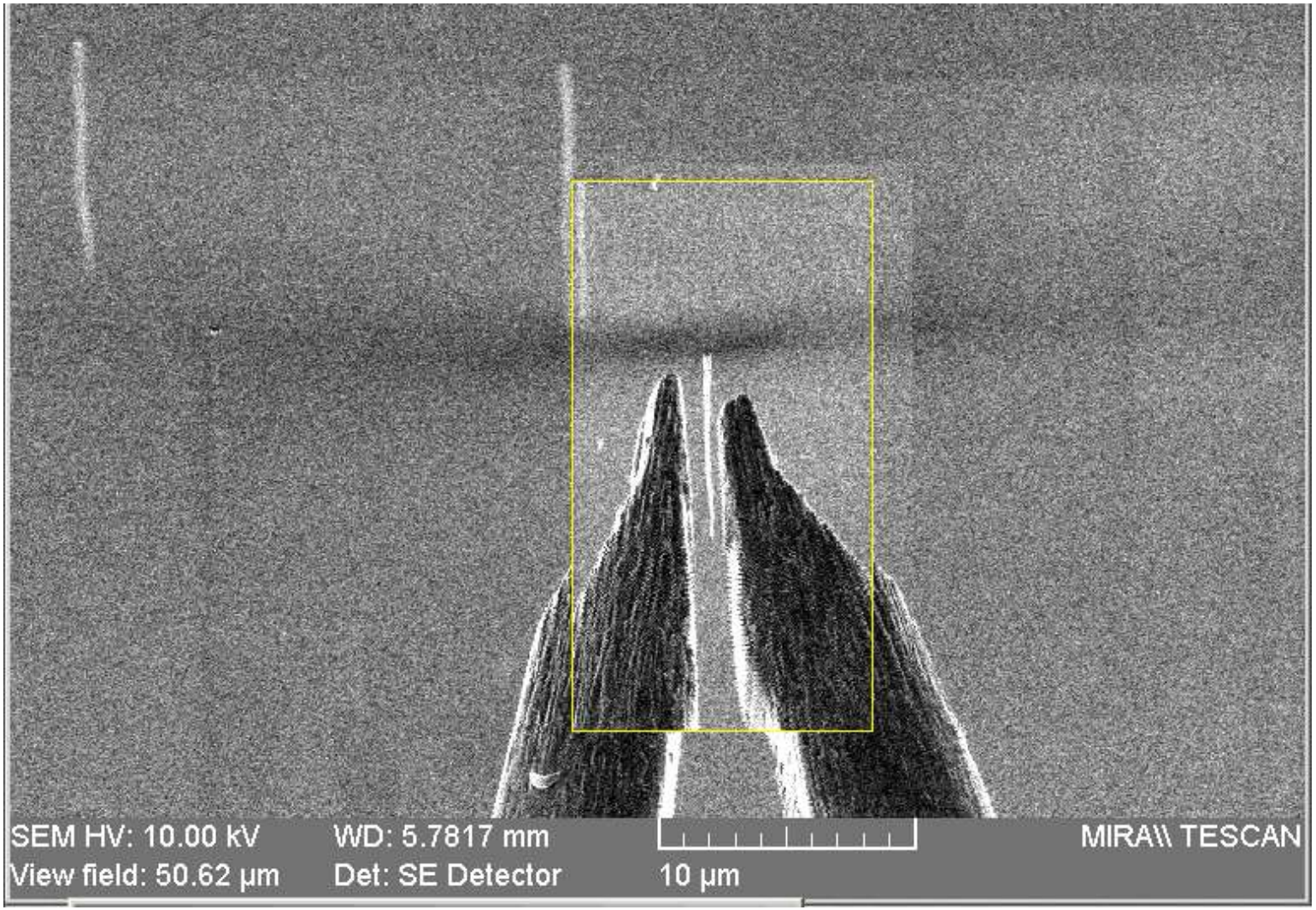
Particle sorting



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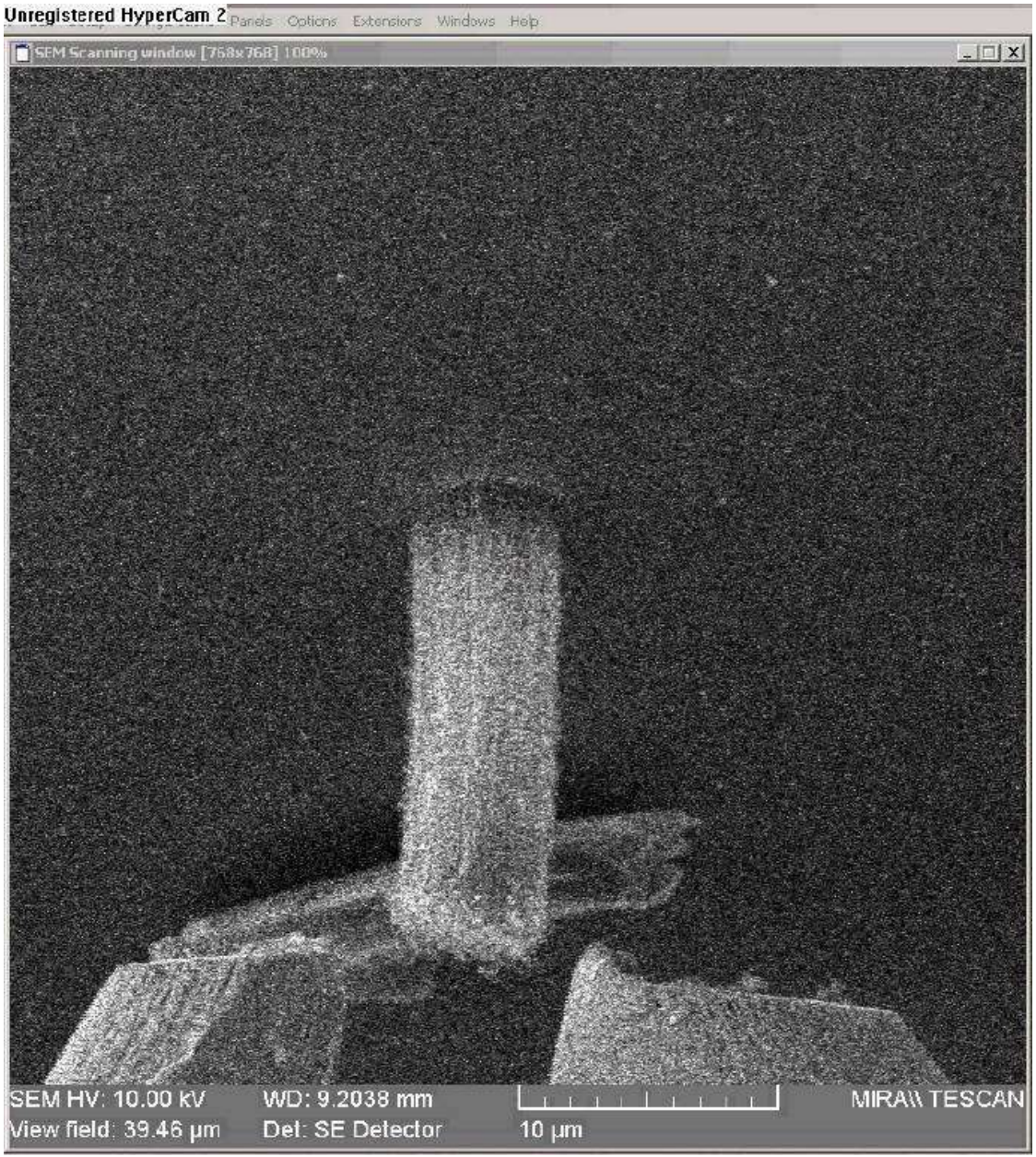
Particle sorting



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Micro Production Systems

The bridge between
Nanotechnology and mechanical
Engineering:

Production island with Nanometer-
resolution for up to Kilograms of load

Operation modes:

- Manual mode with Joysticks
- Automatic functions & manual operation
- Completely automatic process
- Closed loop process with vision control

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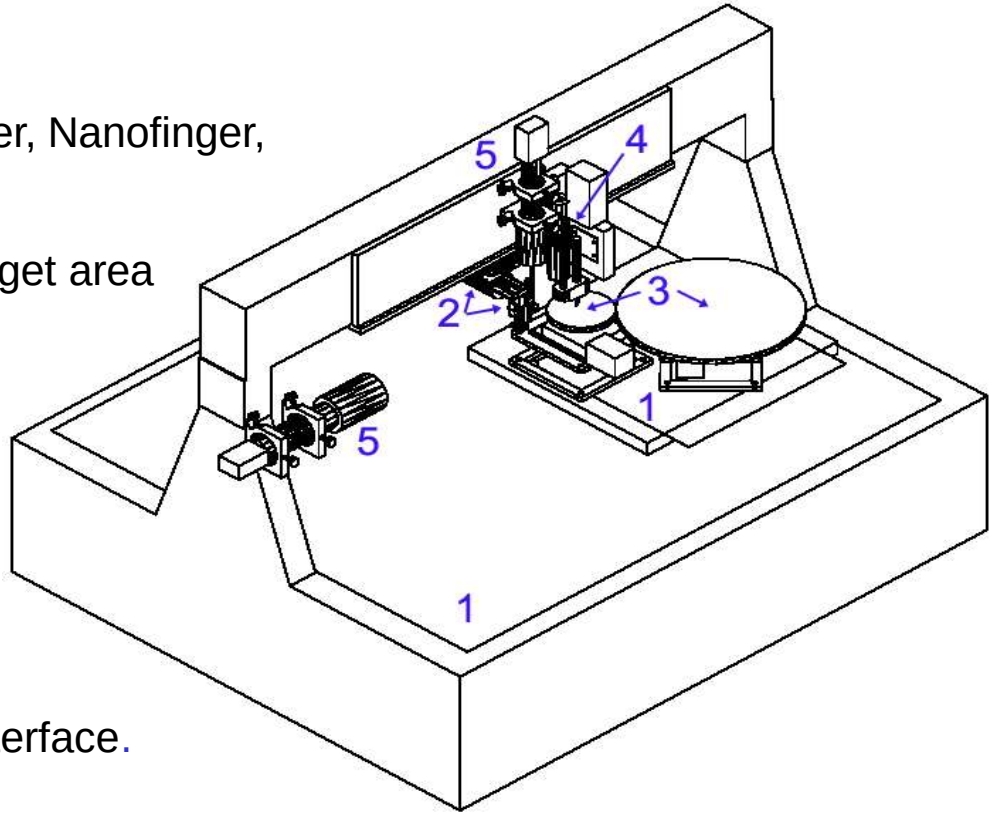
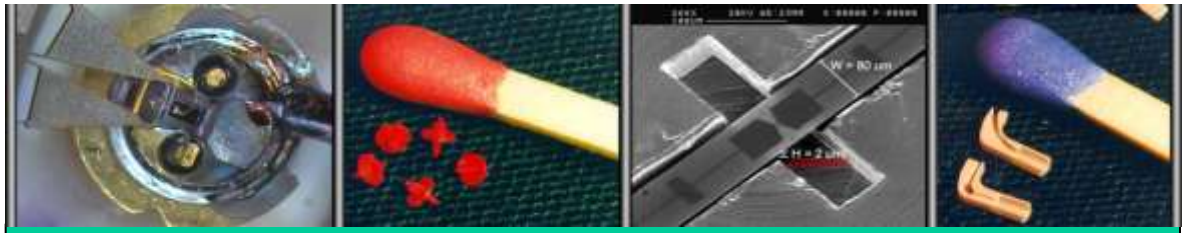
Principle

of setup

1. High precision xy-stage
2. Nanorobotics modules [2], microgripper, Nanofinger, Wafer Prober, ...
3. Two rotation stages for source and target area
4. Adhesive dispenser, Nanomanipulators, Scanning Probe Microscopes, MicroProf®
5. Video cameras with vision software for pattern recognition
6. Process control with graphical user interface.





Laserdiode, Zahnrad mit Welle, HF-Mischer, Sensorgehäuse

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Flexible System Configuration

From Nanomanipulator with Gripper up to:

The most precise production cell available in the market:

- **3D Microassembly and interconnection technology, e.g. including:**
- **Micro Adhesive Bonding, Pattern recognition and Quality Control**

... or a "Universal Testing Bench":

- **For analysis, quality control, reverse engineering, prototyping and repair, incl.:**
- **Nanomanipulators, Wafer Prober, Force Sensors, Inspection Systems for:**
- **I/V or force measurements, failure analysis, prototype development or repair**

... or both, configured by yourself:

- **Choose components out of a wide range of our kit, we deliver that special system.**
- **Change and add components later as you like**

In any case:

- **It's 10 – 100 times more precise than other solutions!**

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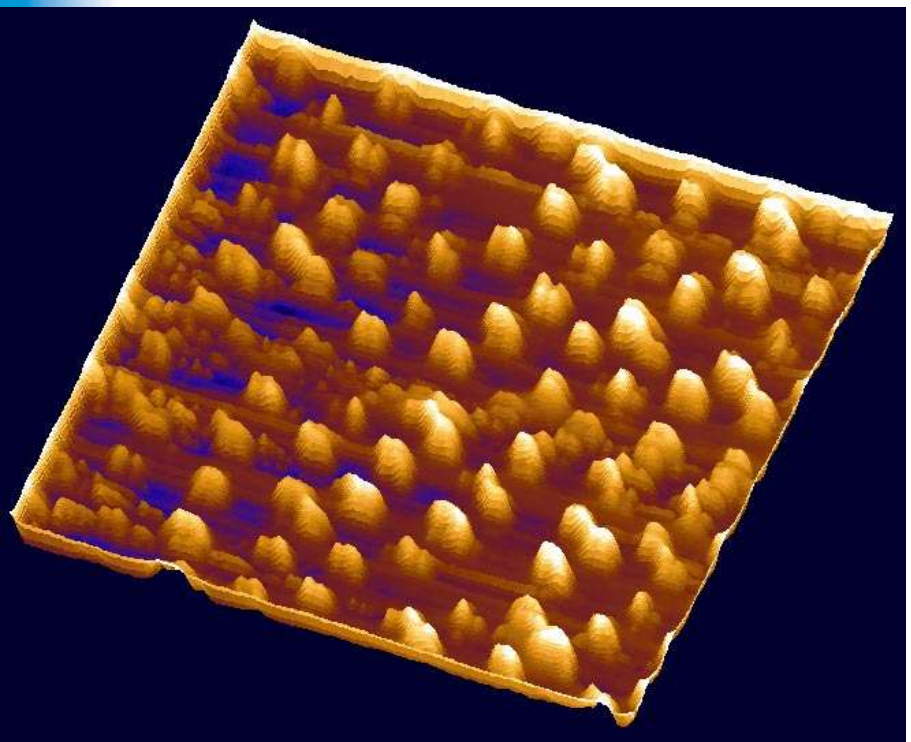
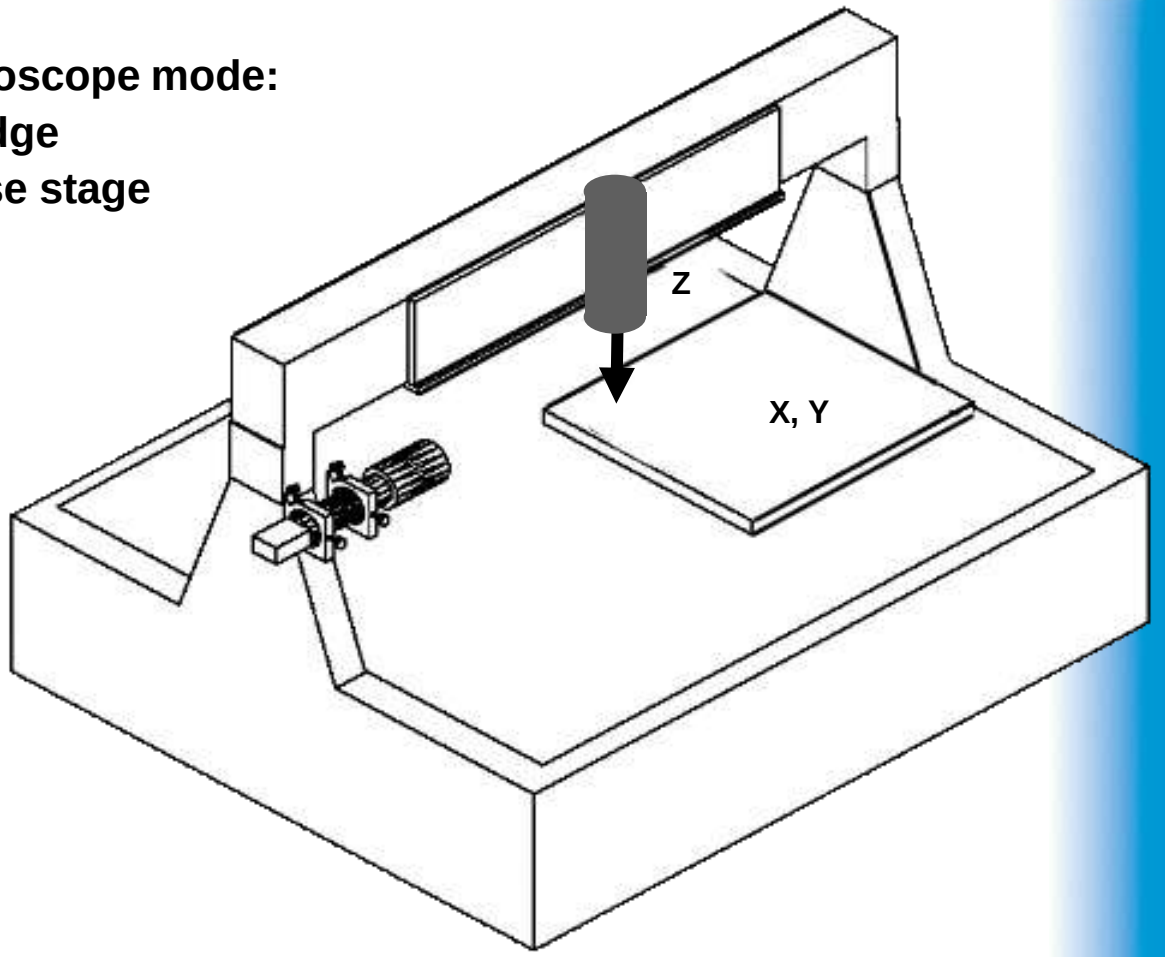
Resolution of the Base Stage

Test in Scanning Tunneling Microscope mode:
Z-axis of an STM fixed at the bridge
XY-movement made with the base stage

=> 3D image of CD bits!





Noise in the image: about 50 nm!

