

# ***The Nanoworkbench***

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Standard Application Packages

## ***NanoProbing:***

***Current measurements  
inside SEM/FIB systems  
with the Nanoworkbench  
from Klocke Nanotechnik***



### NanoProbing at different samples:

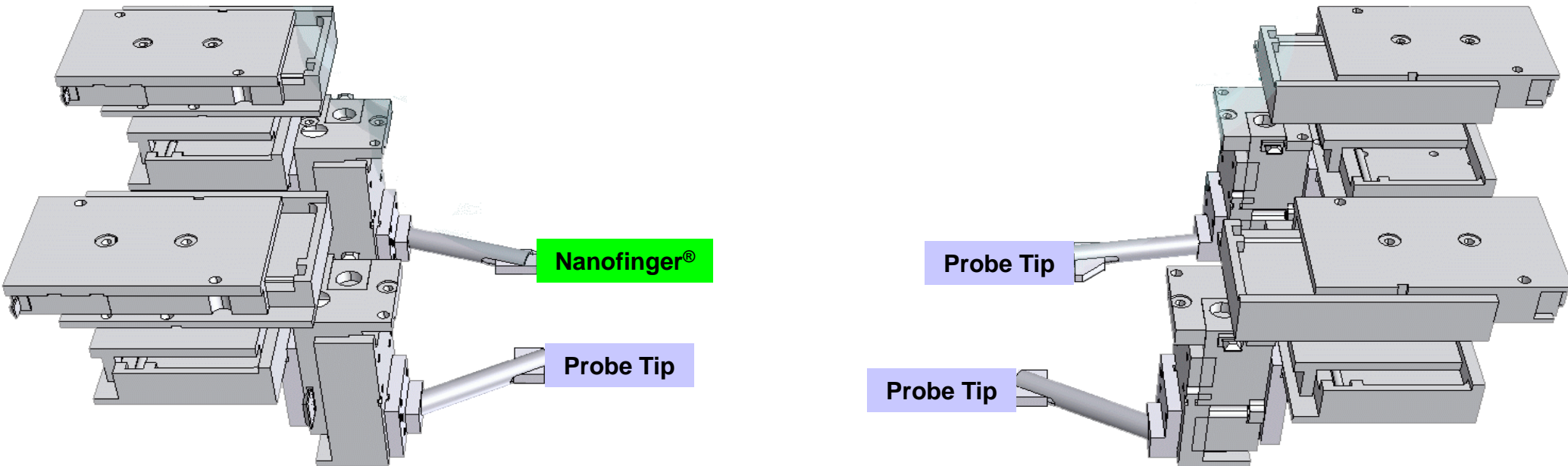
- **1-probe** measurements:
  - at samples with medium resistivity
  - on substrates with very low resistivity
  - the probe current is collected through the substrate
- **2-probe** measurements:
  - at samples with medium resistivity
  - laying on substrates with high resistivity
- **3-probe** measurements:
  - e.g. at Transistor structures
- **4-probe** measurements:
  - at samples with low resistivity
  - laying on substrates with higher resistivity
  - or for Transistor probing including ground electrode

### Option Plasma Cleaner:

- Necessary to avoid hard contamination layers on the sample
- Not useful when samples can oxidize



## Nanoworkbench Configuration:



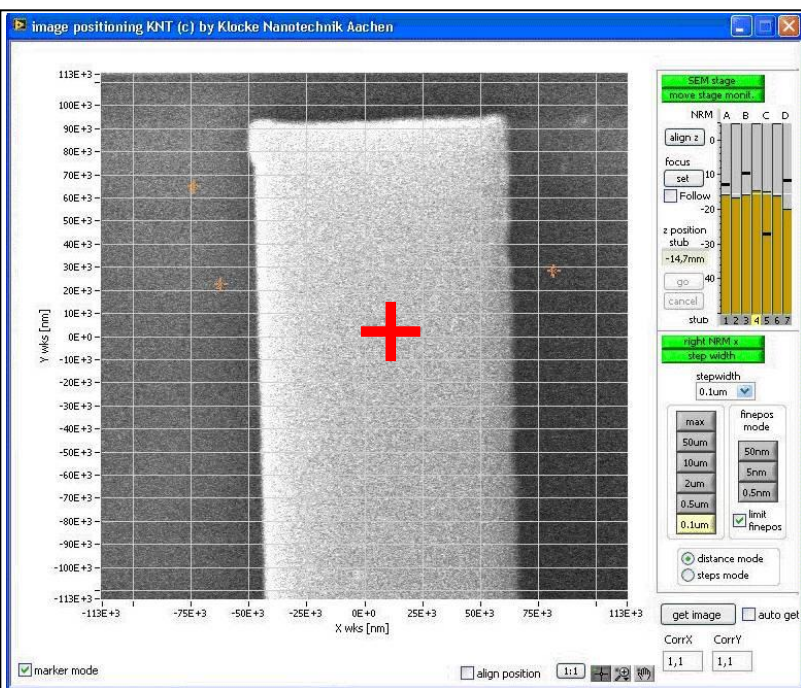
1. Nanomanipulator equipped with: 1D-Nanofinger® as Scout
2. - 4. Nanomanipulator equipped with: Current Probe tip if necessary

