attocube
WITTENSTEIN group

attoAFM I

low temperature scanning probe microscope

Visit the attoAFM I webpage

CRYOGENIC INSTRUMENTS
cool tools for cold science

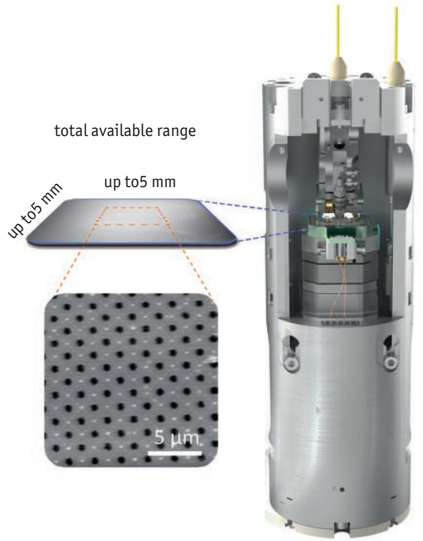
Retrieve nano-features over millimeter ranges!

closed loop scanning & global sample coordinates

Science and technology delve deeper and deeper into the nanoworld. In particular, scanning probe & confocal microscopy have been concerned with features on the nanoscale ever since its invention. Reliably scanning over tens of micrometers range down to a few hundred nm is comparatively easily achieved by using piezo based scanners.

However, using piezo-based scanners usually relies on the assumption that the relation between applied voltage and displacement is linear. In reality, most scanners show large non-linear behaviour and hysteresis, especially for large scan ranges. Creep, i.e. drift in position after approaching a certain location, is a further phenomenon which is common to all piezo scanners.

In many experiments, reproducibly locating a small feature on a surface is crucial, and sometimes hysteresis and non-linearity in the acquired image are not acceptable. Sometimes, SPM images need to be evaluated for particularly and for the specific mutual distances of certain features, and hence, any distortions due to those nonlinearities may impede such analyses significantly.



Much more often, however, finding a certain region of interest or a particular feature on a macroscopic sample at all, or retrieving such locations repeatadly is a critical task.

Based on our patented IDS3010, a fiber-based interferometer, our microscopes can now be equipped with position closed loop sensors with featuring a steady-state resolution of down to 1 nm even in a, despite the cryogenic working environment.

At the same time, we implemented a fully digital scan engine in the Nanonis Mimea controller which now features location based data acquisition (as opposed to time-triggered data acquisition on open loop systems). In closed loop mode, this results in perfectly linearized images. The sophisticated scan engine even allows for an adjustment of the scan acceleration to smoothen the scanning motion at the turning points, which can be is especially useful especially for higher scan speeds.

The most useful new features however is that since the IDS3010 covers the full 5 mm x 5 mmm range of the positioners, the scan widget now contains 'global' sample coordinates: usually, the maximum range accessible in closed loop mode is limited by the maximum range of the scanners. If the user wants to scan outside of this area, he can simply use the global sample coordinate system for navigation. To further facilitate this, any measured SPM images can simply be decorated onto the scan widget's sample 'canvas' via drag-and-drop, where they are put exactly at the measured coordinates. Hence, a virtual map of the whole sample gradually evolves within the scan widget.

Retrieving regions of interest on the nanoscale, which has always been extremely difficult and time consuming especially at low temperatures, is now an easy task thanks to this global sample coordinate system.