First Expansion Step

with 1 nm resolution

Klocke
Nanotechnik

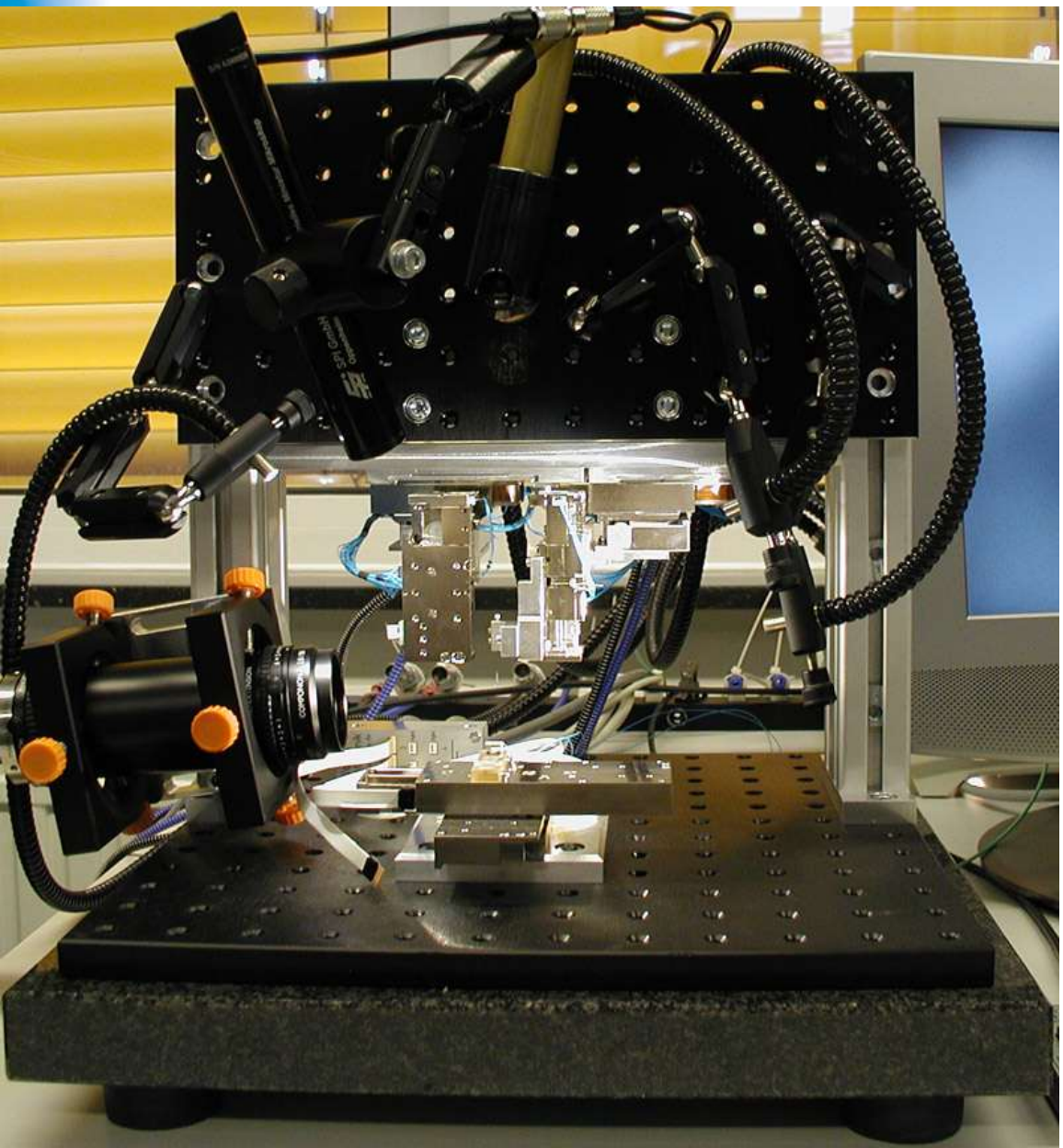
Second Expansion Step

Including Automation

Klocke
Nanotechnik

Second Expansion Step

with more D.O.F.



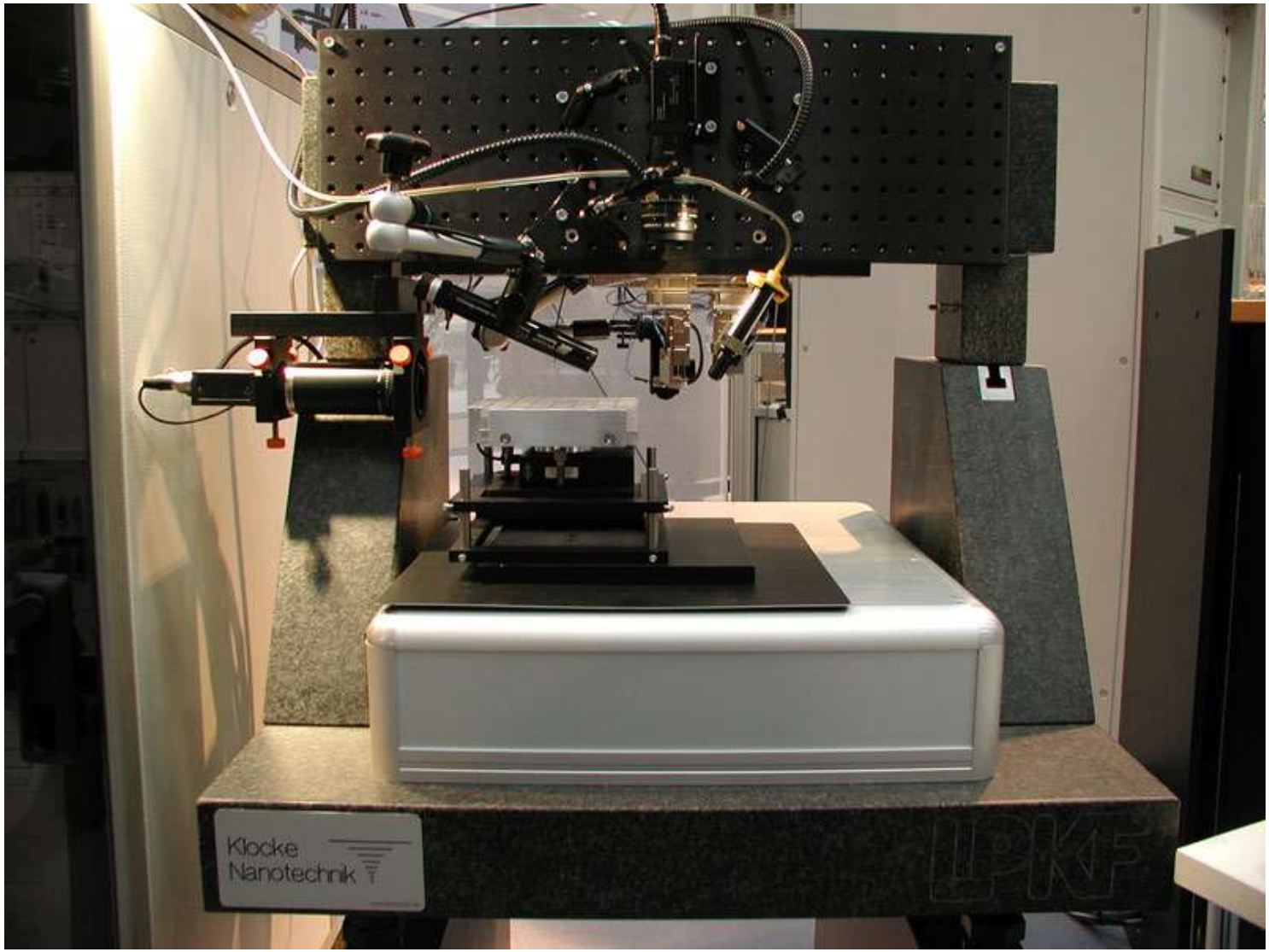
- **Base stage: X, Y, rotation**
- **2 XYZ Manipulators**
- **3 different Microgrippers**
- **Micro adhesive bonding dispenser**
- **Micro Tensile Testing modules**
- **Wide range zoom video microscope**
- **High resolution video microscope**
- **3 Cold light sources**
- **Sequencer for automation**

Klocke
Nanotechnik

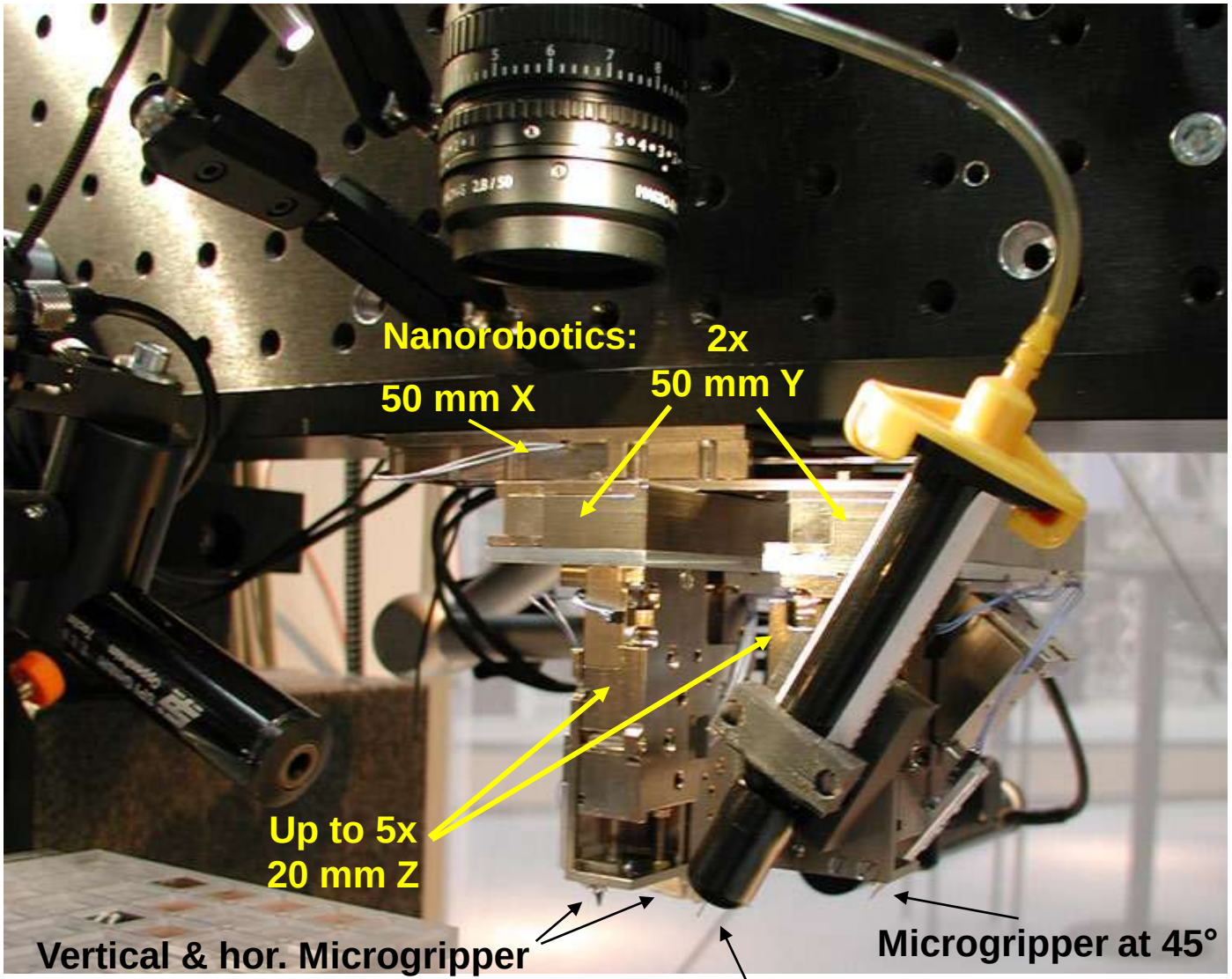
The small System

Klocke
Nanotechnik

... with 100x100 mm² Stroke



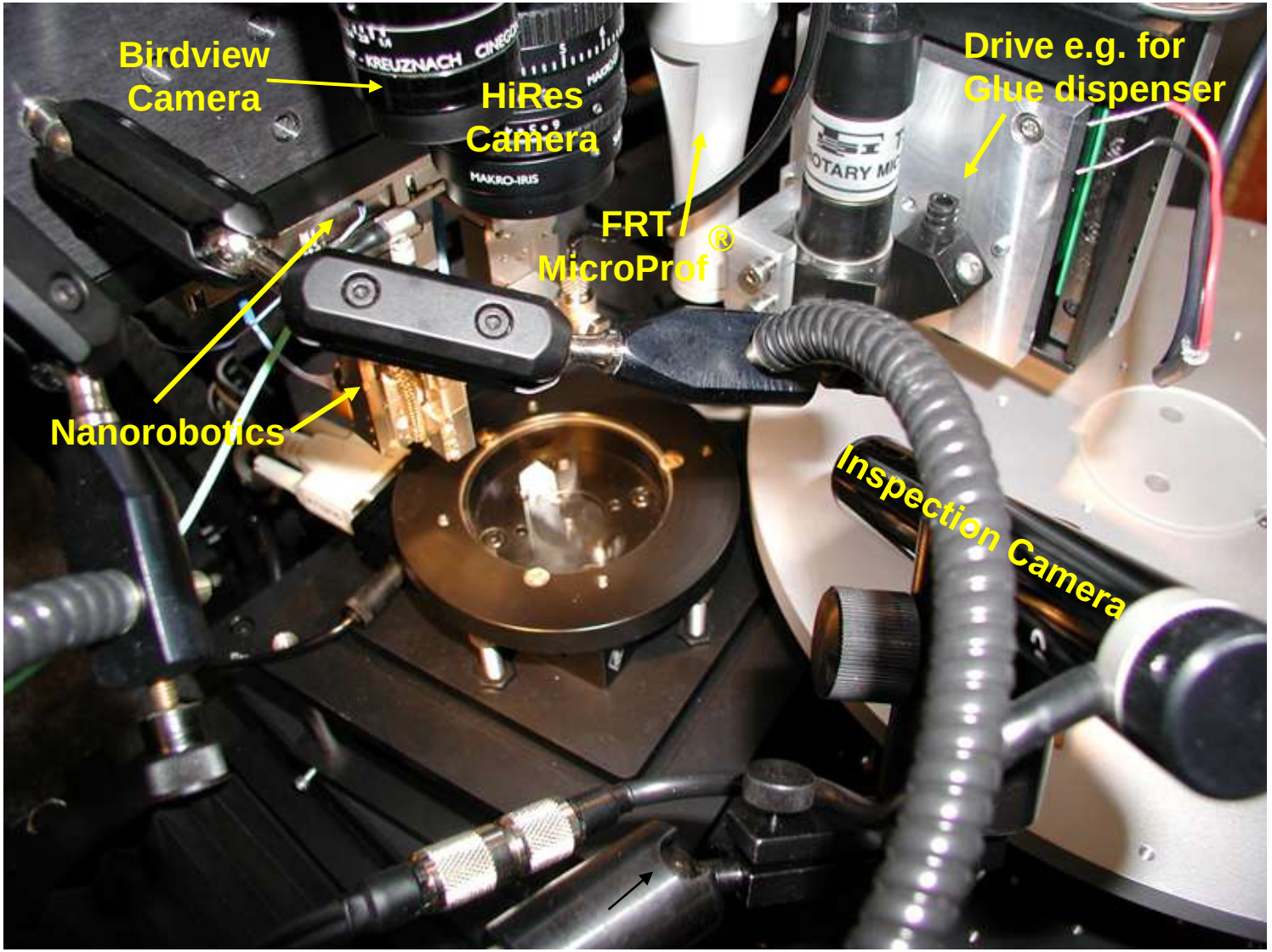
... in Detail



Klocke Nanotechnik

The big System

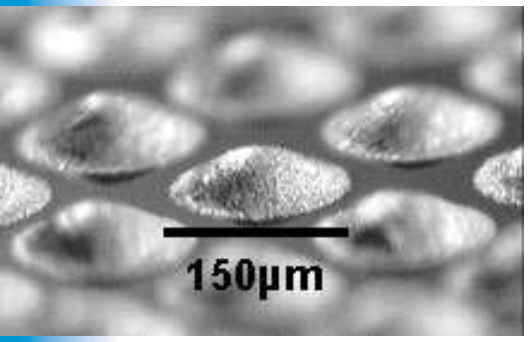
... some components



Klocke Nanotechnik

…including Micro Adhesive Bonding,

- Joining of many different materials
- Multi-functionality of the joint (e.g. mechanical fastening plus conductivity)
- Low heat / cold joining
- Low mechanical stress, uniform stress distribution
- Galvanic isolation of the parts (no contact corrosion)
- Small solutions and new freedom for design



Conductive adhesive

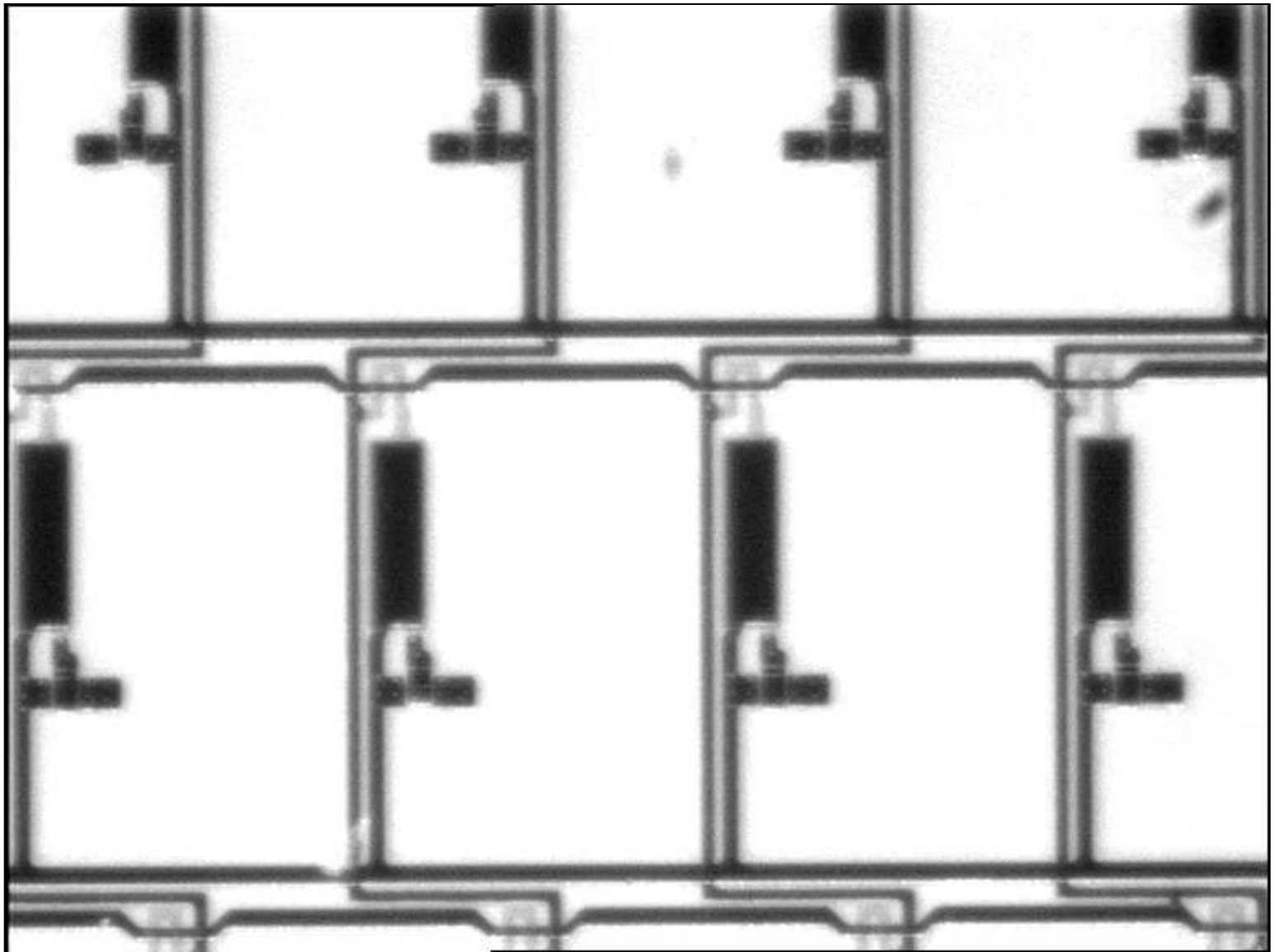
Endoscope Objective,
Ø 1,85 mm (Wolf GmbH)

VCSEL diode after active alignment glued into SMD housing. Coupler to glass fiber (Spinner GmbH)