- Options: Source Measure Unit, software to plot the results
- Standard Software Package: Macro Executor, Live Image Positioning, Assistants, Sequencer

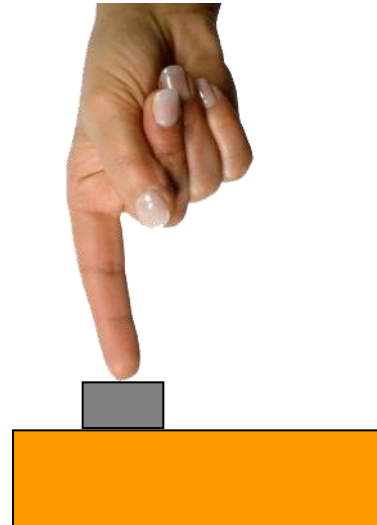
® Nanofinger is a registered Trademark of Klocke Nanotechnik GmbH

# NanoProbing

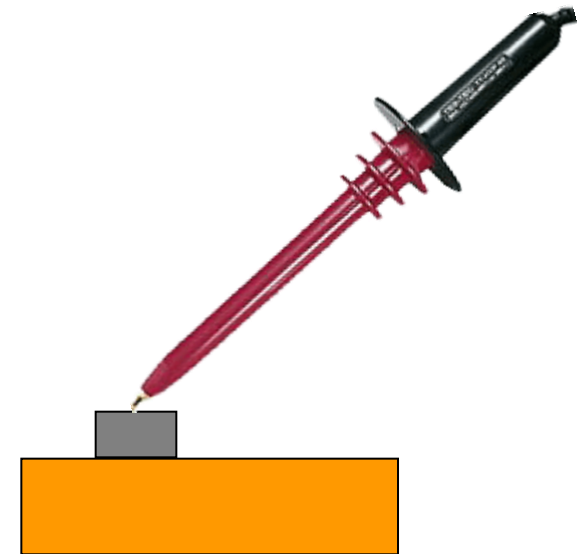
## Process



**Live Image Positioning:**  
**select target**



**1D-Nanofinger®:**  
**finds target**

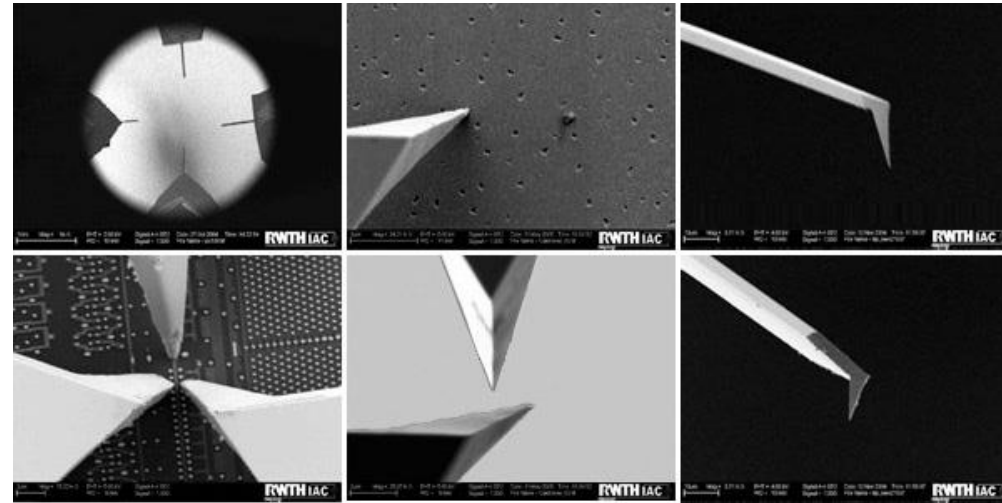
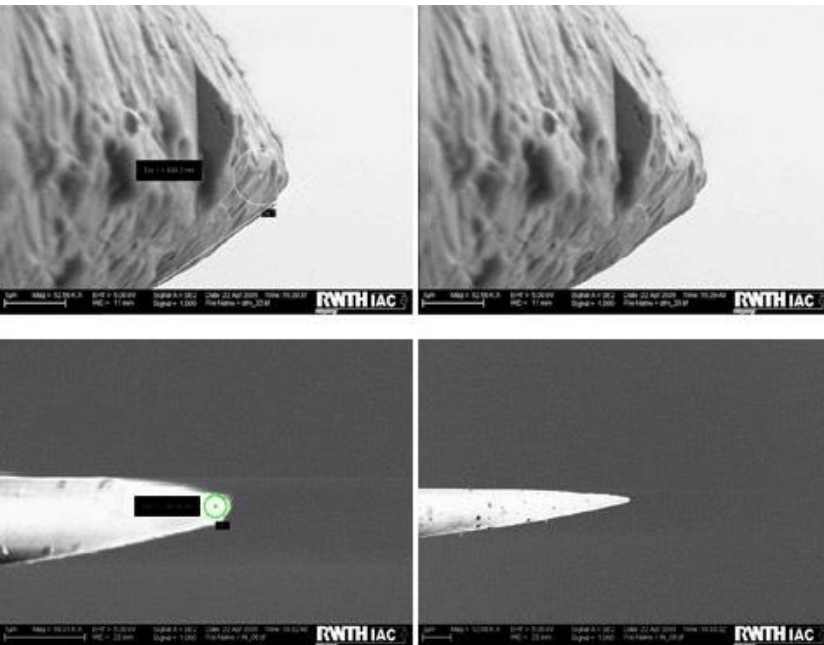


