Next-Level Nanotechnology Tools swiss quality

DriveAFM

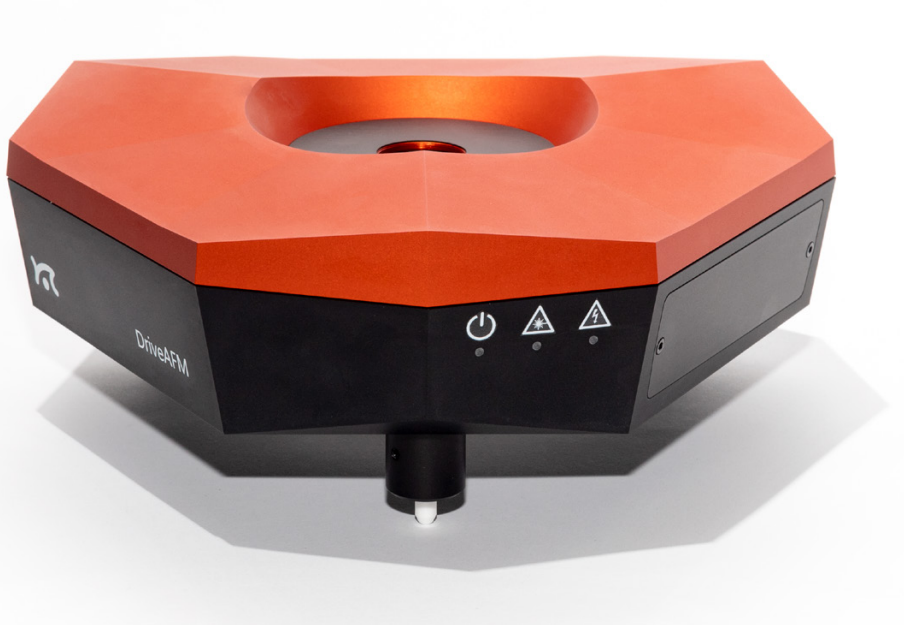
Performance without compromise

nanosurf

Performance without compromise

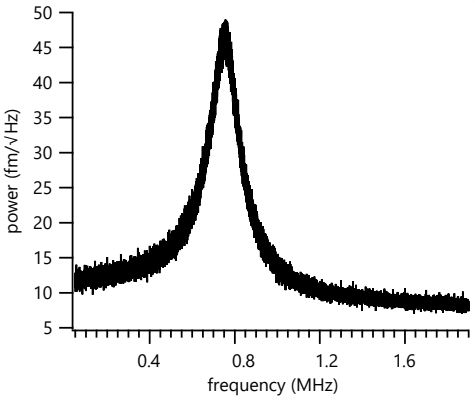
CleanDrive • Ultra-low noise • Direct drive scanner • Fully motorized system

The DriveAFM, Nanosurf's new flagship instrument, utilizes the latest technology to deliver stable, high-end performance. It was designed to fulfill the needs of top-notch research, today and in the future.

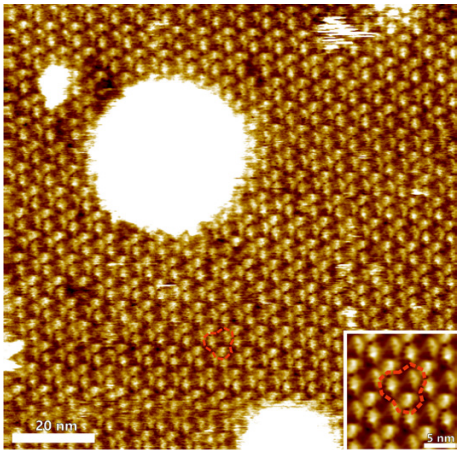


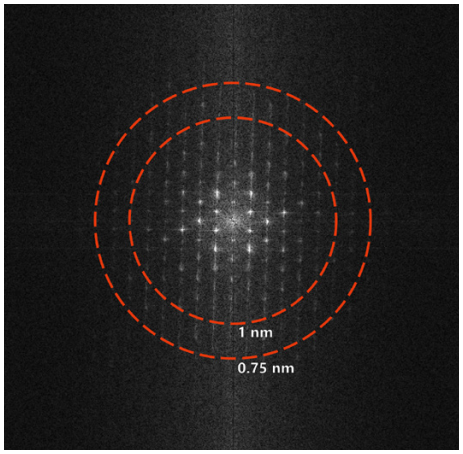
Ultra-low noise

The DriveAFM has a very low overall noise floor, which is achieved through a combination of a low-noise/low-coherence superluminescent diode and a low-noise/high-bandwidth photodetector used in the beam deflection detection module and the low-noise/high-bandwidth CX Controller. This is the basis for the stable, sensitive, and high-resolution imaging and force spectroscopy capability of the DriveAFM.



Thermal noise spectrum of a USF-F1.2-k7.3 cantilever in buffer solution. The thermal noise power spectrum reveals the broad resonance peak of the cantilever at approximately 750 kHz. The noise floor of the system can be clearly identified to be below 15 fm/√Hz, even before the resonance peak. At higher frequencies, the noise floor drops below 10 fm/√Hz.





