attoMICROSCOPY
Sophisticated Tools for Science

attoMICROSCOPY's scanning probe microscope family (AFM, MFM, SHPM, CFM) is also available for any 1” (25 mm) bore size cryostat, in particular the Quantum Design PPMS®. Despite their compactness, all microscopes provide a coarse travel range of 3 x 3 x 2.5 mm³ and a scan range of 15 x 15 μm² at low temperature (4 K).

The outstanding stability of the microscopes allows investigation of nm-sized structures with highest resolution. PPMS users can thus complement their existing equipment with a whole range of versatile tools for state-of-the-art research on the nanometer scale.

attoAFM Ixs
Ultra-Stable, Compact Atomic Force Microscope with interferometric deflection detection for highest stability and sensitivity. Compatible with contact and non-contact AFM mode.

attoMFM Ixs

attoCFM I/IIxs & attoRAMANxs
Ultra-Stable, Compact Confocal Microscope based on fiber or free-beam optics for maximum flexibility and stability.

attoSHPMxs
Ultra-Stable, Compact Scanning Hall Probe Microscope with STM tracking 2DEG Hall sensor for maximum field sensitivity.

PPMS-SPM
the only scanning probe microscopes for the PPMS® certified and endorsed by Quantum Design

Atomic & Magnetic Force Microscopy
- vortex imaging in superconductors
- magnetic nanoparticles & nanowires
- bit patterned media
- multiferroics

Cryogenic Confocal Microscopy
photoluminescence and photoconductivity of:
- quantum dots, nanowires & single molecules
- 2D-layered materials
- photonic crystals

Micro-Raman Spectroscopy/Microscopy
- carbon nanotubes
- graphene
- high Tc superconductors
- semiconductor nanowires

Scanning Hall Probe Microscopy
- superconductors
- magnetic nanostructures
- next generation storage media

PPMS

PPMS-SPM
The attoAFM Ixs is an ultra-compact atomic force microscope designed particularly for applications at low and ultra low temperature. The instrument works by scanning a sample below a fixed cantilever while measuring its deflection with highest precision using a fiber based optical interferometer. Combined with the ASC500 SPM controller, both contact and non-contact modes are applicable, making the attoAFM Ixs a powerful tool for topographic measurements, force spectroscopy and other imaging modes.

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 scan range of 30µm x 30µm at room temperature, and 25µm x 15µm at liquid helium temperature. The adjustment of the cantilever is performed outside of the cryostat prior to cooling down the microscope. The exceptional combination of materials allows absolutely stable high resolution imaging of surfaces.

**Application examples**

- Magnetic Domain Imaging
- Piezo-Response Force Microscopy
- Vortex Imaging

**Magnetic Domain Imaging**

- Schematic of the low temperature attoAFM/MFM Ixs in a PPMS cryostat (not included)
- Other imaging modes: contact-mode, non-contact mode
- NEW: alignment-free cantilever holder (default) compatible with standard commercial cantilevers
- High spatial resolution imaging
- Highly sensitive interferometric deflection detection
- NEW: tip exchange in less than 2 minutes
- Compatible with any commercially available MF probe

**NEW:**
- Alignment-free cantilever holder
- Ultra compact, highly rigid PM head
- Highly sensitive interferometric deflection detection
- Adjustment of the cantilever outside the cryostats prior to cooling the microscope

**PRODUCT KEY FEATURES**

- **NEW:** alignment-free cantilever holder
- Ultra compact, highly rigid PM head
- Highly sensitive interferometric deflection detection
- Adjustment of the cantilever outside the cryostats prior to cooling the microscope

**BENEFITS**

- **NEW:** tip exchange in less than 2 minutes
- High spatial resolution imaging
- Simultaneous ultra high resolution topographic & magnetic force imaging
- Compatible with any commercially available MF probe

**APPLICATION EXAMPLES**

- Investigation of superconductors
- Domain structure studies
- Material science

**COMPATIBLE COOLING SYSTEMS**

- Quantum Design PPMS, see compatibility chart
- Ready for KPP, MPMS, conductive-tip AFM (may require additional hardware)

