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attocRYO

Low Vibration Cryogenic Equipment

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attocube systems AG | Königinstrasse 11a | D - 80539 München | Germany
Tel.: +49 89 2877 809 - 0 | Fax: +49 89 2877 809 - 19 | info@attocube.com
www.attocube.com

Brochure version: 2015 - 02

attoDRY

Closed-cycle Cryostats

The dependence on liquid helium continues to involve heavy logistics, high prices and insecure supplies. Consequently closed-cycle cryostats are becoming more and more popular in all areas involving measurements at variable or low temperatures. With the attoDRY series, attocube provides unique instruments with unmatched and proven low mechanical vibrations, unprecedented low acoustic noise levels, and exceptional temperature stability.

Cryogen-free



Tired of helium costs? The attoDRY closed-cycle cryostats require no liquid helium at all, and hence liberate the user from the increasingly unreliable and ever-more expensive supply of liquid helium.

Large sample space



While most magnet systems feature only 1" diameter sample space, our toploading attoDRY cryostats provide twice the diameter. The attoDRY800 even offers more room at about 3" diameter. This leaves ample space for sophisticated cryogenic experiments, and is of course compatible with our complete line of measurement options.

Automation & touchscreen



Routine procedures such as temperature and magnetic field control are fully automated by a clever gas handling system consisting of integrated pumps, valves and electronics. Moreover, the attoDRY800, 1100 & 2100 are the first cryostats featuring an integrated touchscreen for intuitive control even without a PC.

Versatile platform



A variety of measurement options is available, spanning from a fully 3-dimensional double rotator resistivity module to distinguished characterization techniques such as atomic/magnetic force microscopy (AFM/MFM), scanning Hall probe microscopy (SHPM), confocal microscopy (CFM) and micro-Raman.

Besides, our toploading systems have been optimized for fast turnaround times, and hence enable a maximum number of measurement cycles in a minimum amount of time. Superconducting magnets as single solenoids or vector magnets are available for measurements in high magnetic fields. Last but not least, special emphasis has been put into the ease of use through automation of routine procedures, also contributing to a highly professional user experience.

Ultra-low vibration



Due to a proprietary design, mechanical vibrations created by the coldhead are well decoupled from the measurement platform, thus enabling the use of sensitive techniques such as scanning probe microscopy in a dry low temperature environment.

Silent operation



Special care was taken to reduce the acoustic noise of the inherently loud cold heads by an order of magnitude at the most relevant frequencies. This guarantees a pleasant working environment in your lab.

Fast cooldown



Initial cooldown of a complete toploading system can be as fast as 5-10 hours (without magnet), whereas samples can be cooled within 1-2 hours. The attoDRY800 cryo-optical table with sample in vacuum features a cooldown time of approximately 3 hours.





Temperature stability



The attoDRY cryostats enable precise temperature control over the complete range with a stability measured to be much better than +/- 10 mK at low temperatures. This enables long unattended measurement cycles during your experiment.

Product Finder

compatibility chart

	attoDRY800	attoDRY1000	attoDRY1100	attoDRY2100
base temperature	4 K	4 K	4 K	1.5 K
temperature range	4 .. 350 K	4 .. 300 K	4 .. 300 K	1.5 .. 300 K
cryogen-free	•	•	•	•
automation	•	•	•	•
superconducting magnets		•	•	•
superconducting vector magnets		•	contact us	•
superconducting split coil magnets		•	contact us	•
variable temperature	•	•	•	•
top-loading (sample in exchange gas)		•	•	•
vacuum loading (sample in vacuum)	•			
optical access to sample	•	•	•	•
ultra low vibration	•	•	•	•
integrated positioners	optional	optional	optional	optional
compatibility with microscopes				
attoAFM I	•	•	•	•
attoMFM I	•	•	•	•
attoSHPM		•	•	•
attoCFM I	•	•	•	•
attoCFM II	•	•	•	•
attoCFM III	•	•	•	•
attoRAMAN	•	•	•	•
attoAFM/CFM	•	contact us	contact us	contact us
Photonic Probe Station	•			
attoAFM/STM				
attoAFM III		•	•	•
atto3DR		contact us	contact us	•
				

attoDRY800

cryo-optical table (closed-cycle)

Specifications

attoDRY800

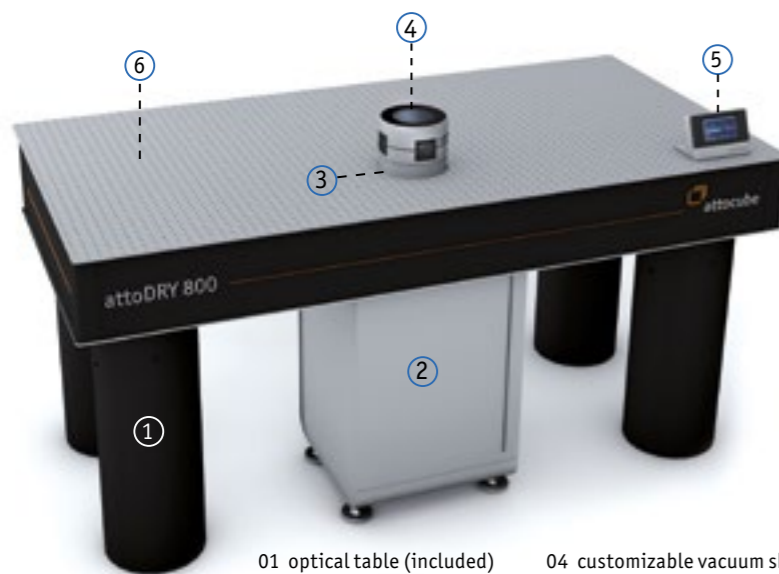
NEW

Quantum optics experiments often require cryogenic temperatures in combination with optical access to the sample space. Most experimental setups contain numerous optical elements that need to be precisely arranged on an optical table to shape and prepare the incident light, as well as to efficiently collect and convert the emitted light from the sample. The available space on the optical table in such cases is of paramount importance to many complex setups.

The revolutionary concept and design of the attoDRY800 presents the perfect solution to satisfy these demanding requirements: it consists of an ultra-low vibration cold breadboard platform which is fully integrated into an optical table. The cryocooler assembly is located in the otherwise unused space underneath. This unique design ensures a free workspace and unobstructed optical access to the cold sample from all directions on the optical table via 4 side and 1 top window. Apochromatic objectives with high numerical aperture (NA=0.81-0.95) can either be integrated into the cryostat, into the vacuum shield, or put in close working distance next to the optical windows from the outside. This ensures extremely low drifts and optimal collection efficiency.

Being a closed-cycle cryostat, the attoDRY800 is the perfect replacement for all helium flow cryostat setups, adding the huge advantage that it requires no liquid cryogen and thus minimizing running costs. In addition, a fully automated temperature control between 3.8 and 320 K conveniently enables unattended long measurement cycles.

While most other off-the-shelf closed-cycle cryostats suffer from severe vibrations at the sample location, during the development process of the attoDRY800 special attention was given to keep the vibration level via a patented vibration isolation technology smaller than 1 nm (RMS). Hence, with the attoDRY800 even extremely sensitive measurements are possible. Its cold breadboard sample space is designed to host several of attocube's patented nanopositioners, as well as complete microscope or photonic probe station solutions.



- 01 optical table (included)
- 02 cryocooler
- 03 cold breadboard
- 04 customizable vacuum shroud with 5 windows (1")
- 05 touchscreen user interface
- 06 obstruction free work space

PRODUCT KEY FEATURES

- cold breadboard integrated into optical table
- low vibrations < 10 nm peak-to-peak
- fully automated variable temperature 3.8 .. 320 K
- customizable vacuum shroud

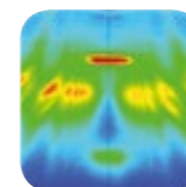
BENEFITS

- free workspace & obstruction-free optical access
- high sample throughput due to fast cooldown
- low running costs (no liquid cryogen)
- flexible combination with attocube equipment: patented cryogenic positioning solutions with multi-degrees of freedom

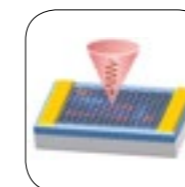
APPLICATION EXAMPLES

- quantum dot spectroscopy
- photocurrent / photoconductivity
- time-resolved spectroscopy
- reflectance / transmittance measurements
- micro-Raman imaging & spectroscopy
- optical resonators coupled to waveguides
- plasmonics on 2D materials
- resonant fluorescence
- optically detected nuclear magnetic resonance
- quantum information processing
- scanning probe microscopy