CUSTOMER FEEDBACK

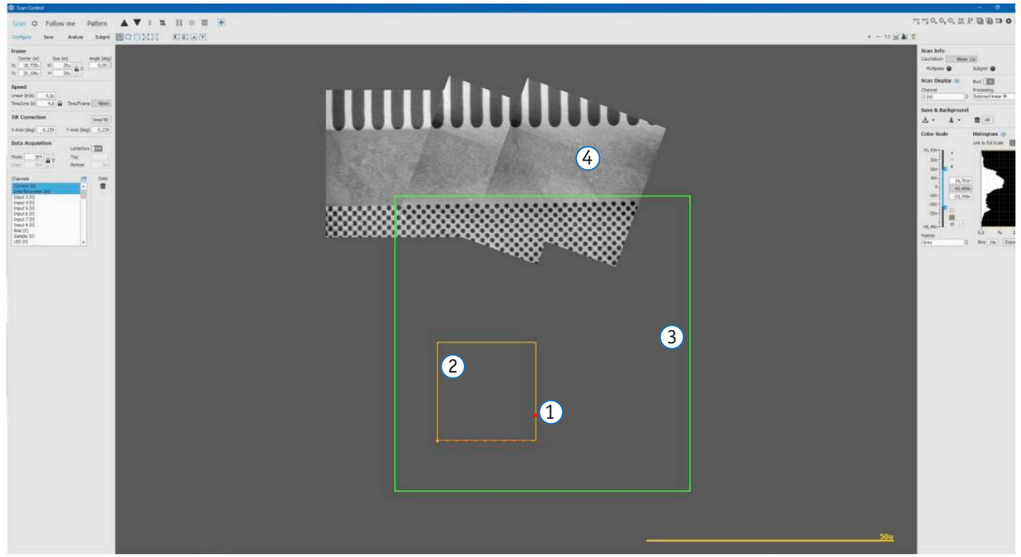
It's clear that attocube builds products with a lot of foret-hought and consideration to take advantage of emerging research opportunities.

Prof. Stuart Parkin

(Max Planck Institute of Microstructure Physics, Halle, Germany)

AFM with Built-In Sample GPS.

closed loop scanning & global sample coordinates



01 SPM tip position indicated by red dot
02 current scan area
03 max. scan range at this position
04 SPM image decoration in globale sample coordinate system

Nanonis Mimea

your companion for efficient cryogenic SPM

attocube edition

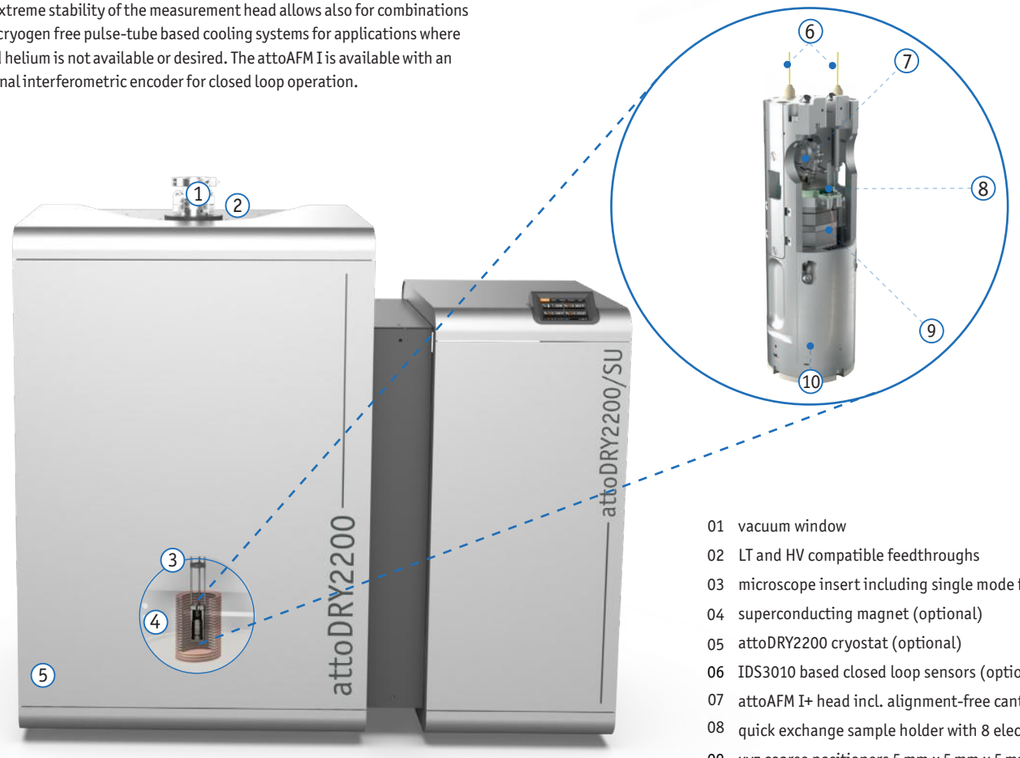
attoAFM I

low temperature atomic force microscope, cantilever based

The attoAFM I is a compact atomic force microscope designed particularly for applications at low and ultra low temperatures. The instrument works by scanning the sample below a fixed cantilever and by measuring its deflection with highest precision using a fiber based optical interferometer. Both contact and non-contact mode are applicable. Furthermore, this system is suited for magnetic force microscopy (MFM), electric force microscopy (EFM), and other imaging modes (KPFM, PFM, ct-AFM).