Left: high-resolution topography image of the cytoplasmic surface of purple membrane from *Halobacterium salinarum*. The topography clearly resolves the trimeric arrangement of bacteriorhodopsin (BR) proteins and substructures within the BR molecules. Inset: correlation average of BR trimers. The red dashed lines indicate a BR trimer.

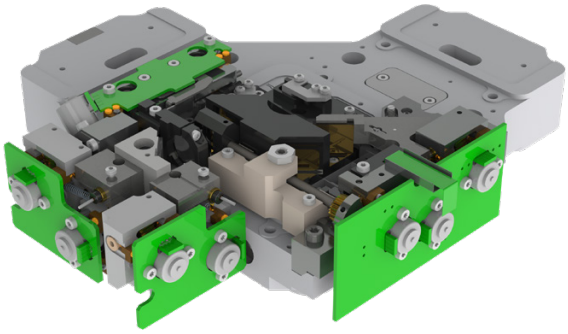
Right: 2D FFT spectrum of the image in the left. The dashed circles indicate resolution of 1 nm and 0.75 nm. The spectrum reveals diffraction peaks beyond the outer circle indicating a resolution better than 0.75 nm.

Direct drive scanner

The DriveAFM exploits the power of direct drive piezo actuation. The 1:1, non-amplified actuation scheme of the DriveAFM's flexure scanner provides more force and can drive stiffer scanners. The resulting higher resonance frequency of the scanner components allows for a higher available actuation bandwidth than with geared drives of the same scan size. Direct drive scanner actuation in combination with the low noise 28-bit CX Controller allows for both imaging at large scales and at high resolution. The DriveAFM is the perfect solution for high-resolution imaging of demanding samples such as nanostructures, proteins, or polymeric structures (e.g. DNA), and also for larger, micrometer-sized structures.

Full motorization

The DriveAFM is the first fully motorized AFM system that can be integrated with an inverted optical microscope. The adjustment of the two light sources for the beam deflection detection system and the CleanDrive photothermal excitation, as well as the adjustment of the photodetector, are fully motorized and can be controlled from the software. Full motorization not only contributes to the ease of use but also allows new possibilities to fully automate the system.

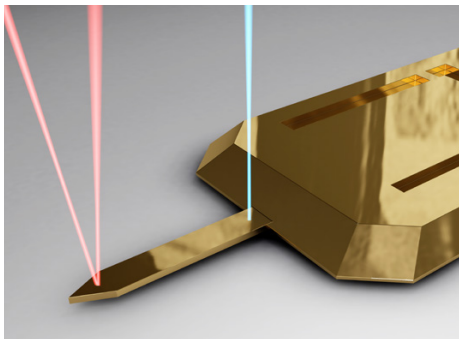


All mechanical adjustments of lasers and photodetector are fully motorized.

CleanDrive: stability in air and liquid with photothermal excitation

Photothermal excitation of the cantilever provides unparalleled stability and a high excitation bandwidth in air and liquid environments. These benefits allow measurements at multiple frequencies and high-speed applications and open new horizons for innovative new measurement modes (e.g. Cytomass Monitor).

These advantages are amplified in liquids since only the cantilever beam is excited and the liquid environment remains largely unperturbed. This results in clean resonance peaks and not the "forest of peaks" commonly seen with the piezo-acoustic excitation of cantilevers. Furthermore, this method of exciting the cantilever is insensitive to changes in the environment and distance to the sample, making the whole measurement system much more stable.