Klocke Nanotechnik

… with Pattern Recognition

of single pixels



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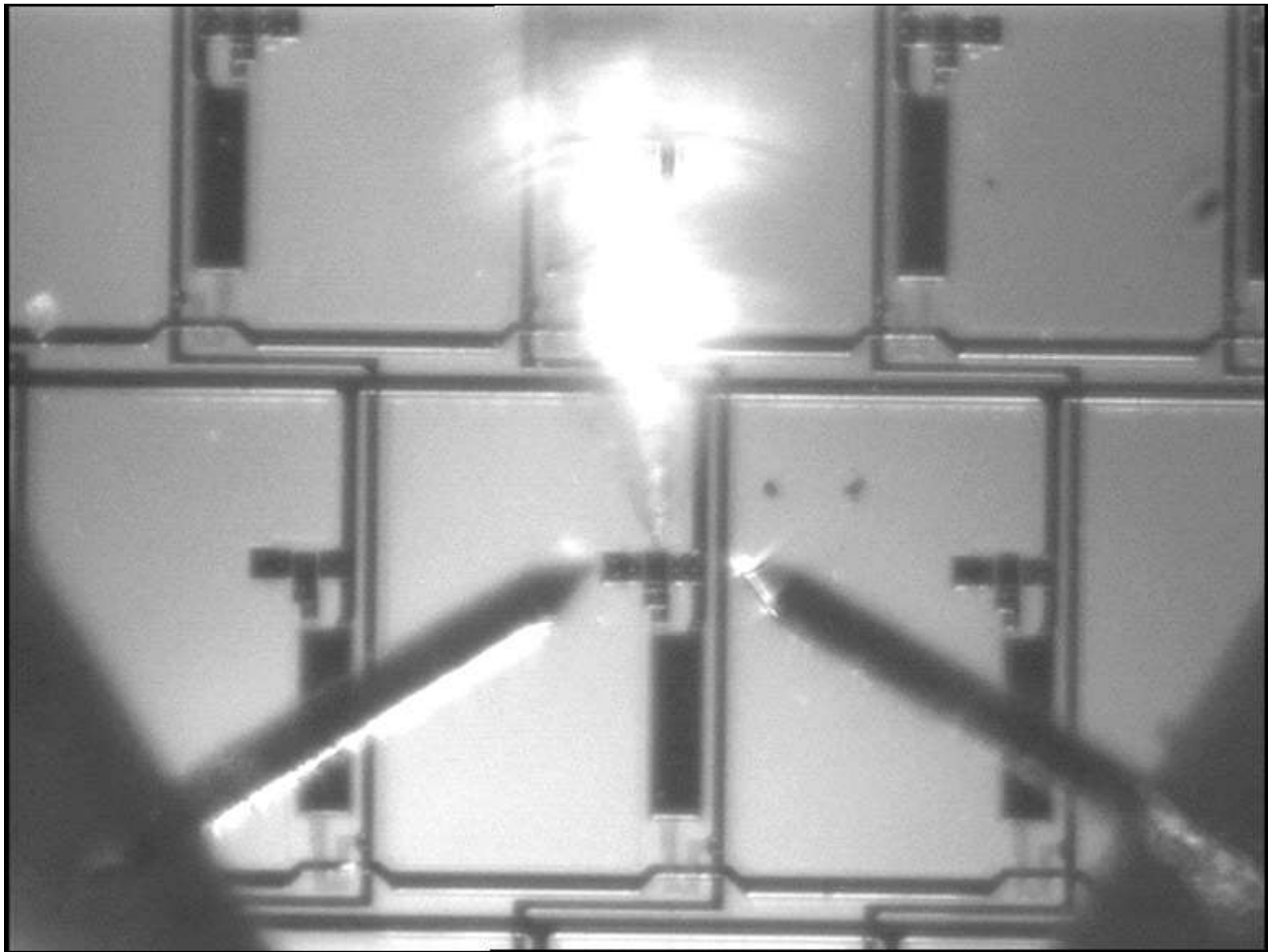
Nanotechnik

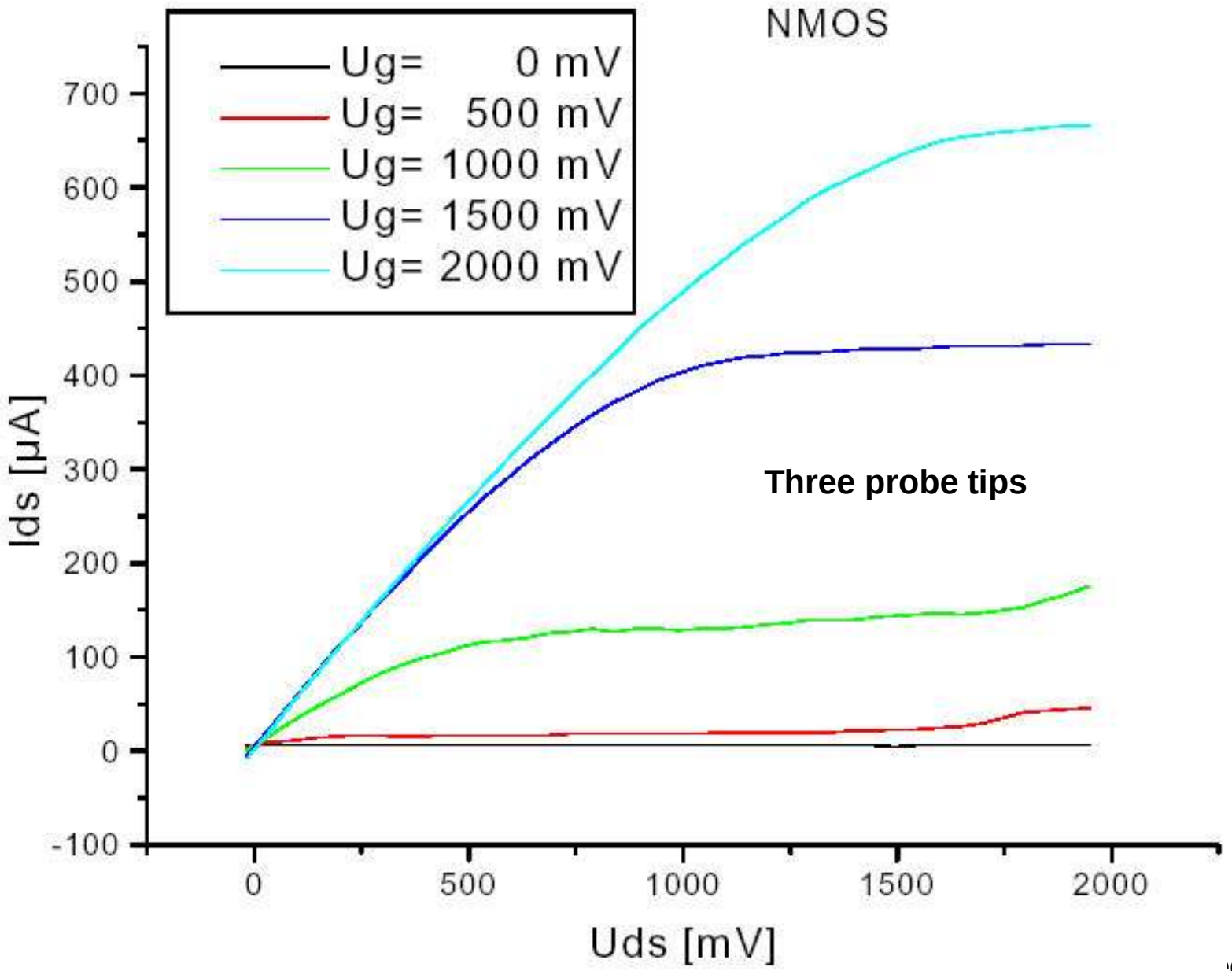
… probe tip approach

For current measurement



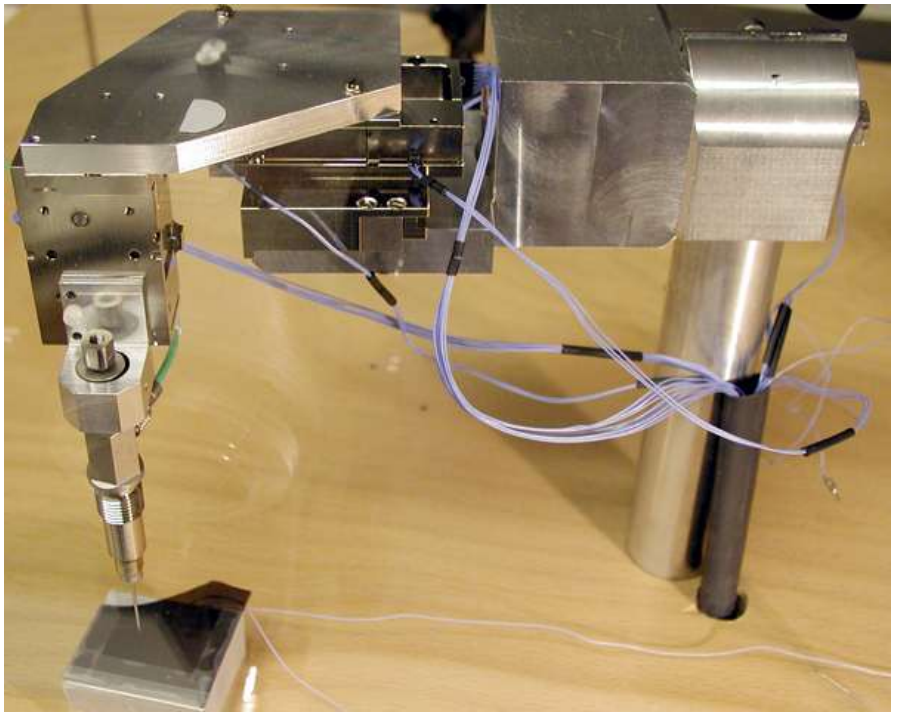
Klocke
Nanotechnik

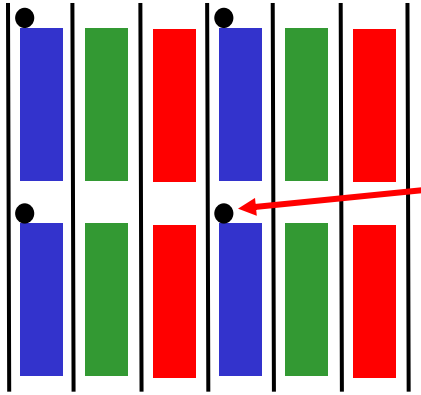
… Current Measurement

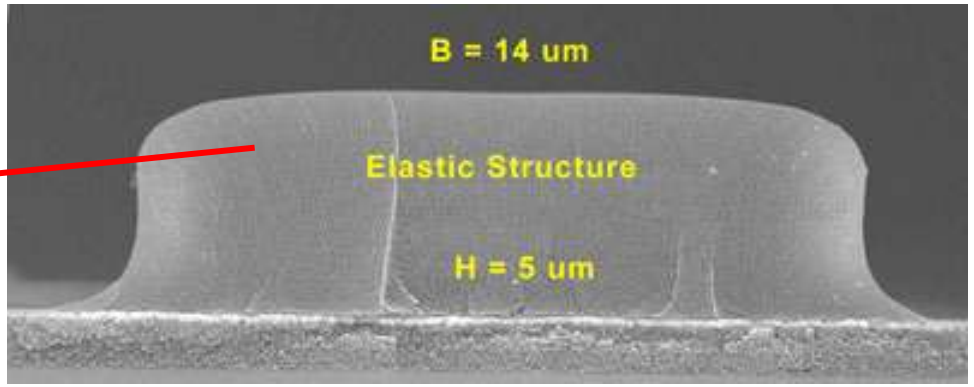


… Force Measurement

at Microstructures





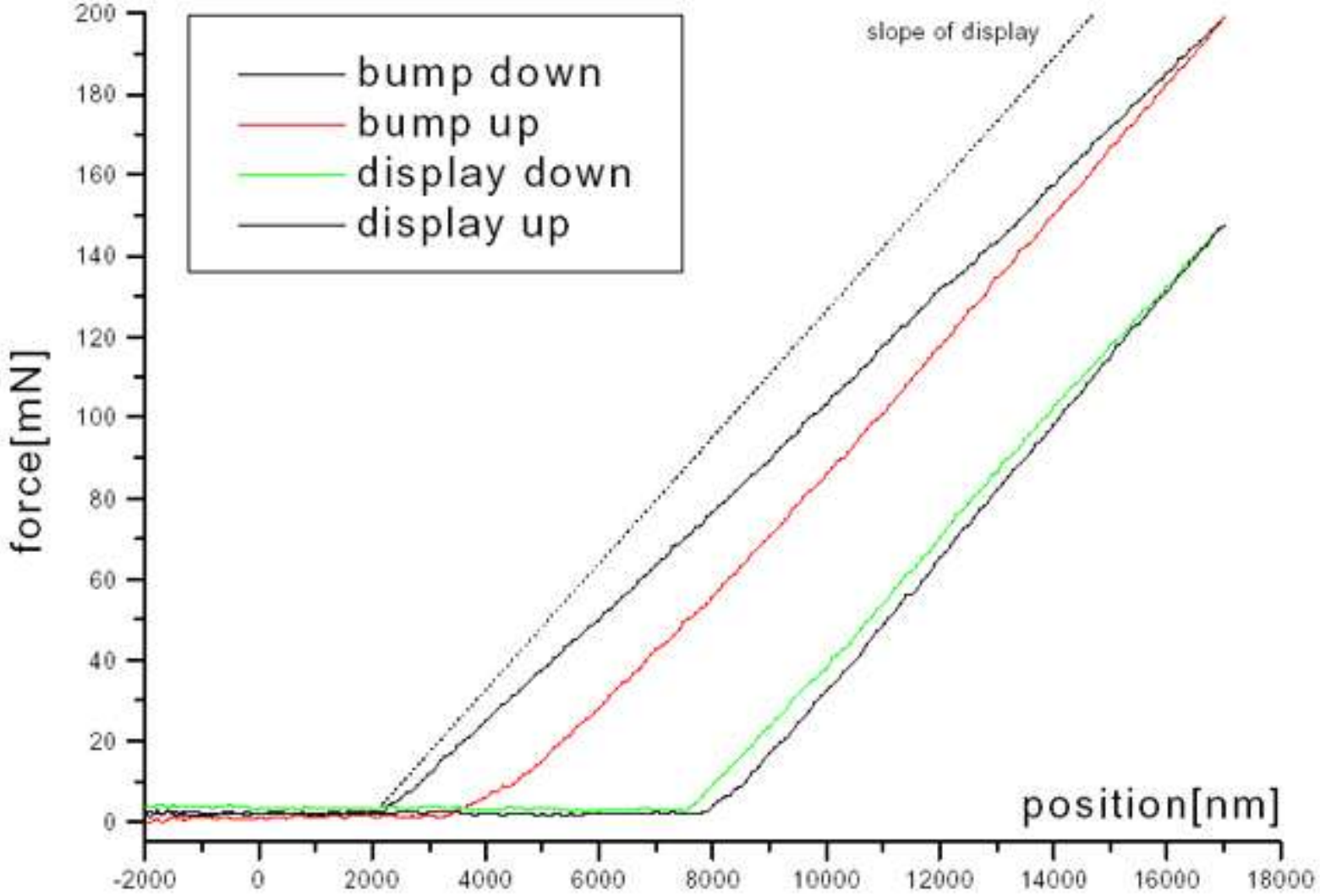


On arrays in automatic measurement: Alignment by pattern recognition

Klocke Nanotechnik

… Force-Distance Diagrams

at Microstructures



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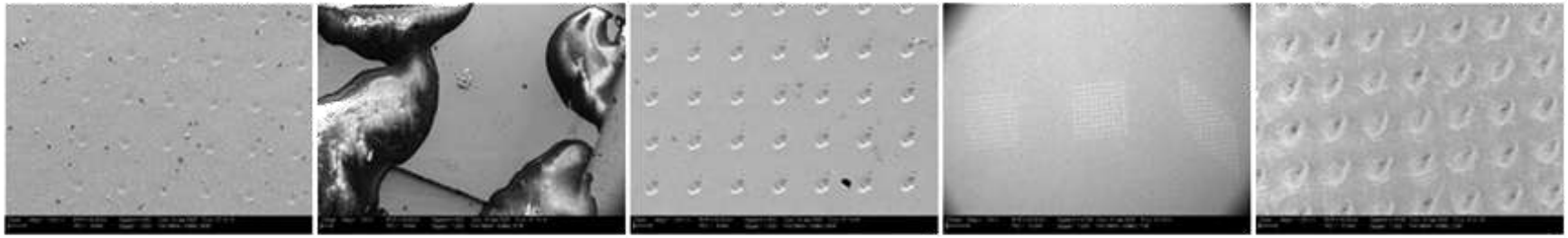
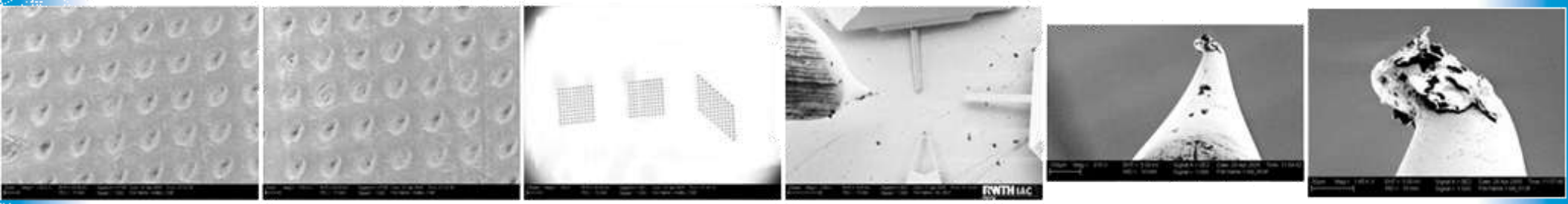
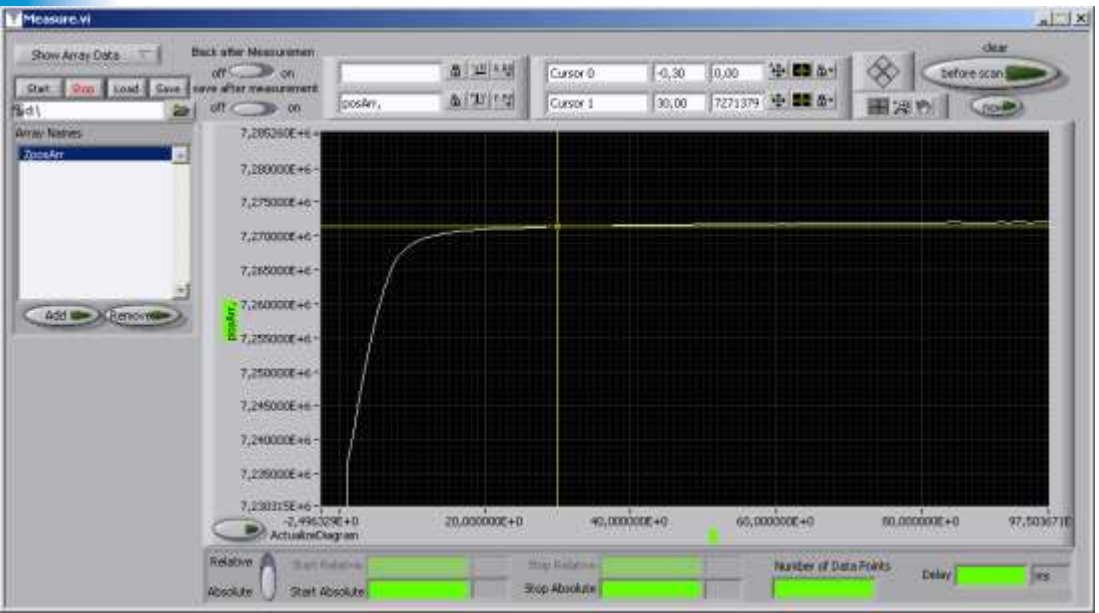
… Nanoindentation

to form structures







Depth measurement for each indent

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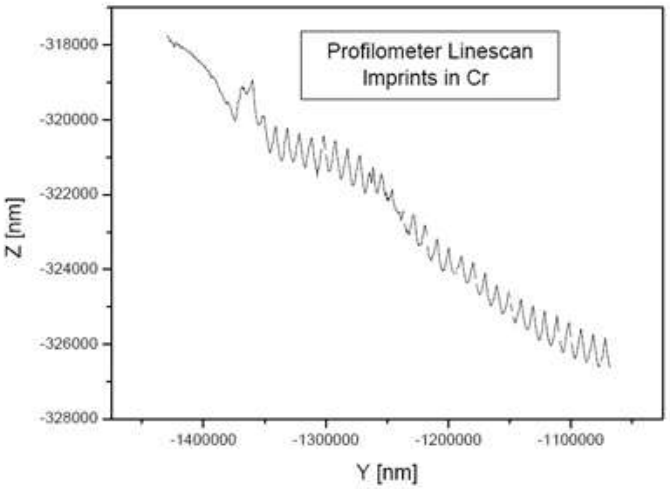
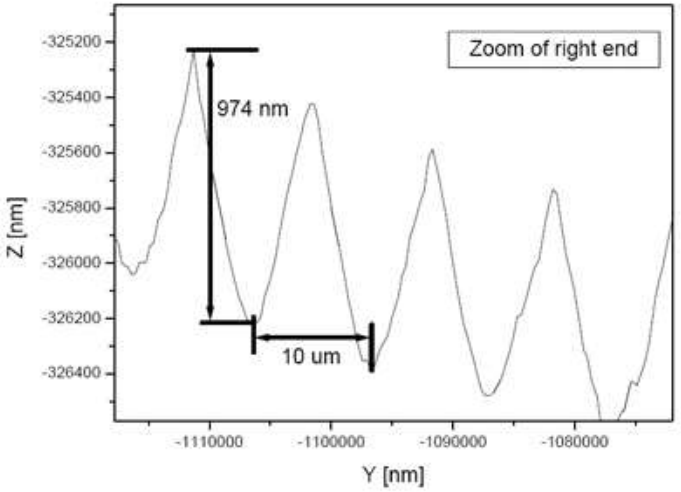
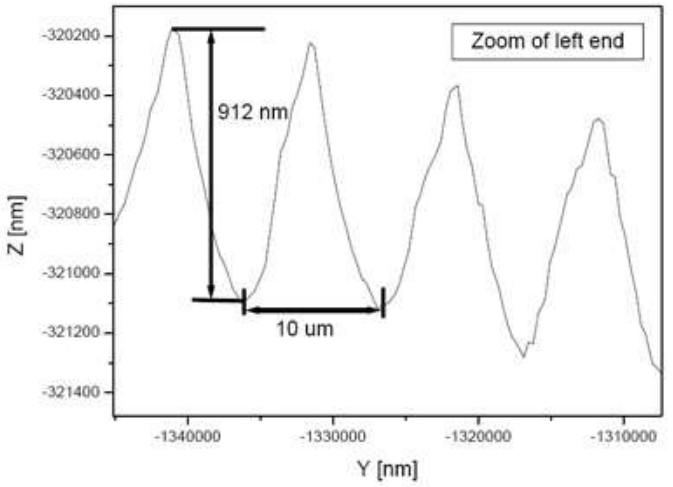
… Nanoindentation