**COMPATIBLE CRYOSTATS**

- Superconducting magnet (optional)
- Liquid He dewar (optional)
- LT and HV compatible feedthroughs
- Suitable Operating Conditions
  - Temperature range: 1.5...300K (dependent on cryostat, compatible setup available on request)
  - Magnetic field range: 0...14 T (dependent on magnet), (SOT compatible version available on request)
  - Magnetic field range: 0...14 T (dependent on magnet)
  - Operating pressure range: 10^(-6) bar...3 bar (designed for exchange gas atmosphere)
  - Conventional cantilever holder (optional)
  - Tip exchange in less than 2 minutes
  - NEW: sensor head alignment-free cantilever holder (default)
  - NEW: sensor head alignment-free cantilever holder (see page 36)
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**NEW:**
- Tip exchange in less than 2 minutes
- Highly sensitive interferometric deflection detection
- Adjustment of the cantilever outside the cryostats prior to cooling the microscope

**Microscope Setup**

- AFM type: cantilever based, interferometric deflection detection
- Sensor head: alignment-free cantilever holder (see page 36)
- Tip exchange in less than 2 minutes
- Titanium housing diameter: 23.9 mm (designed for 1” bore size such as PPMS)
- Sample environment: He exchange gas (other’s on request)

**Operation Modes**

- Feedback modes: amplitude modulation (AM), phase modulation (PM), frequency modulation (FM)
- Imaging modes: contact-mode, non-contact mode
- Sensor head alignment-free cantilever holder (see page 36)
- Standard techniques (Vac.): AFM, NPFM, KPFM

**Sample Preparing**

- Positioners and scanners: coarse positioners ANPhys101 with piezo scanner ANSxyz100
- Coarse range (open loop): 3 x 3 x 2.5 mm³
- Step size: 0.01...30 µm @ 300 K, 10...5000 µm @ 4 K
- Free scan range (open loop): 30 x 30 x 2 µm² @ 300 K, 15 x 15 x 2 µm² @ 4 K

**Suitable Cooling Systems**

- Sample environment: He exchange gas (other’s on request)
- Compatible cryostats see PPMS compatibility chart
- Sample environment: He exchange gas (other’s on request)
- Magnetic force imaging description: PointProbe® Plus XY Alignment Series by Nanosensors

**NEW: tip exchange in less than 2 minutes**
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The attoSHPMxs is a compact scanning Hall probe microscope, designed particularly for operation at low temperature and high magnetic fields. At the heart of the attoSHPMxs, a molecular beam epitaxy (MBE) grown GaAs/AlGaAs Hall sensor measures magnetic fields with unrivalled sensitivity. Local measurements of the magnetization of a sample are obtained by scanning the sample underneath the Hall sensor and simultaneously recording the Hall voltage, directly yielding the local magnetic field.

While other local probes may outperform the Hall sensor with respect to its lateral resolution, its ability to non-invasively obtain quantitative values for the local magnetic field makes the Hall sensor a unique tool for the study of superconductors and magnetic materials.

**Product Key Features**
- STM distance tracking for conductive samples
- High spatial resolution: 250 nm & 400 nm sensors available
- Noise-equivalent magnetic field: 15 nT/√Hz @ 4 K (40 µA Hall current)
- Typical attainable field detection limit: 15 µT (bandwidth 10 Hz @ 277 K)

**Benefits**
- Gain quantitative & non-invasive magnetic information
- Ultra high field sensitivity combined with sub-micron resolution
- Fits standard cryogenic and magnet sample spaces

**Application Examples**
- Investigation of superconductors
- Domain structure studies
- Material science

**Compatible Cooling Systems**
- Quantum Design PPMS, see compatibility chart
- Any cryostat with bore size ≥ 1" (25.4 mm)

