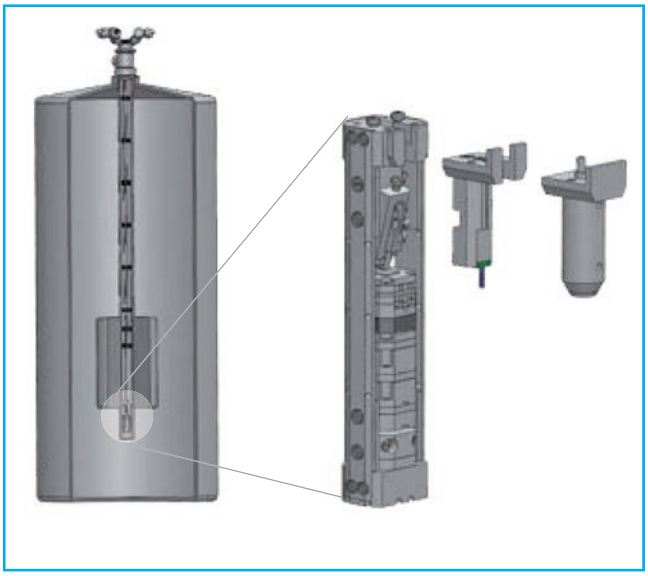
PPMS®-Scanning Probe Microscopy

AFM, MFM, CFM



Schematic drawing of a PPMS cryostat showing the close-up of the AFM module and the exchangable SPM inserts

Key Benefits

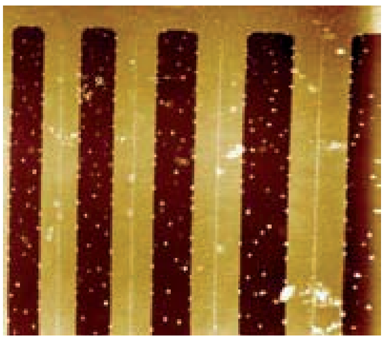
- plug-and-play compatibility with the PPMS®
- suitable for a temperature range from 2 K to 400 K
- suitable for magnetic fields up to 16 T
- easily interchangeable SPM heads
- large cryogenic scan range (12 x 12 μm^2)
- minimum drift in variable field/temperature

With the SPM insert for the Physical Property Measurement System (PPMS®) of Quantum Design, attocube meets growing demands for a highly sophisticated yet easy-to-use scanning probe microscope. Due to its modular design and interchangeable microscopy head, the PPMS®-SPM can be operated in a variety of microscopy modes such as Atomic Force (AFM), Magnetic Force (MFM), and Confocal Microscopy (CFM). The insert is designed for plug-and-play compatibility with the Quantum Design PPMS®, granting access to a large variety of experimental conditions (such as low temperatures and high magnetic fields) and a high degree of automatization.

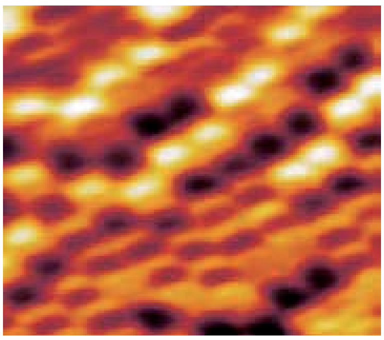
The ultra-compact, high resolution PPMS®-SPM uses advanced technologies such as low temperature compatible objectives or a fibre-optical interferometer for outstanding signal-to-noise force detection. The rugged housing construction is made from highest quality Titanium, ensuring maximum stability and minimum sample drift during variation of temperature and/or magnetic field. The patented driving technology of the coarse positioning system warrants a precise and reliable sample approach and positioning in three axes with nanometer precision over several millimeters range. Plus, the instrument is fully compatible with commercially available cantilevers.

In combination with the Quantum Design PPMS® with its broad temperature and magnetic field range, stability and ease of use, exciting new measurements are only one click away ...

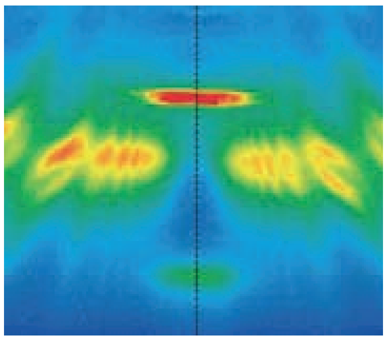
Resolution



AFM contact mode image of a Si-substrate/ SiO_2-Layer; height of the substrate: 20 nm ±2 nm recorded at low temperature.



MFM image of a harddisk at room temperature



Photoluminescence intensity of a triply charged InAs quantum dot vs. magnetic field (red corresponds to high intensity) recorded at cryogenic temperature.