measured with the 3D-Nanofinger







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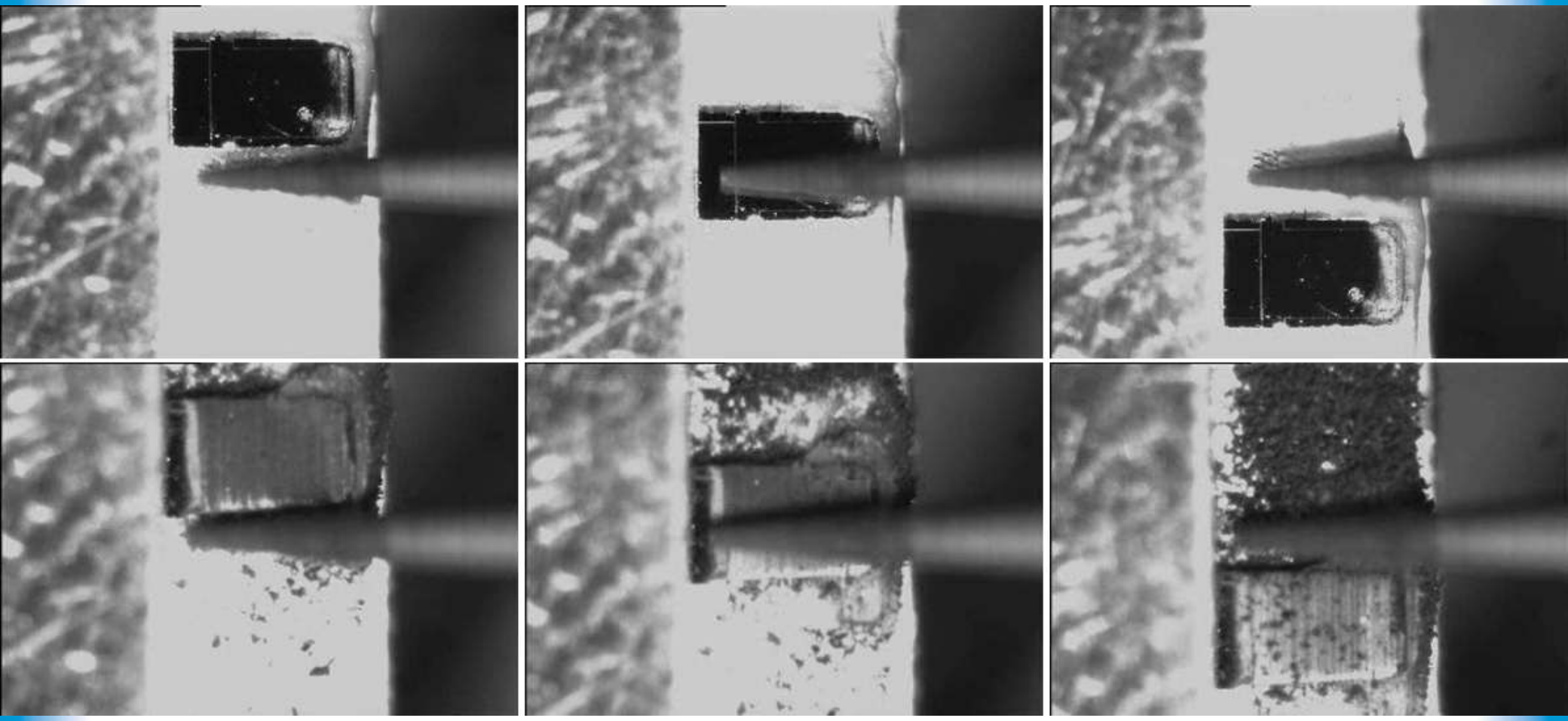
… incl. Nanomachining

by grinding



Grinding of a wedge structure into Silicon

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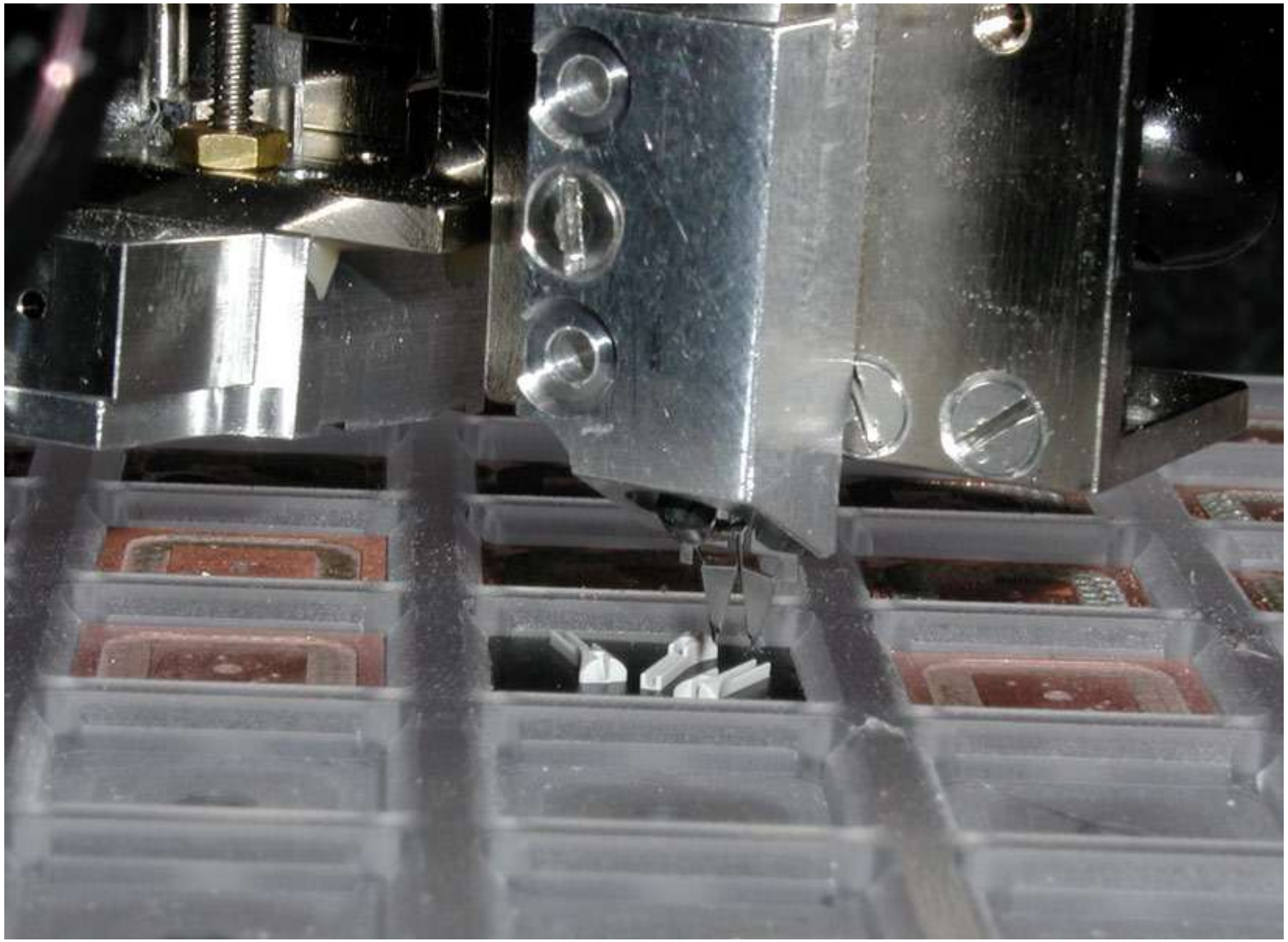
Nanotechnik

... or Automatic Microassembly



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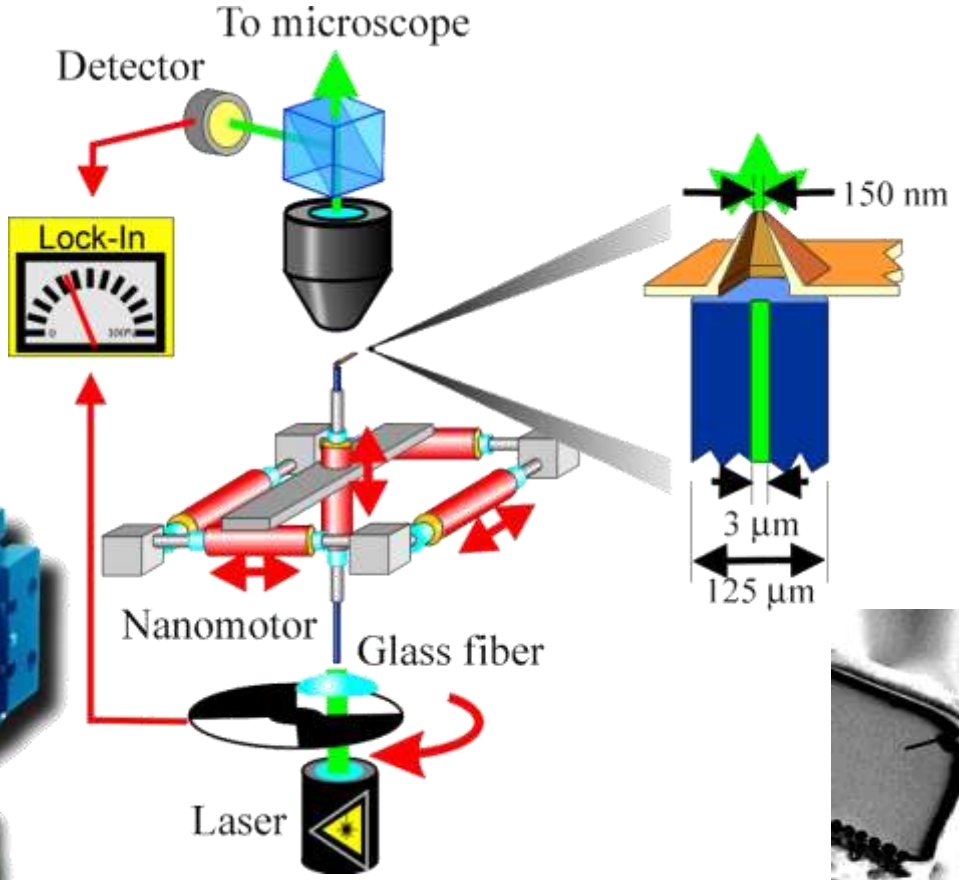
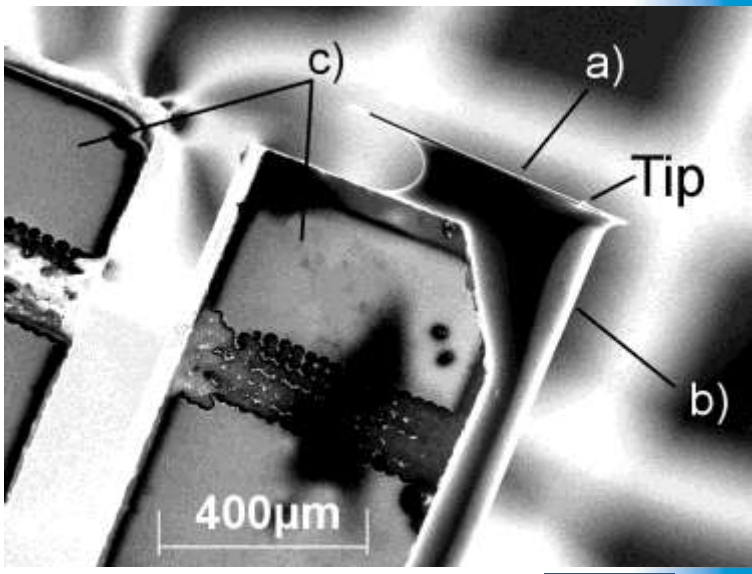
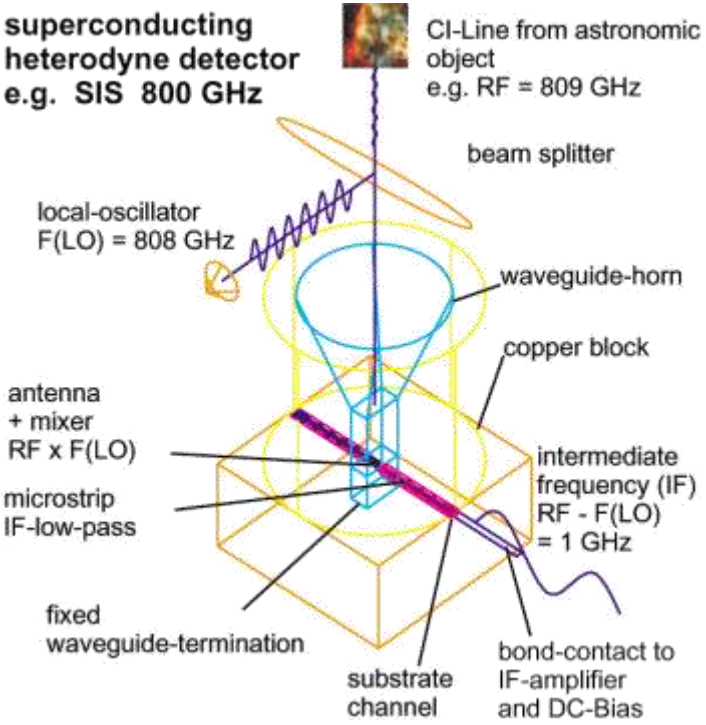
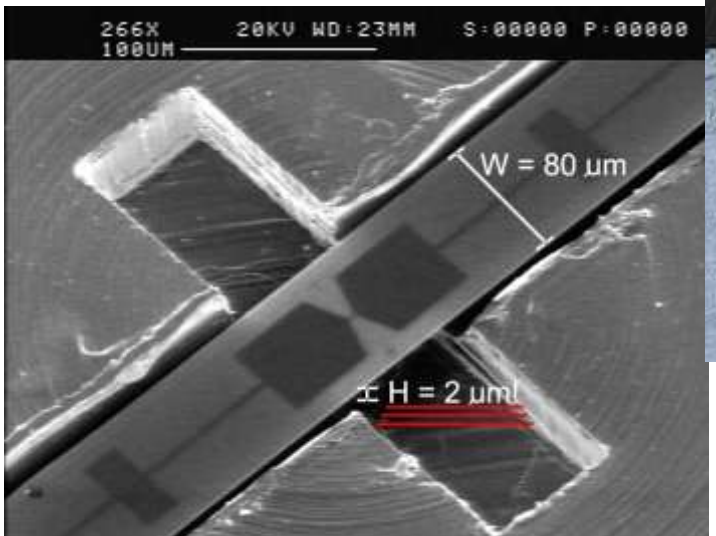
e.g. to „sharpen hairs“

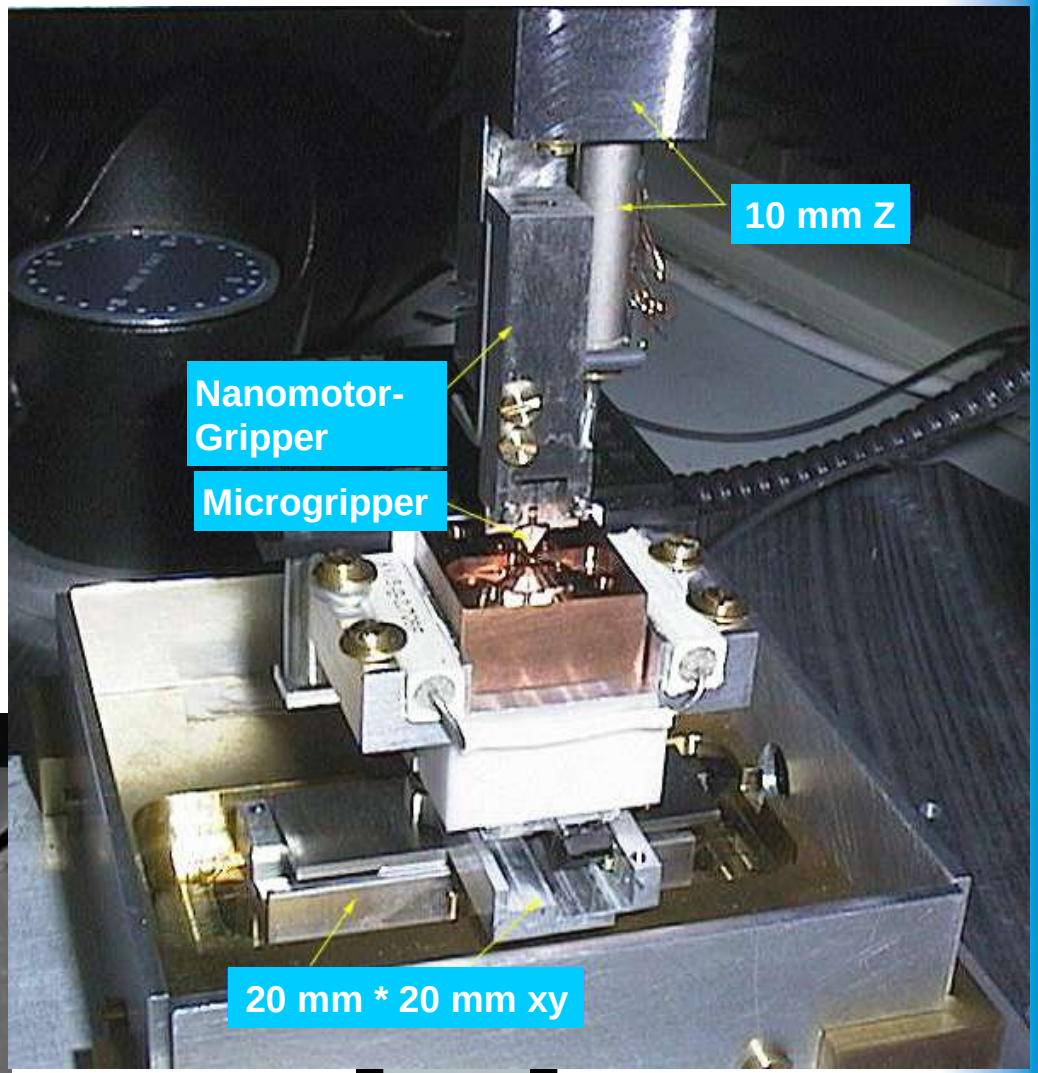




e.g. Microassembly of RF-Modules







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Micro Production Systems:

Link:

http://www.nanomotor.de/aa_production_system.htm

Strength:

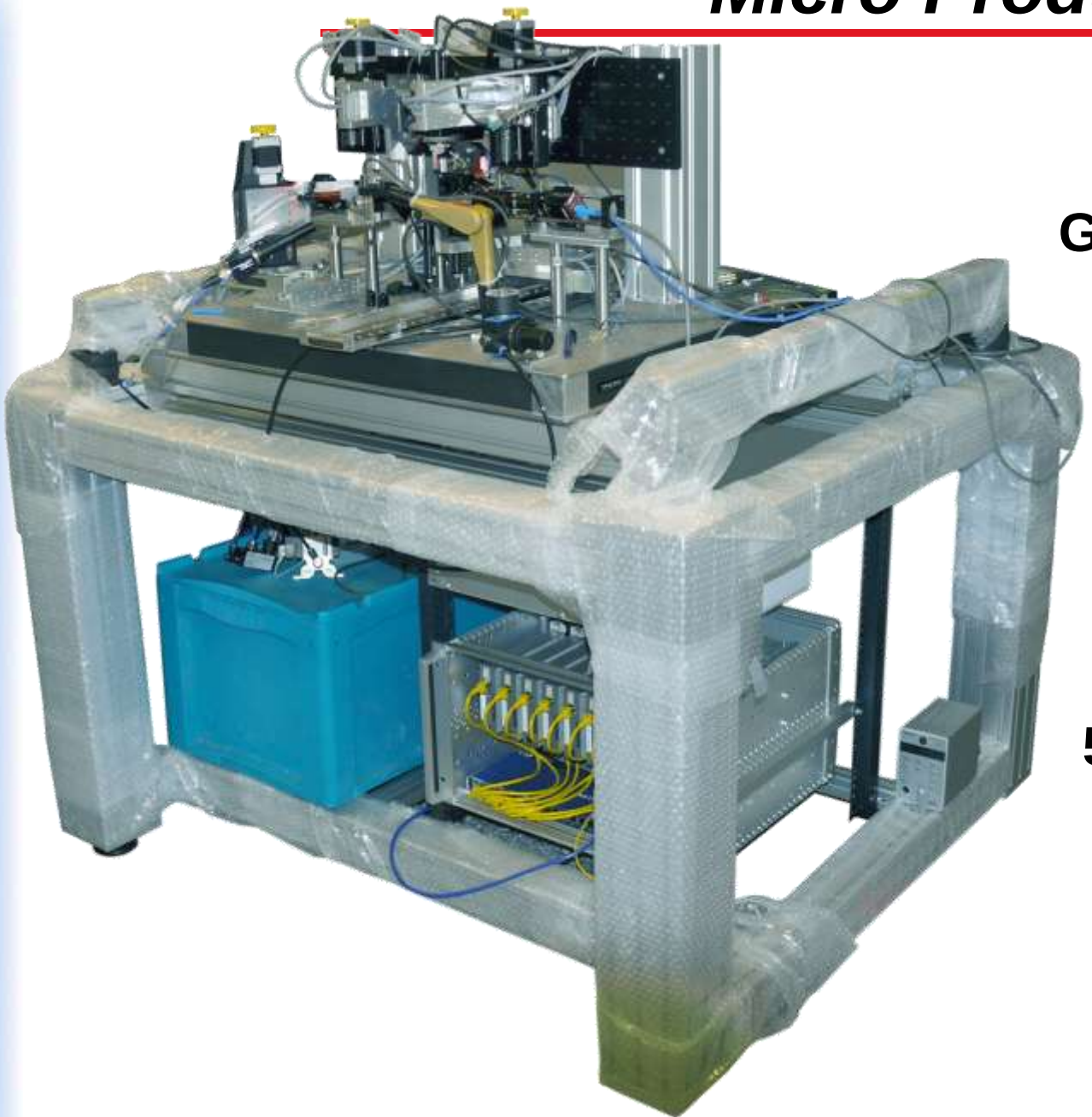
- flexible configuration, also by user
- ideal for changing production tasks
- Flexible upgrade options avoid investment risks

Weakness:

- not developed for single type mass production ***(…. ?!)***

Micro Production System

for mass production



Glass fiber assembly

in

mass production:

500-700 good parts

per week

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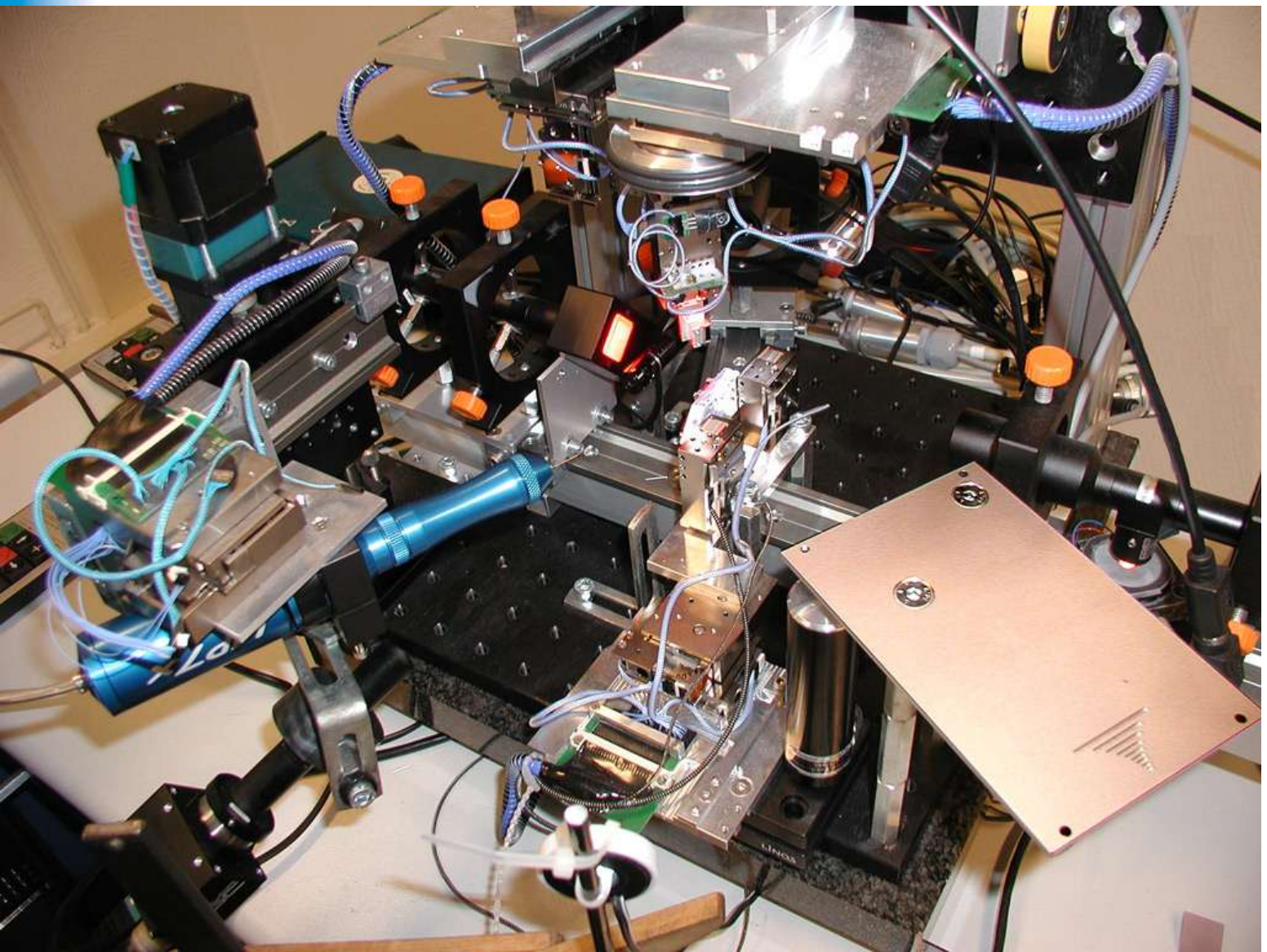
Micro Production System

First Prototype, upgraded to Service machine



400-500

good parts

per week

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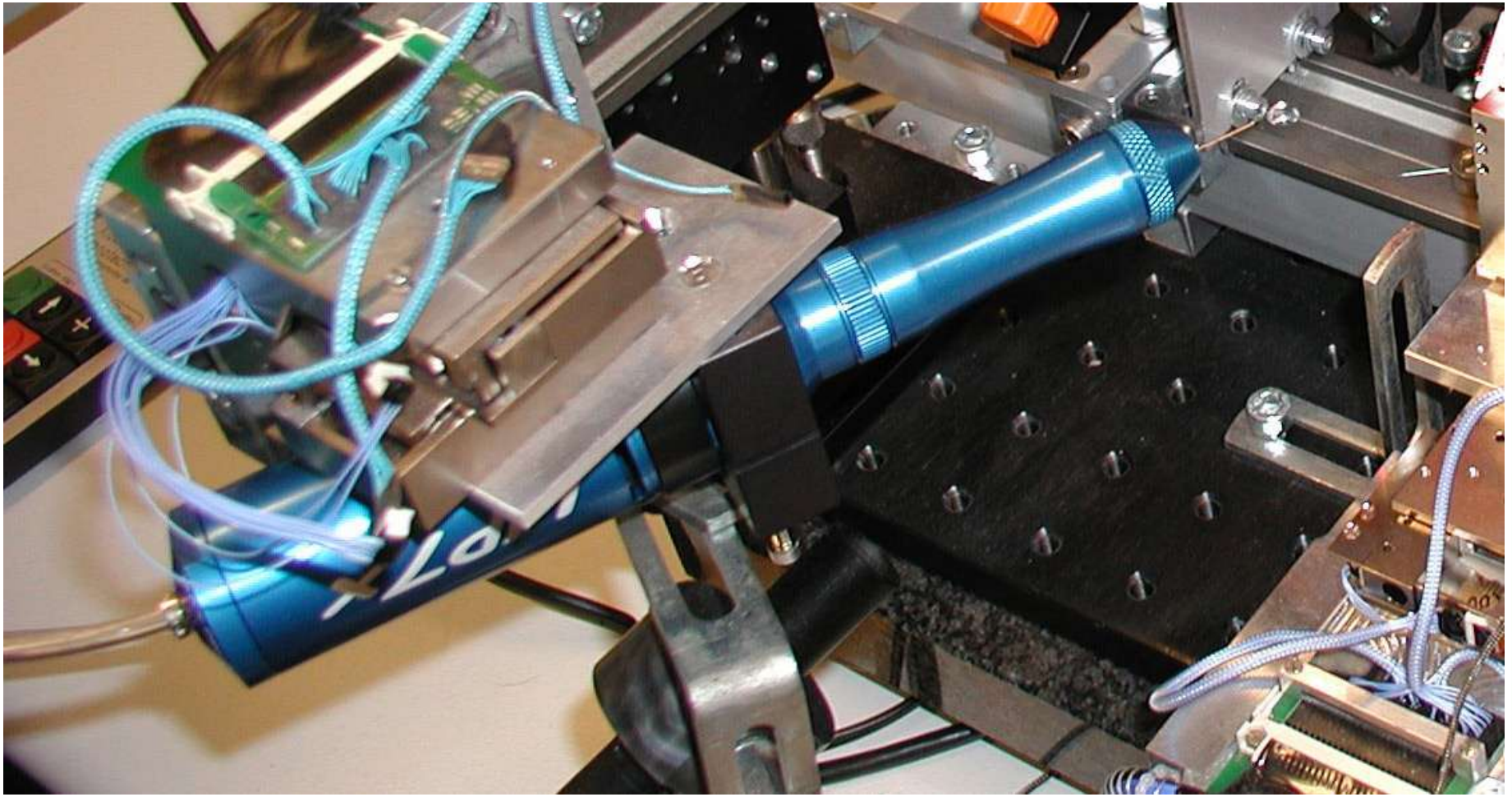
Micro Production System

Service machine, future backup system

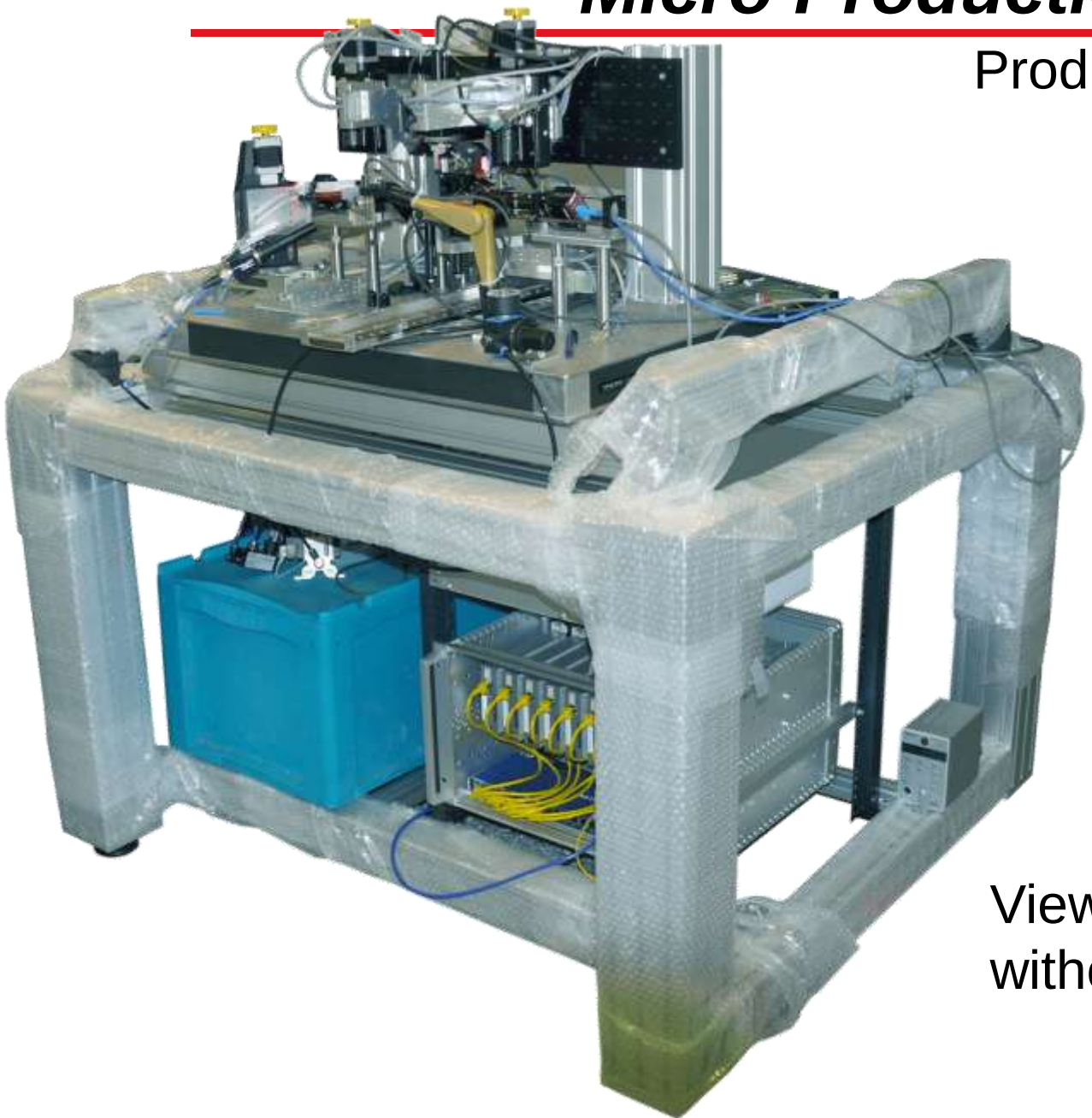


All commercial dispensers failed => own development

Klocke Nanotechnik

Micro Production System

Production machine



View at the machine
without housing

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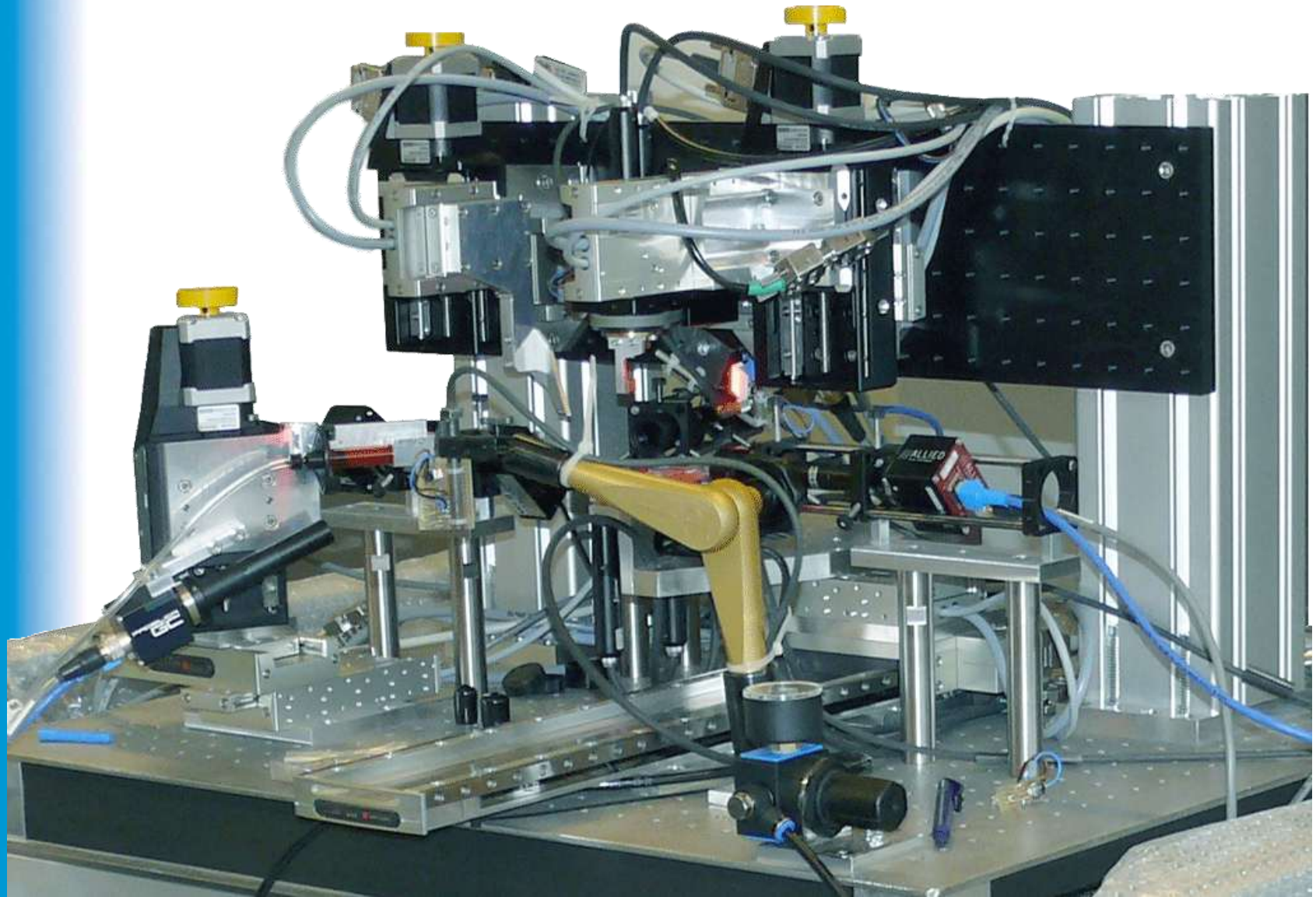
Micro Production System

Production machine



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Micro Production System

Specification

- 87 good parts per day
- Cycle time < 3,5 minutes
- Yield > 80%
- Light point position +- 5µm
- Adhesive & fiber position error < 2µm at 15mm length
- Axial Fiber rotation < +-5°
- Varying fiber diameter: 27µm - 45µm