The extreme stability of the measurement head allows also for combinations with cryogen free pulse-tube based cooling systems for applications where liquid helium is not available or desired. The attoAFM I is available with an optional interferometric encoder for closed loop operation.

The microscope uses a set of xyz-positioners for coarse positioning of the sample over a range of several mm. Developed particularly for cryogenic applications, the piezo-based scanner provides a large scan range of 50 µm x 50 µm at room temperature, and 30 µm x 30 µm at base temperature. The exceptional combination of materials allows absolutely stable high resolution imaging of surfaces. Possible applications are the measurement of local sample properties such as topography, magnetic forces, or elasticity of urface structures.



Schematic drawing of the low temperature attoAFM I and the attoDRY2200 cryostat (optional)

01 vacuum window
02 LT and HV compatible feedthroughs
03 microscope insert including single mode fiber
04 superconducting magnet (optional)
05 attoDRY2200 cryostat (optional)
06 IDS3010 based closed loop sensors (optional)
07 attoAFM I+ head incl. alignment-free cantilever holder
08 quick exchange sample holder with 8 electrical contacts
09 xyz coarse positioners 5 mm x 5 mm x 5 mm
10 ultra stable titanium housing

Available Upgrade Options

- closed loop scanning & global sample coordinates
- inspection optics
- closed loop upgrade for positioners

...for further details, see accessories section

PRODUCT KEY FEATURES

- interferometric encoders for closed loop scanning with 1 nm resolution (optional)
- attoAFM I+ head feat. alignement-free cantilever holder
- quick exchange sample holder with 8 electrical contacts
- ultra compact, highly rigid AFM head
- highly sensitive interferometric deflection detection
- adjustment of the cantilever outside the cryostat prior to cooling the microscope

BENEFITS

- easy tracking of regions of interest & distortion-free images (optional)
- tip exchange in less than 2 minutes
- high spatial resolution imaging
- simultaneous ultra high resolution topographic & magnetic force imaging
- compatible with Nanosensors'XY-auto alignment AFM tips

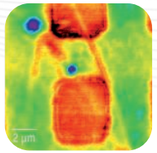
APPLICATION EXAMPLES

- moiré structures in 2D materials
- magnetic domains, skyrmions, antiskyrmions, merons
- superconducting vortices
- nanoelectrical characterization

COMPATIBLE COOLING SYSTEMS

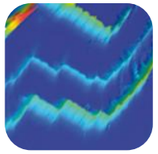
- attoDRY1000/2200
- mK cryostats (on request)

The attoAFM I microscope module



Kelvin Probe Force Microscopy

Piezoresponse Force Microscopy



Conductivity Mapping

attoAFM I + Head

featuring an alignement-free cantilever holder

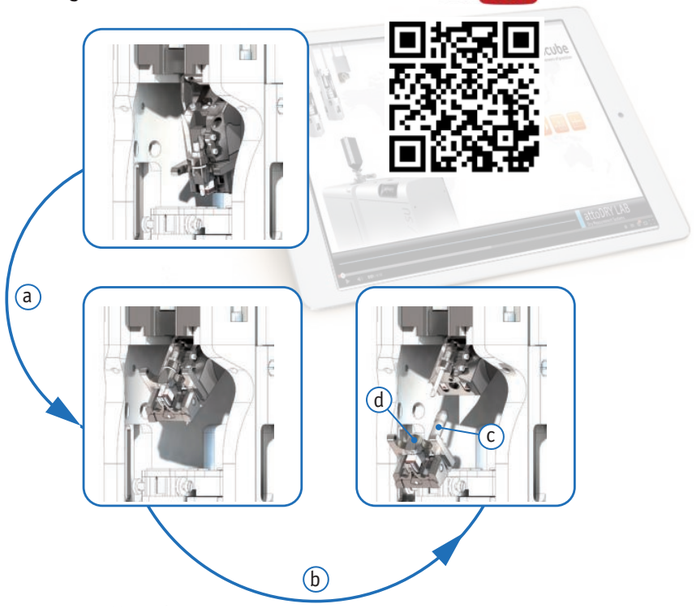
The attoAFM I+ head features an alignment-free cantilever holder for tip exchange, and hence takes over the complete mechanical alignment of the cantilever with respect to the fiber used for deflection readout. A folding mechanism allows for easy extraction of the cantilever holder for tip exchange without dismounting the AFM head itself.