**Current Probe:**  
**measures I/V curve**

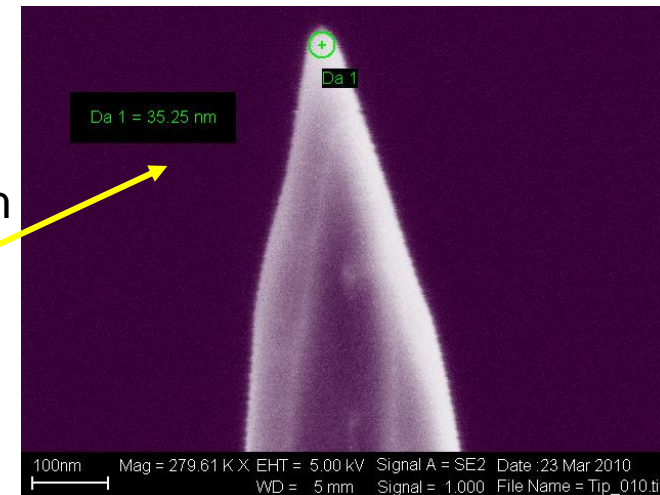


### Different probe tips:

- Cantilever shapes with visible tip
- Wire shape in different stability,  
- optional with coating

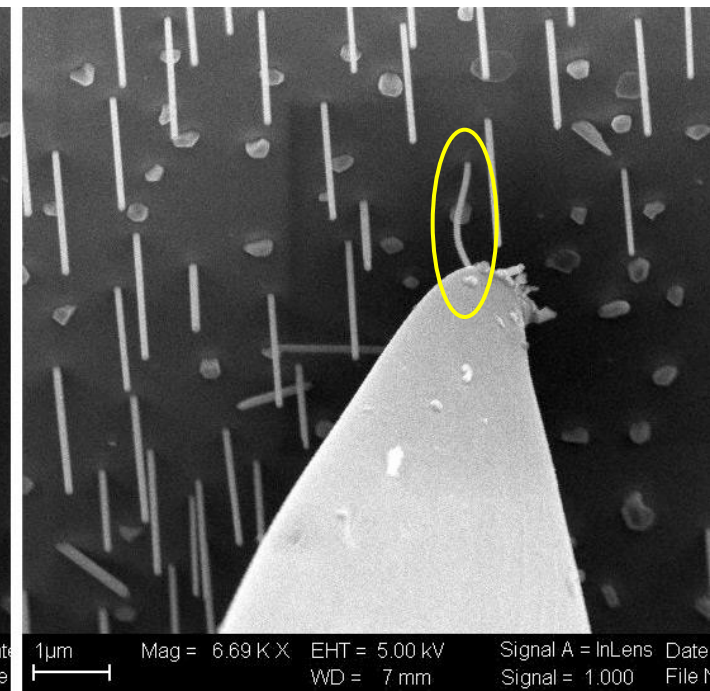
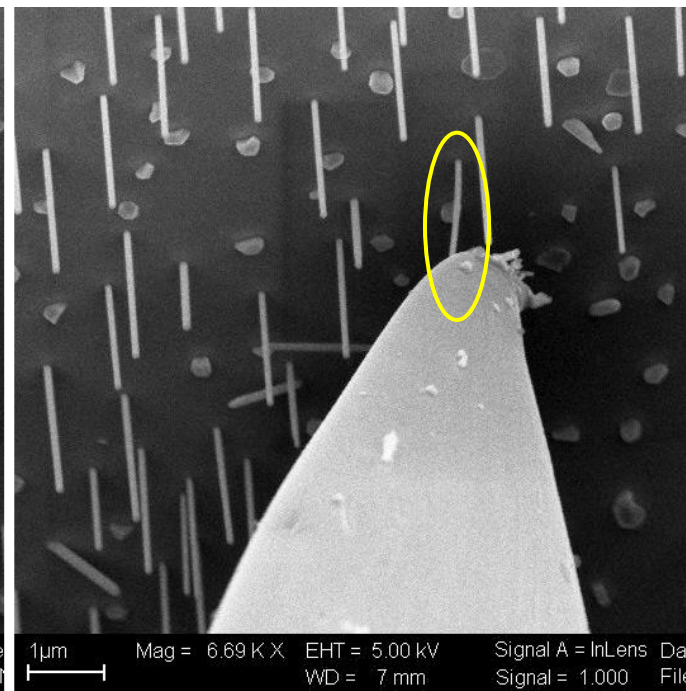
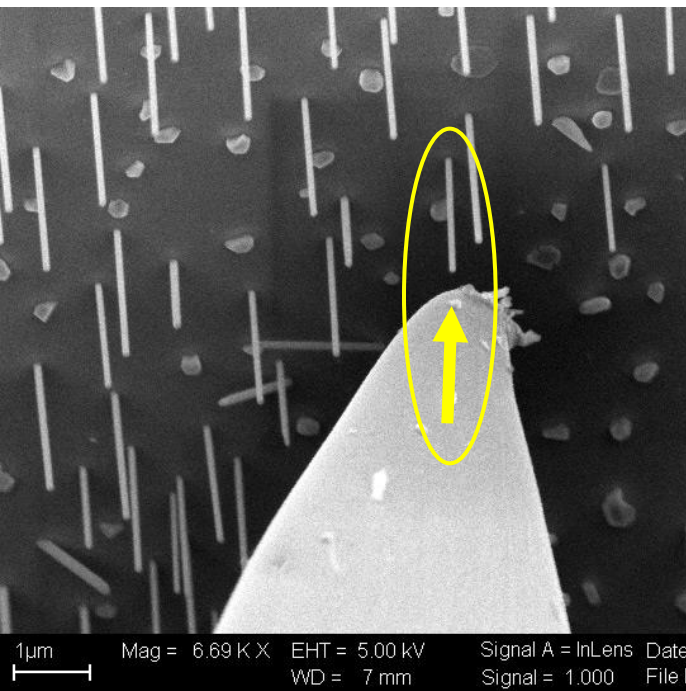