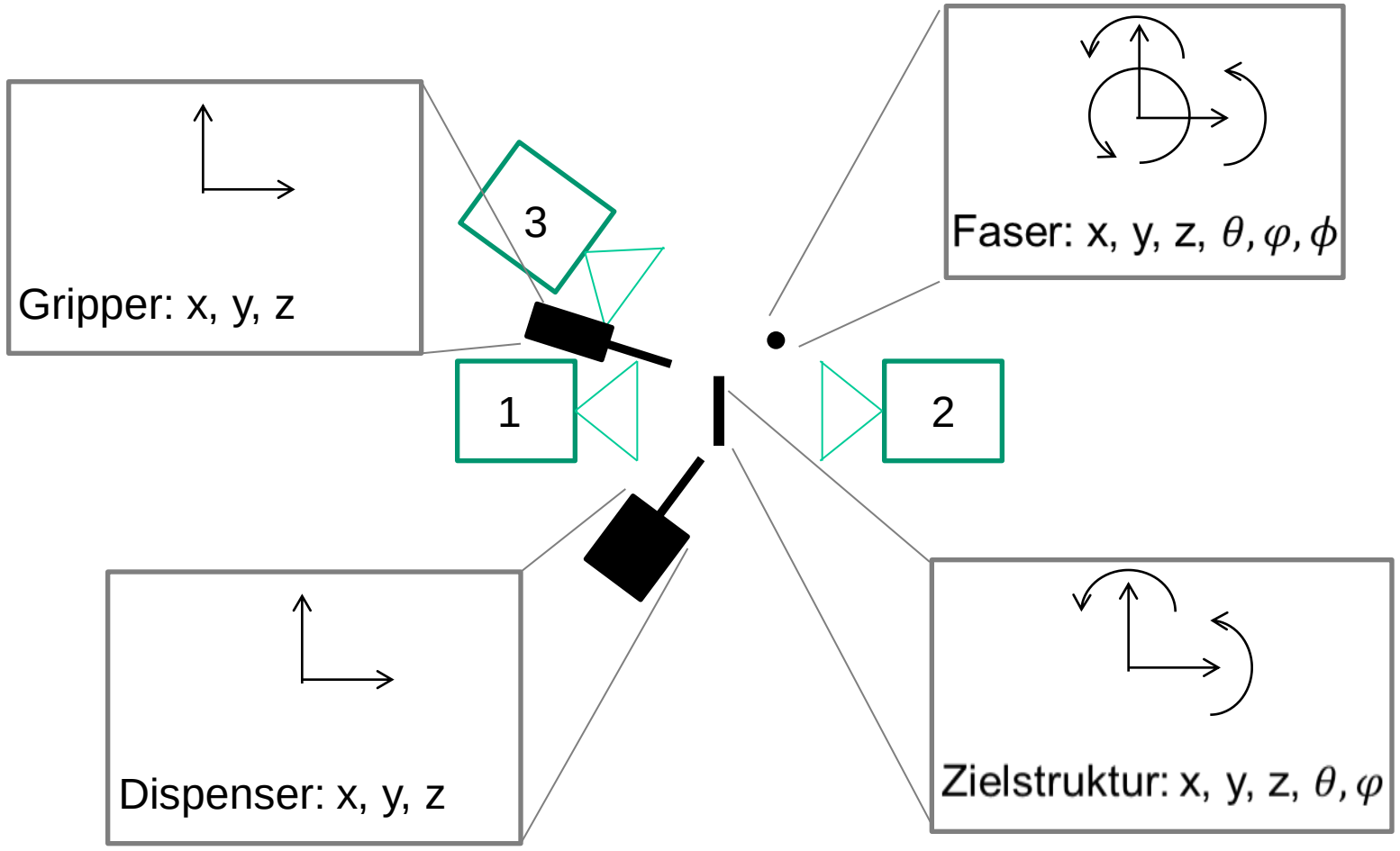
- Several different pre-defined production processes
- Data base interface
- Remote service
- Operation possible by „everybody“
- Replacement machine ready in < 3 days

Klocke
Nanotechnik

Micro Production System

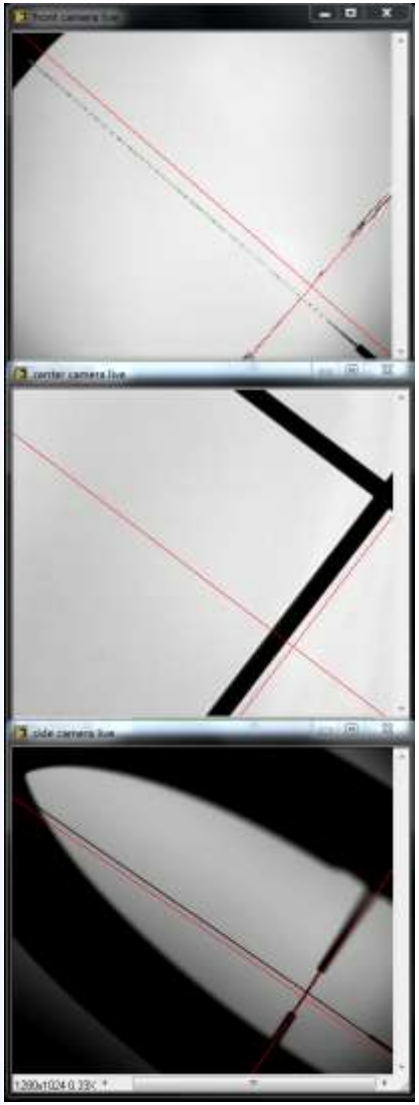
D.O.F.

3 Cameras
17 Degrees of Freedom



Micro Production System

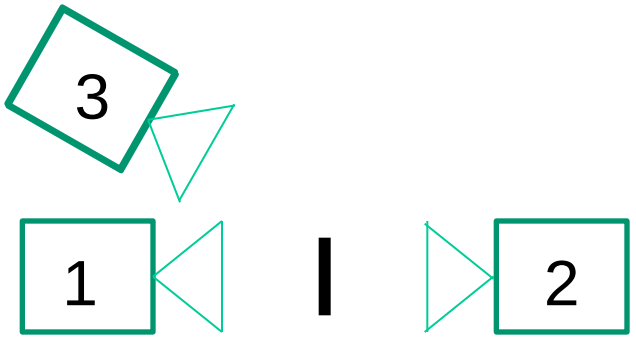
Coordinate systems



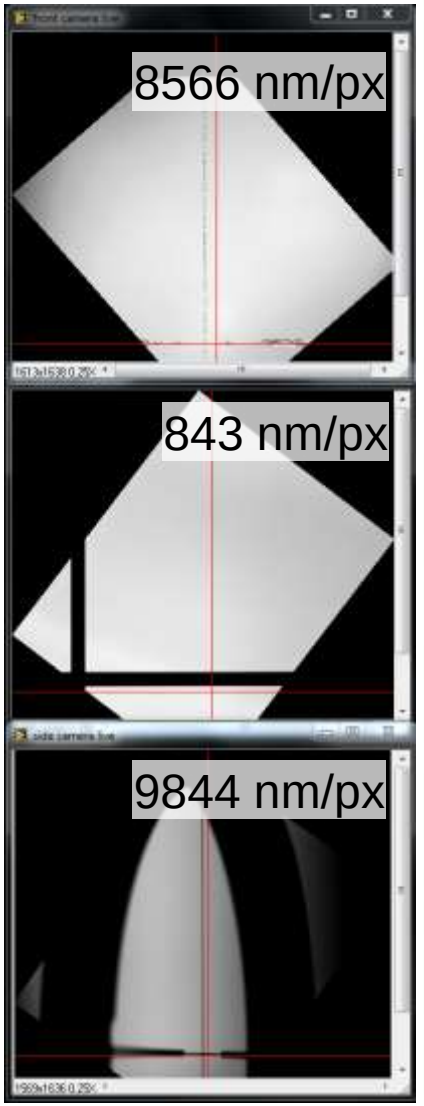
1

2

3



Automatic Calibration



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Micro Production System

Data rates and precision

256 gray scales with 1280x1024	→	1.3 MB
30 pictures per second	→	39 MB/s
4 Cameras	→	156 MB/s

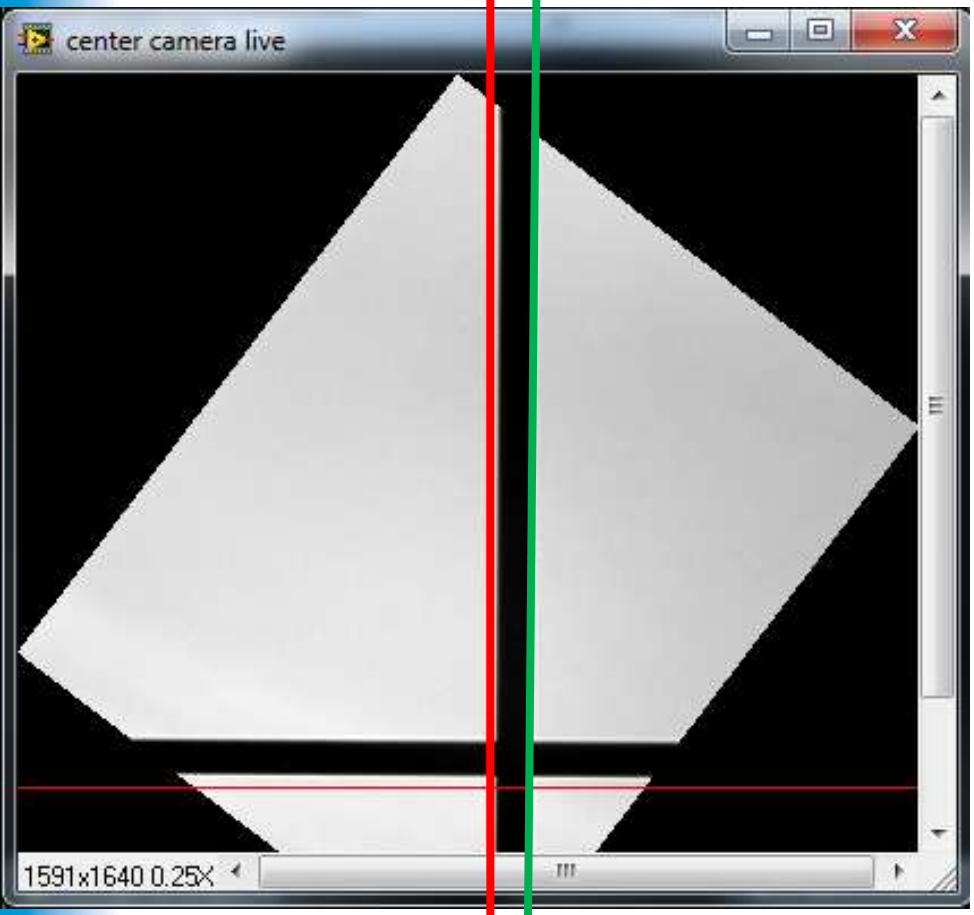
= 1,25 GBits/s

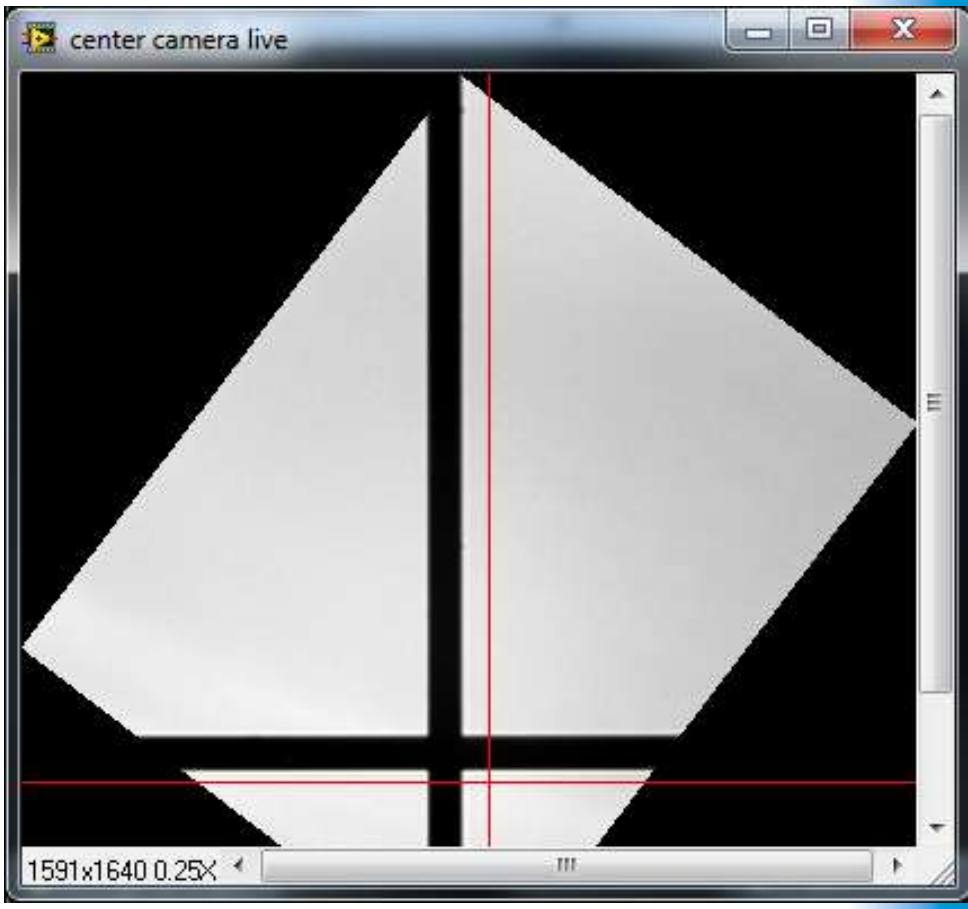
Bandwidth must be dispersed to the cameras,

depending on speed and optical parameters.

Micro Production System

Positioning the target structure





Angle correction: -0,4855°
Axes: z1, z2

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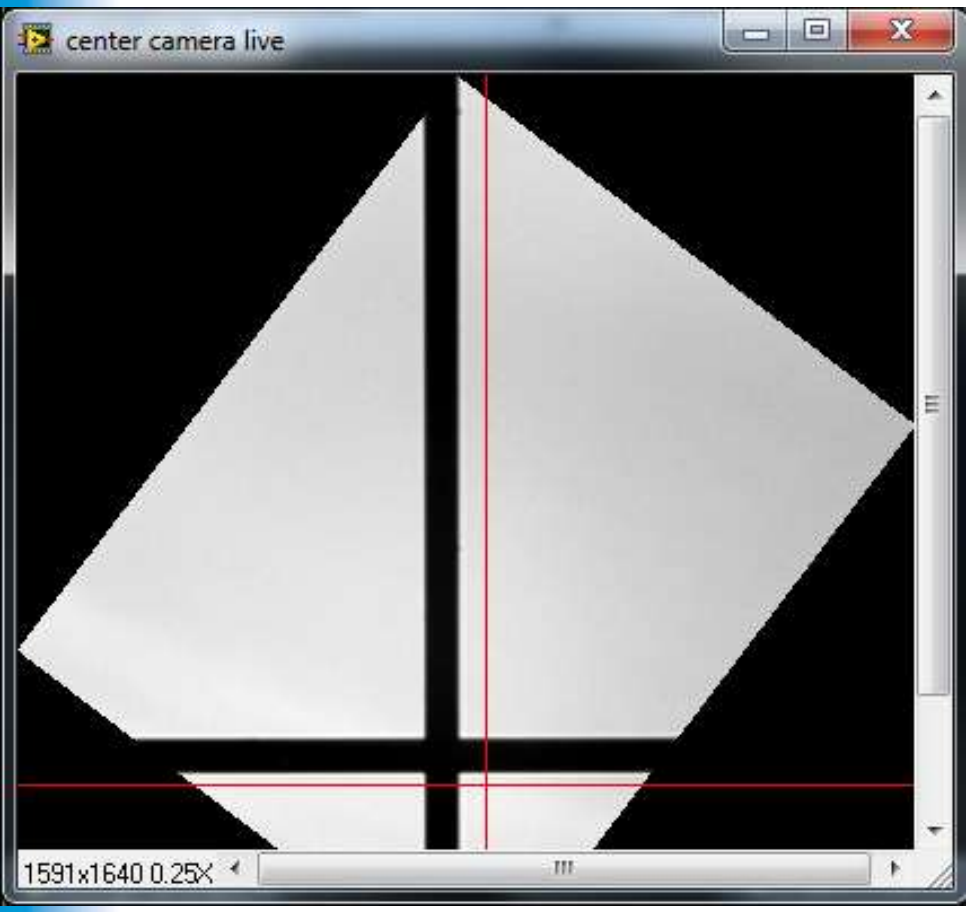
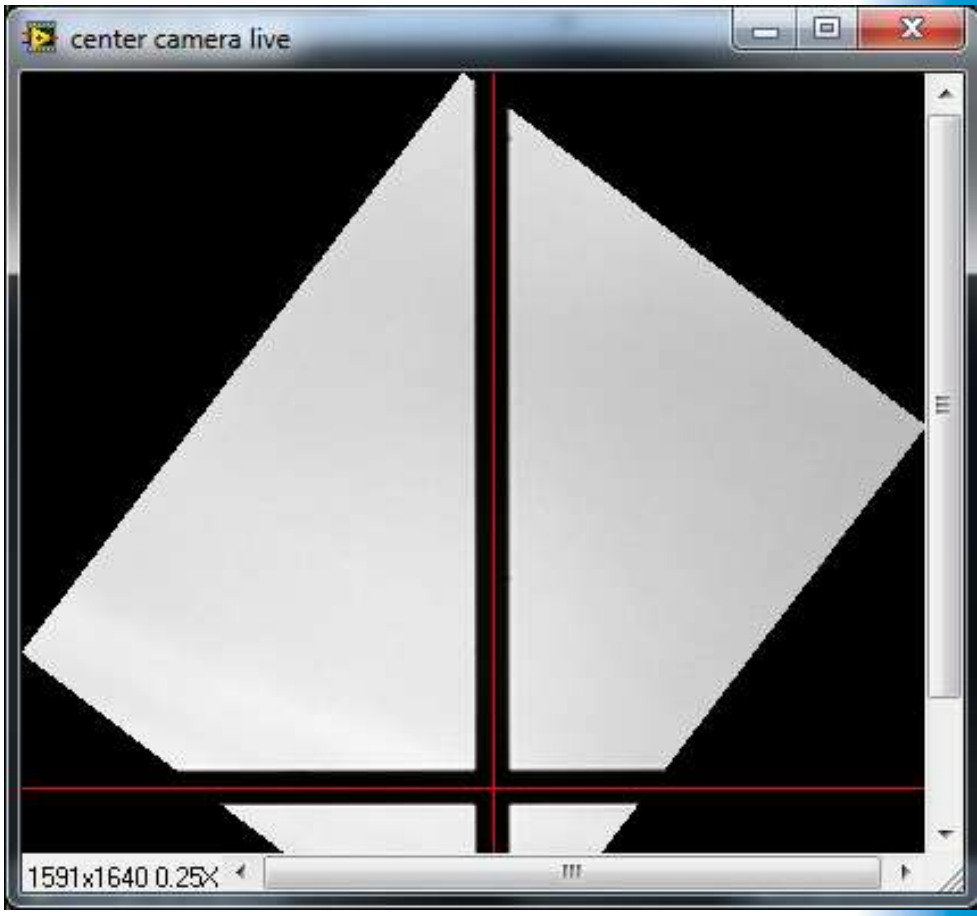
Nanotechnik