To exchange the tip, the holder is simply put into an exchange basis with a leveled platform. This enables to easily slide in and out cantilevers, thus minimizing the danger of damaging the costly and valuable tips during handling. The tip itself is held in place by a spring blade, which can be slid open and closed via another clever quick folding mechanism.

This way, the tip can be replaced within tens of seconds. During re-attachment, a guiding rod automatically centers the cantilever holder. When folding the head back into its initial parking position, the fiber end is perfectly aligned with respect to the cantilever. The desired interference pattern with ideal contrast is thus automatically achieved without any further mechanical alignment.

The attoAFM I+ head incl. the alignment-free cantilever holder is included with every attoAFM I (2" and 1" version, as well as any upgrades such as MFM, PFM, KPFM and ct-AFM), and is compatible with all commercially available XY-auto alignment AFM tips (patented technology by NANOSENSORS™).

Tip exchange in < 2 minutes! Watch the video on YouTube



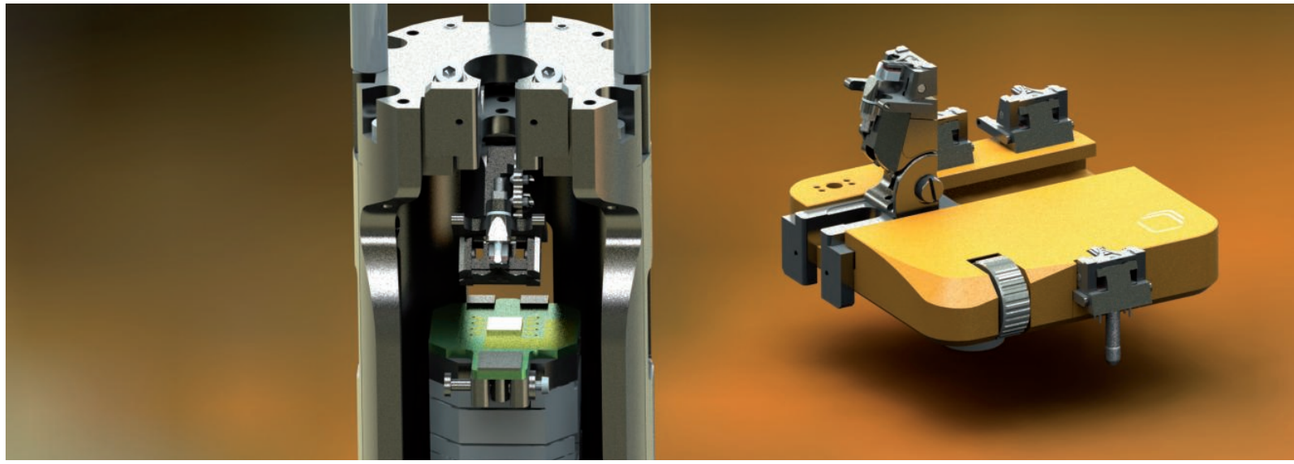
1. Flip the AFM head upwards. (a)
2. Remove the cantilever holder. (b)
3. Perform the AFM tip exchange (for details, see description of the cantilever holder on the right)
4. Once the new tip is mounted, reattach the cantilever holder:
   A guiding rod (c) automatically centers the cantilever holder by fixing one degree of freedom, while the fiber ferrule is still far away from any potentially harmful obstacle.
5. Feed the ferrule into the cantilever holder through another guiding sleeve (d). The ferrule is protected by a soft sleeve.
6. Tilt the head back into the housing – it flips conve niently and firmly into its dedicated parking position.