Sharp tip with  
Pt- coating:  
 $r = 15 \text{ nm}$



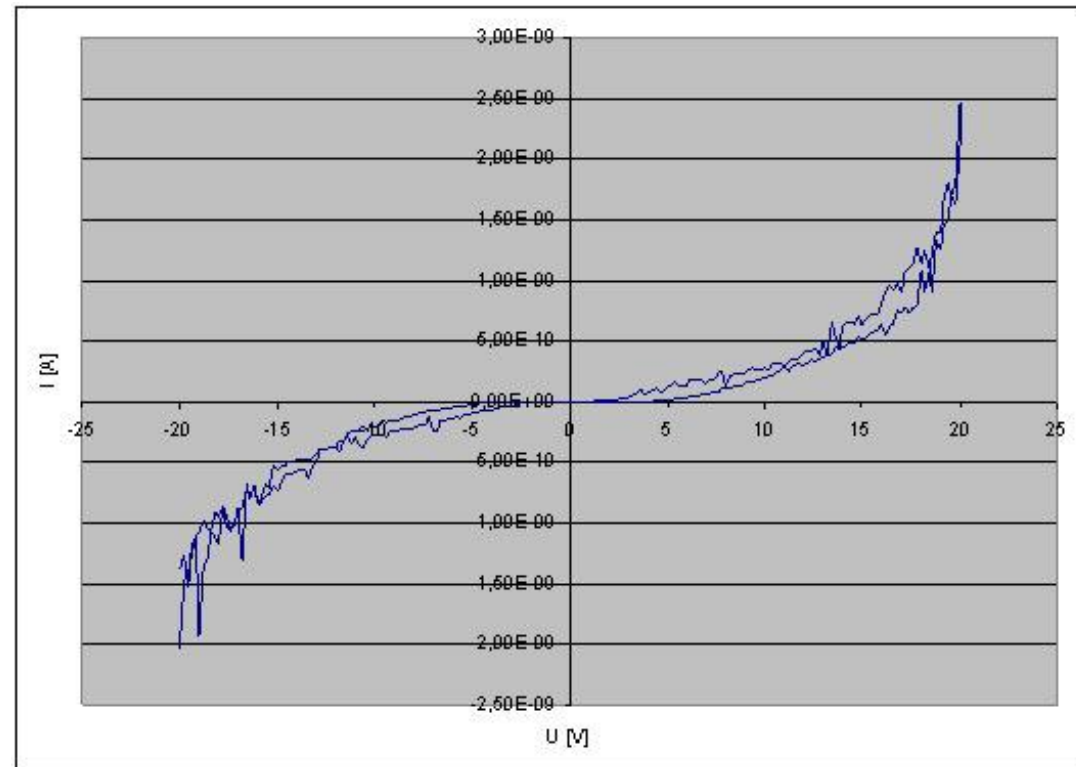
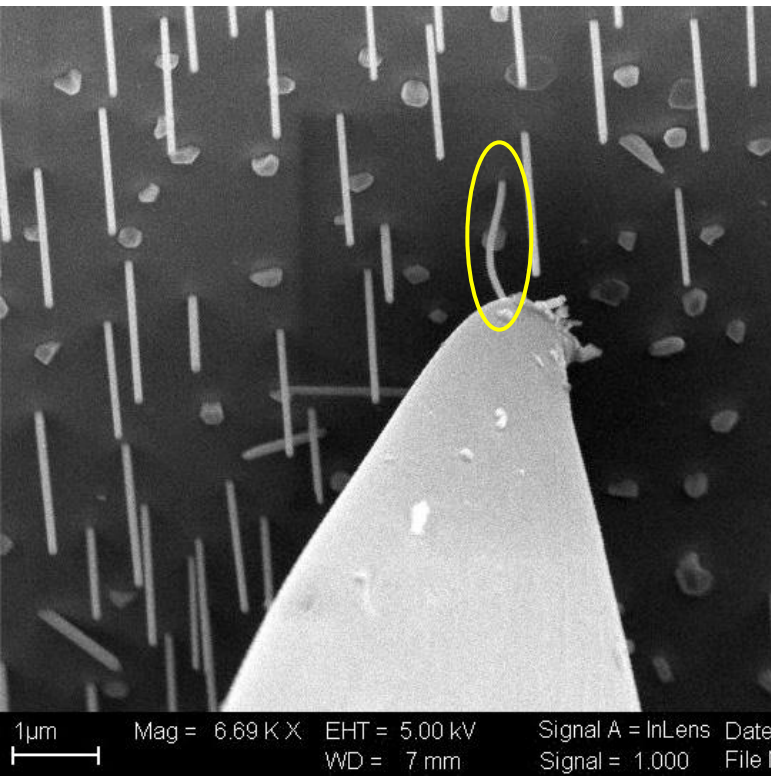
### I/V measurement at a single standing nanowire:

- The probe tip touches a standing nanowire which then bends slightly



### I/V measurement at a single standing nanowire:

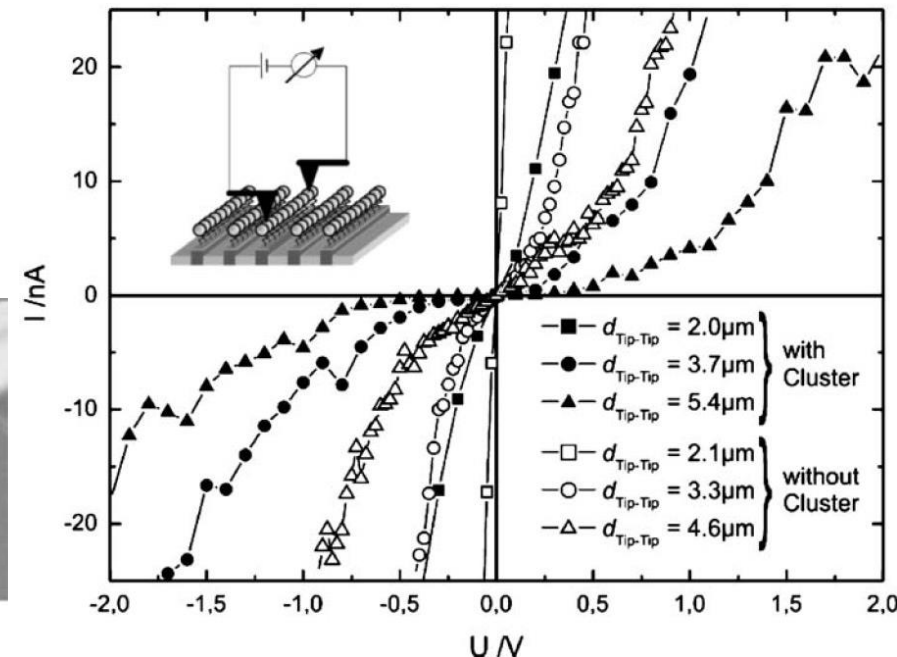
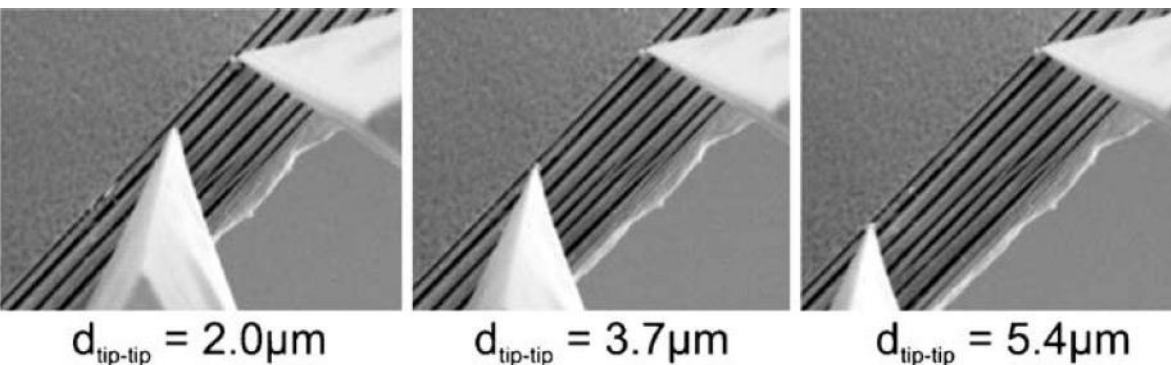
- Current flow:  
Source Measure Unit (SMU) → probe tip → nanowire → substrate → SMU



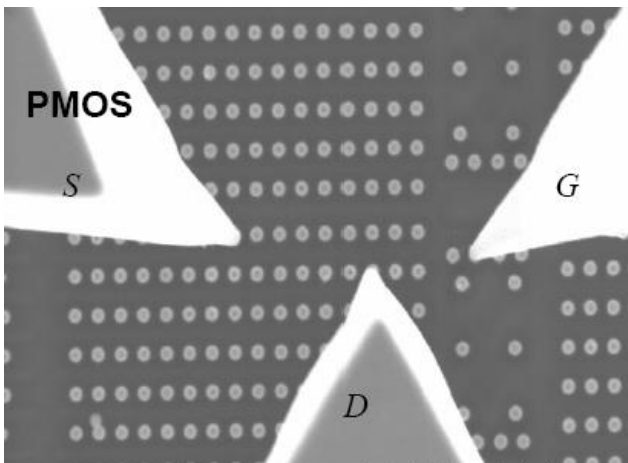


### I/V measurement at a chain of gold clusters:

- Length of chain is varied by changing the tip distance
- Resistivity depends on chain length



