

# Flex-Axiom

The most flexible AFM for  
materials research



## The most versatile AFM system for materials research

For success in research, scientists depend on professional tools that can readily provide the information needed, regardless of the tasks at hand. By advancing key technologies and designs, Nanosurf has made the Flex-Axiom system one of the most versatile and flexible atomic force microscopes ever, allowing a large variety of applications to be handled with ease. Together with the C3000 controller anything is possible.

### Key features & nenefits

Flat and linear scanning thanks to flexure-based scanner technology

Measurement versatility with the FlexAFM's scanning capabilities in liquid and a multitude of measurement modes

Flexible stage concept allows to extend your system to meet different requirements. The FlexAFM scan head is even compatible with inverted microscopes

True flexibility with exchangeable cantilever holders that have been optimized for specialized tasks to support all kinds of different applications



Flex-Axiom system inside the Acoustic Enclosure 300, with FlexAFM video camera, FlexAFM sample stage 204 with XY translation capability, Isostage 300, I100 scan head interface and C3000 controller.

## Stage solutions

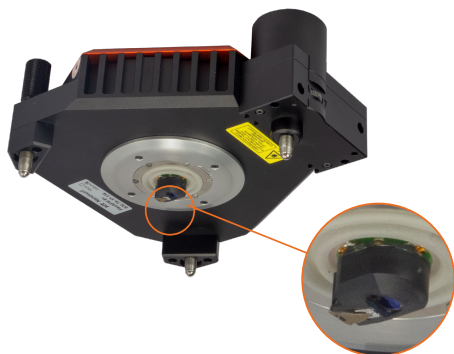
Nanosurf offers different stages designed for specific experimental needs. Every stand-alone stage can be securely attached to the active vibration isolation table. The range begins with simple stages that can be optionally extended with an XY micrometer stage or height extensions to allow thicker samples.

For automated movement of the sample in X, Y, and Z, the ATS 204 is available. It is an automated translation stage that allows the user to control movement via the Nanosurf stage control unit and accompanying software. It can optionally be equipped with a high-resolution 100- $\mu\text{m}$  Z-actuator with position sensor that is ideally suited for force spectroscopy measurements.

To facilitate electrochemical corrosion and deposition studies using the FlexAFM, we offer the ECS 204. It features an inert liquid cell embedded in a solid steel frame, a small protected compartment for oxygen-free atmosphere above the solution, and an integrated micrometer stage for lateral positioning (2 mm range). The electrochemical cell can accommodate a true reference electrode, flat or rod-like samples and allows for liquid exchange. With the additional standard sample platform it functions as a normal sample stage.



The inverted microscope option provides a seamless integration with many types of inverted microscopes, allowing the combination of AFM and optical data (fluorescence/phase contrast/bright field).



## The cantilever holder

As central part of the AFM detection system, the cantilever holder contains cantilever alignment structures for exact cantilever positioning and all optics related to Nanosurf's top and side view technology. It is magnetically attached to the scanner unit to allow quick removal from the scan head for easy cleaning and fast cantilever exchange. Multiple cantilever holder models are currently available, each optimized for its own specific task.

### Cantilever holder liquid/air flat

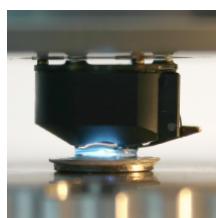
The default cantilever holder supplied with each FlexAFM system is the type liquid/air flat. Its planar glass optics allow measurements in liquid and air. In addition to measuring in a liquid droplet, it can dive directly into a layer of liquid with up to 6 mm in height, e.g. in a cell culture dish.

### Cantilever holder scanning thermal

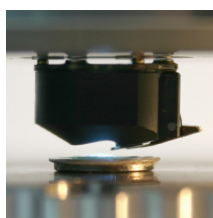
Optimized for use with AppNano Vertisense SThM probes, the cantilever holder scanning thermal allows scanning thermal microscopy measurements to be performed.

### Cantilever holder FluidFM®

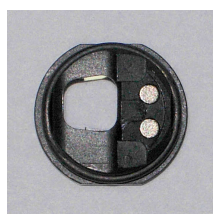
The cantilever holder FluidFM® and matching CytoClips with premounted hollow cantilevers can be coupled to the microfluidics pressure control system to allow fluidic force microscopy in single cell applications and beyond.