Done.

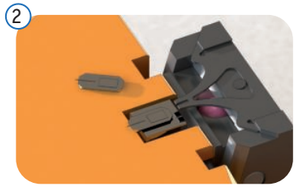
There is no further mechanical alignment necessary – perfectly aligned, yielding the desired interferogram used for the deflection detection of the cantilever.

Quick. Intuitive. Efficient.

AFM/MFM tip exchange in less than 2 minutes



1 Put the cantilever holder into the exchange basis.



2 Slide back the spring blade.

3 Perform the cantilever exchange; alignment grooves on chip guarantee perfect positioning.

4 Close the holder and remove holder from the exchange basis, and insert it back into the AFM head.

MAIN ADVANTAGES

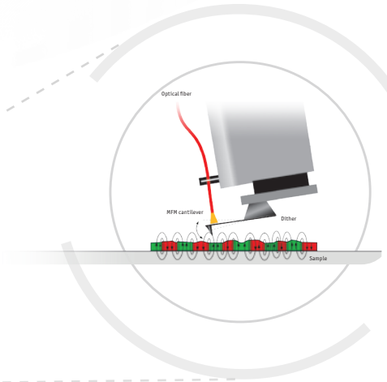
- compact design
- ultra-stable
- easy to use
- no special tools needed
- fully pre-aligned
- no re-alignement needed after cantilever exchange
- electrical pin contacts included, no wires to be detached

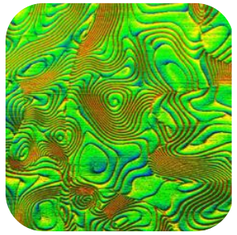
Magnetic Force Microscopy (MFM)

additional AFM mode upgrades

Magnetic Force Microscopy (MFM)

MFM is one of the most widely used AFM techniques, and makes use of a magnetic tip to map out the z-component of the gradient of the magnetic stray field.





MFM image of chiral magnet

The MFM upgrade contains

- 10 MFM tips
- MFM test sample
- MFM factory test at room temperture and low temperature
- MFM demonstration and training during the installation

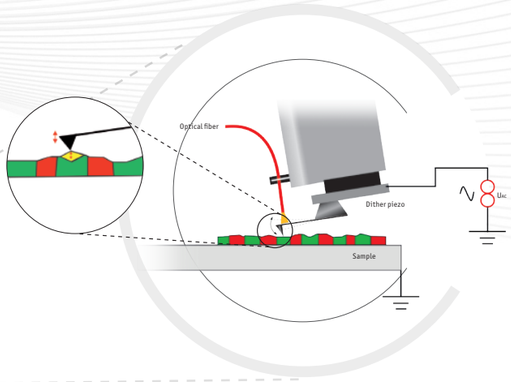
Article	Art.No.
MFM upgrade	1012468

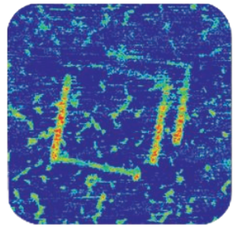
Piezoresponse Force Microscopy (PFM)

additional AFM mode upgrades

Piezoresponse Force Microscopy (PFM)

PFM is capable of imaging the local deformation of a multiferroic material in response to a local electric field caused by a voltage supplied to the AFM tip.





attocube logo written into BFO by PFM

The PFM upgrade contains

- 10 conductive AFM tips
- PFM test sample
- PFM factory test at room temperture and low temperature
- PFM demonstration and training during the installation

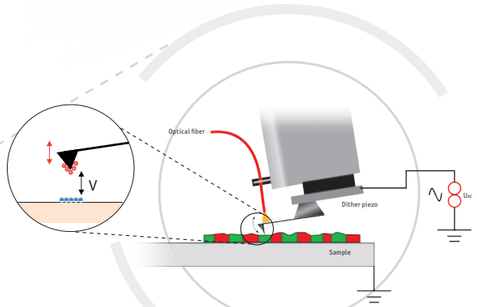
Article	Art.No.
PFM upgrade	1009869

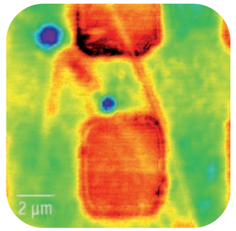
Kelvin Probe Force Microscopy (KPFM)

additional AFM mode upgrades

Kelvin Probe Force Microscopy (KPFM)

KPFM yields information about the local variations of the work function of a material with respect to the AFM tip.