“Single Transistor characterization by Nano-probing to identify failures”, **TSMC**



Current flow		Id (uA)	Ig (uA)	Is (uA)	Ib (uA)
Bad die	Ioff	<b>-6.81</b>	6.08E-5	<b>1.83</b>	<b>4.99</b>
	Isat	-113.66	-0.00523	106.45	<b>7.06</b>
Good die	Ioff	-1.27	2.04E-5	1.11	0.164
	Isat	-155.04	-0.00734	155.07	0.197

Table1. It shows the current value of source, drain, gate, and well/substrate. Strong signals labeled with red indicate leakage existed between drain and substrate.

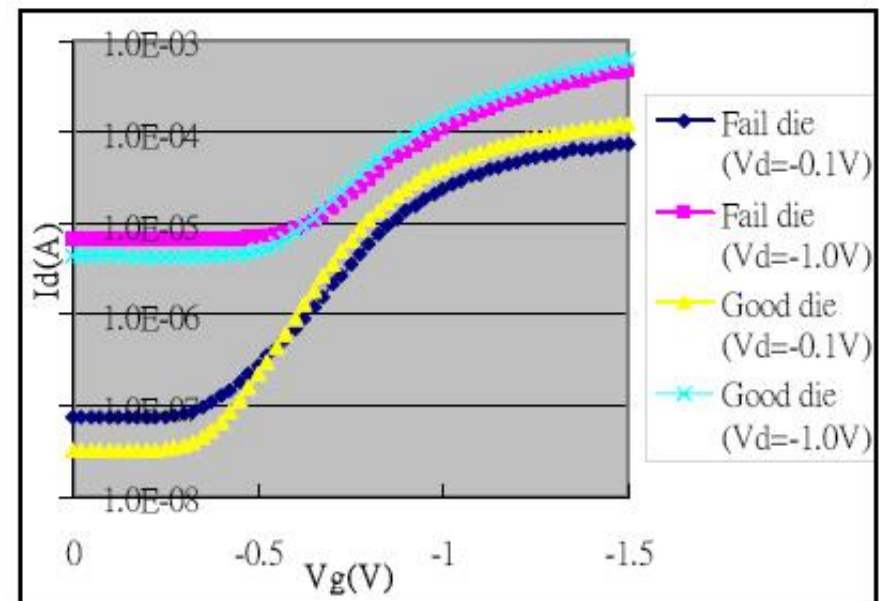
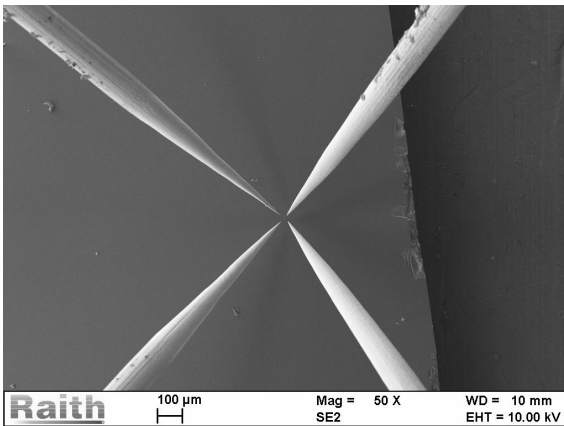


Figure 2 Device behavior is different between the PMOS transistors of bad and good dice. The device of bad die has higher Ioff.

# NanoProbing

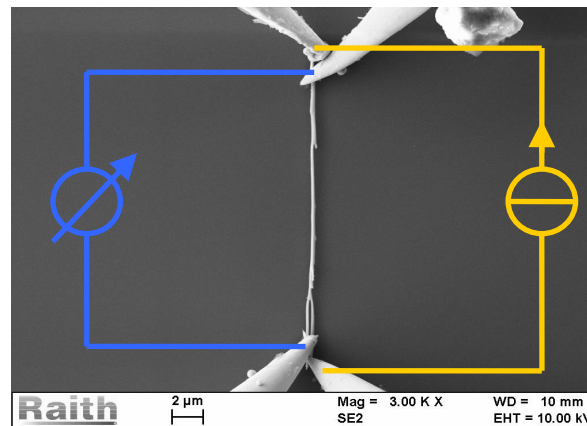
## 4-probe measurements

I/V measurement at a nanowire with 4 probes (@RAITH):