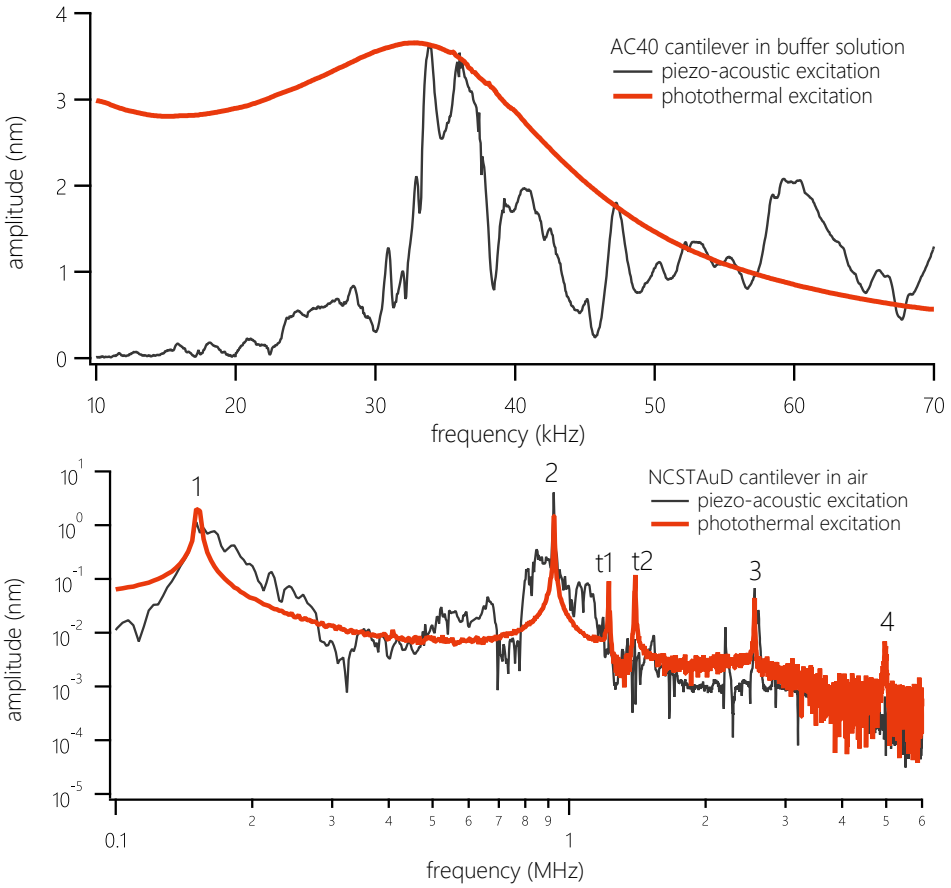


CleanDrive principle: cantilever is photothermally excited by a modulated laser at the base.

Small cantilevers

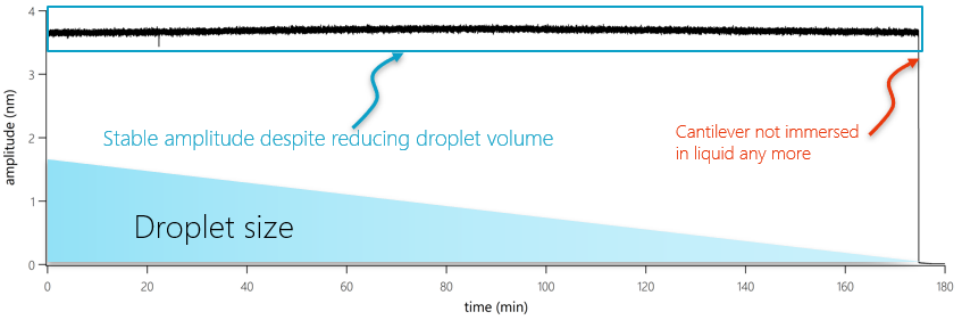
The DriveAFM, with its small laser spots, is compatible with the use of small cantilevers, which have several advantages that make them superior in performance. While they have the same spring constant as a conventional cantilever, small cantilevers show a significantly higher resonance frequency and operational bandwidth. Due to the small dimensions, the sensitivity is increased, and hydrodynamic drag is decreased. All of this results in better imaging performance.

Comparison of a small and a conventional AFM cantilever. The small and regular cantilevers have tip view dimensions of 10 µm x 20 µm (w x l) and 27 µm x 150 µm (w x l), respectively.

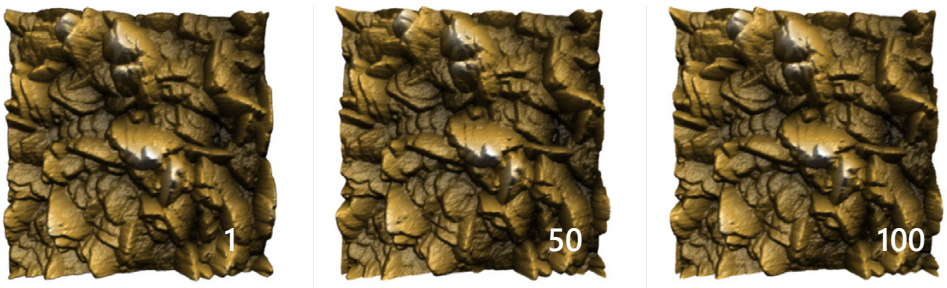


Top: comparison of frequency sweeps using piezo-acoustic and photothermal excitation (CleanDrive) in liquid. CleanDrive shows textbook-like amplitude response and no "forest of peaks".

Bottom: comparison of frequency sweep in air. Far cleaner peaks over a wide frequency range.



A cantilever immersed in a 100 µl buffer droplet was excited to an amplitude of 3.6 nm. The amplitude of the cantilever was observed while the buffer droplet was allowed to evaporate. Until the cantilever lost contact with the droplet, the amplitude of the cantilever did not change significantly. As the cantilever was released from the liquid, the amplitude suddenly dropped, as expected.



Consecutive unattended imaging of a TipCheck sample with CleanDrive excitation. After 100 images no noticeable change in the tip curvature could be observed. Image size: 1 µm. Z-height: 90 nm.