Scanning & Magnetic Force Microscopy

AFM, MFM, EFM

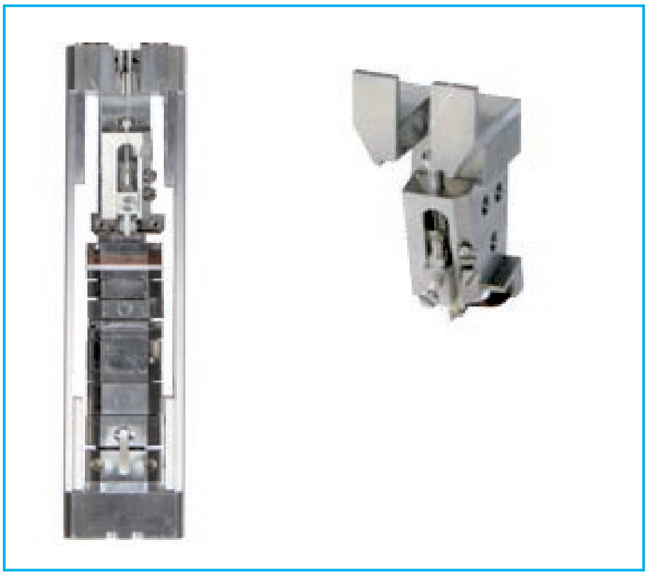


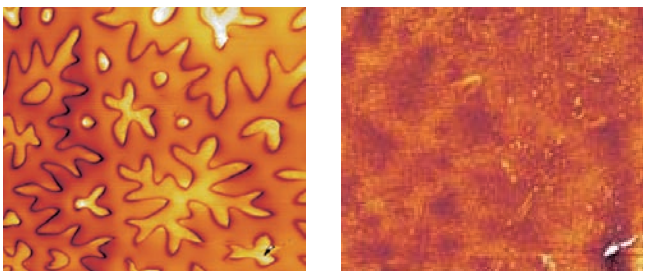
Photo of the AFM module and exchangable AFM head

The PPMS®-AFM is the the perfect choice if it comes to demanding imaging applications such as high-resolution scanning of topographic or magnetic information of a sample under variable magnetic field or temperature.

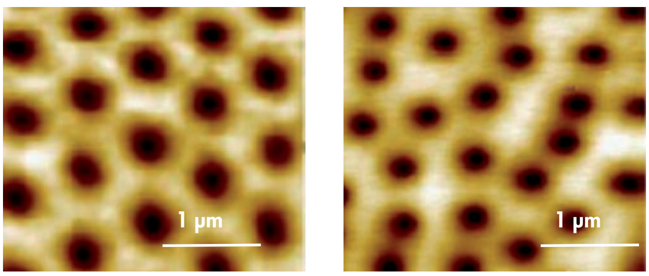
Key Benefits

- high resolution AFM and MFM imaging
- quick sample and cantilever exchange
- highest stability in variable magnetic fields
- highest stability at variable temperature
- offers all common contact and non-contact modes (contact, intermittent contact, true non-contact) and high resolution magnetic imaging
- interferometric deflection detection
- large scan range at low temperature
- designed to work seamlessly with the QD PPMS®
- large range, patented coarse positioning system
- patented coarse positioning driving technology

Key Specifications	
Operation Modes	
feedback	PI feedback loop with additional PLL
imaging modes	contact mode, non-contact mode, high-resolution MFM mode, EFM, SGM
Sample Positioning	
coarse range	3 x 3 x 2.5 mm^3
step size	0.025 .. 2 µm @ 300 K, 10 .. 500 nm @ 4 K
scan range	30 x 30 x 5 µm^3 @ 300 K, 12 x 12 x 2 µm^3 @ 4 K
Operating Conditions	
temperature range	1.9 .. 400 K (full PPMS® temperature range)
magnetic field range	16 T (full PPMS® magnetic field range)
operating pressure	10^{-6} mbar .. 1 bar (designed for exchange gas atmosphere)
Resolution	
control electronics	16 bit over selected scan range
lateral (xy) bit resolution at 300 K	0.46 nm at 30 µm scan range
z bit resolution at 300 K	0.075 nm at 5 µm scan range
lateral (xy) bit resolution at 4 K	0.18 nm at 12 µm scan range
z bit resolution at 4 K	0.03 nm at 2 µm scan range
MFM resolution at 300 K and 4 K	20 nm
Sample Size	
sample size	10 x 10 x 5 mm^3 (max.)



MFM measurements on a BaFeO sample with the PPMS®-AFM. Scan size 25 µm. Left: Phase image in high-resolution MFM mode at 100 nm tipsample separation.
Right: topographic image, recorded close to the surface.



Unprocessed MFM images of two different high-Tc superconductor samples at 4 K and 45 G magnetic field recorded with the PPMS®-AFM. Left: hexagonal vortex lattice in optimum doped $Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212).
Right: disordered vortex lattice in the iron pnicitide $Ba_{1-x}KxFe_2As_2$.