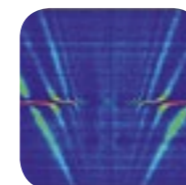
Application examples



Quantum Dot Spectroscopy



Photocurrent / Photoconductivity Measurements



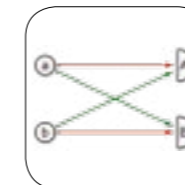
Micro-Raman Imaging / Spectroscopy



Optically Detected Nuclear Magnetic Resonance



Resonant Fluorescence



Quantum Information Processing



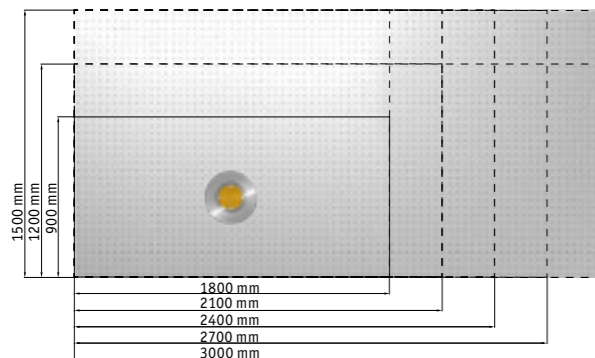
- **Obstruction free** work space
- **Optical table included** (different sizes available)
- 29 customer wires included, **heat sunk @ 4 K**
- Touchscreen based control interface, **no PC required**

General Specifications	
technology	ultra-low vibration, closed-cycle cryostat intimately integrated into optical table, optical table included (water or air-cooled compressor available)
sample environment	cryogenic vacuum, sample cooled via braids (ATC100)
sample space	75 mm (diameter)
sample exchange	easy access via removal of vacuum shroud
vibration & acoustic noise damping system	proprietary low vibration design
usability	obstruction free work space, touchscreen based control interface, no PC required, fully automated temperature control (vacuum, cooldown, T control, warmup)
Performance Data*	
temperature range	3.8 .. 320 K
cooldown time to 6 K (4 K)	approx. 3 h (4-5 h), depending on load
temperature stability	15 mK (peak-to-peak with damped sample mount)
vibration level	< 10 nm (peak-to-peak)
cooling power at sample location	100 mW @ 4.2 K
Closed-cycle cooler	
power consumption	max. 3 kW
cooling of compressor	water cooling (default; requires local infrastructure) air cooling (optional)
Dimensions	
Optical table	standard size 900 mm x 1800 mm x 305 mm (leg height 597 mm); metric or imperial mounting threads (other table sizes available)
Options	
temperature controller	included
pumping kit	included
electrical access	29 customer wires included, heat sunk @ 4 K (additional wiring on request)
optical windows	4 side windows, 1 top window (1" diameter) up to 9 windows possible (optional)
type of windows	BK7 (others on request)
UHV version	on request
larger sample space	on request (200 mm)
vacuum shroud	customized height and diameter (on request)
feedthroughs	electrical (DC, HF), optical fibers, gas capillary (on request)
sample motion	Preimum Line positioners and scanners

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.

attoDRY800 Options

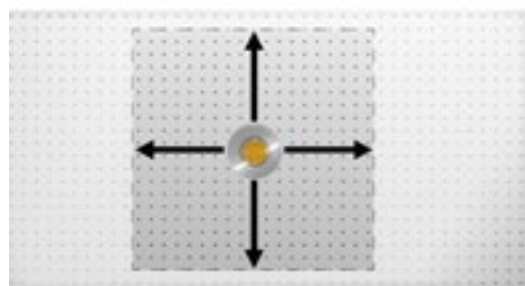
optional items for the cryo-optical table



Decide on the table size

Customized Newport optical tables with metric M6 or imperial hole pattern are available with the following dimensions:

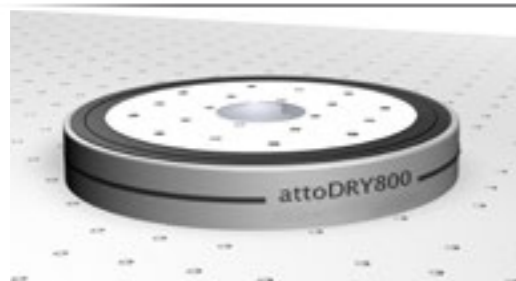
Default size: 900 mm x 1800 mm Leg height: 597 mm, Table thickness: 305 mm	
1200 mm x 1800 mm	1500 x 1800 mm
1200 mm x 2100 mm	1500 x 2100 mm
1200 mm x 2400 mm	1500 x 2400 mm
1200 mm x 2700 mm	1500 x 2700 mm
1200 mm x 3000 mm	1500 x 3000 mm



Choose location of cold breadboard

In order to optimally adapt the system to specific experimental needs, the location of the cold plate of the cryostat can be specified by the customer upon ordering. It can be placed as close as 200 mm to the long edge, as well as off-center with respect to the short edge on wider tables (depending on table size).

Contact attocube for more details.



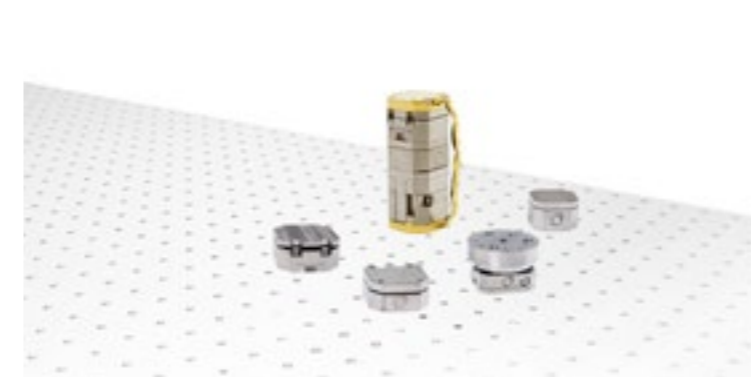
Ultra-low working distance – replace your flow cryostat!

A popular option for flow cryostats is to bring the cold sample as close as possible to an ultra-low working distance window. This allows to flexibly use external optics with a very high angle of admittance, maximizing the collection efficiency via high numerical aperture objectives. The ultra-low working distance option (ULWD) is available with a fixed sample holder, or ready to host either XY or XYZ positioners respectively.

Specifications	
minimum working distance (without cold window)	1 mm
minimum working distance (with cold window)	2 mm
window material	fused silica (others on request)
window thickness	0.5 mm
clear aperture outer window	10 mm

Reclaim your optical table

...don't let the cryostat obstruct the access to your cold sample...

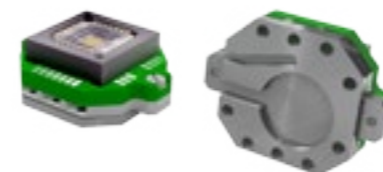


Add multiple degrees of freedom for sample motion

The attoDRY800 is predestined to host your choice of nanopositioners, be it linear, rotary, tilting or scanning stages. Combine many degrees of freedom, or more than one stack of positioners to fulfill all requirements of your application! With our dedicated ATC100 thermal link, we ensure a perfect thermalization of your sample that is straightforward to mount and easy to use.

Sample holder (ASH/LCCC)

For users that require a sample holder with electrical contacts, attocube offers a chip carrier socket for standard 20, 28 or 32 pin leadless ceramic chip carriers. The replaceable PCB base features conveniently accessible contacts for the wiring. Good thermal contact is ensured via a Cu post which extends all the way through the assembly from the thermal link (ATC100) to the leadless ceramic chip carrier. Precise temperature control is achieved via an additional calibrated temperature sensor and heater integrated into the sample holder base.



Article	
ASH/LCCC/20	No: 1010435
ASH/LCCC/28	No: 1010436
ASH/LCCC/32	No: 1010437

Electrical and optical feedthrough options

Additional optional wiring is either provided upon ordering directly through the cryostat, with convenient electrical access at pin connectors close to the sample in vacuum for customer use, or pre-wired and interfaced directly to the cold plate. Retrofit extra wiring or optical feedthroughs are possible via electrical feedthroughs in an adapter ring at the bottom of the sample chamber.



Article	
Electrical access in vacuum	10, 25 or 41 wires, terminated in vacuum
Pre-wired to cold plate	10, 25 or 41 wires, low resistance, compatible with nanopositioners
Coaxial feedthroughs	2 or 4 SMA connectors
Fiber feedthroughs	1, 2 or 4 FC/APC or FC/PC connectors

attoDRY800 Optical Cryo-Microscope

integrated apochromatic low temperature optics for maximum collection efficiency

When collecting small optical signals, e.g. from single photon emitters, which constitute promising candidates for solidstate based qubits, it is a crucial requirement to maximize the collection efficiency. This is best done with objectives that feature high numerical apertures, which usually implies a low working distance. In this case getting the objective close to the specimen is necessary. Most high quality optics are designed for room temperature use, which would not survive periodic thermal cycling. Putting an objective outside of a cryostat often results in large drifts, which are unacceptable for the long measurement cycles required when focusing on a single quantum emitter.