DriveAFM for biological research

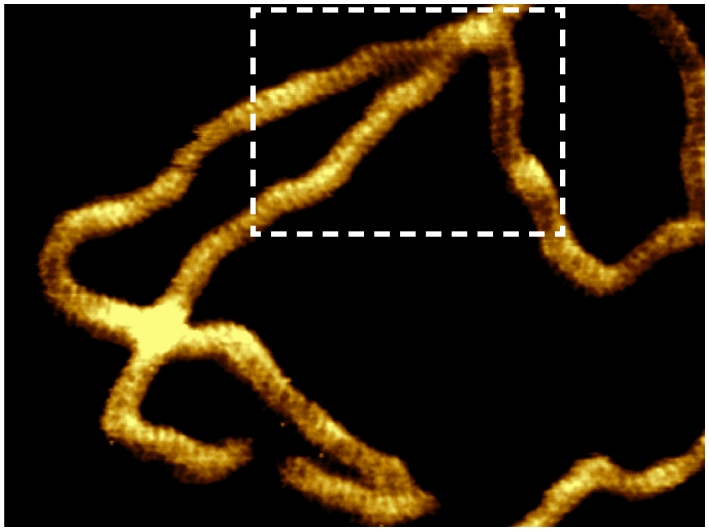
Stability without compromise

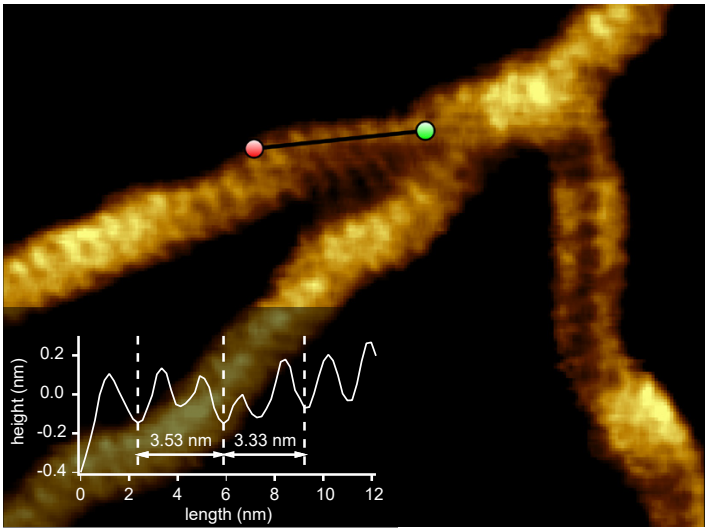
The DriveAFM plays out all its advantages when it comes to biological applications. Full motorization allows adjusting the lasers and photodetector, and navigating the sample, without interfering with a temperature-controlled environment. CleanDrive excitation provides reliable and clean cantilever tuning in liquid environments. The insensitivity of the CleanDrive towards environmental changes and the sensitivity of small cantilevers facilitate imaging of delicate samples over long periods of time with ease.

Seamless integration of the DriveAFM with an inverted optical microscope allows transmitted light and fluorescence microscopy to be combined with AFM imaging and force spectroscopy. The light sources' wavelengths used for CleanDrive (785 nm) and the deflection detection (840 nm) were selected to avoid interference with biological samples and to make fluorescence imaging possible.

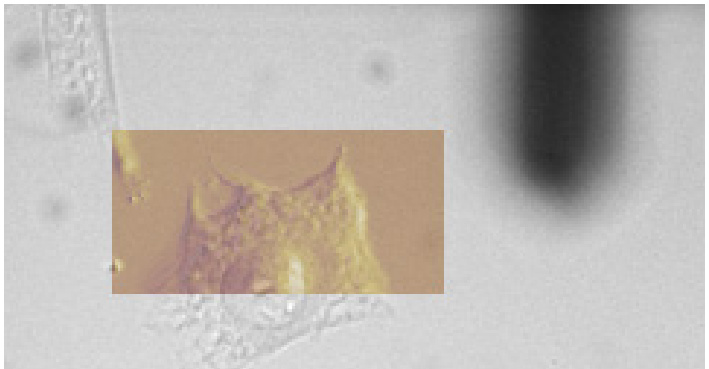
The DriveAFM comes with a new line of accessories for biological applications from single-molecule investigations to live cell observations. It includes a new Petri dish holder and a new 150 µm z-actuator, which is essential for cell adhesion experiments. Both sample holders are designed to maintain biological samples at physiological temperature and to be ultimately converted into a live cell incubator with temperature and CO_2 control.

The DriveAFM is ready for research that goes beyond conventional imaging. FluidFM®, Cytomass and ANA expand the capabilities of the DriveAFM with multifunctional hollow cantilevers, cell mass measurements and nanomechanical measurement automation.