**Suitable Operating Conditions**
- Temperature range: 1.5 to 300 K (dependent on cryostat)
- Magnetic field range: 0 to 14 T (dependent on magnet)
- Operating pressure range: 1E-6 m bar to 1 bar (designed for exchange gas atmosphere)

**Probes**
- Probe design: MBE grown GaAs/AlGaAs heterostructure
- Active area: 250 nm (high resolution); 400 nm (ultra high resolution)
- Field sensitivity: 1500 V/AT
- Noise-equivalent magnetic field (measured): 15 nT/√Hz @ 4 K and 40 µA Hall current; 80 nT/√Hz @ 77 K and 40 µA Hall current
- Typical attainable field detection limit (measured): 15 µT typ. (bandwidth 10 Hz @ 277 K)

**Scan Controller and Software**
- ASC500 SPM Controller for detailed specifications please see attoCONTROL section

**Microscope Setup**
- SHPM sensor unit: Hall cross sensor (MBE grown GaAs/AlGaAs heterostructure)
- Titanium housing diameter: 23.9 mm (designed for 1" bore size such as PPMS)

**Scanning Hall Probe Microscopy**
Magnetic Domain Imaging
Vortex Imaging
Scanning Hall Probe Microscopy

**Schematic of the low temperature attoSHPMxs in a PPMS cryostat (not included)**

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**AttoMICROSCOPY**
Sophisticated Tools for Science

**attoSHPMxs**
low temperature scanning Hall probe microscope

**Application examples**
- Quantum Design PPMS, see compatibility chart
- Any crystal with bore size ≥ 1" (25.4 mm)
the attoCFM Ixs has been developed to offer a maximum amount of flex-
ibility for a convenient adaption to a large number of different quantum
optics applications. This is realized by an external optics head, posi-
tioned outside the cryostat. Furthermore, the free-beam optical design
allows for completely independent adjustment of the excitation and
collection port. Therefore, applications such as Raman spectroscopy
become accessible by appropriately filtering of the excitation and de-
tection signals. The easy handling opens up new possibilities in quan-
titative surface characterization in the sub-micron range.

PRODUCT KEY FEATURES
• optical setup offering highest flexibility
• modular beam splitter head outside of cryostat
• wavelength and polarization filtering of the excitation
  and collection signal possible
• large coarse positioning range at low temperatures
• interferometric optional encoders for closed loop
  scanning (optional)
• low temperature objectives with NA up to 0.82
• sample monitoring via CCD camera (field of view:
  75 μm)

BENEFITS
• fits standard cryogenic and magnet sample spaces
• very broad variety of applications, ranging from clas-
sical CFM measurements to Raman spectroscopy
• excellent stability in high magnetic fields
• highest measurement sensitivity
• access to a large area on the sample surface

APPLICATION EXAMPLES
• solid state phyc and quantum dot optics
• fluorescence observation
• biological and medical research on tissue samples
  in cytolical and neurological applications

COMPATIBLE COOLING SYSTEMS
• Quantum Design PPMS, see compatibility chart
• any cryostat with bore size >= 1” (25.4 mm)
• compatible cryostats see PPMS compatibility chart

Microscope Setup
Confocal microscope head Free-beam based external optics head coupled to low-temperature objective
Titanium housing diameter 23.9 mm (designed for 1” bore sizes such as PPMS)
Confocal Unit
configuration compact and modular design, up to three optical channels standard configuration: 1 excitation channel, 1 detection channel
key benefits quick and reliable alignment of each channel, steering mirror for the combined beams
quick-exchange of optical components beam splitters, fiber mount for up to 6 filters/ polarizers (1” diameter), optional piezo-electric rotator with fiber mount
LT- compatible objective achromat, NA = 0.82, WD = 0.6, confocal resolution ~ 550 nm (@ 633 nm reflection)
inspection unit sample imaging with large field of view: ~75 mm (attoDRY), ~150 mm (attoLIQUID)

Illumination
• excitation wavelength range 632 nm, others on request
• port specification FC/APC-connector for single mode fibers

