The AFM in SEM from nano analytik GmbH is not only used for imaging, but can be employed for metrology as well. For this purpose, we are offering a compact AFM system, applicable in any SEM without chamber modification for micro manipulation and metrology scanning.

The naB73 scanner is a non-magnetic, closed loop XYZ nanopositioner with 60 μm x 60 μm x 20 μm range of motion (Position noise (nm): x, y = 0.4; z = 0.2) and extremely low out-of-plane motion.

It has a high resonant frequency in x, y of 750 Hz and z of 2000 Hz. It is designed for space-constrained applications that require high precision positioning. Furthermore, the specially developed 3-axes cantilever head-positioning system is offering motion capabilities in the range of 18 mm in X, Y and 10 mm in Z with a closed loop accuracy of < 5 nm and a closed loop repeatability of +/- 25 nm.

nano analytik GmbH employs self-transduced and self-sensed (2DEG read-out) cantilevers in SEM, which meet the following criteria: (I) low spring constant (low longitudinal stiffness), (II) high resonance frequency, (III) high quality factor of the cantilever, (IV) high lateral spring constant (high transversal stiffness), arranged for electronic read-out actuation and conductive tip ensures that no electric charging can occur.

For more information see:
Six-axis AFM in SEM with self-sensing and self-transduced cantilever for high speed analysis and nanolithography; T. Angelov et al., Journal of Vacuum Science & Technology B34, 06KB01 (2016); doi: 10.1116/1.4964290
AFM in SEM

Standard configuration
- naB73 bottom scanner for vacuum operation
- High addressing accuracy of the AFM-tip by integrated 3D-positioner (of < 5 nm and a closed loop repeatability of +/- 25 nm)
- High voltage amplifier
- In head readout electronics
- Kronos® 125 MHz Controller
- AFM-Starterkit including 10 SmartActiveProbes® for easy probe exchange system

Optional configuration
- Extended scan range for up to 100 µm²
- Windows dll, com-port for independent function access and programming
- Ambient operating AFM mount
- 2-channel 125 MHz Kronos® controller for multiple applications
- Upright digital navigation microscope for ambient use
- Acoustic enclosure for ambient operation
- Active piezoelectrical damping stage for ambient operation
- Passive mechanical damping stage for ambient operation
- Full environmental enclosure for ambient operation

FUNCTIONS
- Operation mode: AC mode / DC mode
- Topography imaging: YES
- Amplitude / phase imaging: YES
- Force curve chart: YES
- Sample / probe approach: Automatic
- Probe tuning: Automatic
- Detection principle: Piezoresistive
- Scan range: naB73 scanner: 60 µm × 60 µm × 20 µm
  naB74 scanner: 100 µm × 100 µm × 10 µm
- *Background noise: 0.01 nm rms in vertical direction
- *Lateral accuracy: 99.7 % closed loop scanning
- *Scan speed: 0.01 to 10 Hz
- Simultaneous images: Phase, frequency, amplitude, topography
- Measurement modes: MFM, EFM, PFM, C-AFM, SThM, Nanolithography

ELECTRONICS
- Resolution amplitude / phase: 16-bit
- Feedback control platform: Real-time FPGA
- Bandwidth: 8 MHz
- Computer interface: USB, ethernet optional
- Sensor conditioning: 0 to - 4 V programable bridge supply

AFM-TIP POSITIONER
- Motion range (x, y, z): 18 x 18 x 10 mm
- Accuracy: < 5 nm
- Repeatability: +/- 25 nm

SOFTWARE
- Realtime correction: Line, Plane, Polynomial
- Line profile measurement: YES
- Roughness measurement: YES
- Contrast / brightness: YES
- Multiple color palettes: YES
- 3D image: YES
- Line average: YES
- Image export: bmp file, png file, jpg file
- Raw data export: txt file
- Image size: 2 to 1024 pixels
- Raw data export: For Matlab, Excel, Gwyddion and WSxM

© nano analytik GmbH; CONTACT: info@nanoanalytik.net; Phone: +49 (0)3677/4690112; Fax: +49 (0)3677/4690099
nano analytik GmbH, Ehrenbergstr. 1, 98693 Ilmenau, GERMANY

Dynamic in situ vacuum analysis
AFM in SEM MEMS inspection
AFM SmartActiveProbe in SEM
Phoebus® 125 MHz controller for most nano analytik GmbH applications including AFM in SEM
**Standard cantilever:**
Integrated 2DEG readout and actuation