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Confocal Microscopy

CFM

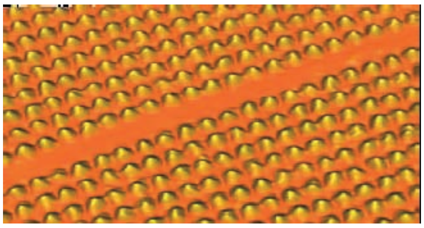
Photo of the CFM module and exchangable CFM head

Confocal microscopy (CFM) is the method of choice for obtaining clear optical images with high resolution (diffraction limited) and high optical throughput. At cryogenic temperatures, the combination of high resolution power, clear optical spectra, and reduced thermal noise can be achieved. The plug-and-play experimental setup has made this technique the method of choice for a variety of applications ranging from examining physical structures like semiconductor quantum dots and NEMS/MEMS devices to the emerging area of nano-optics.

Microscope Configuration	
Operation Modes	
confocal unit	modular beam splitter microscope head outside of the cryostat, excitation and collection port fully adjustable, free beam optics, optional polarizer & retarder possible
pinhole configuration	two pinholes (fiber apertures), adjustable in x-, y-, z-direction, different illumination and collection wavelength possible
Operating Conditions	
temperature range	1.9 .. 400 K (full PPMS® temperature range)
magnetic field range	16 T (full PPMS® magnetic field range)
operating pressure	10^{-6} mbar .. 1 bar (designed for exchange gas atmosphere)
Optical Parameters	
pinhole size	dependent on fibers, typically 3 .. 9 µm mode field diameter
spot size	diffraction limited
Illumination	
excitation wavelength range	400 .. 1600 nm
light source	fiber coupled laser, typically 635 nm
Sample Size	
sample size	10 x 10 x 5 mm^3 (max.)

Key Benefits

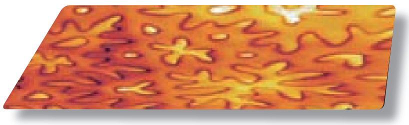
- high resolution confocal imaging
- various detection modes such as reflection, luminescence, fluorescence, ...
- highest stability in variable magnetic fields
- highest stability at variable temperature
- coupling of the light to other detectors possible, e.g. spectrometer, APD, ...
- interferomteric deflection detection
- large scan range at low temperature
- designed to work seamlessly with the QD PPMS®
- large range, patented coarse positioning system

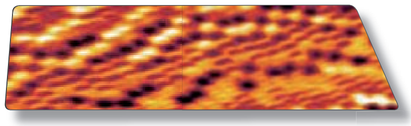


Confocal image of a chess board grating (SiO_2 on Si) with a period of 2 µm, recorded in reflection mode.

The next Level PPMS solution

nanoSCOPYxs





Y	yotta ital. otto = eight	$(10^3)^8 = 10^{24}$ = 1 000 000 000 000 000 000 000 000 septillion
Z	zetta ital. sette = seven	$(10^3)^7 = 10^{21}$ = 1 000 000 000 000 000 000 000 sextillion
E	exa gr. hexákis = six times	$(10^3)^6 = 10^{18}$ = 1 000 000 000 000 000 000 quintillion
P	peta gr. pentákis = five times	$(10^3)^5 = 10^{15}$ = 1 000 000 000 000 000 quadrillion
T	tera gr. téras = monster / tetrákis = four times	$(10^3)^4 = 10^{12}$ = 1 000 000 000 000 trillion
G	giga gr. gígas = giant	$(10^3)^3 = 10^9$ = 1 000 000 000 billion
M	mega gr. mégas = large	$(10^3)^2 = 10^6$ = 1 000 000 million
k	kilo gr. chílioi = thousand	10^3 = 1 000 thousand
h	hecto gr. hekatón = hundred	10^2 = 100 hundred
da	deca gr. déka = ten	10^1 = 10 ten
d	deci lat. decimus = tenth	10^{-1} = 0.1 tenth
c	centi lat. centesimus = hundredth	10^{-2} = 0.01 hundredth
m	milli lat. millesimus = thousandth	10^{-3} = 0.001 thousandth
μ	micro gr. mikrós = small	$(10^{-3})^2 = 10^{-6}$ = 0.000 001 millionth
n	nano gr. nános and ital. nano = midget	$(10^{-3})^3 = 10^{-9}$ = 0.000 000 001 billionth
p	pico ital. piccolo = tiny	$(10^{-3})^4 = 10^{-12}$ = 0.000 000 000 001 trillionth
f	femto scand. femton = fifteen	$(10^{-3})^5 = 10^{-15}$ = 0.000 000 000 000 001 quadrillionth
a	atto scand. arton = eighteen	$(10^{-3})^6 = 10^{-18}$ = 0.000 000 000 000 000 001 quintillionth
z	zepto lat. septem = seven	$(10^{-3})^7 = 10^{-21}$ = 0.000 000 000 000 000 000 001 sextillionth
y	yocto lat. octo = eight	$(10^{-3})^8 = 10^{-24}$ = 0.000 000 000 000 000 000 000 001 septillionth

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