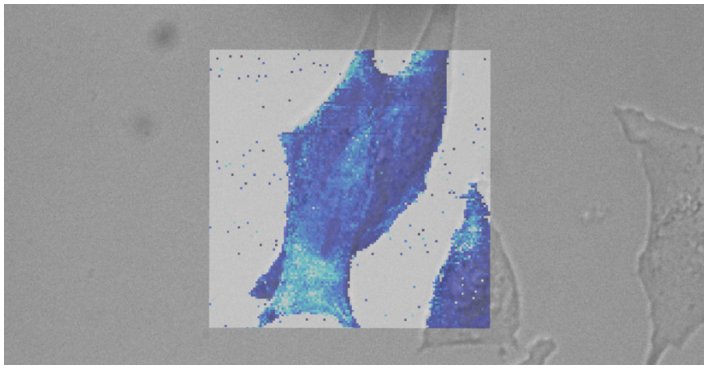




Left: high-resolution topography image of double-stranded DNA on mica in buffer solution. Several DNA molecules can be observed. All of them show a characteristic periodic pattern. Image width: 110 nm. **Right:** zoomed-in section of the left area indicated in the left image. The black line indicates the location of the cross section shown in the inset. The average spacing between every second-next groove in the section corresponds to 3.4 nm, the characteristic pitch distance of a helical turn of B-DNA. The valleys in the section correspond to the major and minor grooves found in dsDNA. Image width: 45 nm



Semi-transparent AFM amplitude image over optical DIC image of the cell.



Superimposed force map of live fibroblast cell in cell culture medium at 37°C.

FluidFM® ready

FluidFM® probe microscopy (FPM) combines the force sensitivity and positional accuracy of an AFM with FluidFM technology by Cytosurge to allow a whole range of exciting applications in single-cell biology and nanoscience. The DriveAFM is fully integratable with this technology.

Cytomass ready

The Cytomass Monitor is the only research tool currently available that allows the recording the cell mass in physiological conditions over time, while simultaneously conducting fluorescence and/or DIC in order to link cell mass dynamics to cell morphology and state. The DriveAFM can be equipped with cytomass functionality.

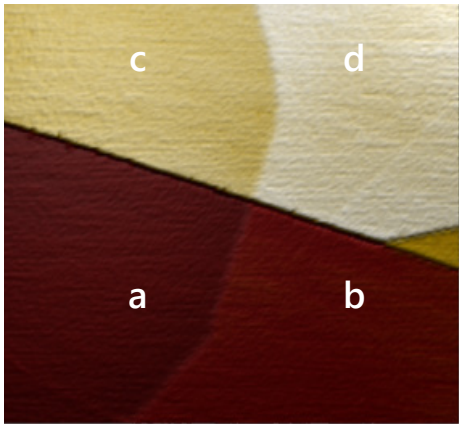
ANA ready

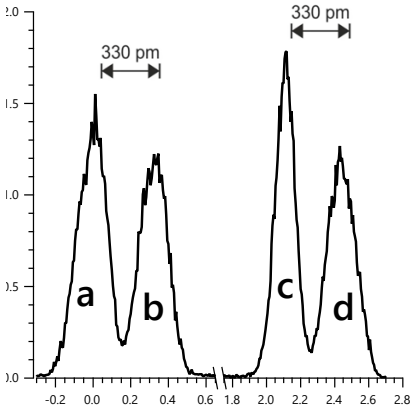
ANA - Automated Nanomechnical Analysis - is designed to investigate the nanomechanical properties of materials such as cells, tissues, scaffolds, hydrogels, and polymers on multiple or large samples in an easy-to-use fashion. On the DriveAFM with a motorized stage, ANA performs at new levels.

DriveAFM for materials science

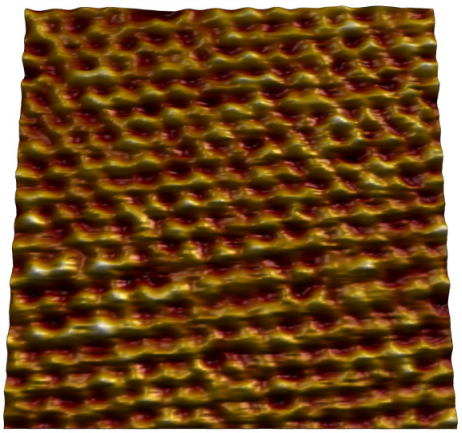
Versatility without compromise

The DriveAFM combines performance and a wide range of applications important for material science research. Its unique direct drive tip scanner technology paired with CleanDrive are key for fast and stable operation in air and liquid. The tip scanner design makes the performance of the DriveAFM independent of the mass of the sample under investigation also allowing measurement on heavy samples. The full motorization not only simplifies working with the system but also facilitates automated measurements addressing different areas of a sample.