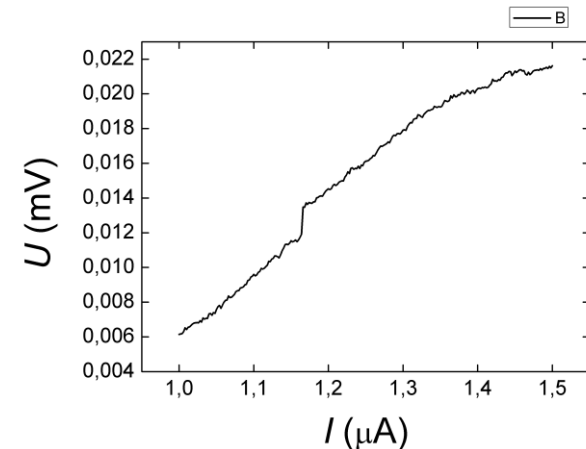
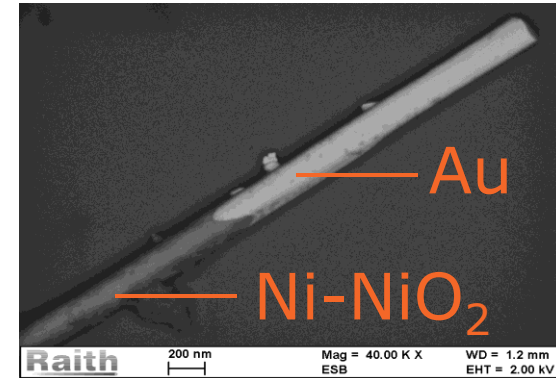


- Approach of 4 tips

- Measurement:

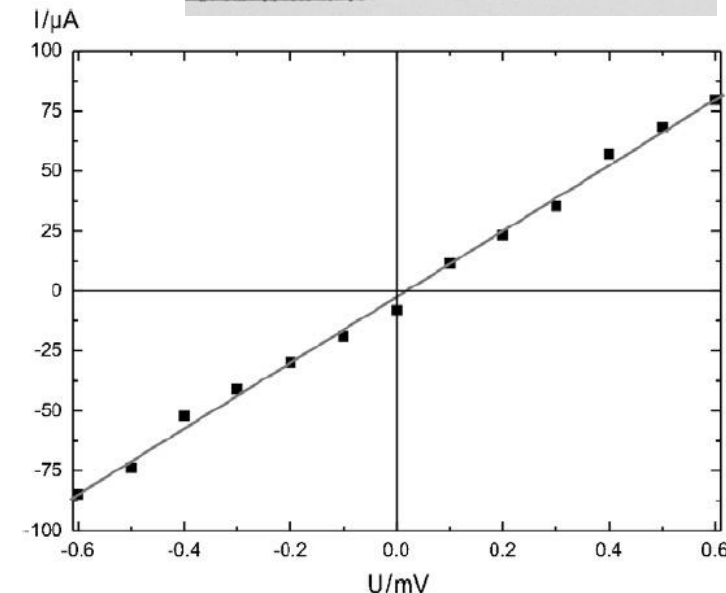
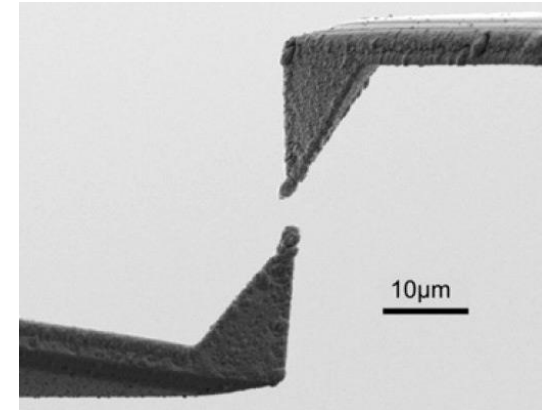


- Nanowires:



### Resistivity of the setup itself:

- COAX or TRIAX cable sets offer excellent measurement quality:
- Current flow:  
SMU  $\rightarrow$  cable set  $\rightarrow$  probe tip  $\rightarrow$  probe tip  $\rightarrow$  cable set  $\rightarrow$  SMU
- The  $I / V$  curve measured over this experimental setup reflects ohmic behavior with a total resistance of about 8 Ohm
- Enabling sample measurement with very low serial resistance, even with only 1-2 probes.



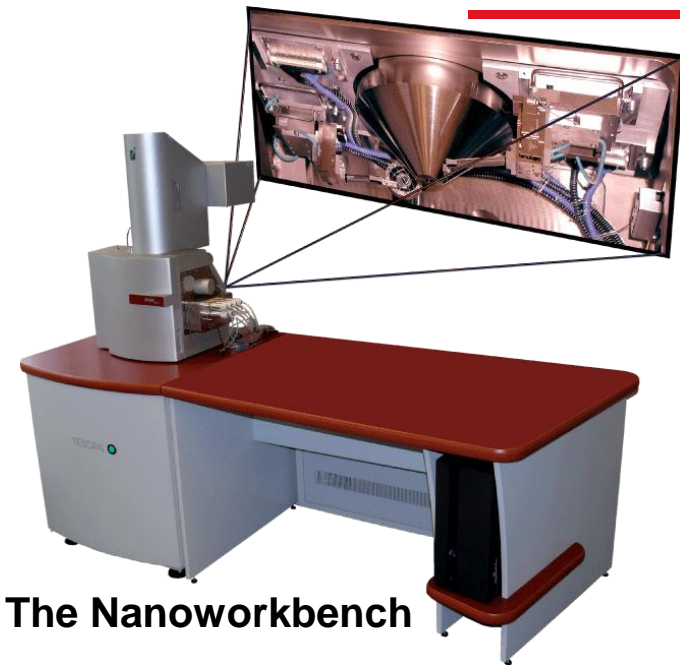


### Summary

- in-SEM/FIB NanoProbing is a Standard Application Package of the Nanoworkbench. Further nanorobotics manipulators can be added for using more than 2 tips.
- The Live Image Positioning module allows to direct the probe tip in XY to the target area just by mouse-click into the SEM image.
- The Nanofinger<sup>®</sup> operating as Scout allows a fast and safe tip approach.
- COAX or TRIAX shielded cable sets offer excellent measurement quality.