The solution is provided by the attoDRY800 optical cryo-microscope: based on the unique low vibration design of the attoDRY800 cryo-optical table, it features a fully integrated cold objective, hence minimizing drift while maximizing the collection efficiency. The apochromatic objective is located in cryogenic vacuum in close proximity to the sample. Aside from the high numerical apertures ranging from 0.81-0.82 of the objective, their biggest advantage is their small chromatic shift. Optimized for working ranges of 465-600 nm, 565-770 nm and 700-985 nm respectively, the LT-APO objectives keep the focal plane within one depth of focus ($\sim 1 \mu\text{m}$), ensure a uniform spot size, and an intensity of emitters which stays within 75-100%.

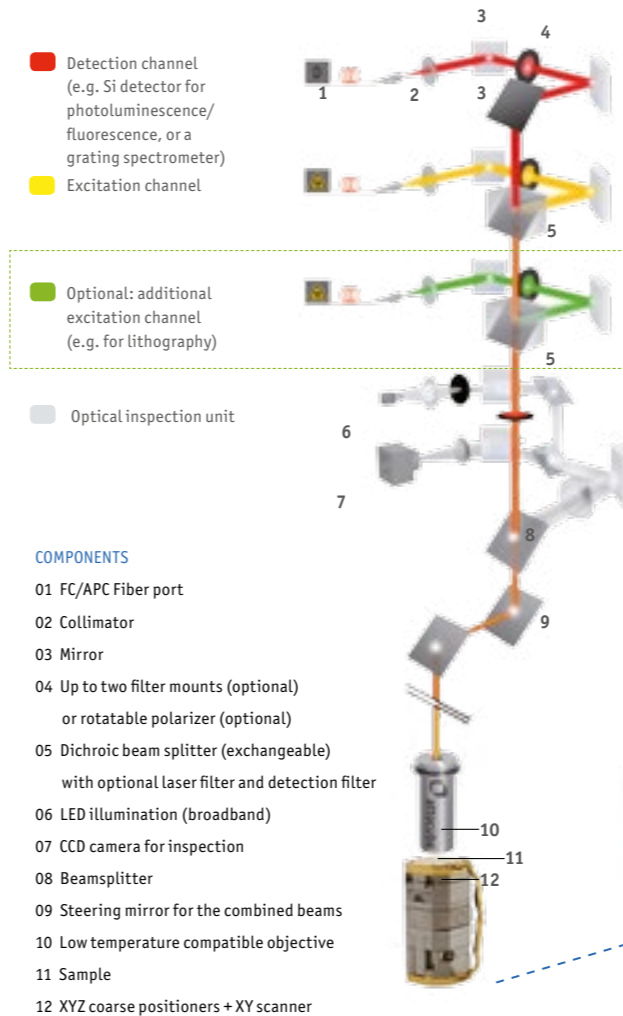


attoCFM/800

complete cryogenic confocal microscope

For many years, attocube has been pioneering cryogenic confocal microscopy. With the introduction of the attoCFM series of confocal microscopes almost a decade ago, the optical investigation of single quantum devices on the sub-micron scale at low temperature suddenly became available as a standard tool for scientists worldwide. Today, the attoCFM/800 is once again redefining the state-of-the-art for low temperature confocal microscopy.

It combines the revolutionary concept of the world's first cryo-optical table with integrated low temperature objectives and the external optics head of the attoCFM I. The researcher is provided with a complete cryogenic confocal microscope system which arrives in his laboratory fully integrated and tested. Accompanied by an on-site installation and hands-on training by our experienced optics experts, this will jump start your measurements, and enable useful research results in a minimum amount of time. .



Cryogenic apochromatic objectives

- negligible chromatic focal shift in working range
- uniform spot size and intensity within apochromatic range

attoDRY1000

cryogen free cryostat with optional superconducting magnets

The attoDRY1000 is a cryogen-free cooling system setting new performance benchmarks. The attoDRY1000 was specifically designed to provide an ultra-low vibration measurement platform for cryogenic scanning probe experiments without the need for liquid helium. The standard closed-cycle system enables vibration-sensitive experiments in a temperature range from 4 K to 300 K. The optionally available microscope inserts are cooled by a controlled exchange gas atmosphere. Superconducting magnets up to 9 T are available as an option. Due to a proprietary design, mechanical vibrations created by the pulse-tube coldhead are decoupled from the measurement platform.

When measured with the attoAFM I, vibration amplitudes of less than 0.15 nm RMS are routinely achieved (bandwidth of 200 Hz, vertical direction)*. Despite the mechanical decoupling between coldhead and sample platform, the cooling performance of the attoDRY1000 is simply outstanding. Temperatures as low as 3 K and probe cooldown times as fast as 1 hour make cryogenic scanning probe experiments a delight. For the attoDRY1000, a wide variety of scanning probe microscopy inserts is available, ranging from confocal (CFM) to magnetic force microscopy (MFM).

*Further reading: F.P. Quacquarelli *et al.*, arXiv:1404.2046v1



PRODUCT KEY FEATURES

- cryogen-free, low vibration cryostat platform
- very fast cooldown and turn-around times
- temperature control range: 4 K to 300 K
- optional superconducting magnets

BENEFITS

- scanning probe microscopy experiments in a cryogen-free, low vibration environment
- fast exchange of samples and/or scanning probe tips
- measurements at a broad range of temperature and magnetic field (optional) with highest stability

APPLICATION EXAMPLES

- solid state physics and quantum dot optics
- material science research on ceramics, polymers, additives, alloys, ..
- semiconductor device characterization

COMPATIBLE MICROSCOPE SYSTEMS

- attoCFM I, attoCFM II, attoCFM III, attoRAMAN, attoAFM I, attoMFM I, attoSHPM

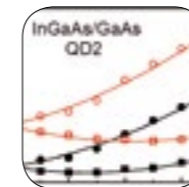
CUSTOMER FEEDBACK

Prof. M. Atature

Since the installation of the attoDRY1000 in our lab, all quoted specifications were fulfilled or exceeded and the service and support have proven to be excellent. The unit has been operational since the first day and continues to function with no interruptions. I can verify that, in contrast to typical liquid systems, the attoDRY1000 continues to operate without the typical interruption of cryogenics refill, allowing data acquisition around the clock for months.

(University of Cambridge, Department of Physics, UK)

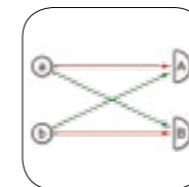
Application examples



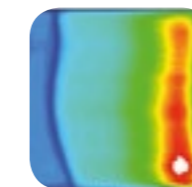
Confocal Imaging



Photocurrent



Quantum Information Processing



Photoluminescence Spectroscopy



Resonant Fluorescence

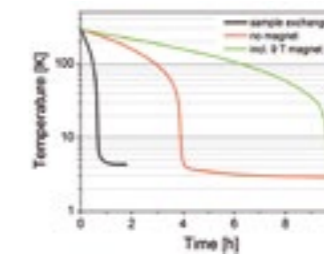


Kerr-Effect Measurements

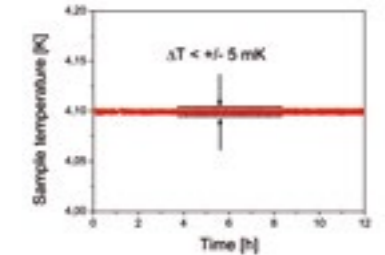
Cryogen-Free. Low Vibration.

exceptional cooling performance

COOLDOWN TIME



TEMPERATURE STABILITY



General Specifications	
technology	ultra-low vibration, pulse-tube based closed-cycle cryostat designed for scanning probe microscopy applications
sample environment	helium exchange gas
sample space	49.7 mm diameter probe bore fitting all attocube inserts
sample exchange	top loading system for quick access
vibration & acoustic noise damping system	proprietary low vibration design
Performance Data*	
temperature range	4 .. 300 K (opt. temp. controller required)
cool down time of sample	approx. 2 h (depending on insert)
cool down time of system (system without magnet)	approx. 5 .. 10 h (unattended)
cool down time of system (system incl. 9 T magnet)	approx. 10 .. 15 h (unattended)
temperature stability	< ± 10 mK expected (4 .. 50 K) < ± 25 mK guaranteed (4 .. 50 K)
cooling power at sample location	> 5 mW @ 5 K
Closed-cycle cooler	
nominal cooling power (4.2 K)	> 900 mW
power consumption	max. 9.0 kW, 7.2 kW steady state
cooling of compressor	water cooling (requires local infrastructure)
Dimensions	
cryostat (width x depth x height)	1120 x 640 x 1050 mm ³ (depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1050 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	2 channel (magnet + sample temperature)
pumping kit	turbomolecular pump with suitable backing pump for sample space preparation

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.

attoDRY1100

touchscreen control of field & temperature

The attoDRY1100 offers a truly unique low temperature measurement platform with a fully automated gas handling system. The integrated touchscreen allows for conveniently setting the desired field (B) and temperature (T) without even using a PC. More elaborate measurement schemes such as programmable sweeps of B and T are easily possible via a USB connection and a LabVIEW interface.