L: 350µm; W: 120µm
T: 4µm ±1
Force constant: 20N/m ±2
$f_{Res}$: 50kHz ±5

**Application:**
• Multifrequency operation
• High eigenmode operation
• Contact mode
• Non-contact mode

**Fast cantilever:**
Integrated 2DEG readout and actuation

L: 50µm; W: 20µm
T: 2-3µm
Force constant: 100N/m ±5
$f_{Res}$: 200kHz ±10

**Application:**
• Multifrequency operation
• High eigenmode operation
• Contact mode
• Non-contact mode

**Electric cantilever:**
Integrated 2DEG readout and actuation

Conductive tip
L: 350µm; W: 120µm
T: 3-5µm
Force constant: 20N/m ±2
$f_{Res}$: 50kHz ±2.5

**Application:**
• Multifrequency operation
• High eigenmode operation
• Contact mode
• Non-contact mode
• Kelvin-mode
• Spreading resistance
• Field-Emission mode (lithography mode)

**Cantilever as “atomic assembler”**
Integrated 2DEG readout and actuation

L: 350µm; W: 120µm
T: 3-5µm
Force constant: 20N/m ±2
$f_{Res}$: 70kHz ±2.5

**Application:**
“The heart” of the Toolkit for Silicon- or Diamond-based Quantum Computing

• Single-ion-implantation
• Contact mode
• Non-contact mode
• SNOM
SmartActiveProbes® SOLUTIONS

In comparison to other probe-makers, nano analytik GmbH attempts to achieve full customer satisfaction by tracking a complete technical approach that combines specialized expertise with exceptional service and professional technological support. We provide our customers with extensive technological assistance throughout the complete product development cycle - from design support to prototyping and fabrication support.

Send us your request: info@nanoanalytik.net

Technology working for you
NANO ANALYTIK GMBH SELF-SENSING AND SELF-

The nano analytik GmbH measurement read-out circuit was proposed in 1993 by Ivo W. Rangelow (Microelectronic Engineering 23, 365-368) where all four resistors are mechanically loaded. This approach provides the highest possible z-sensitivity (atomic resolution) and first-order temperature compensation. nano analytik GmbH employed a full Wheatstone bridge design with two longitudinal and two transverse piezoresistors to increase the read-out sensitivity and compensate.

flexible solutions for your scanning-probe re

INNOVATIVE SCANNING READ-OUT

nano analytik GmbH’s SmartActiveProbes® are capable of sensing and detecting forces and displacements on an atomic scale at a high-speed imaging. The SPM-sensor with piezoresistive read-out achieves temperature compensation, allows offset compensation of the Wheatstone bridge and is comparable with the capabilities of conventional optical force measurement instruments.

NEW STANDARDS FOR KNOWN TECHNOLOGY

The piezoresistive effect in p-type 3D Si was carefully investigated in the case of the tensile stress. We discovered that along that direction a fully confined hole wave function conducts the loss of the translation invariance. Today, nano analytik GmbH sensors have about two times higher piezoresistive coefficients in comparison to standard piezoresistors.
The SmartActiveProbe uses the thermomechanical principle for actuation (see: Surf. Interface Anal. 33, 59–64 and SPIE. 9424, doi: 10.1117/12.2085760). These cantilevers could be incorporated into every SPM tool. AFM Integrations for operation in vacuum, liquids and extreme temperatures can be realized for many customer-specific applications.

The geometry of an AFM tip plays a crucial role when imaging surfaces. nano analytik GmbH employs a conical shape, which is especially favorable when imaging well-defined features or randomly generated topological structures. The tips are formed in highly doped, single crystal silicon, and offer long operational life in case of Scanning Probe Lithography (SPL) (see: Journal of Vacuum Science and Technology B34 (6); doi: 10.1116/1.4966556).

Cantilever as atomic assembler

In comparison to other probe- and AFM- makers, nano analytik GmbH attempts to achieve full customer satisfaction by tracking a complete technical approach that combines specialized expertise with exceptional service and professional technological support. We provide our customers with extensive technological assistance throughout the complete product development cycle - from design to system prototyping and fabrication support. For example, nano analytik GmbH established a method for qubit formation by deterministic single ion implantation. Solid state implementations of quantum computers scaled to hundreds of quantum bits (“Qbits”) promise to revolutionize the information technology. A “direct Qbits exchange coupling” requires a qubit spacing of ~20 nm with a gate pitch of about 7 nm, while electron shuttling would allow qubit spacings of ~100 nm. The alignment of gates, SETs, and single donors represent the task for the formation of single atom devices. nano analytik GmbH has developed an AFM-instrument in which single ions can be aligned to sample qubit-read-out features. It has been shown that the spatial resolution of ion implantation is now approaching the nanometer level.