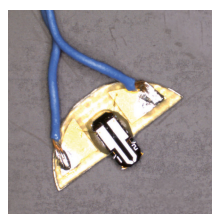
Liquid



Air



Holder



Thermal probe



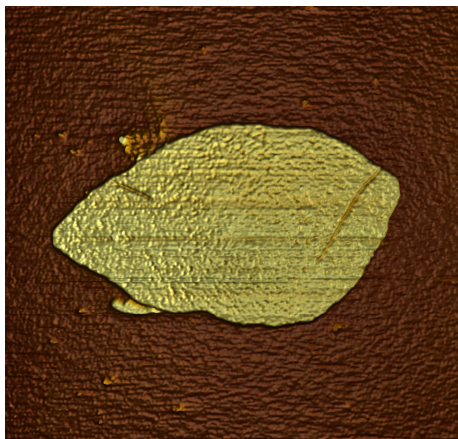
Holder



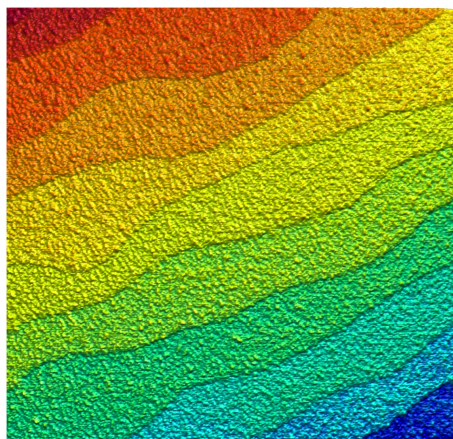
CytoClip



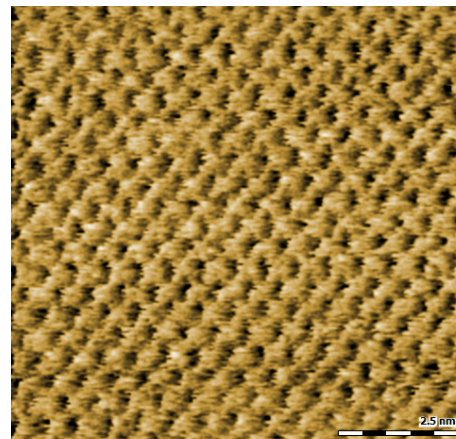
## Standard and advanced imaging modes



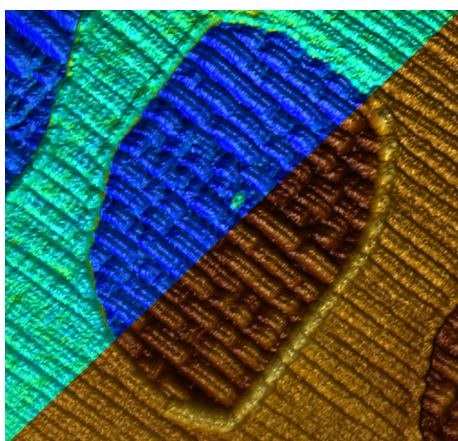
Topography of single pyrene nanosheet (adapted with permission from Chem. Mater. 27, 1426–31. Copyright 2015 American Chemical Society)



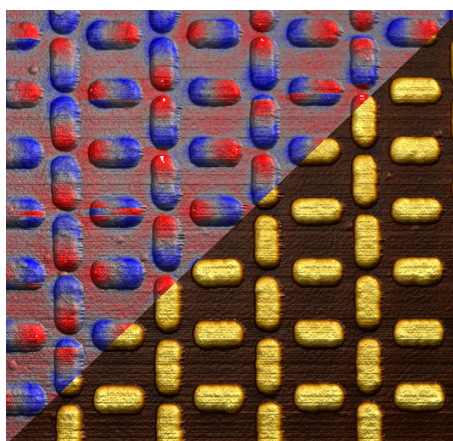
Topography of SrTiO<sub>3</sub> in dynamic mode. Scan size: 1  $\mu\text{m}$



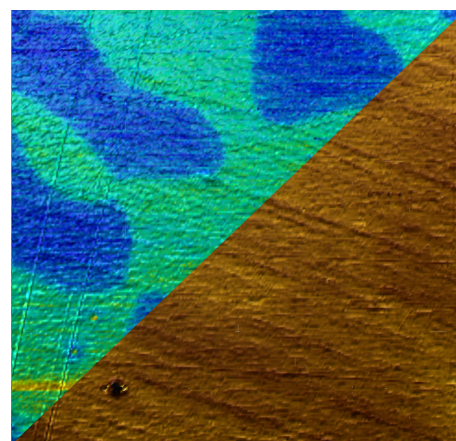
Atomic grid on mica measured with lateral force microscopy



Quality control of CVD-grown graphene flakes on post-oxidized copper measured by friction (data courtesy: Newtec engineering A/S)