The toploading design enables quick and easy sample exchange, while offering a generous sample space of 49.7 mm in diameter. The unmatched cooling performance via exchange gas coupling enables probe cooldown times as fast as 1-2 hours, and the initial cooldown time of the complete system is around 10-15 hours including a 9 T magnet. The

temperature stability was measured to be better than ± 5 mK over 14 hours at 4 K.

Last but not least, the attoDRY1100 was specifically designed to provide an ultra-low vibration measurement platform for cryogenic scanning probe experiments without the need for liquid helium. Due to a proprietary design, mechanical vibrations created by the pulse-tube coldhead are decoupled from the measurement platform. When measured with the attoAFM I, vibration amplitudes of less than 0.15 nm RMS are routinely achieved (bandwidth of 200 Hz, vertical direction)*.

*Further reading: F.P. Quacquarelli *et al.*, arXiv:1404.2046v1



KEY FEATURES

- scanning probe microscopy experiments in a cryogen-free, low vibration environment
- fast exchange of samples and/or scanning probe tips
- measurements at a broad range of temperature and magnetic field (optional) with highest stability

BENEFITS

- no liquid helium required
- integrated 4.3" touchscreen
- full automation of field and temperature control
- USB/Ethernet interface, LabVIEW control
- designed for vibration sensitive measurements
- in-situ double rotator for full field (9 T) in 3D (optional)

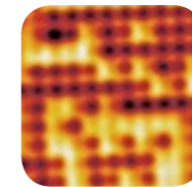
APPLICATION EXAMPLES

- solid state physics and quantum dot optics
- material science research on ceramics, polymers, additives, alloys, ..
- semiconductor device characterization

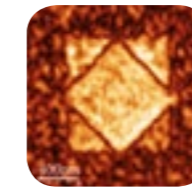
COMPATIBLE MICROSCOPE SYSTEMS

- attoAFM I, attoMFM I, attoSHPM, attoAFM III, attoCFM I, attoCFM II, attoCFM III, attoRAMAN
- attoAFM/CFM (on request)

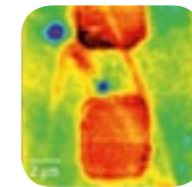
Application examples



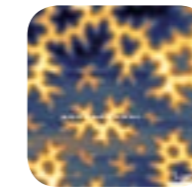
Magnetic Domain Imaging



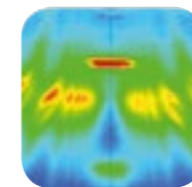
Piezo-Response Force Microscopy



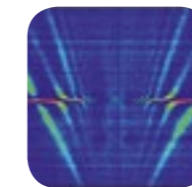
Kelvin Probe Force Microscopy



Scanning Hall Probe Microscopy



Quantum Dot Spectroscopy

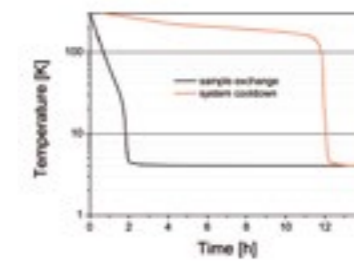


Micro-Raman Spectroscopy

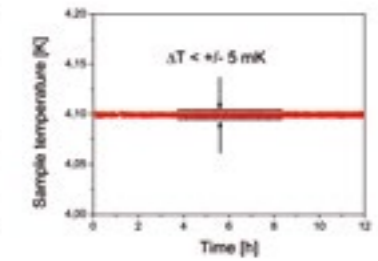
Fully Automated. Turnkey Operation.

exceptional cooling performance

COOLDOWN TIME



TEMPERATURE STABILITY



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Closed-cycle cooler	
nominal cooling power (4.2 K)	> 900 mW
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cooling of compressor	water cooling (requires local infrastructure)
Dimensions	
cryostat (width x depth x height)	1120 x 640 x 1050 mm ³ (depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1050 mm ³
Options	
superconducting magnet	9 T (other magnets on request)
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	included

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.

attoDRY2100

cryogen free 1.5 K cryostat with optional superconducting magnet

Our range of toploading, dry, low vibration cryostats has been further extended by the attoDRY2100. It offers a continuous base temperature of 1.5 K, a fully automated gas handling & temperature control from 1.5 K to 300 K and your choice of superconducting magnet.

The integrated touchscreen allows to conveniently set the desired field (B) and temperature (T) without even using a PC. More elaborate measurement schemes such as programmable sweeps of B and T are easily possible via a USB connection and a LabVIEW interface. The temperature stability was measured to be better than ± 5 mK at 1.5 K over 10 hours. The toploading design enables quick and easy sample exchange, while offering a generous sample space of 49.7 mm in diameter. The unmatched cooling performance via exchange gas coupling provides



an initial cooldown time of the complete system of around 5-10 hours, while the turn-around time during sample exchange is less than 10 hours.

Last but not least, the attoDRY2100 was specifically designed to provide an ultra-low vibration measurement platform for cryogenic scanning probe experiments without the need for liquid helium. Due to a proprietary design, mechanical vibrations created by the pulse-tube coldhead are decoupled from the measurement platform. When measured with the attoAFM I, vibration amplitudes of less than 0.15 nm RMS are routinely achieved (bandwidth of 200 Hz, vertical direction)*.

*Further reading: F.P. Quacquarelli *et al.*, arXiv:1404.2046v1

PRODUCT KEY FEATURES

- continuous 1.5 K operation with automated gas handling
- cryogen-free, low vibration cryostat platform
- very fast cooldown and turn-around times
- temperature control range: 1.5 K to 300 K
- optional superconducting magnets up to 9 T

BENEFITS

- scanning probe microscopy experiments in a cryogen-free, low vibration environment
- fast exchange of samples and/or scanning probe tips
- measurements at a broad range of temperature and magnetic field (optional) with highest stability

APPLICATION EXAMPLES

- solid state physics and quantum dot optics
- material science research on ceramics, polymers, additives, alloys, ..
- semiconductor device characterization

COMPATIBLE MICROSCOPE SYSTEMS

- attoAFM I, attoMFM I, attoSHPM, attoAFM III, attoCFM I, attoCFM II, attoCFM III, attoRAMAN, atto3DR
- attoAFM/CFM (on request)

CUSTOMER FEEDBACK

Prof. A. Holleitner

We are absolutely happy with the cooling performance of the attoDRY2100, both concerning base temperature as well as duration to cool it down from room temperature! Therefore, many thanks for developing such a great system!

(Technical University Munich, Germany)

Application examples



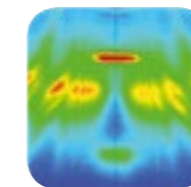
Conductivity Mapping



Vortex Imaging



Multi-Ferriox Characterization



Quantum Dot Spectroscopy



Resonant Fluorescence

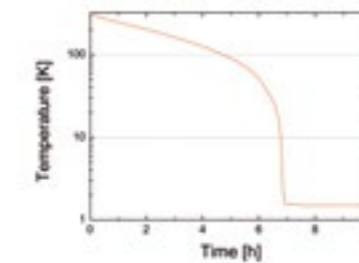


Transport Measurements

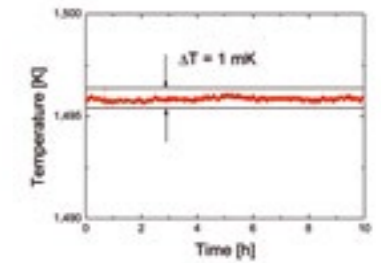
1.5 K Continuous Operation.

exceptional cooling performance

COOLDOWN TIME



TEMPERATURE STABILITY

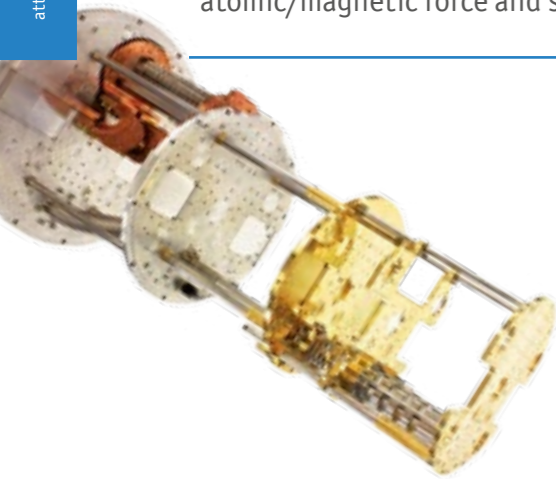


General Specifications	
technology	ultra-low vibration, pulse-tube based closed-cycle cryostat designed for scanning probe microscopy applications
sample environment	helium exchange gas
sample space	49.7 mm diameter probe bore fitting all attocube inserts
sample exchange	top loading system for quick access
vibration & acoustic noise damping system	proprietary low vibration design
usability	fully automated temperature and magnetic field control via integrated touchscreen, USB interface for remote control
Performance Data*	
temperature range	1.5 .. 300 K (automated control)
base temperature	1.5 K (expected), 1.8 K (guaranteed)
cool down time of sample	approx. 8-10 hours (depending on insert)
cool down time of system (system without magnet)	approx. 5 .. 10 h (unattended)
cool down time of system (system incl. 9 T magnet)	approx. 10 .. 15 h (unattended)
temperature stability	< ± 5 mK (1.5 .. 10 K)
cooling power at sample location	> 2 mW @ 2 K
Closed-cycle cooler	
nominal cooling power (4.2 K)	> 900 mW
power consumption	max. 9.0 kW, 7.2 kW steady state
cooling of compressor	water cooling (requires local infrastructure)
Dimensions	
cryostat (width x depth x height)	1120 x 640 x 1050 mm ³ (depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1050 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	turbomolecular pump with suitable backing pump for sample space preparation

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.