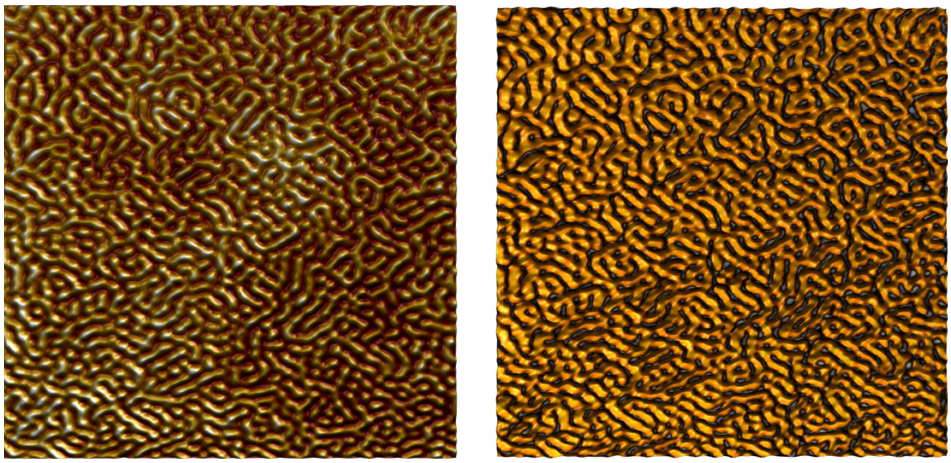


Left: topography image of an HOPG surface imaged in air. The surface shows different steps between different graphite layers. Image size: 500 nm. **Right:** height histogram of the HOPG surface. The spacing of two neighboring peaks in the histogram corresponds to 330 pm, the expected height of a graphite layer.

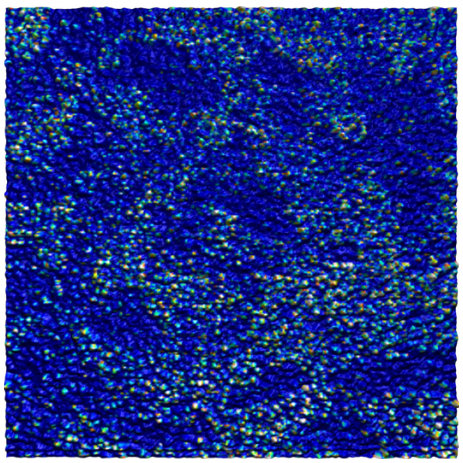


Atomic lattice of mica imaged in air. Image size: 7 nm.

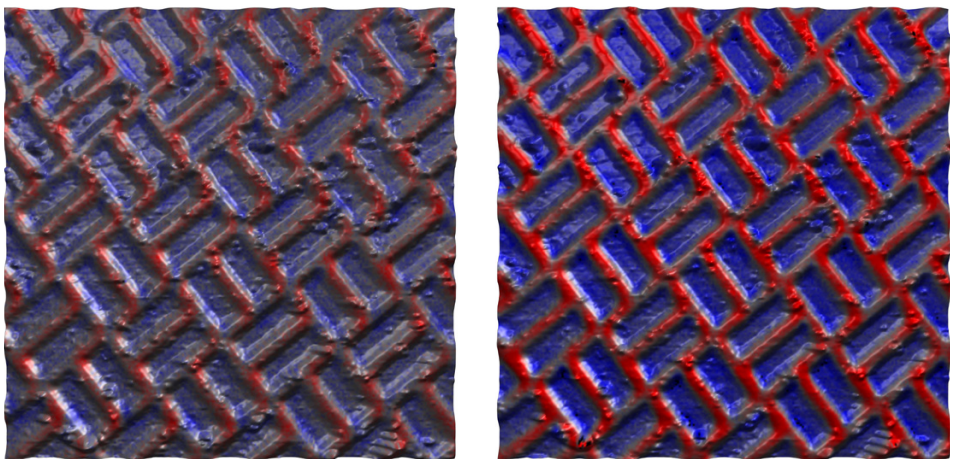
Besides reliable topographic imaging, the DriveAFM also features a complete set of different modes to investigate the nanoelectrical (e.g. C-AFM, KPFM, or PFM) or nanomechanical properties of your sample. The universe of accessories available for the DriveAFM offers extended functionality such as heating or cooling the sample, applying a variable magnetic field, detecting low electrical currents or investigating with *in situ* AFM imaging the changes taking place on electrodes during electrochemical processes.



Topography (left) and phase image (right) of an unannealed PS-PB-PS triblock copolymer thin film on mica imaged at 20 Hz line rate using an USC-F1.2-k7.3 cantilever. Image size: 500 nm



Conductive AFM on indium tin oxide revealing its heterogeneous conductivity. The image was recorded using an EFM cantilever with a tip bias of 5 mV. The current was measured using the C-AFM sample holder. Color scale 1.5 nA. Image size: 2 µm.



MFM images of a Shakti lattice while applying different in-plane magnetic fields (left: 50 mT, right: 200 mT). The images represent the 3D topography of the lattice and the color scale overlaid corresponds to phase shift induced by magnetic interactions.

Image size: 8 µm, phase signal range: 1°.

Functional accessories

Nanosurf has developed a wide range of accessories for the DriveAFM to provide a complete solution for both biological and materials research. These accessories help optimize the environment in which the system is operated or expand the system's functionality.

150 µm z-actuator sample holder

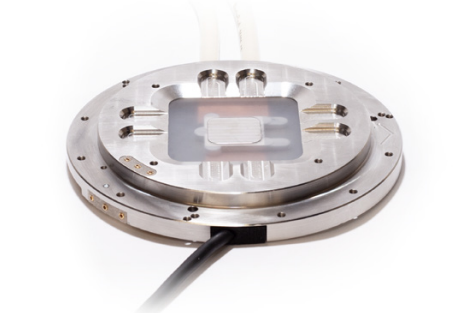
Designed for long-range force spectroscopy applications like cell-cell and cell-substrate force spectroscopy or force mapping on corrugated surfaces. The sample holder can accommodate flat samples as well as petri dishes, which can be maintained at physiological temperatures and beyond (50°C). It offers the possibility to upgrade to a 2-chamber cell incubator, which can maintain physiological conditions.