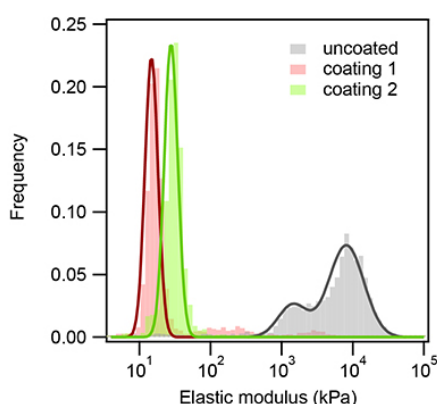
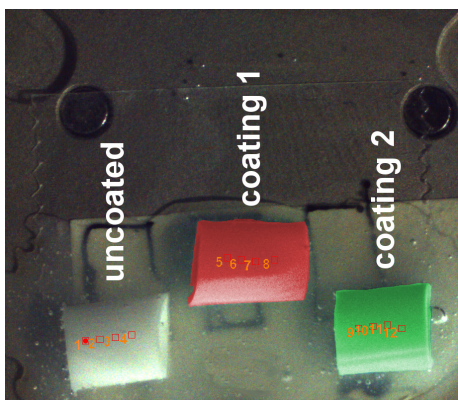
MFM and topography on artificial spin ice (data courtesy: Prof. S. Ferreira)



KPFM and topography recorded in a single run

## More than a simple imaging tool

For complex automated measurements on large or multiple samples, we offer our ANA add-on. It consists of an additional top-view camera and a dedicated software package. Using the camera, you can select measurement points on screen and let the system perform the measurement automatically.



Flex-ANA was used to investigate the mechanical properties of three different medical tubings in a single run.

The overview image of the sample shows the three pieces of tubing overlayed with the locations at which the system will automatically perform the mechanical testing experiments (numbered 1-12).

Elastic modulus recorded on the different medical tubings. The polymeric coatings confer elastic moduli to the tubing surfaces that are orders of magnitude below the uncoated tubing. This softness is comparable to that found in soft biological tissue. The histogram shows the pooled results of at least three different areas probed on each tubing.



## Accessories and upgrades



### Sample stage 204

Simple stage with sample holder, fits on Isostage 300



### Micrometer translation stage (on sample stage 204)

Manual sample positioning with 13 mm x 13 mm xy range, 10  $\mu$ m positioning accuracy



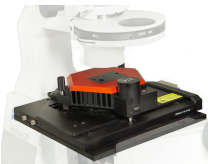
### Motorized translation stage 204

Motorized xyz sample positioning with 32 mm x 32 mm x 5 mm xyz range  
Automated measurements using stage control, scripting and batch manager



### Electrochemistry stage ECS 204

For in situ surface characterization under potentiostatic or galvanostatic control



### Sample stage for inverted microscopes

Available for Zeiss, Nikon, Olympus, Leica

Parallel AFM and optical image axes



### Height extension for FlexAFM sample stage

For measuring samples from 0 to 12 mm thickness



### Isostage 300

Active vibration isolation

Spike-Guard: detects anomalies and automatically rescans the line



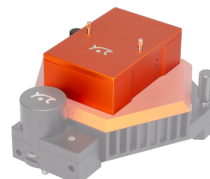
### Acoustic Enclosure 300

For use with FlexAFM systems with or without Isostage active vibration isolation table



### Cantilever holders

With / without alignment grooves for topography in air and liquid, for electrical measurements, for FluidFM® and for SThM



### FlexAFM video camera

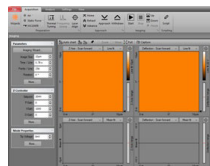
Simultaneous top and side view:

5 MP, 1.5 x 1.1 mm, color top view and 5 MP, 3.2 x 3.2 mm, color side view of sample and cantilever



### Environmental control option

Perform sample measurements under controlled, dry and/or inert gas atmospheres



### SW options

Options for advanced imaging, advanced lithography, advanced modes, advanced spectroscopy, cantilever calibration, KPFM, PFM, scripting interface, signal I/O, stage control



### FluidFM® upgrade

Micro-manipulation of single cells and other small objects, surfaces and tissues.