Scanning Probe Microscopy goes Dry mK

atomic/magnetic force and scanning gate microscopy in dry dilution refrigerators

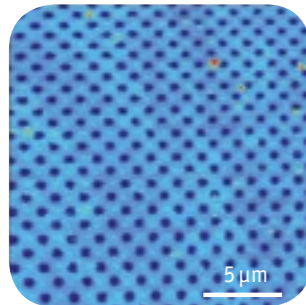


Since 2001, attocube has been pioneering cryogenic scanning probe microscopy, and hence substantial experience has also been gained in mK environments with our instruments. Even when it comes to dry systems, which pose a particular challenge to sensitive techniques due to the vibrations induced by the cold head, we have achieved outstanding results both in terms of base temperature (despite the additional thermal heat load due to scanning) and noise specifications. Our instruments are based on state-of-the-art dry dilution refrigerators with a cooling power of several hundred μ Watts at 100 mK, fully automated gas handling systems and wiring that is perfectly matched to both the operation of the microscope as well as to the additional requirements of the customer.

Long Term Measurement at mK Temperatures

This scan above nicely demonstrates the stability of a complete system, an attoAFM I together with a LD400 cryo-cooler from BluFors Cryogenics. For this $25 \times 25 \mu\text{m}^2$ (800×800 pixel) scan, which took about 12 hrs, the pulse-tube cooler was enabled the whole time. The temperature was stable at ~ 40 mK measured at the mixing chamber – it was slightly higher due to the higher scan speed of close to $1 \mu\text{m/s}$.

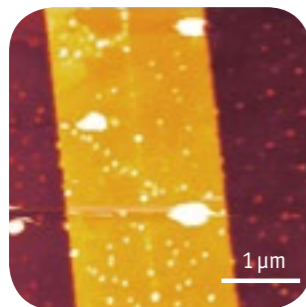
(attocube applications in collaboration with BluFors Cryogenics, 2014)



Atomic Force Microscopy at 80 mK

This AFM-topography test-measurement of a 20 nm high calibration grating was performed in a pulse-tube based dilution fridge from Leiden Cryogenics. Even though the sample was scanned with $3 \mu\text{m/s}$, the temperature did not rise above 80 mK, while the base temperature of the (not yet optimized) braid cooled sample was at around 62 mK. Geophone measurements verified the low vibrations of the platform and showed that it is a suitable approach for high resolution, ultra-low temperature AFM-type experiments. attocube now also offers sensitive applications like scanning gate microscopy in dry dilution refrigerators. Contact us for more information.

(attocube applications in collaboration with Leiden Cryogenics, 2011)



Free-beam confocal optics at Dry mK

confocal microscopy in dry dilution refrigerators

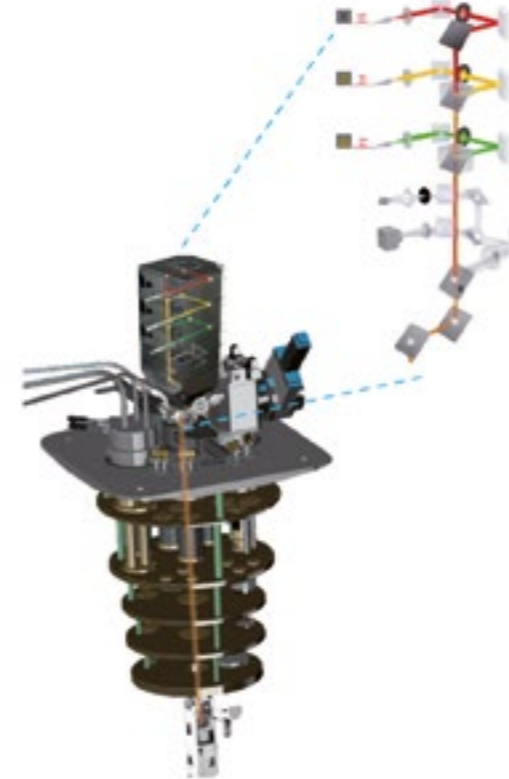
Confocal Free-Beam Microscopy at Dry mK

Due to recent advances in several fields of solid state physics, there is a growing interest in performing quantum optics, quantum opto-mechanics and other measurements in the sub-100 mK regime. For example, since a few years, it has become possible to prepare macroscopic mechanical oscillators in their groundstate, which opens the door to sophisticated experiments which couple such quantum resonators to quantum dots, single spins in diamond, or high-finesse optical cavities. Applications range from single-molecule mass detection to magnetic resonance force detection of single electron spins [1].

Other experiments utilize resonant fluorescence to directly measure the power spectrum of a single quantum dot, photo conductivity, Kondo excitons, spin cooling or nuclei polarization. Also, optically detected magnetic resonance for magnetometry can benefit from ultra-low temperatures (quantum spin hall effect, topological insulators).

At the same time, realizing such experimental setups within closed-cycle dilution refrigerators even for free-beam confocal optics is now within reach. Since years, attocube maintains close ties to many leading scientists in these fields, and is eager to combine our own expertise with state-of-the-art dry dilution refrigerators to deliver new platforms for groundbreaking experiments in quantum optics.

[1] M. Aspelmeyer and K. Schwab, *New J. Phys.* 10, 095001 (2008).



Optional CFM base kit for magneto-optics

attoDRY1000/1100/2100 options

While many researchers opt for a complete and carefree system solution, others prefer to work on the basis of their own vast experience with homebuilt setups. The latter involves a substantial investment into development time within the research group, but adds to the flexibility of the setup, and of course does save the researcher some costs initially.

It is for this reason that attocube also offers CFM base kits for the experts, based on our proven optics components. Instead of a fully tested complete setup, the customer receives the components of his choice for building his own dream setup. Combine a basic measurement insert in our patented design with the wiring of your choice, the world's only low temperature compatible apochromatic objectives, and our patented nanopositioners with a sample holder to kick-start your laboratory!

This base kit approach allows to equip each attoDRY cryostat with several different optical inserts, each one optimized for a specific experiment. Or, put differently, one insert per researcher!

Basis insert incl. cabling



...twisted pairs, coaxials, semi-rigid...

Cryogenic apochromatic objective



Nanopositioners & sample holder



Optional coupling of cryostat to optical table

combine the convenience of an optical table with fast turnaround time of a toploading magnet system