KPFM image of Au-on-Pt pattern

The KPFM upgrade contains

- KPFM software upgrade
- 10 conductive AFM tips
- KPFM test sample
- KPFM factory test at room temperture and low temperature
- KPFM demonstration and training during the installation

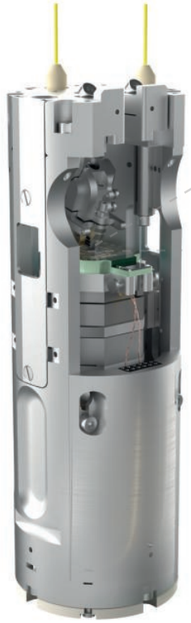
Article	Art.No.
KPFM upgrade	1009977

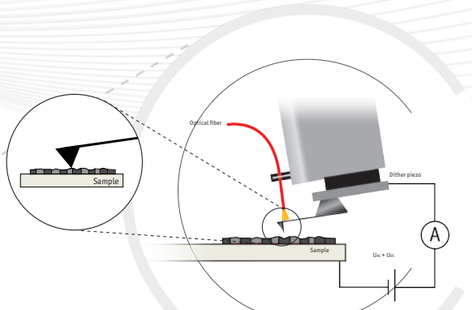
Conducting-tip Atomic Force Microscopy (ct-AFM)

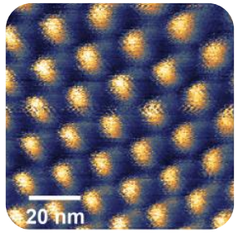
additional AFM mode upgrades

Conducting-tip Atomic Force Microscopy (ct-AFM)

Ct-AFM allows to map out the local electric response of a sample to an applied bias voltage via the AFM tip.







ct-AFM on twisted bilayer graphene

The ct-AFM upgrade contains

- low noise current amplifier
- 10 conductive tips
- ct-AFM test sample
- ct-AFM factory test at room temperture and low temperature
- ct-AFM demonstration and training during the installation

Article	Art.No.
ct-AFM upgrade	1008504

attoAFM I

technical specifications

Find the complete specs on our website

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General Specifications	
type of instrument	cantilever based AFM with interferometric deflection detection
sensor head specifics	attoAFM I+ head feat. alignment-free cantilever holder, tip exchange in less than 2 minutes
alignment-free cantilever holder (default)	compatible with PointProbe® Plus XY-Alignment Series by Nanosensors
Modes of Operation	
imaging modes	contact mode, non-contact mode, constant height, constant force
slope compensation	2 axis scan plane correction
z feedback	PI feedback loop for amplitude modulation (AM), phase modulation (PM) or frequency modulation, (FM) using included PLL, constant force
optional upgrades	MFM, KPFM, PFM, conductive-tip AFM
Resolution	
measured RMS z-noise (constant force @ 4 K, 5 ms pixel time)	< 0.10 nm (expected for attoDRY), < 0.15 nm (guaranteed)
lateral resolution	< 20 nm expected, < 30 nm guaranteed (in attoDRY2200)
Sample Positioning	
total travel range	5 x 5 x 4.8 mm³ (open loop)
step size	0.05 .. 3 µm @ 300 K, 10 .. 500 nm @ 4 K
fine scan range	50 x 50 x 24 µm³ @ 300 K, 30 x 30 x 15 µm³ @ 4 K (open loop)
Suitable Operating Conditions	
temperature range	1.8 K .. 300 K (dependent on cryostat); mK compatible setup available on request
magnetic field range	0..12 T (dependent on magnet) and vector fields
operating pressure	designed for He exchange gas (vacuum compatible version down to 1E-6 mbar on request)

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