Nanofluidics through a hollow cantilever combined with the positional accuracy and force control of the Nanosurf FlexAFM

Injection, pick-and-place, adhesion force spectroscopy, elasticity measurements, and spotting

Suitable for stand-alone setup and on the inverted microscope



### Flex-ANA upgrade

Nanomechanical tissue diagnostics and soft material analysis

Fully automated measurements on rough and non-even surfaces

Quantitative analysis of tissues and soft materials alike

Fast, objective, and routine sample categorization

## C3000 controller

The versatility and performance of the FlexAFM scan head is brought to its full potential by the C3000 controller. This AFM controller has fully digital internal data processing, 24-bit ADC/DAC conversion depth, and programmable FPGA CPU. It allows dynamic filtering and analysis, and real-time signal monitoring directly from within the C3000 control software.

Through soft- and firmware changes, the C3000 controller can be updated and upgraded to support new options and features at any time!

## Main features

All digital data processing in FPGA

24-bit DACs for accurate scanning with widely varying scan ranges

24-bit ADCs and adaptive filters for high-resolution and low-noise data

Fast and sensitive digital Z-feedback and spectroscopy

Fully equipped with integrated thermal tuning, data monitoring, user I/O and signal access, advanced operating modes

## Additional options

Available C3000 controller options/packages include: advanced spectroscopy, signal modulation, advanced lithography, scripting interface, external synchronization.

### C3000 controller — Standard functionality

<b>Standard imaging modes</b>	Static force, dynamic force, phase contrast, MFM, friction force, force modulation, spreading resistance
<b>Imaging functions</b>	Up to 8000×8000 data points with 24-bit zoom in 8 acquisition channels with dynamic digital filters X/Y sample slope correction
<b>Standard spectroscopy modes</b>	Force–distance, amplitude–distance, phase–distance Tip current–tip voltage
<b>Spectroscopy functions</b>	Setup wizard for each spectroscopy mode XY-position table: point, line, and grid (max. 64 positions) 3 distinct spectroscopy phases
<b>Standard lithography modes</b>	Free vector objects drawing or real-time drawing by mouse Tip lift or force control during movement from point to point
<b>Sample approach</b>	Fast home, retract, and advance movement Automatic approach with definable final end position Continuous or step-by-step approach mode

### C3000 controller — Core hardware specifications

<b>X/Y/Z-axis scan and position controller</b>	3× 24-bit DAC (200 kHz)
<b>X/Y/Z-axis position measurement</b>	3× 24-bit ADC (200 kHz)
<b>Excitation &amp; modulation outputs</b>	4× 16-bit DAC (20 MHz)
<b>Analog signal input bandwidth</b>	0–5 MHz
<b>Main input signal capturing</b>	2× 16-bit ADC (20 MHz) 2× 24-bit ADC (200 kHz)
<b>Additional user signal outputs</b>	3× 24-bit DAC (200 kHz)
<b>Additional user signal inputs</b>	3× 24-bit ADC (200 kHz)
<b>Additional monitor signal outputs</b>	2× 24-bit ADC (200 kHz)
<b>Digital synchronization</b>	2× digital out, 2× digital in, 2× I2C Bus
<b>FPGA module and embedded processor</b>	ALTERA FPGA, 32-bit NIOS-CPU, 80 MHz, 256 MB RAM, multitasking OS
<b>Communication</b>	USB 2.0 hi-speed to PC
<b>System clock</b>	Internal quartz (10 MHz) or external clock
<b>Power</b>	90–240 V AC, 70 W, 50/60Hz





# Scan head specifications

## FlexAFM 5 scan head features

<b>General design</b>	Tripod stand-alone scan head with tip scanner; Flexure-based electro-magnetically actuated XY-scanner with superb linearity; Piezo-based Z-actuator; Optical Z-position sensor; Closed loop Z-control
<b>Laser / detector</b>	High-speed, low-noise 4-quadrant photodiode detector; Choice between red laser and near-infrared SLD; Laser on/off through software and scan head tilting; Optical filters for use with optical microscope phase contrast and fluorescence
<b>Approach</b>	Approach with continuous DC-motor; Up/down arrows on scan head for manual approach; Software-driven automated final approach
<b>Cantilever holder</b>	Automatic self-alignment for cantilevers with alignment grooves. Manual laser adjustment possible for special cantilevers.
<b>Sample observation</b>	Top and side view in air and liquid; White LEDs (brightness 0–100%); Axial illumination for top view
<b>Operating modes</b>	Static Force, Lateral Force, Dynamic Force, Phase Contrast, MFM, EFM, KPFM, Piezo Force, Force Modulation, Scanning Thermal, Spreading Resistance, Multiple Spectroscopy modes, Lithography and Manipulation modes. Some modes may require additional hardware and/or activating of the respective C3000 controller options.