NEW

CUSTOMER FEEDBACK

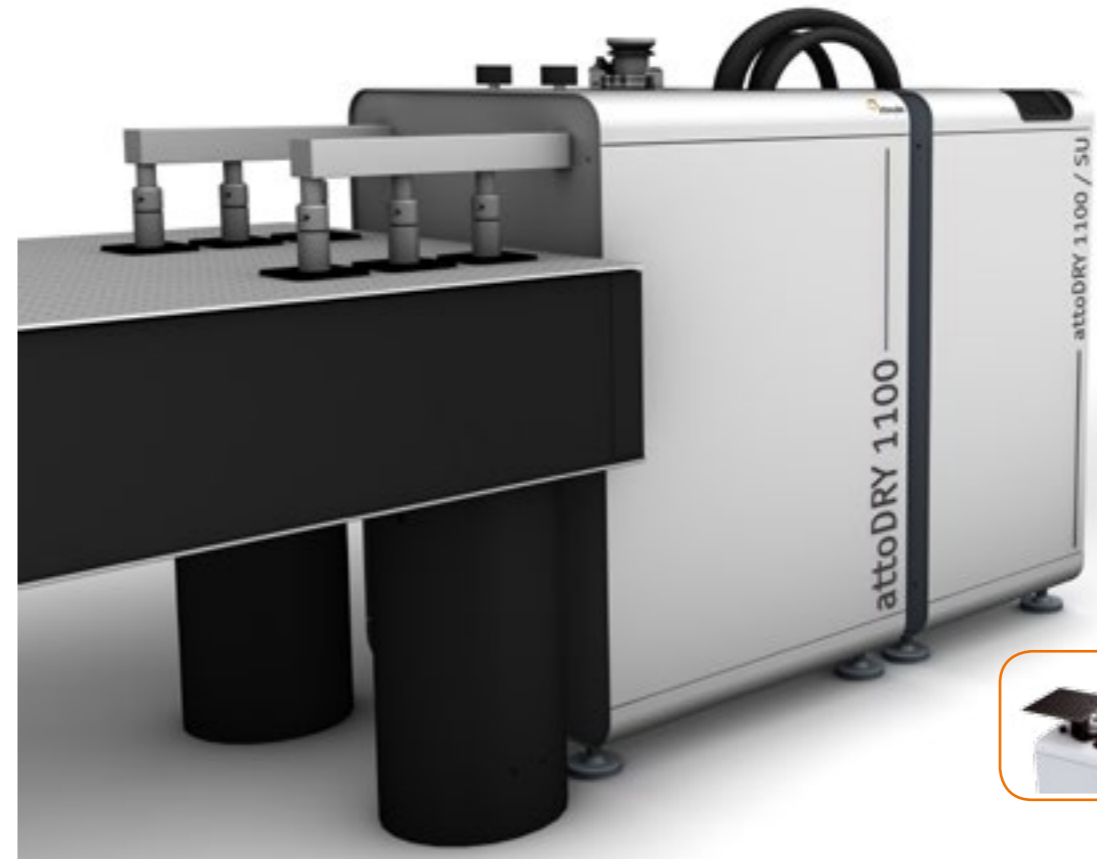
Prof. David Gershoni

The attoDRY cryostat has been the workhorse of our quantum optics research group over the last 5 years, running almost 24/7. The most convenient feature of the system is the stable coupling between the cryostat insert and our optical table. This feature, which was custom made for us, enables the combination of an elaborate free-beam optical setup with the convenience of an extremely stable, toploading cryostat. The cryostat stability is excellent, and sample turnaround times are kept minimal due to the cryostat design, in which the studied sample is cooled by exchange gas.

(Technion - Israel Institute of Technology, Haifa, Israel)

Add-on for free-beam experiments: Some optical setups (e.g. many time-resolved experiments) consist a number of complex optical components mounted on an optical table, before the free-beam is sent onto the cold sample.

For such configurations, attocube offers an optional anchoring of the attoDRY1000/1100 to the optical table. It defines a fixed reference position between the external optics and the sample inside the cryostat. For seamless interfacing of complex free-beam based optical setups with the cryogenic sample environment and high magnetic fields. The distance between the vertical axis of the inner vacuum tube in the cryostat and the optical table is adjustable.



Breadboard add-on also available

...for further details see next page

Breadboard add-on with free-beam coupling

attoDRY1000/1100/2100 options

attocube's breadboard add-on offers easy access for challenging optical experiments conducted in cryogenic temperatures and high magnetic fields. Various components can be mounted onto the optical platform, which can be directly attached to any of attocube's top-loading cryostats (attoDRY1000/1100/2100). The elaborate design enables a seamless integration of platform and cryostat, thus offering maximum stability for free-beam experiments.



Mount your optics directly on the cryostat

application example: ultimate flexibility combined with exceptional stability

NEW

CUSTOMER FEEDBACK

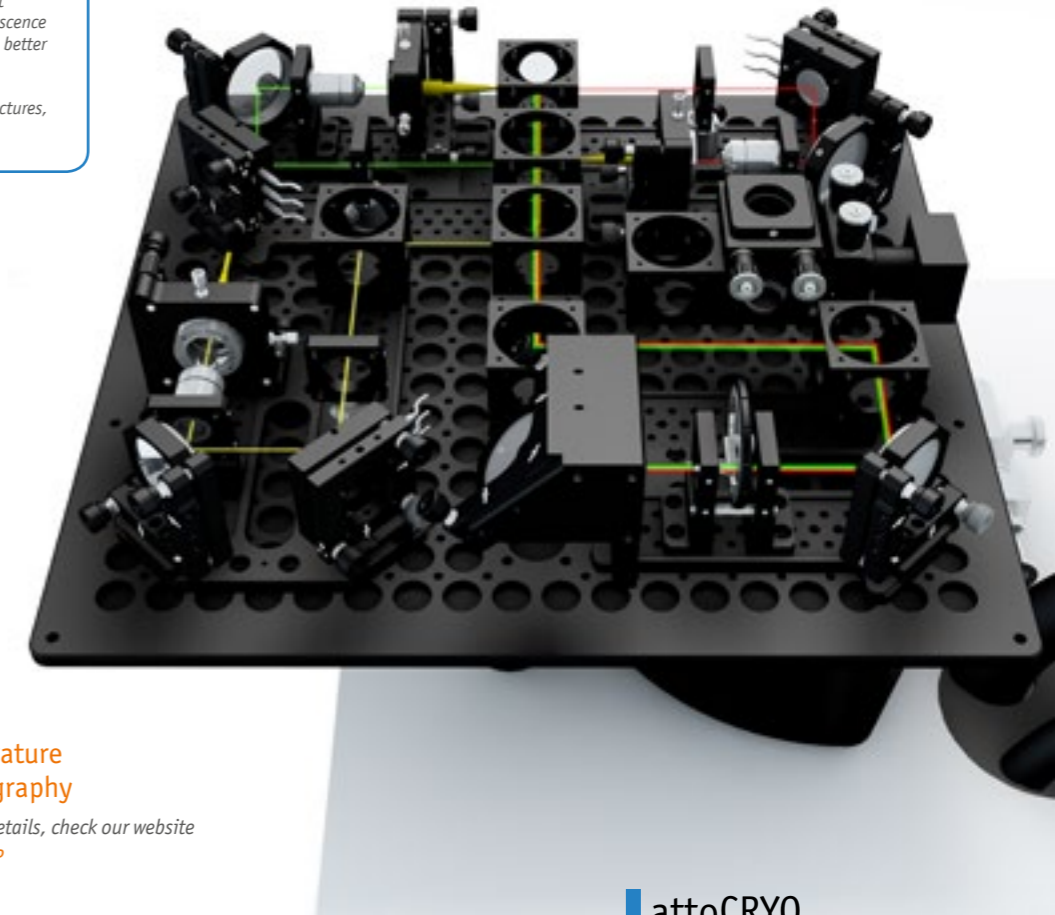
Dr. Pascale Senellart

We wanted to modify our cryogenic in-situ lithography setup to a dry cryogenic technology. This setup is our most demanding one, requiring sophisticated multicolor optical alignment and long term stability. attocube's new breadboard add-on to the attoDRY1000 offers great flexibility to our measurements: it provides enough space for three different excitation lines, a camera visualization, and still we can easily add additional optical components like polarization control, etc. Everything worked perfectly well right after installation and we could immediately start again our most demanding resonant fluorescence measurements. The optical stability is even better than before!

(Laboratoire de Photonique et de Nanostructures, LPN-CNRS, Marcoussis, France)

One of the most impressive examples of how attocube's breadboard add-on for the toploading dry cryostats can help to conduct quite influential science has been set up by the French group around Dr. Pascale Senellart at the Laboratory for Photonics and Nanostructures at CNRS. The group has pioneered a technique called in-situ optical lithography at low temperatures, which consists of three independent optical channels for confocal microscopy mounted on the breadboard on top of the cryostat.

This application demonstrates the unique flexibility as well as the proven stability of the breadboard add-on, see also the testimonial by Dr. Senellart on the left.



Low temperature photolithography

...for further details, check our website
bit.ly/attoLTP

attoLIQUID

Liquid Research Cryostats

When ultimate stability is required for cutting edge measurements in vibration sensitive experiments, and helium supplies are secured by an appropriate infrastructure, liquid helium based cryostats are still the instrument of choice. The attoLIQUID product line features a variety of helium bath cryostats with different base temperatures down to 20 mK. Each system can be equipped with superconducting magnets, either single solenoids, split coils or 2D/3D vector magnets.

attoDAMP



Our attoLIQUID cryostats are delivered with an attoDAMP anti-vibration cabinet, enabling ultimate stability for extremely sensitive measurements. This is achieved via careful acoustic and mechanical damping of the dewar inside the cabinet.

High magnetic fields



Choose from a range of high field single solenoid, vector field or split coil magnets for your attoLIQUID system with appropriate magnet power supply.