Detection
• detection mode e.g. reflection, luminescence, fluorescence, Raman (optional)
• detection wavelength detector upon user’s choice, typically Si detector (coupling of the light to other detec-
tors possible, e.g. photomultiplier, APD, ...)
• port specification FC/APC-connector for single mode fibers (other connector types on request)

pinhole size dependent on fibers, typically 1...4 μm, medium field diameter
options low temperature compatible detector below the sample for transmission measurements
• temperature range stability 1 mK compatible setup available on request
• magnetic field range 1.5...150 T (dependent on cryostat)
• operating pressure range 10-4 mbar...1 bar (designed for exchange gas atmosphere)

Scan Controller and Software
• A3E400 CFM Controller

for detailed specifications please see attoCONTROL section
attoCFM IIxs
low temperature confocal microscope, highly stable and compact

The attoCFM IIxs is a compact confocal microscope based on one single-mode fiber. The one-of-a-kind combination of materials allows absolutely stable measurements at low temperature over weeks on a single quantum object, even when refilling the bath cryostat with liquid helium. This opens up many new possibilities in cryogenic long-term investigations while considerably reducing operational costs. Objectives with a working distance of up to 3 mm or with a numerical aperture of up to 0.68 are available, see page 184.

**Principle** - A laser beam is coupled into one arm of a single mode optical fiber coupler. The fiber end of the second arm is placed in a ceramic female to guarantee an accurate position of the fiber in the objective axis. This single mode fiber illuminates the sample and plays the role of the blocking pinhole aperture when collecting the scattered light from the sample.

**Schematic of the low temperature attoCFM IIxs in a PPMS cryostat (not included)**

**COMPATIBLE COOLING SYSTEMS**
- LT and HV compatible feedthroughs
- vacuum window
- microscope insert
- superconducting magnet (optional)
- liquid He dewar (optional)
- ultra stable Titanium housing
- xyz coarse positioners
- xyz scanner
- sample
- fiber coupled low temperature objective
- spot size
- coarse range (open loop)
- fine scan range (optional, open loop)
- scan controller and software
- compatible cryostats
- compatible microscope
- compatible magnet
- AASCO CPM Controller for detailed specifications please see attoCONTROL section

**APPLICATION EXAMPLES**
- solid state physics and quantum dot optics
- fluorescence observation
- highly stable long term experiments on single quantum dots
- biological and medical research on tissue samples in cytological and neurological applications
- fast 3D-imaging

**APPLICATION EXAMPLES**
- Quantum Design PPMS, see compatibility chart
- any crystal with bore size >= 1" (25.4 mm)

**BENEFITS**
- minimalized microscope head
- interferometric or capacitive encoders for closed loop scanning
- designed for highest stability
- optimized for minimal light loss
- large coarse positioning range at low temperatures
- ultra compact version for 1 inch (25.4 mm) setups available

**PRODUCT KEY FEATURES**
- fits standard cryogenic and magnet sample spaces
- minimized drifts enable long term measurements
- excellent stability in high magnetic fields
- highest measurement sensitivity
- access to a large area on the sample surface

**APPLICATION EXAMPLES**
- photocurrent
- minuscule quantum dot fluorescence
- multimode fiber
- excitation mode e.g. reflection, luminescence, fluorescence, ...

**Suitable Operating Conditions**
- temperature range
- magnetic field range
- operating pressure range

**COMPATIBLE DETECTORS**
- e.g. reflection, luminescence, fluorescence, ...
- detector configuration
- detector upon user’s choice, typically Si detector (coupling of the light to other detectors possible, e.g. spectrometer, APD, ...)
- sample monitoring via CCD camera
- sample/focus monitoring via CCD camera

**Sample Positioning**
- fine scan range
- step size
- spot size
- coarse range
- step size

**Microscope Setup**
- fiber optics based for maximum stability
- one single-mode fiber for excitation and detection (blocking pinhole)
- fiber coupled low temperature objective
- fiber coupled laser, typically 830 nm
- fiber power on the sample: 1 µW - 500 µW
- port specification: FC/APC connector for single mode fibers