SEARCH

ACTUATED SPM/SPL CANTILEVERS

resistance drift due to temperature. When only one resistor in the bridge is mechanically loaded, the stress sensitivity of the sensor is reduced by a factor of four from the 4-wire configuration. nano analytik GmbH introduced for the first time the piezoresistive quantum size effect and developed the most sensitive piezoresistive cantilever readout system.

CUSTOM SOLUTIONS

Research and development areas:

- Intelligent surface scanning
- Multi-Cantilever Concept
- High-Speed cantilever imaging
- Advanced applications in sensor systems
- Next-Generation AFM systems
- Nano-Marking readout systems
- High-Performance AFM image processing
- New sensor technologies
- Ion-positioning technology
- Health & environment
- Biomedical & biomolecular healthcare solutions
- Tip-Transistor for molecular diagnostics
- Biomedical systems environmental sensors
- Technologies innovation

ACTUATED SPM/SPL CANTILEVERS
The nano analytik GmbH's SmartActiveProbes® are extremely user friendly. Manual cantilever exchange is possible in less than 10 sec, tip-approach in 5 sec (from 2.5 mm over the sample) and in 20 sec an image is ready for the highest AFM productivity.

The stiff mechanical design ensures very low noise and high stability during all imaging and lithography processes providing sub-nanometer resolution on large scanning extents.

Scanning speed of 100 l/sec, (10 x 10 µm for 50 nm topography height) is established using nano analytik GmbH Controller and Scanner. No more groping with tweezers, no more laser beam adjustments are required. Pre-qualified, pre-aligned, self-actuated, and self-sensing cantilevers are supplied in an easy-to-load box and make them very easy for use.

References:


Pattern-generation and pattern-transfer for single-digit nano devices; Journal of Vacuum Science and Technology and Microelectronics 34 (6(624,974),(998,997); doi: 10.1116/1.4966556 (November 03, 2016) I. W. Rangelow et al.

Large area fast-AFM scanning with active “Quattro” cantilever arrays; Journal of Vacuum Science & Technology B 34, 06KM03 (2016) doi: 10.1116/1.4967159 (November 09, 2016); A. Ahmad et al.


Self-actuated, self-sensing cantilever for fast CD measurement; Proc. SPIE. 9424, Metrology, Inspection, and Process Control for Microlithography XXIX, 94240P. doi: 10.1117/12.2085760 (March 19, 2015); A. Ahmad


Nano Analytik GmbH Software

All AFM-system parameters e.g. the used hardware, the operation mode, parameter control, display control, video control, speed control of the stage, the timing and the actuation of the SmartActiveProbe are configured and controlled by a simple mouse click. Parameters are controlled and clearly displayed giving the user the possibility to follow the acquiring operation and simultaneously monitor and adjust multiple data signal channels in real-time. The software runs under Microsoft Windows.

<table>
<thead>
<tr>
<th>VALUE / Version</th>
<th>NANO-COMPASS BASIC</th>
<th>NANO-COMPASS ADVANCED</th>
<th>NANO-COMPASS PROFESSIONAL</th>
<th>NANO-COMPASS SPBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-automatic cantilever set-up</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Full-automatic fast surface approach</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Non-contact mode support</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Export to image formats</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>2d scan image view</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Multi-user support (per-user settings)</td>
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<tr>
<td>Graphical sample navigation</td>
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<tr>
<td>3d scan image view</td>
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<tr>
<td>Export to raw formats</td>
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<tr>
<td>Live signal display (oscilloscope)</td>
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<tr>
<td>Selective screen capture</td>
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<tr>
<td>Multi-monitor support</td>
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<tr>
<td>Direct camera integration (selected models)</td>
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<tr>
<td>Scripting language</td>
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<tr>
<td>Point-and-click tip positioning</td>
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<tr>
<td>Contact mode support</td>
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<tr>
<td>Adaptive scan speed technology</td>
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<td>2nd level positioning stage integration (selected models)</td>
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<tr>
<td>Basic SPBS support (Scanning Probe Based nano Structuring)</td>
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<tr>
<td>SPBS pattern editor</td>
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<tr>
<td>Parallel scan channels</td>
<td>1</td>
<td>1</td>
<td>2 + n</td>
<td>2 + n</td>
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<tr>
<td>Update support (months)</td>
<td>6</td>
<td>12</td>
<td>24</td>
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<tr>
<td>Interface library</td>
<td>-</td>
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<tr>
<td>Compatible controllers (probably not all features available)</td>
<td>Attogram, Zelos, nanoMETRONOM, Phoebus, Kronos</td>
<td>Zelos, nanoMETRONOM, Phoebus, Kronos</td>
<td>Phoebus, Kronos</td>
<td>Kronos</td>
</tr>
<tr>
<td>Recommended controllers</td>
<td>nanoMETRONOM</td>
<td>nanoMETRONOM</td>
<td>Phoebus</td>
<td>Kronos</td>
</tr>
</tbody>
</table>