Micro Production System

Positioning the target structure



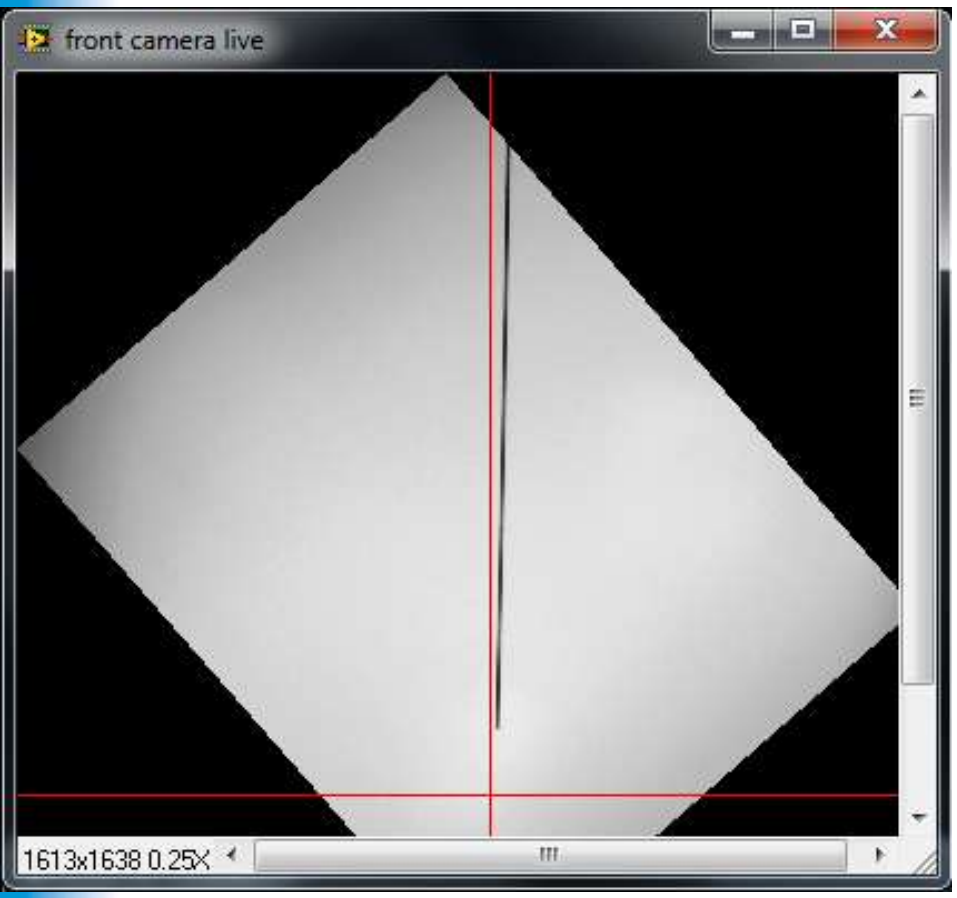


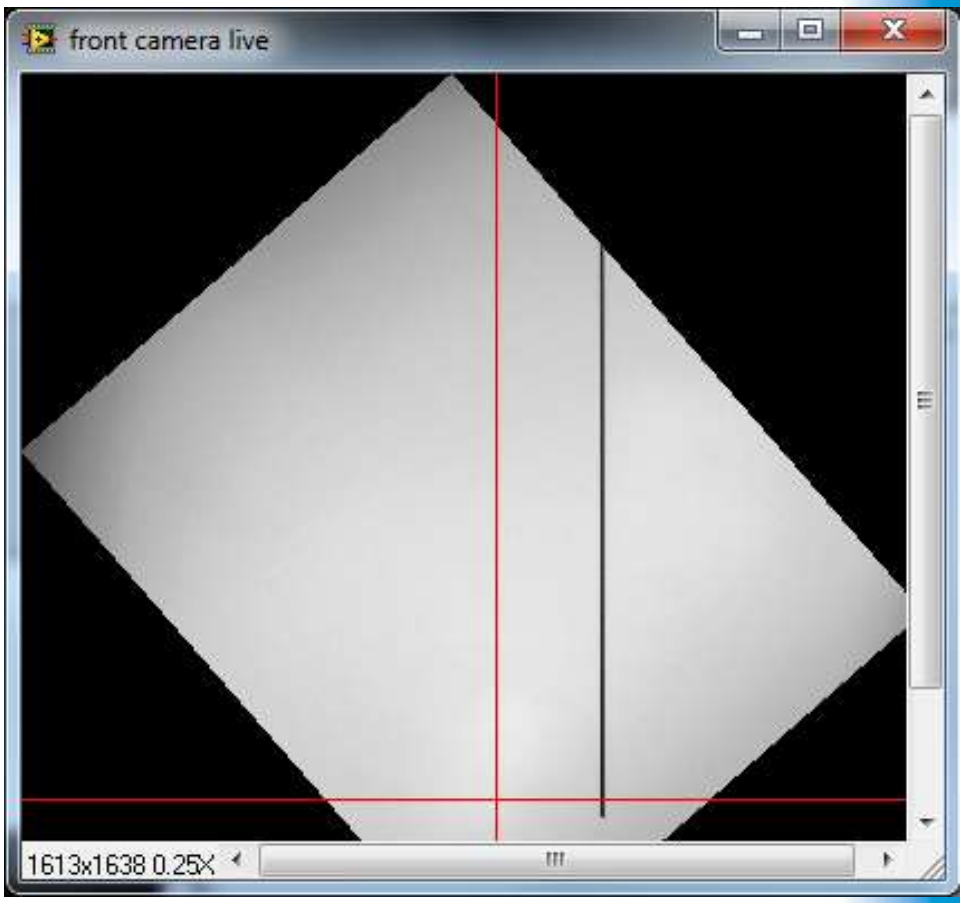
Position correction: +68800nm, -57432nm
Axes: y, z1, z2

Klocke Nanotechnik

Micro Production System

Positioning of Fiber





Angle correction: Axis: θ

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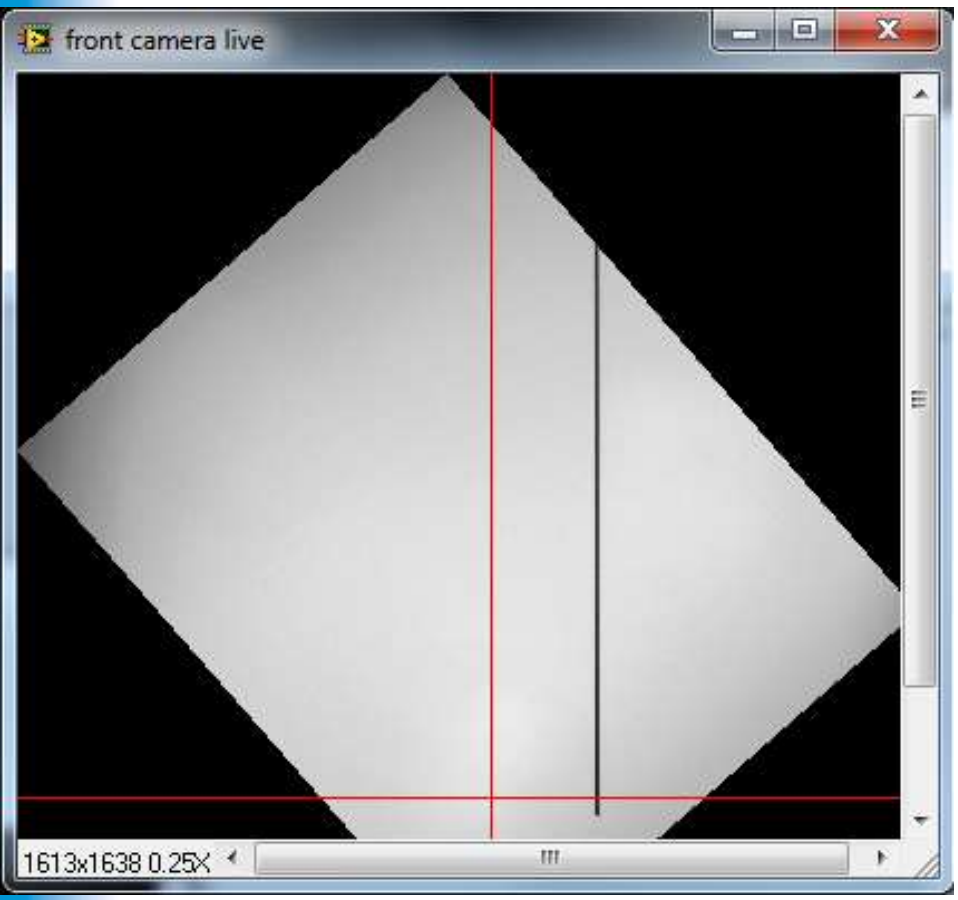
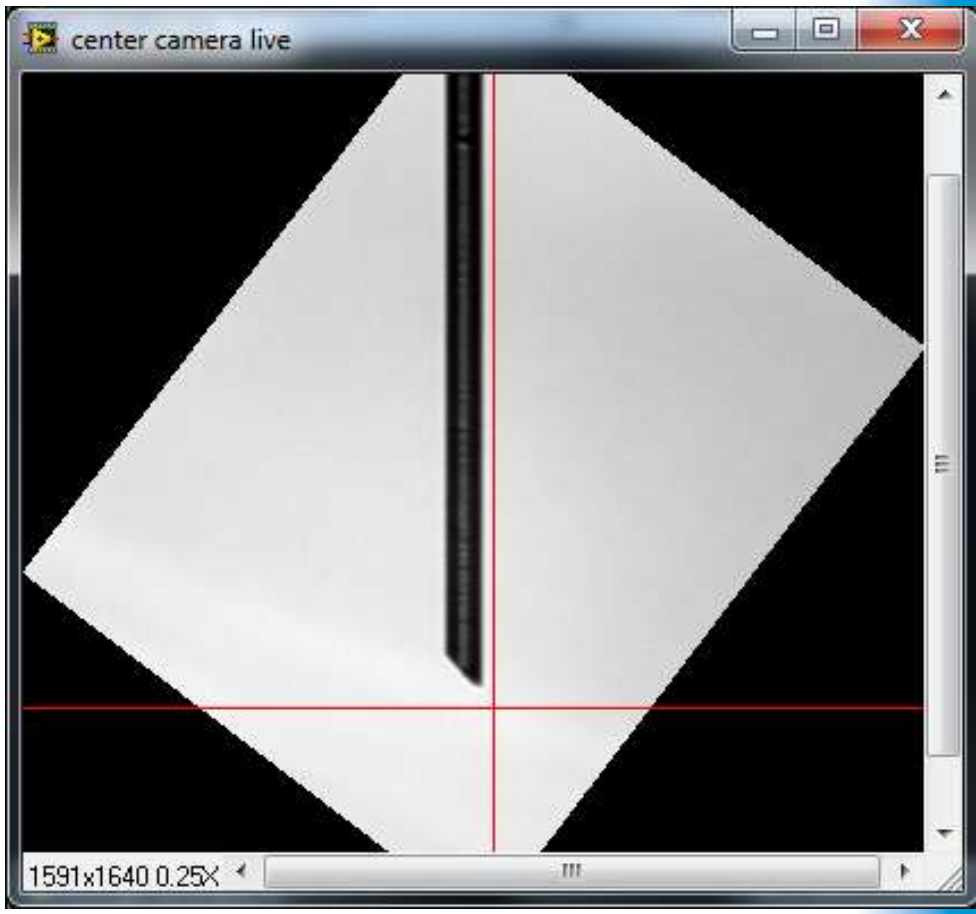
Micro Production System

Positioning of Fiber



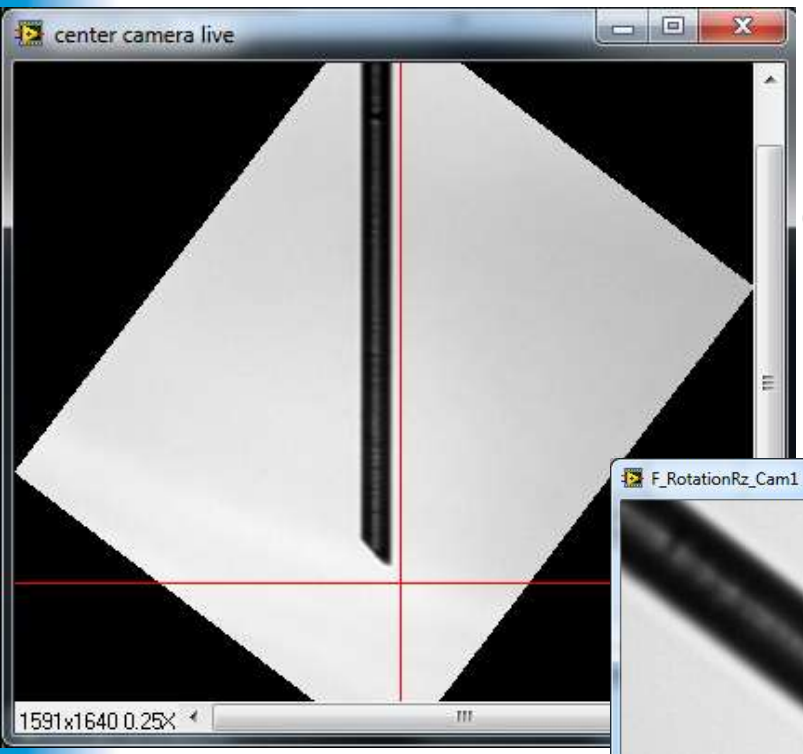


Position correction: Axes: x, y, z

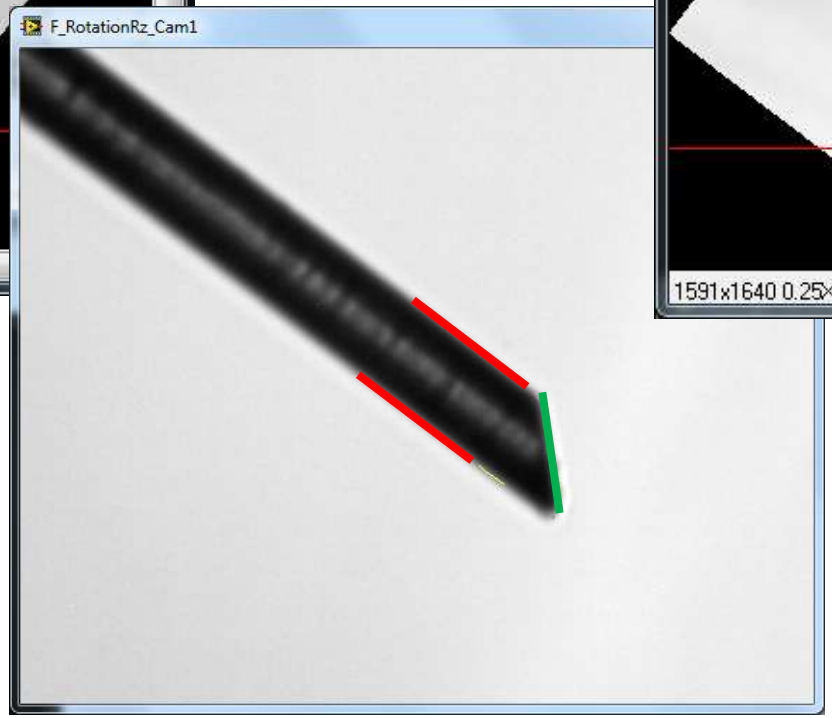
Klocke Nanotechnik

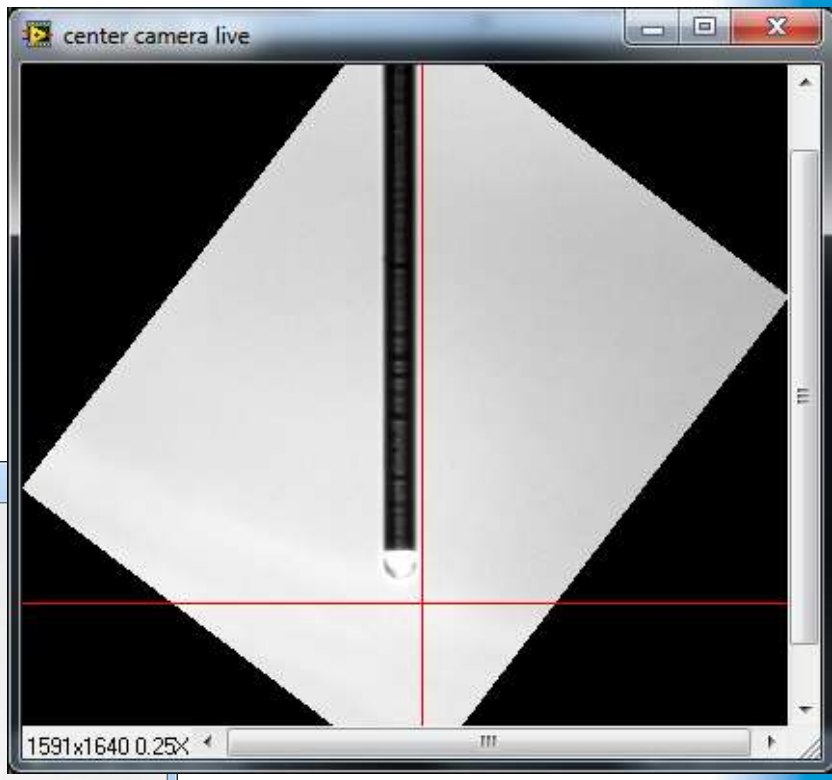
Micro Production System

Positioning of Fiber



Correction of rotation
Axes: x, y, z, ϕ





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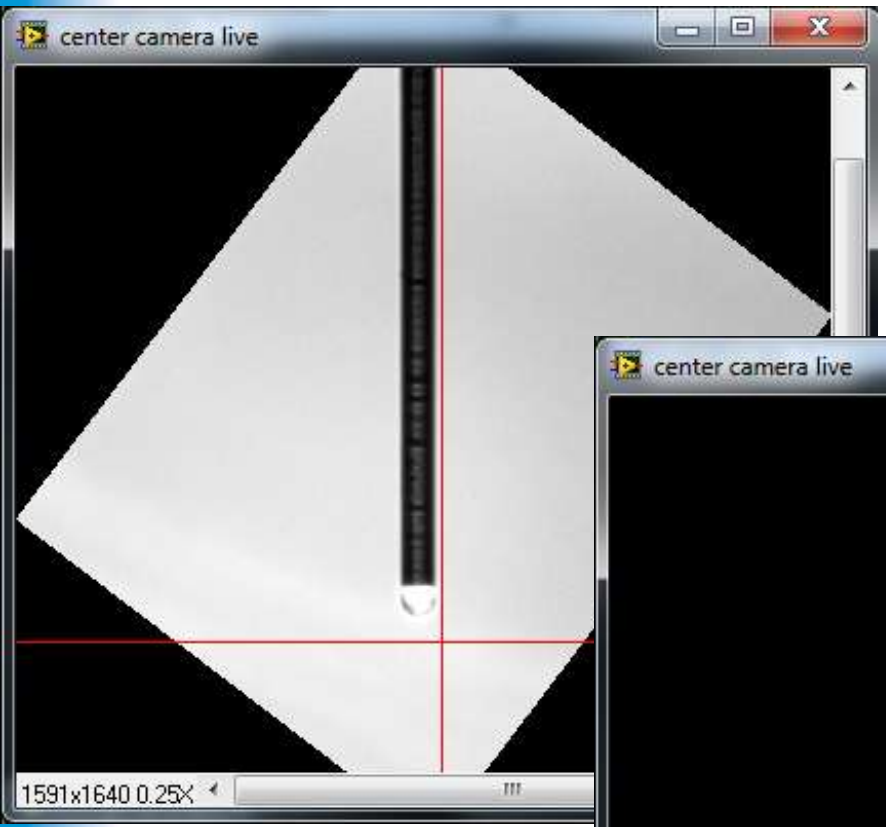
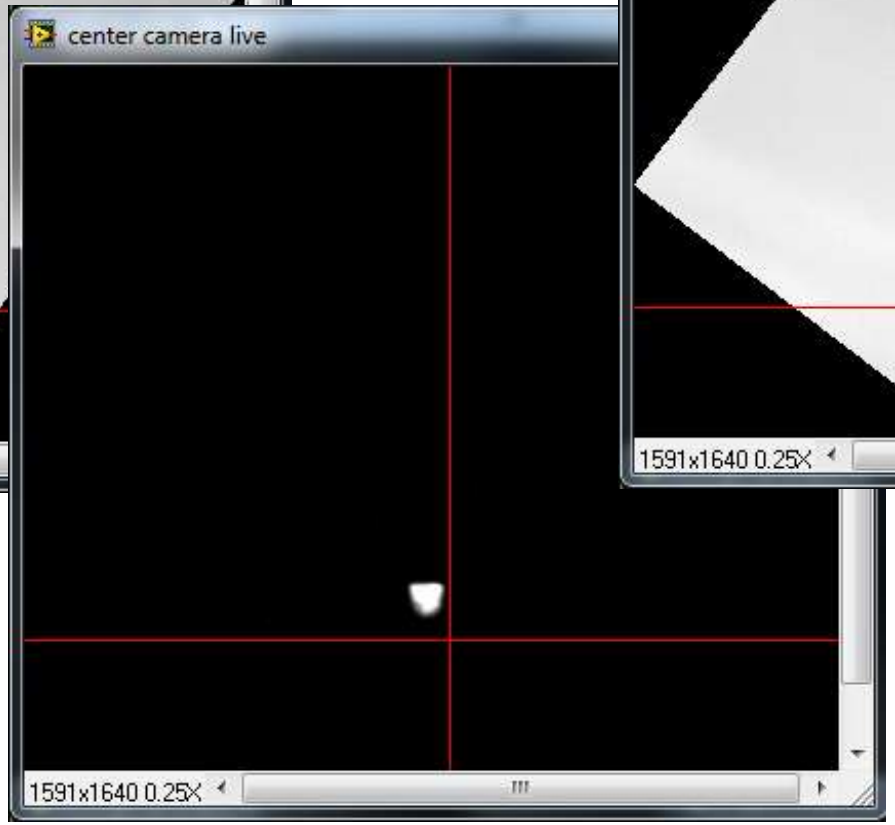
Nanotechnik