**Optical Parameters**
- pinhole size
- dependent on fibers, typically 3 - 9 µm mode field diameter
- spot size
- defraction limited
- compatible objective
- LT, HV compatible (for details, see page 186)

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- fine scan range
- step size
- spot size
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- step size
The cryogenic Raman instrument combines a high resolution, low temperature confocal microscope with ultra-sensitive Raman optics. This innovative product enables state of the art confocal Raman measurements at cryogenic environments combined with magnetic fields of up to 1.5 T. The attoRAMANxs is a ready-to-use system and is delivered with a Raman laser source (532 nm / 633 nm wavelength as excitation source available), ultra-high throughput spectrometer including a polychromator, back-illuminated CCD, and a state-of-the-art Raman controller/software package. The attoRAMANxs uses a set of xyz-positions for coarse positioning of the sample over a range of several cm, and is also available with an interferometric encoder for closed loop operation. Developed particularly for cryogenic applications, the piezo-based scanner provides a large scan range of 300 µm x 300 µm at room temperature, and 150 µm x 15 µm at liquid helium temperature. The Raman image is obtained by scanning the sample with respect to the laser focus and measuring the spectral distribution of the Raman signal for each point.

**Application examples**

- 2D layered Materials
- Phased Transitions
- Raman Imaging
- Phase Transitions
- Imaging of surface plasmon waves
- Stress measurements
- Defect analysis and phase separations
- Diamond films and inclusions
- Sample positioning and scanning in x, y, and z direction. Control Software for extensive time and single point Raman spectra

**APPLICATION EXAMPLES**

- Nanotechnology and nano-structured surface inspection
- Stress measurements
- Imaging of surface plasmon waves
- Surface structure and properties
- Optical filter laser line filter
- Light power on the sample
- Optical filter
- Laser line filter
- Optical filter laser line filter
- Laser line filter
- Pumped laser, single-mode fiber coupled
- LT-compatible objective
- Laser focus and measuring the spectral distribution of the Raman signal for each point.

**PRODUCT KEY FEATURES**

- optical setup offering highest flexibility
- modular beam splitter head outside of cryostat
- large coarse positioning range at low temperatures
- low temperature objectives with NA up to 0.82
- sample monitoring via CCD camera (field of view: 50 µm)

**BENEFITS**

- fits 1” bore crystallites and magnets
- highest flexibility and sensitivity combined
- with minimal light loss
- high signal to noise ratio
- large coarse positioning range at low temperatures
- ultra-high throughput spectrometer
- state-of-the-art Raman controller/software package

**COMPATIBLE COOLING SYSTEMS**

- Quantum Design PPMS, see compatibility chart
- compatible cryostats see PPMS compatibility chart
- compact and modular design
- three optical channels
- 300 µm x 300 µm at 532 nm
- 100 µm (attoDRY), ~56 nW
- 500 µm, 1024x127 pixels
- typicaly 1 µm, 10 mW
- 50% quantum efficiency at 532 nm
- dedicated FPGA-based RAMAN controller providing coarse positioning and scanning signals
- confocal and 2D confocal images in reflection and transmission mode
- sample positioning and scanning in x, y, and z direction. Control Software for extensive time and single point Raman spectra
- designed for a 2” (50.8 mm) crystallographic base
- compatible crystallites see PPMS compatibility chart
- dedicated FPGA-based Raman controller providing coarse positioning and scanning signals for sample positioning and scanning in x, y, and z direction. Control Software for extensive Raman signal data acquisition and post processing.

**Suitable Cooling Systems**

- temperature range 1.5 – 300 K (dependent on cryostat)
- magnetic field range 0 – 14 T (dependent on magnet)
- operating pressure range 10-6 mbar – 1 bar (designed for exchange gas atmosphere)
- dedicated FPGA-based Raman controller providing coarse positioning and scanning signals for sample positioning and scanning in x, y, and z direction. Control Software for extensive Raman signal data acquisition and post processing.

**Suitable Operating Conditions**

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