Z-range: 150 µm
Petri dish diameter: 35 mm and 50 mm
Temperature range: ambient to 50°C

Electrochemical AFM sample holder

The EC-AFM sample holder allows electrochemical experiments with *in situ* AFM observation. It can accommodate 2 mm diameter reference electrodes and can be combined with the environmental control option for controlled gas atmosphere during experiments.

Working electrode: 25 mm x 25 mm, 0.2 mm - 2 mm thickness
Bath chamber material: PVDF or PEEK



Heater/cooler sample holder

Two sample holders are available to control the temperature of the sample from ambient to 250°C or from -35°C to 180°C. The sample holders are compatible with the Environmental Control Option and the EC-AFM sample holder.

Temperature range: ambient to 250°C or -35°C to 180°C
Max. sample size: 16 mm x 16 mm x 3 mm
Temperature stability: 0.1°C

Conductive AFM sample holder

Sample holder with integrated low noise preamplifier to detect small currents from the pA to the nA range. Suited for C-AFM imaging and I-V spectroscopy. The sample holder is compatible with the environmental control option.

Input range: +/- 25 nA
Amplification: 0.1 V/nA
Noise: typ. 3pA @ 3 kHz bandwidth

Variable magnetic field sample holder

The sample holder empowers MFM measurements with a DC magnetic in-plane field applied to the sample to investigate samples such as ferromagnetic films and nanostructures. The sample holder can be combined with the environmental control option.

Max. sample size: 10 mm x 10 mm x 0.5 mm
Max. magnetic field: +/- 800 mT (at 2mm gap)
Field adjustment: software controlled with integrated Hall sensor

For further details on these and more accessories, please consult Nanosurf's accessories brochure or contact our applications team.

Specifications

The DriveAFM is a completely new high-end atomic force microscopy system. Its Nanosurf-typical ingenious design and the CX Controller, developed especially to maximise the potential of this scan head, yield the following specifications.

DriveAFM scan head features

Stand-alone tip scanning AFM scan head
Direct drive XYZ piezo flexure scanner
Easy accommodation of the largest variety of different samples and sample holders without restrictions to size, geometry and weight
Open/closed loop operations for XYZ axis
Interference-free SLD for beam deflection detection
Photothermal drive of the cantilever for clean and stable excitation
Compatible with small cantilevers: as small as 10 µm width
Compatible with most inverted microscopes (Zeiss, Nikon, Olympus, Leica)
Fully motorized alignment of the photodetector and the light sources
Maximum Petri dish height of 13 mm

DriveAFM scan head specifications

Scan size	typ. 100 µm x 100 µm x 20 µm min. 95 µm x 95 µm x 18 µm
Read-out light source	850 nm low-coherence SLD
CleanDrive light source	785 nm laser
Photodetector bandwidth	≥8 MHz
Standard / maximum sample size	100 mm / 150 mm
Z-height noise dynamic	<30 pm (RMS)
Z-height noise static	<30 pm (RMS)
DC detector noise*	<5 pm (RMS, 0.1 Hz – 1 kHz)
AC detector noise*	<25 fm/√Hz above 100 kHz
Approach	10 mm motorized, parallel

*measured with a USC-F1.2-k7.3 cantilever

CX Controller specifications

High resolution outputs (DAC)	12x 28 bit, 1 MHz/sampling; thereof 4x user DAC (optional)
Fast outputs (DAC)	4x 16 bit, 100 MHz/sampling; thereof 1x user DAC (optional)
High resolution inputs (ADC)	12x 20 bit, 1 MHz/sampling; thereof 4x user ADC (optional)
Fast inputs (ADC)	3x 16 bit, 100 MHz/sampling; thereof 1x user ADC (optional)
Signal analyzers	2 signal analyzer function blocks that can be configured as dual channel lock-in
FPGA module and embedded processor	System-on-chip module with low-latency FPGA signal processing at 100MHz and dual-core ARM processor, 2GB RAM, 1.5GHz clock
Scan control	28-bit X/Y/Z-DAC
Detector inputs	Deflection/lateral signals each 20 bit
Digital sync, Spike-Guard	2-bit line/frame sync out 5 V/TTL galvanically isolated, Spike-Guard input
Clock sync	10MHz/3V clock input to synchronize data acquisition and processing
Communication to PC	Gigabit Ethernet, galvanically isolated

System functionality

Standard imaging modes	Static force, dynamic force, phase contrast, MFM, friction force, force modulation, EFM
Advanced imaging modes (optional)	PFM, KPFM, 2nd lock-in amplifier, advanced dual pass, C-AFM
Imaging functions	Up to 8000×8000 data points X/Y sample slope correction
Standard spectroscopy modes	Force–distance, amplitude–distance, phase–distance
Spectroscopy functions	Setup wizard for each spectroscopy mode XY-position table: point, line, and grid
Standard lithography modes	Free vector objects drawing or real-time drawing by mouse Tip lift or force control during movement from point to point
Sample approach	Fast home, retract, and advance movement

DriveAFM stand-alone setup.