## FlexAFM 5 scan head with C3000 controller

<b>Scan head type</b>	100- $\mu$ m	10- $\mu$ m
<b>Sample size</b>	Unlimited w/o sample stage 100 mm on sample stage	
<b>Maximum Petri dish height (fluid level)</b>	9 mm (6 mm)	
<b>Manual height adjustment range</b>	6 mm	
<b>Motorized approach range (at tip position)</b>	2 mm	
<b>Maximum scan range</b>	100 $\mu$ m <sup>(1)</sup>	10 $\mu$ m <sup>(1)</sup>
<b>Maximum Z-range</b>	10 $\mu$ m <sup>(2)</sup>	3 $\mu$ m <sup>(1)</sup>
<b>XY-linearity mean error</b>	< 0.1%	
<b>XY-flatness at maximum scan range</b>	typ. 5 nm	typ. 1 nm
<b>Detector bandwidth</b>	DC – 4 MHz	
<b>Detector noise level</b>	typ. 60 pm / max. 100 pm <sup>(3,4)</sup>	
<b>Z-sensor noise level (RMS)</b>	typ. 180 pm / max. 200 pm <sup>(3)</sup>	
<b>Z-measurement noise level (RMS, static mode in air)</b>	typ. 100 pm / max. 200 pm	
<b>Z-measurement noise level (RMS, dynamic mode in air)</b>	typ. 35 pm / max. 50 pm	
<b>Scan head dimensions</b>	143 × 158 × 53 mm	
<b>Scan head weight</b>	1.25 kg	

(1) Manufacturing tolerances  $\pm$  5%

(2) Manufacturing tolerances  $\pm$  10%

(3) Measured at 2 kHz

(4) Measured with XYContr cantilever

## Software options

### C3000 signal I/O option

<b>Clock input</b>	Input for an external digital clock (10 MHz, $\pm$ 1 V) Synchronization of internal Lock-In, PLL, function generators
<b>Analog inputs</b>	2 user inputs for imaging and spectroscopy
<b>Analog outputs</b>	2 user outputs for spectroscopy modulation, Z-control, etc.
<b>Digital sync</b>	2 digital outputs for synchronization

### C3000 stage control option

<b>Drivers</b>	Direct control for all supported stage controllers
<b>Manual move</b>	Via buttons in the C3000 control software
<b>Batch Manager</b>	Automated movement via position list and scripts

### C3000 cantilever calibration option

<b>Spring constant calibration</b>	Free resonance detection via thermal tuning Q-Factor calculation Spring constant calculation by Sader method FFT spectrum analyzer, many windowing modes, averaging
<b>Deflection sensitivity calibration</b>	Wizard for deflection sensitivity calculation from force–distance measurements Automatic mode or user-defined parameters

### C3000 advanced spectroscopy option

<b>Additional spectroscopy functions</b>	Additional “Stop by input value reached” modulation mode Automatic cantilever drift recalibration Unlimited number of spectroscopy data points 5 distinct spectroscopy phases
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### C3000 advanced lithography option

<b>Additional lithography modes</b>	Vector-based lithography with objects on layers with different lithography parameters Bitmap-based lithography Nano printing
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### C3000 scripting interface option

<b>Internal scripting</b>	Visual Basic script editor Ribbon drop-down menu to access user scripts
<b>COM-API</b>	Control of measurement process and data analysis
<b>Compatibility</b>	All applications that support the Microsoft COM Automation standard: e.g. LabVIEW, C#, etc.

### C3000 advanced modes option

<b>Additional operating modes</b>	Enables advanced measurement modes via an additional digital 2-channel Lock-In. Measure amplitude and phase of an additional signal from many inputs. (e.g higher harmonics, higher resonances, torsional cantilever oscillations, tip voltage modulation, etc.) during imaging and spectroscopy
<b>Secondary lock-in amplifier</b>	Frequency range: 1 kHz–5 MHz Demodulation bandwidth: 11 Hz–23 kHz Amplitude resolution: 20 bit; Phase range: $\pm$ 180° Reference phase shift: 0–360° (digital) Excitation: tip voltage, 2× user output

### C3000 KPFM work package

Extends the advanced modes option with the Kelvin probe force microscopy (KPFM) mode. In addition to the Lock-In, it provides a tip voltage feedback controller through a special user interface. In addition to the standard signals, contact potential can be measured during imaging and spectroscopy.

### C3000 PFM work package

Extends the advanced modes option with the Piezoresponse force microscopy (PFM) mode through a special user interface. In addition to the standard signals, amplitude and phase of the piezo response signal can be measured during imaging and spectroscopy

### C3000 advanced imaging

Unlocks the contour-following mode and advanced AFM parameter settings for the second scan pass



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