Also for our liquid systems, we have taken special care to minimize vibrations and acoustic noise coupling into the sample environment by hosting every cryostat in our attoDAMP anti-vibration cabinets. Hence, independently of your choice of base temperature down to mK or magnet system, we can guarantee a proven ultra-low vibration performance for any of our attoLIQUID setups. This enables scanning probe microscopy measurements at variable temperatures with ultimate resolution and sensitivity.

Large sample space



While most magnet systems feature only 1" diameter sample space, our attoLIQUID cryostats provide twice the diameter, and four times the area in cross-section. This leaves ample space for sophisticated cryogenic experiments, and is of course compatible with our complete line of measurement options.

Plug & Play



Every attoLIQUID cryostat comes fully equipped with all necessary items for operation such as temperature controller, bipolar magnet power supply, pumps and KF fittings for a convenient and flawless operation straightaway.

Product Finder

compatibility chart

	attoLIQUID1000	attoLIQUID2000	attoLIQUID3000	attoLIQUID5000
base temperature	4 K	1.8 K	270-350 mK	20-100 mK
temperature range	4 .. 70 K	1.8 .. 300 K	0.3 .. 300 K	
superconducting magnets	•	•	•	•
superconducting vector magnets	•	•	•	•
superconducting split coil magnets	•	•	•	•
variable temperature		•	optional	
top-loading (sample in exchange gas)	•	•		optional (no exchange gas)
vacuum loading (sample in vacuum)			•	•
optical access to sample	•	•		
ultra low vibration	•	•	•	•
compatibility with microscopes				
attoAFM I	•	•	•	•
attoMFM I	•	•	•	•
attoSHPM	•	•	•	contact us
attoCFM I	•	•	contact us	contact us
attoCFM II	•	•	•	•
attoCFM III	•	•	•	•
attoRAMAN	•	•	contact us	contact us
attoAFM/CFM	•	•	contact us	contact us
Photonic Probe Station			not compatible	
attoAFM/STM	•	•	•	•
attoAFM III	•	•	•	•
atto3DR	contact us	•	contact us	contact us



attoLIQUID1000

liquid helium based superconducting magnet systems

attocube's attoLIQUID1000 cryogenic system is based on highly efficient liquid helium bath cryostats with 50 l cryogenic liquid reservoir. As with the whole attoLIQUID family, the attoLIQUID1000 has been optimized for highest stability, enabling experiments such as ultra high resolution imaging and/or spectroscopy using scanning tunneling microscopy (STM) or long-term optical investigations of single quantum dots over several weeks. All of attocube's available scanning probe microscopy inserts are compatible with the attoLIQUID1000 and are cooled by a controlled exchange gas atmosphere in thermal equilibrium with the surrounding liquid helium.

The attoLIQUID1000 provides a base temperature of 4.2 K which can be further reduced down to 2 K by pumping on the helium reservoir (optional).

Superconducting solenoids (up to 15 T), split coils and vector magnets are available as upgrade options. The magnet can be used in driven or in persistent mode.

The system includes all necessary components needed for the operation such as the renowned attoDAMP anti-vibration cabinet with acoustic damping, dual channel temperature controller, liquid helium level meter and probe, transfer line and all necessary vacuum fittings.

PRODUCT KEY FEATURES

- ultra high stability
- highest flexibility
- base temperature 4.2 K (< 2 K when pumping on the reservoir)
- compatible with superconducting magnets up to 15 T
- attoDAMP system for shielding against acoustic noise and mechanical floor vibrations

BENEFITS

- perform experiments with highest demands on thermal and mechanical stability
- optimize sample throughput due to minimized turn-around time

APPLICATION EXAMPLES

- ultra high resolution imaging with STM or AFM/MFM on high-T_c superconductors, semiconductor structures, ..
- solid state physics and quantum dot optics (CFM)
- materials science research on ceramics, polymers, additives, alloys, ..
- quantitative surface characterization in the sub-micron range

COMPATIBLE MICROSCOPE SYSTEMS

- attoCFM I, attoCFM II, attoCFM III, attoRAMAN, attoAFM I, attoAFM III, attoMFM I, attoSHPM



Application examples



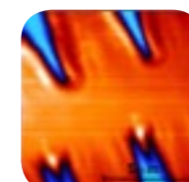
Multi-Ferroids
Characterization



Scanning Hall Probe
Microscopy



Scanning Tunneling
Microscopy



Scanning Near-Field
Optical Microscopy



Optically Detected Nuclear
Magnetic Resonance



Cryogenic
Photolithography

General Specifications	
technology	liquid helium bath cryostat vacuum isolation, vapor shielded (LN2 shielded on request)
liquid helium dewar	50 l capacity, vacuum isolation, vapor shielded (LN2 shielded on request)
sample environment	He exchange gas
sample space	2" diameter probe bore fitting all attocube inserts
sample exchange	top loading system for quick access
vibration & acoustic noise damping system	dewar isolated and suspended in attoDAMP cabinet
Performance Data	
temperature range	4 .. 70 K (< 2K with optional pumping kit)
estimated liquid helium static loss rate	0.25 l/hr (standard edition, without insert)
cool down time of sample	approx. 30 min. (depending on insert and acceptable helium consumption)
cool down time of system (system without magnet)	approx. 6 .. 24 h
cool down time of system (system incl. 9 T magnet)	approx. 6 .. 24 h
temperature stability	< ± 0.1 %
Dimensions	
cryostat (width x depth x height)	900 x 750 x 1500 mm ³ (including attoDAMP; depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1350 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	turbomolecular pump with suitable backing pump for sample space preparation
helium transfer line	included
helium level meter	included

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.

attoLIQUID2000

liquid helium based cryostats for variable temperature operation

attocube's attoLIQUID2000 cryogenic system is based on highly efficient liquid helium bath cryostats with 50 l cryogenic liquid reservoir, but also includes a variable temperature insert (VTI) for convenient temperature control in the range between 1.8 K and 300 K. The system includes all necessary components needed for the operation such as the renowned attoDAMP anti-vibration cabinet with acoustic damping, a suitable rotary pump for the VTI, a dual channel temperature controller, a liquid helium level meter and probe, a transfer line and all necessary vacuum fittings.

The system can be equipped with your choice of super-conducting magnet, be it a single solenoid (up to 15 T), split coils or 2D/3D vector magnets, including a suitable magnet power supply and the superconducting leads. The magnet can be used in driven or in persistent mode.

PRODUCT KEY FEATURES

- liquid 4He bath cryostat with 50 l liquid helium reservoir and variable temperature insert
- temperature range: 1.8 .. 300 K
- capillary heater close to the needle valve to avoid accidental blockage
- compatible with superconducting magnets up to 15T

BENEFITS

- conduct scanning probe microscopy measurements at any temperature between 1.8 K and 300 K
- minimized helium consumption compared to directly pumping the liquid helium reservoir
- minimized mechanical vibrations

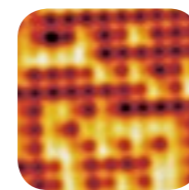
APPLICATION EXAMPLES

- investigation of temperature dependent phenomena such as superconducting and pseudogap behaviour in high-T_c cuprates or pnictides
- solid state physics and quantum dot optics
- materials science research on ceramics, polymers, additives, alloys, ..
- semiconductor device characterization

COMPATIBLE MICROSCOPE SYSTEMS

- attoAFM I, attoMFM I, attoSHPM, attoCFM I, attoCFM II, attoCFM III, attoRAMAN, attoAFM III, attoAFM/STM, atto3DR

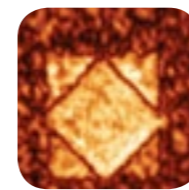
Application examples



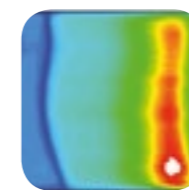
Magnetic Domain Imaging



Vortex Imaging



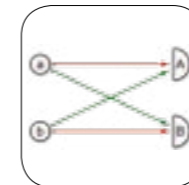
Piezo-Response Force Microscopy



Photoluminescence Spectroscopy



Resonant Fluorescence



Quantum Information Processing

General Specifications	
technology	liquid helium bath cryostat with variable temperature insert vacuum isolation, vapor shielded (LN2 shielded on request)
liquid helium dewar	50 l capacity, vacuum isolation, vapor shielded (LN2 shielded on request)
sample environment	He exchange gas
sample space	2" diameter probe bore fitting all attocube inserts
sample exchange	top loading system for quick access
needle valve blockage prevention	capillary heater close to needle valve
vibration & acoustic noise damping system	dewar isolated and suspended in attoDAMP cabinet
Performance Data	
temperature range	1.8 .. 300 K
estimated liquid helium static loss rate	approx. 0.35 l/hr (standard edition, without insert)
cool down time of sample	approx. 30 min. (depending on insert and acceptable helium consumption)
cool down time of system (without magnet)	approx. 6 .. 24 h
cool down time of system (incl. 9 T magnet)	approx. 6 .. 24 h
temperature stability	< ± 0.1%
Dimensions	
cryostat (width x depth x height)	approx. 900 x 750 x 1500 mm ³ (including attoDAMP; depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1350 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	VTI pumping kit included
helium transfer line	included
helium level meter	included

*Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.



attoLIQUID3000

liquid helium based cryostats for variable temperature operation

The attoLIQUID3000 is a liquid helium based cryostat with a ^3He -insert for operation at temperatures from 0.3 to 300 K. The system is equipped with special low resistance wiring for attocube positioners used in our microscopes, as well as a number of coaxial lines and twisted pairs for customer use. It can be equipped with your choice of superconducting magnet, e.g. a single solenoid, split coil or 2D/3D vector magnet including suitable magnet power supply.