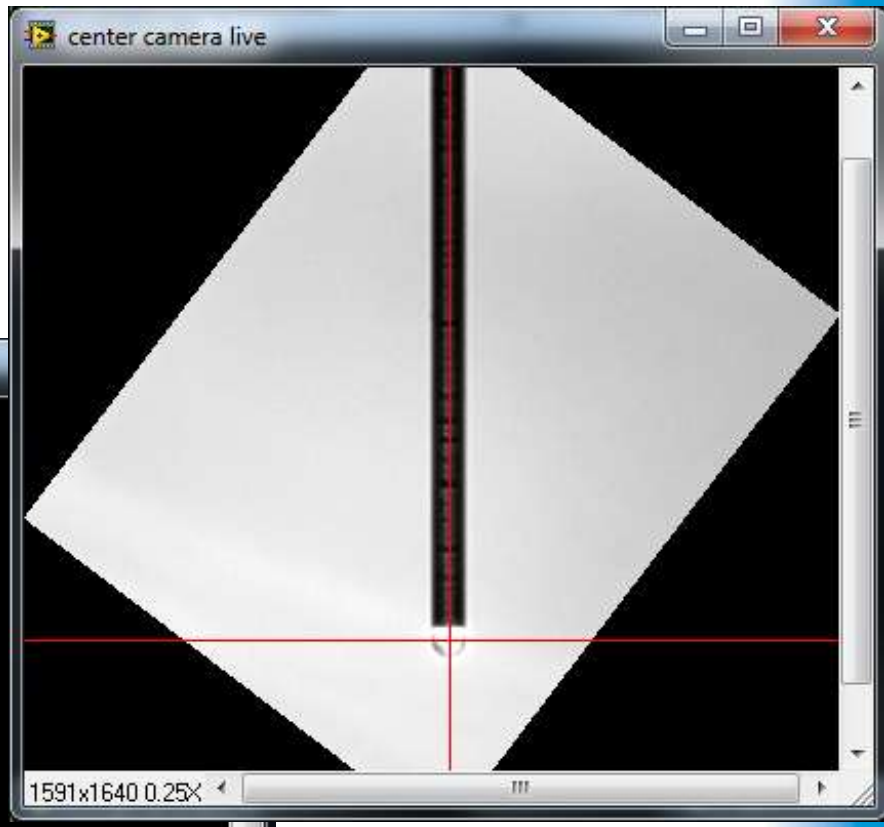
Micro Production System

Positioning of Fiber



Correction of fiber end
Axes: y, z

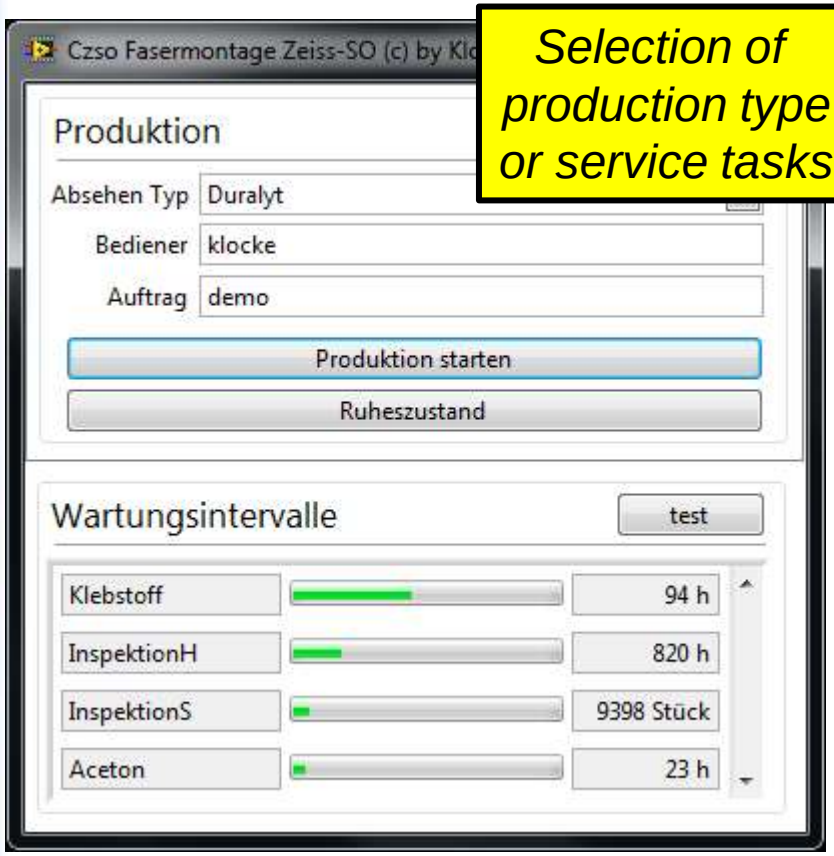




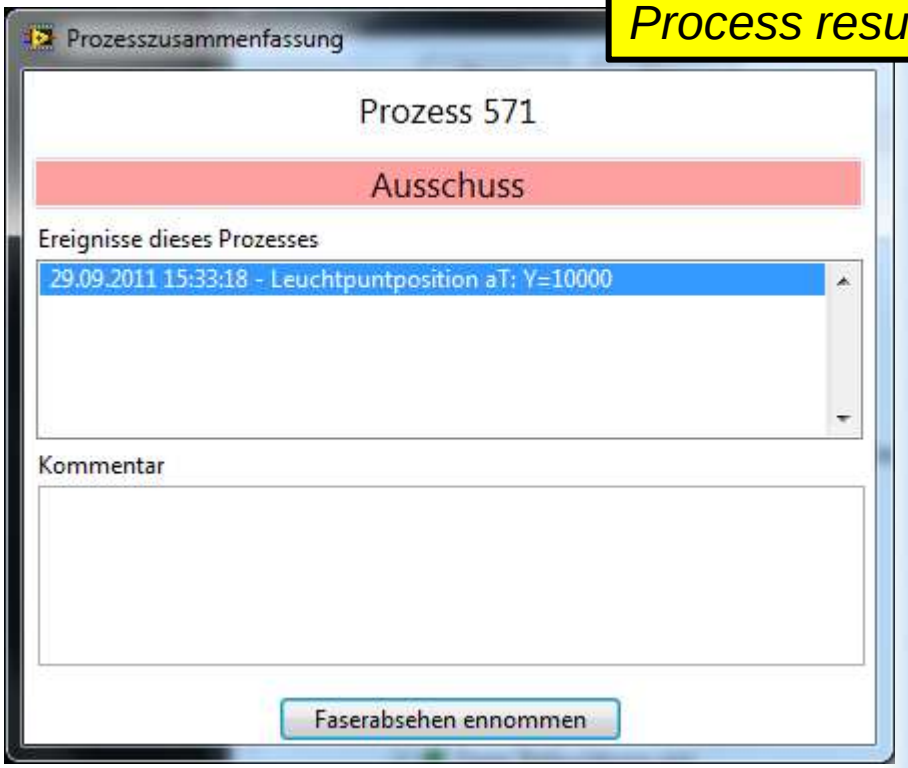
Klocke Nanotechnik

Micro Production System

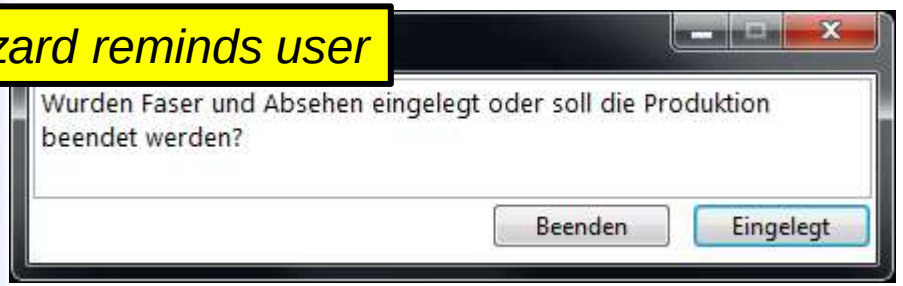
User interface



Selection of production type or service tasks



Process result



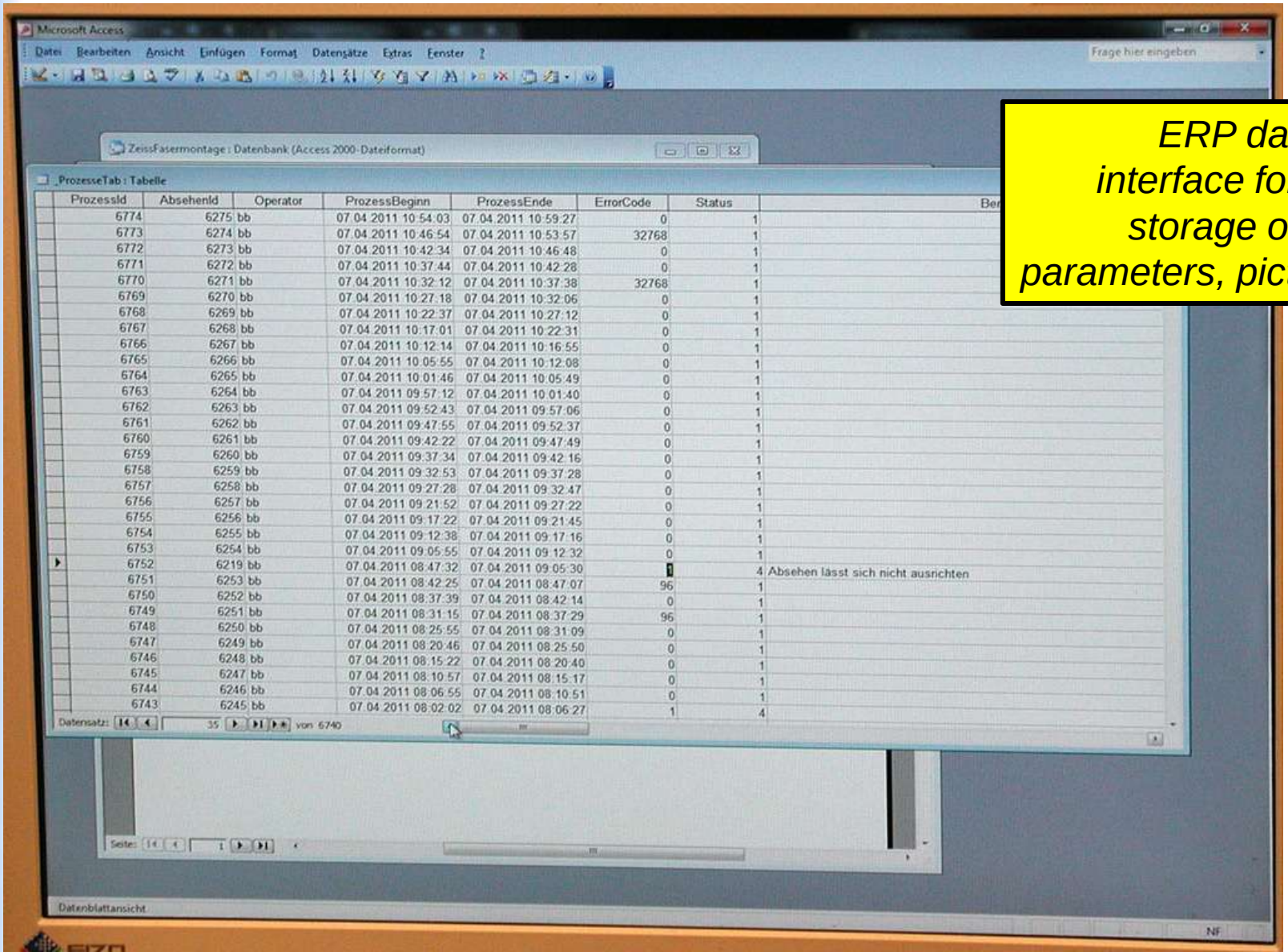
Wizard reminds user

...

Klocke Nanotechnik

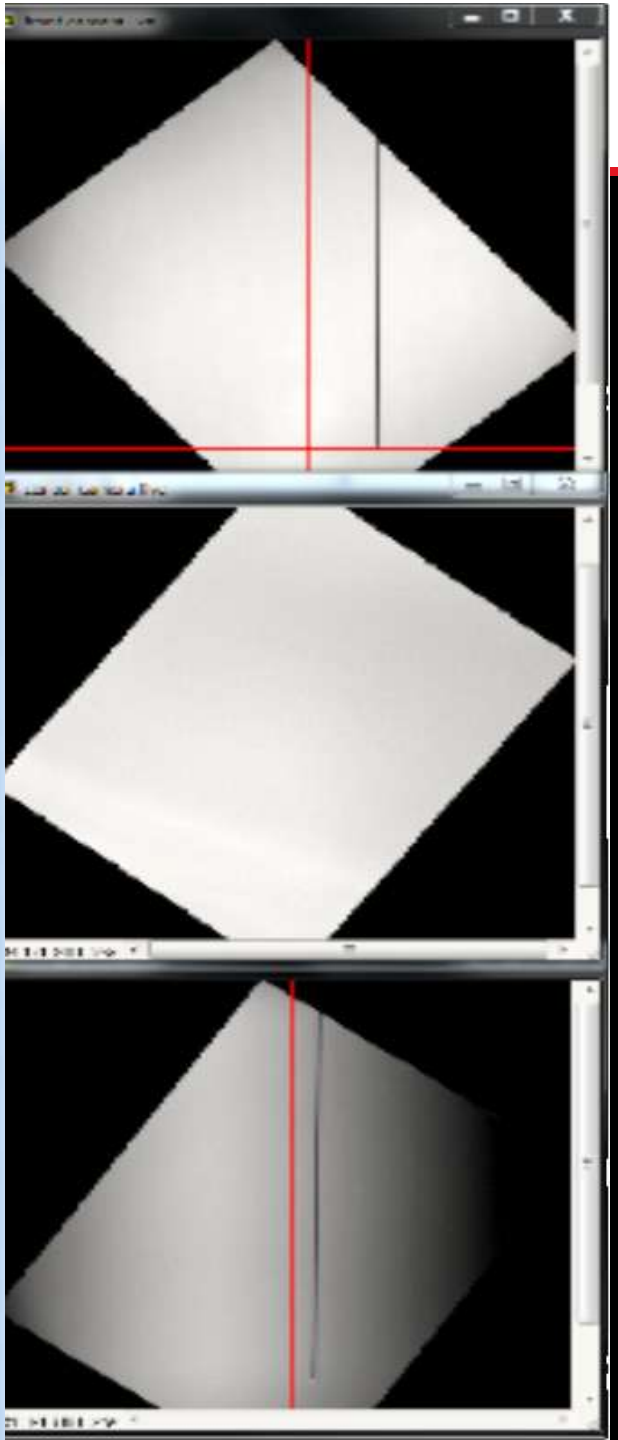
Micro Production System

Database interface



ERP data base interface for automatic storage of process parameters, pictures, movies…

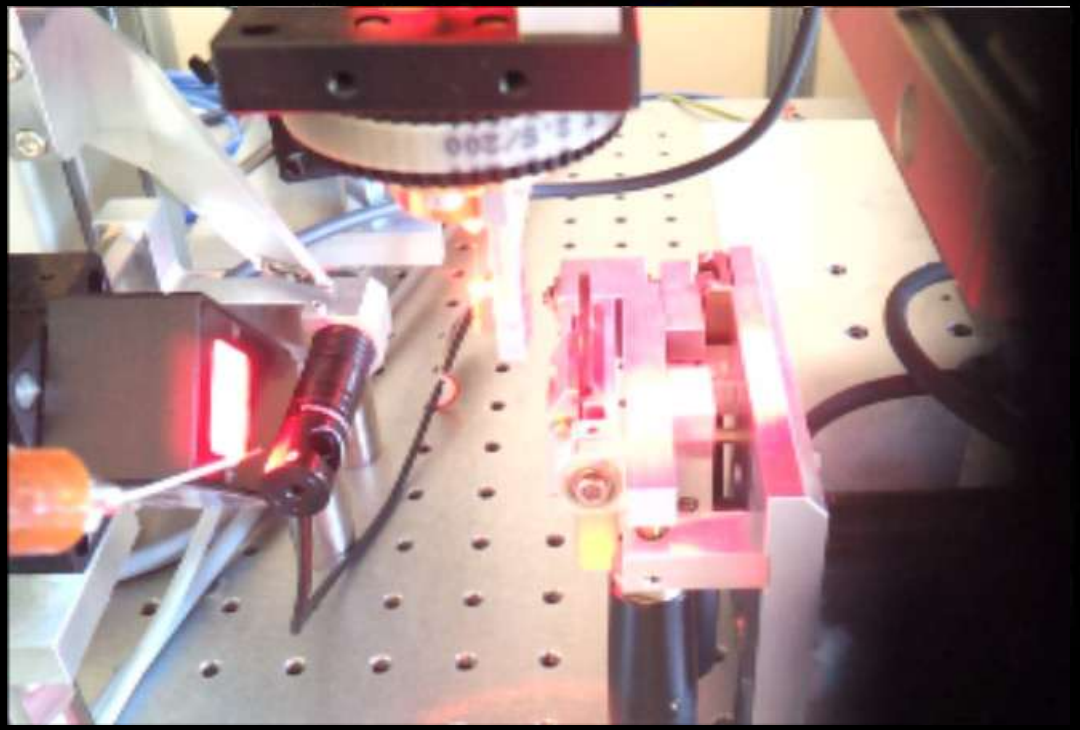
Klocke Nanotechnik



Micro Production System

The assembly process

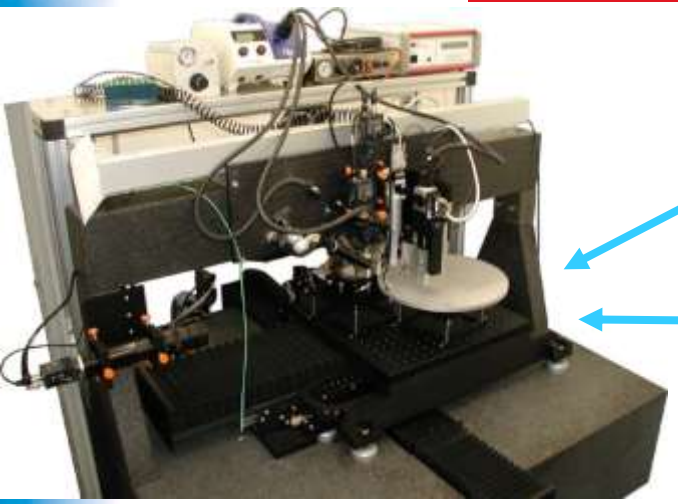
← Process Control



Hardware

Click 2 times onto this background to see the movie

Complete Micro Production Line



IFAM

Institut
Fertigungstechnik
Materialforschung

LPKF Laser & Electronics

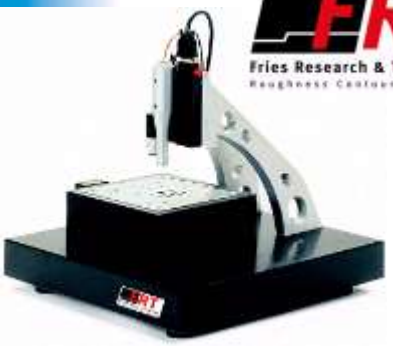
LPKF Motion & Control GmbH

Organisation:
VDMA

IBM

Klocke
Nanotechnik

FRT
Fries Research & Technology



Summary

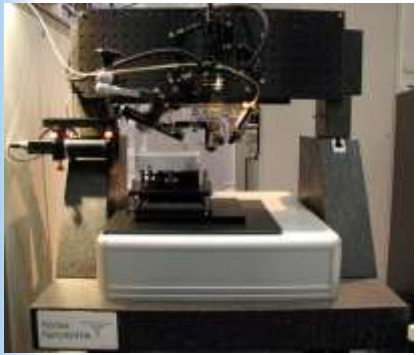
Modular Nanorobotics

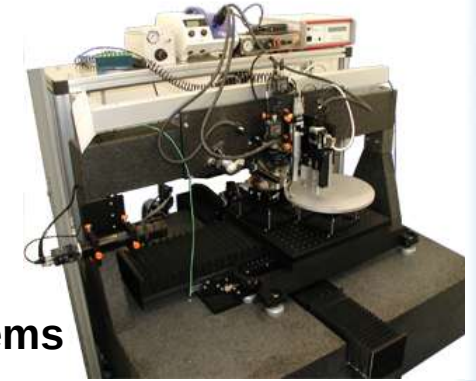
Pool of more than 200 Nanorobotics Components

Configuration to individual machines

µ-Assembly, µ-Tensile-Machine, 3D-Nanofinger, SPM-Lithographer, ... **The SEM/FIB Workbench**

Integration in Nanorobotics systems



Universal Testing Benches

Micro Production Systems