# The Nanoworkbench

and its Application Packages

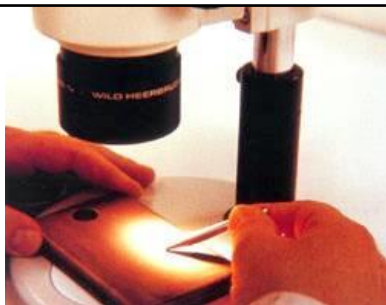


The Nanoworkbench

**NanoProbing ...**

**is one out of several “Standard Application Packages” of our [Nanoworkbench](#).**

The Nanoworkbench enables the hand-eye coordination as used at Light Microscopes now in any SEM/FIB, together with automation of the SEM/FIB (@ZEISS, FEI, TESCAN)



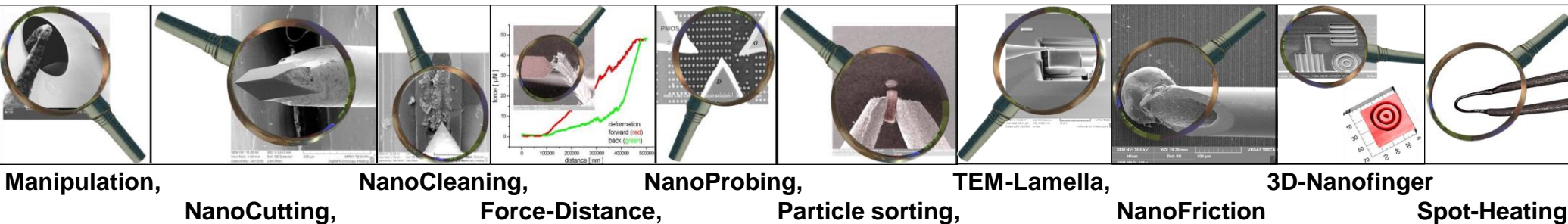
**At Light Microscopes** it is natural for everybody to use tool sets like tweezers, knives, hooks, probes and several different measurement tools, so it is with the Nanoworkbench.

# The Nanoworkbench

One Product for all applications

## The Nanoworkbench Standard Packet includes:

- The basic application package “Nanomanipulation” and
- one additional “Application Package” out of:



Each application package includes a standard tool, a standard sample and pre-defined processes as source-code and origin for own projects.

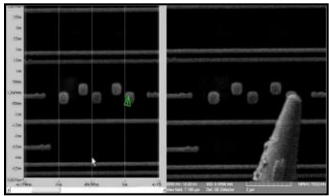
- The following set of modules for easy usage and application control:

# The Standard Packet

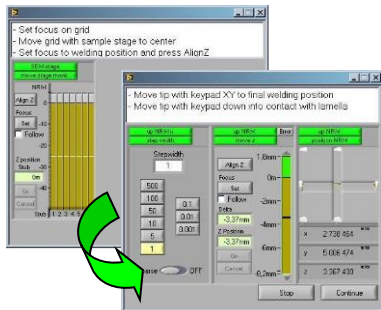
Hand-eye coordination:



Nanofinger® as Scout, guiding the  
Nanoworkbench Tools,

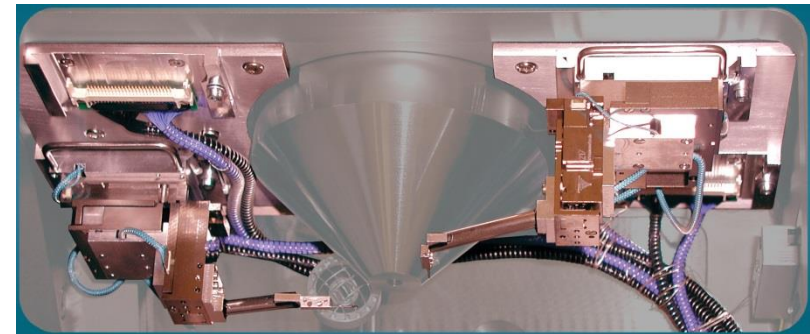
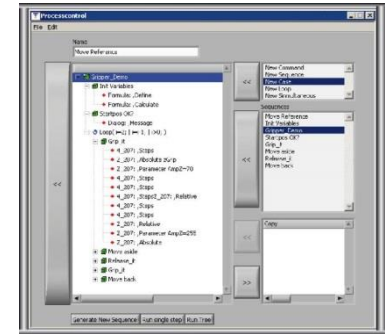


Live Image Positioning,



Assistants  
(Wizards),

Sequencer for automation,  
Macro Executor,  
Remote Control,  
...



2 Nanorobotics Manipulators  
with docking stations

**More information?**

**Please ask for the leaflet “Nanoworkbench”**

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