All necessary components needed for a convenient operation are included, such as the renowned attoDAMP anti-vibration cabinet with acoustic damping, a suitable pump for the 1 K pot, a multi-channel temperature controller, a liquid helium level meter and probe, a transfer line and all necessary vacuum fittings.

The most outstanding feature of this system is that the 1 K pot is only needed to be pumped during recondensation of the ^3He . Afterwards, the unique design allows to turn off the pump at the 1 K pot, which minimizes the residual vibrations considerably. This is what enables the use of sensitive techniques such as scanning probe microscopy in this cryostat at mK temperatures with proven performance (see application section).



PRODUCT KEY FEATURES

- system can be operated without pumping continuously at 1 K pot, hence ultra-low vibrations at base temperature
- liquid ^4He bath cryostat with 50 l liquid helium reservoir and single-shot ^3He insert
- temperature range: 0.3.. 300 K
- compatible with superconducting magnets up to 12 T

BENEFITS

- conduct scanning probe microscopy measurements at any temperature between 0.3 and 300 K
- ultra-low mechanical vibration levels because of special cryogenic layout
- fast ^3He recondensing/ turn-around times

APPLICATION EXAMPLES

- investigation of temperature dependent phenomena at very low temperature, such as superconducting gap on organic superconductors
- solid state physics and quantum dot optics
- materials science research on ceramics, polymers, additives, alloys, ..
- semiconductor device characterization

COMPATIBLE MICROSCOPE SYSTEMS

- attoAFM I, attoMFM I, attoSHPM, attoCFM I, attoCFM II, attoCFM III, attoAFM III, attoAFM/STM
- on request: attoAFM/CFM, atto3DR

CUSTOMER FEEDBACK

Dr. Stefan Heun

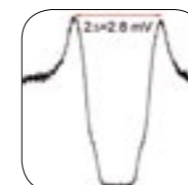
The attoLIQUID3000 with the attoDAMP anti-vibration cabinet has been serving us very well as mK platform for scanning gate microscopy since 2008. Its handling is straightforward and easy, and due to the special 1 K pot design, vibrations are of no big concern even at base temperature.

(Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy)

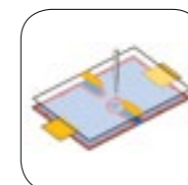
Application examples



Vortex Imaging



Scanning Tunneling Microscopy



Scanning Gate Microscopy

General Specifications	
technology	liquid helium bath cryostat with ^3He insert vacuum isolation, vapor shielded (LN2 shielded on request)
liquid helium dewar	50 l capacity liquid nitrogen shield (capacity 45l)
sample environment	cryogenic vacuum, sample is cooled via braids
sample space	2" diameter probe bore fitting all attocube inserts
vibration & acoustic noise damping system	dewar isolated and suspended in attoDAMP cabinet
Performance Data	
base temperature	approx. 270 mK (1 K pot ON, no load) approx. 350 mK (1 K pot OFF, incl. microscope)
estimated liquid helium static loss rate	< 0.35 l/h (incl. microscope and wiring)
cool down time of sample	approx. 3 h
cool down time of system (system without magnet)	approx. 6 .. 24 h
cool down time of system (system incl. 9 T magnet)	approx. 6 .. 24 h
^3He regeneration time	typ. 30 min
temperature stability	± 3 mK for $T < 1.2$ K
cooling power at sample location	approx. 150 μW @ 350 mK for 12.5 hours (1 K pot ON, no load)
additional heat load when scanning	approx. 10-15 μW per μm^2 scan speed
thermometry	control thermometer on charcoal sorption pump, thermometer on 1 K pot with standard calibration, RuO2 thermometer on ^3He pot
Dimensions	
cryostat (width x depth x height)	800 x 800 x 1800 mm ³ (including attoDAMP; depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1350 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	1 K pot pumping kit included
helium transfer line	included
helium level meter	included

**Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.*

attoLIQUID5000

liquid helium based dilution refrigerators for ultra low temperature operation

The attoLIQUID5000 is a liquid helium based cryostat with a $^3\text{He}/^4\text{He}$ dilution refrigerator insert for operation at temperatures below 100 mK. The system is equipped with special low resistance wiring for attocube positioners used in our microscopes, as well as a number of coaxial lines and twisted pairs for customer use. It can be equipped with your choice of superconducting magnet, be it a single solenoid, split coil or 2D/3D vector magnet including suitable magnet power supply.

All necessary components needed for a convenient operation are included, such as all necessary pumps, a fully automated gas handling system, a multi-channel temperature controller, a liquid helium level meter and probe, a transfer line and all necessary vacuum fittings.



PRODUCT KEY FEATURES

- $^3\text{He}/^4\text{He}$ dilution refrigerator with high-cooling power and fast cooldown times
- base temperatures of less than 20 mK (no load)
- oil-free $^3\text{He}/^4\text{He}$ gas handling system
- optional superconducting magnets up to 12 T (split coils and vector magnets also available)

BENEFITS

- confocal microscopy and atomic force microscopy (ct-AFM, MFM) measurements at ultra-low temperature
- microprocessor controlled gas handling system for single button operation
- cooling power up to 400 μW at 120 mK

APPLICATION EXAMPLES

- spectroscopic measurements on quantum dots with ultra-low thermal broadening
- ultra-high energy resolution density of state measurements on classical and heavy fermion superconductors

COMPATIBLE MICROSCOPE SYSTEMS

- attoAFM I, attoMFM I, attoCFM II, attoCFM III, attoAFM III, attoAFM/STM
- on request: attoCFM I, attoSHPM, attoAFM/CFM, atto3DR

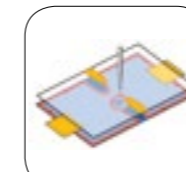
CUSTOMER FEEDBACK

Dr. M. Kroner

The confocal microscope attoCFM II together with the liquid dilution refrigerator system from attocube provides a unique platform for optical spectroscopy & microscopy at ultralow temperatures. Its flexible design, fast turnaround times and remarkable long term stability make it a perfect system for elaborate long term experiments at high magnetic fields, but also for quick sample testing. Besides, the first-class support from attocube in developing new experimental setups has been really excellent!

(Institute for Quantum Electronics, ETH Zurich, Switzerland)

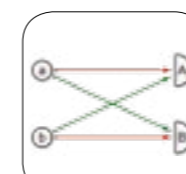
Application examples



Scanning Gate Microscopy



Scanning Tunneling Microscopy



Quantum Information Processing

General Specifications	
technology	liquid helium bath cryostat with dilution refrigerator insert vacuum isolation, vapor shielded (LN2 shielded on request)
sample environment	cryogenic vacuum, sample cooled via braids
sample space	2" diameter probe bore fitting all attocube inserts
Performance Data	
base temperature	< 20 mK (no load) < 100 mK (incl. MIC)
estimated liquid helium static loss rate	< 0.5 l/h
cool down time of sample	approx. 8 .. 12 h
cool down time of system (system without magnet)	approx. 24 h
cool down time of system (system incl. 9 T magnet)	approx. 24 h
cooling power at sample location	up to 400 μW @ 120 mK
additional heat load when scanning	approx. 10-15 μW per $\mu\text{m}/\text{s}$ scan speed
thermometry	1 K pot and still: resistance thermometers, mixing chamber: calibrated RuO2 thermometer
Dimensions	
cryostat (width x depth x height)	approx. 900 x 750 x 1500 mm ³ (including attoDAMP; depending on magnet choice)
optional electronics rack (width x depth x height)	640 x 640 x 1350 mm ³
Options	
superconducting magnet	solenoids: 7, 9, 12 T vector magnets: e.g.: 8/2 T, 9/3 T, 9/1/1 T, ...
bipolar magnet power supply	included (with optional magnet)
temperature controller	included
pumping kit	full pumping kit included
helium transfer line	included
helium level meter	included

**Note: All product specifications are based on a standard system. Optional items or upgrades, other configurations or customization may change one or several of the indicated values. Specifications and other information subject to change without notice.*