DriveAFM inverted optical microscope setup.

nanosurf

Nanosurf AG
Liestal, Switzerland
+41 61 927 47 47

Nanosurf GmbH
Langen, Germany
+49 6103 202 7163

Nanosurf UK
Bracknell, UK
+44 1344 388 008

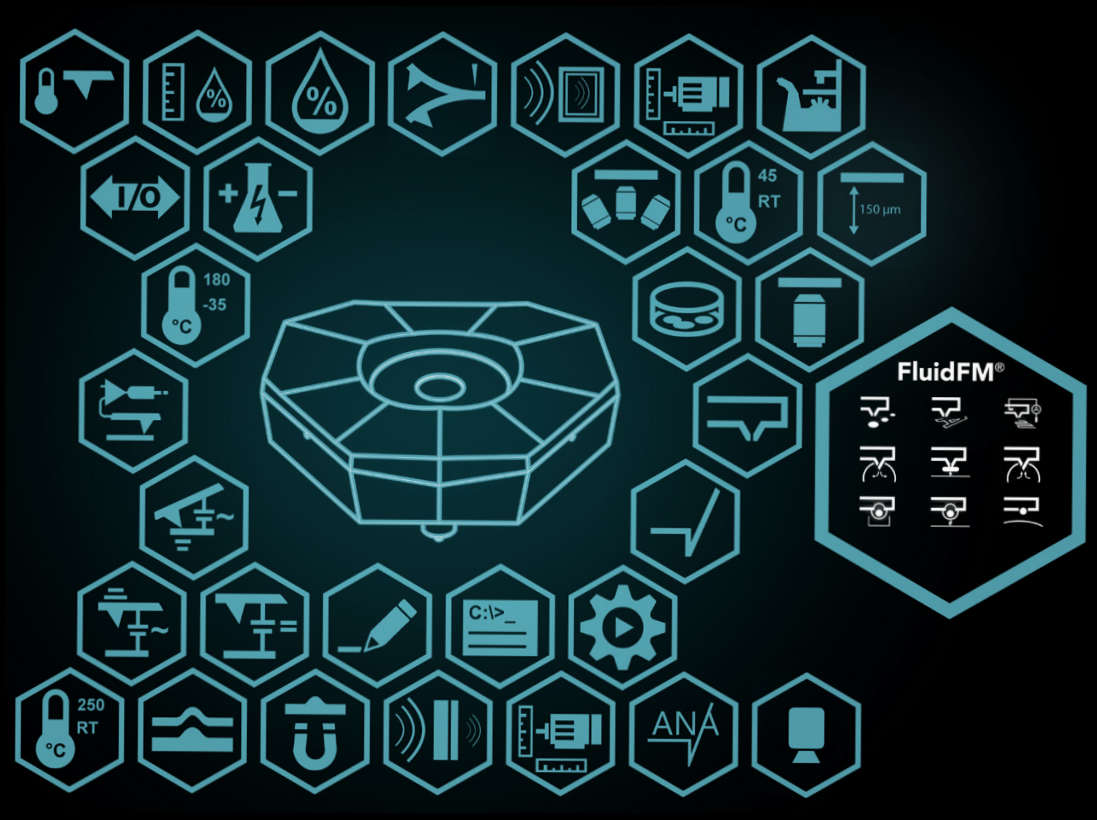
Nanosurf Inc.
Woburn, MA, USA
+1 781 549 7361
Berkeley, CA, USA
+1 510-214-2409

Nanosurf 中国
Nanosurf China, Shanghai
上海市天宝路578号 (200086)
+86 18621896399

Nanosurf India
Hyderabad, India
+91 92 0552 0378

Nanosurf Singapore
574827 Singapore
+65 9839 9938

info@nanosurf.com
www.nanosurf.com



- Sample heating
- Electrochemistry
- Signal I/O option
- Scanning thermal microscopy
- Environmental control option
- Relative humidity control
- Inverted microscope stage
- Motorized inverted microscope stage
- Petri dish sample holder
- Petri dish heating option
- 150 µm z-actuator sample holder
- Digital inverted microscope option
- Inverted optical microscope
- Cantilever holder FluidFM®
  - Spotting
  - Nanolithography
  - SICM
  - Single cell injection
  - Single bacteria adhesion
  - Single cell extraction
  - Single cell isolation
  - Single cell adhesion
  - Colloidal spectroscopy
- CleanDrive photothermal excitation
- Acoustic enclosure 1100
- Advanced spectroscopy
- Flex-ANA add-on
- Automation
- Motorized translation stage
- Scripting interface
- Acoustic enclosure 350
- Variable magnetic field sample holder
- Advanced lithography
- Dual pass option
- Heater/cooler sample holder
- Conductive AFM sample holder
- PFM mode
- EFM mode
- KPFM mode
- Camera