- standard features  | available on request  | - not available
<table>
<thead>
<tr>
<th>VALUE / MODEL</th>
<th>ATTOGRAM</th>
<th>ZELOS</th>
<th>nanoMETRONOM</th>
<th>PHOEBUS</th>
<th>KRONOS</th>
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</thead>
<tbody>
<tr>
<td><strong>Input channels</strong></td>
<td>125 MHz</td>
<td>80 MHz</td>
<td>80 MHz</td>
<td>125 MHz</td>
<td>125 MHz</td>
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<tr>
<td></td>
<td>2 x 16 bit</td>
<td>1 x 16 bit</td>
<td>1 x 16 bit</td>
<td>(2 + N) x 16 bit</td>
<td>(2 + N) x 16 bit</td>
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<tr>
<td><strong>Bandwidth (input channels)</strong></td>
<td>500 Hz - 10 MHz</td>
<td>500 Hz - 2 MHz</td>
<td>500 Hz - 6 MHz</td>
<td>0 - 10 MHz</td>
<td>0 - 10 MHz</td>
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<tr>
<td><strong>Excitation sources</strong></td>
<td>2 x 16 bit (250 MS/s)</td>
<td>1 x 16 bit (250 MS/s)</td>
<td>1 x 16 bit (250 MS/s)</td>
<td>(2 + N) x 16 bit (250 MS/s)</td>
<td>(2 + N) x 16 bit (250 MS/s)</td>
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<tr>
<td><strong>Bandwidth (excitation sources)</strong></td>
<td>10 MHz</td>
<td>2 MHz</td>
<td>6 MHz</td>
<td>12 MHz</td>
<td>12 MHz</td>
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<tr>
<td><strong>PLL</strong></td>
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<td><strong>Lock-In amplifier</strong></td>
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<tr>
<td><strong>Input channel noise</strong></td>
<td>&lt; 10 nV/√Hz</td>
<td>&lt; 12 nV/√Hz</td>
<td>&lt; 10 nV/√Hz</td>
<td>&lt; 8 nV/√Hz</td>
<td>&lt; 8 nV/√Hz</td>
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<td><strong>X/Y/Z-axis DAC</strong></td>
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<td>3 x 18 bit (250 kS/s)</td>
<td>3 x 18 bit (250 kS/s)</td>
<td>3 x 18 bit (250 kS/s)</td>
<td>3 x 18 bit (250 kS/s)</td>
<td>3 x 18 bit (250 kS/s)</td>
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<td><strong>X/Y/Z-axis closed loop-ADC</strong></td>
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<td><strong>Number of PID controllers</strong></td>
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<td><strong>General purpose input channels</strong></td>
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<td><strong>General purpose output channels</strong></td>
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<td><strong>Motor drivers</strong></td>
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<td></td>
<td>Stepper motor</td>
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<td><strong>Front panel indication</strong></td>
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<tr>
<td><strong>Digital outputs</strong></td>
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<td><strong>PC connection</strong></td>
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<td>UART (RS232)</td>
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<td><strong>Peripheral supply</strong></td>
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<td>Possible applications:</td>
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<td>Scanning Probe Based nano</td>
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<tr>
<td>Structuring SpBS</td>
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<td>Single Ion Implantation</td>
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<tr>
<td>AFM in SEM</td>
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<tr>
<td>Inspection AFM</td>
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<td>Q-Control AFM</td>
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<td>Shear-Force AFM</td>
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<td>Fast AFM</td>
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<td>Junior AFM</td>
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<td>Attobalance</td>
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</table>

- standard features   - available on request   - not available