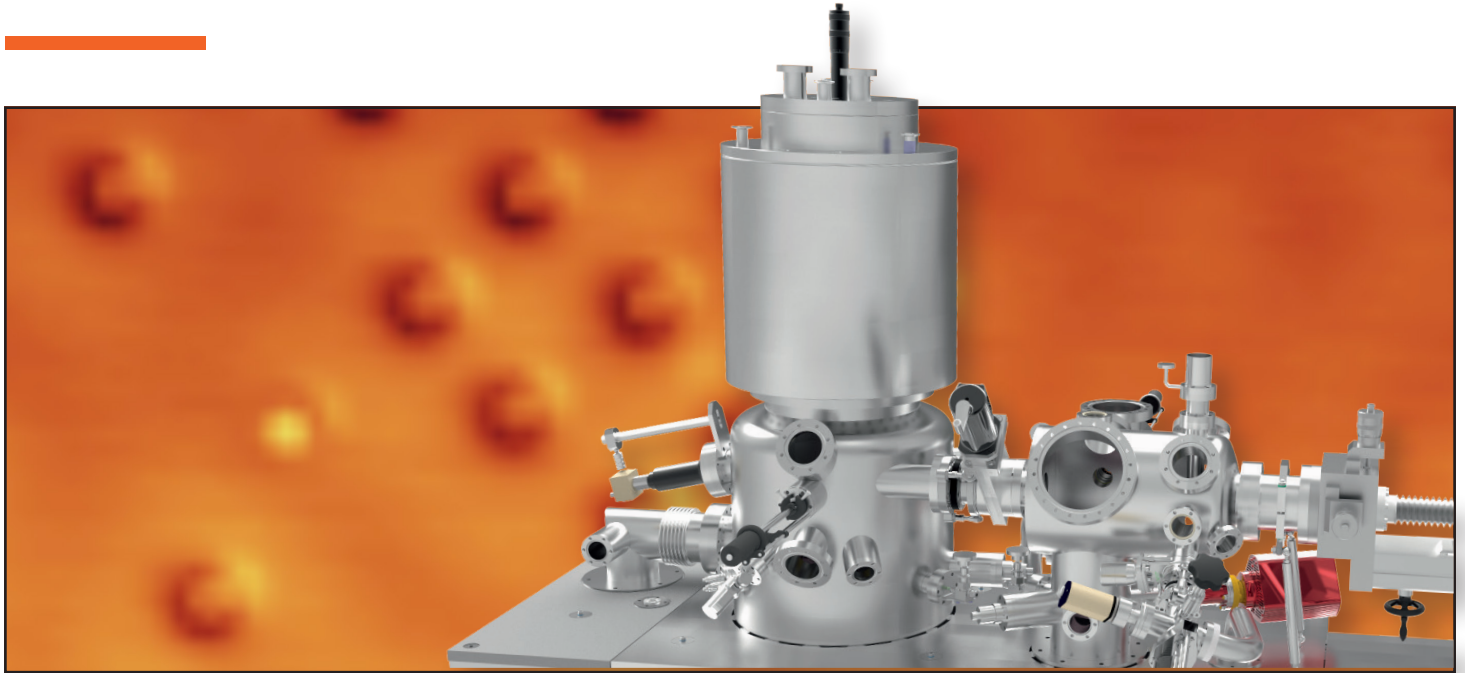


POLAR SPM LAB

Compact, Stable, Cold and with Magnetic Field



- STM, QPlus® AFM & Spectroscopy
- Integrated TRIBUS Head
- Excellent SPM Stability
- Minimum Temperature: < 5 K
- Helium Holding Time: > 200 h
- Vertical Magnetic Field: $B_z = \pm 5$ T
- Optical Access
- Optional 1 K pot for $T < 1.7$ K

SPM between < 1.7 K and 420 K and in high magnetic fields (up to 5 Tesla)

The new POLAR UHV SPM is a low-temperature Scanning Probe Microscope (SPM) for highest resolution STM, QPlus® AFM, and spectroscopy experiments in a temperature range of between < 1.7 K and 420 K and in high magnetic fields of up to 5 Tesla. The 1 K pot option extends the base temperature to < 1.7 K.

To date, the twin requirements of long hold time and high mechanical stiffness desired in an optimised Low-Temperature SPM cryostat have been conflicting requirements. For this reason conventional SPM cryostats are a compromise between being mechanically stable for good SPM performance or have a reasonable hold time. POLAR solves these compromises with our new unique proprietary cryostat concept.

The ultra-compact design of the cryostat with a height of < 60 cm ensures an immense mechanical stiffness and thus an excellent STM stability. The hold time is optimised through a series of thermal decoupling stages and thermal radiation shields, designed to deliver an extremely low helium consumption. With a liquid helium (LHe) consumption of less than 1 litre per 24 hours, the instrument achieves a hold time of > 200 hours at < 5 K before the cryostat needs to be refilled. Alternatively, the SPM can be operated with liquid nitrogen (T < 79 K).

Viewports and closable entry doors in the radiation shields allow for SPM in-situ tip/sample exchange, optical access or in-situ evaporation. The low helium consumption offers both, an economic benefit and it permits long term measurement sessions.

TRIBUS SPM head

The heart of the multi-application POLAR SPM is the TRIBUS SPM head. TRIBUS SPM head is integrated into a compact bath cryostat system and employs a spring suspension and eddy current

damping system for optimum mechanical decoupling.

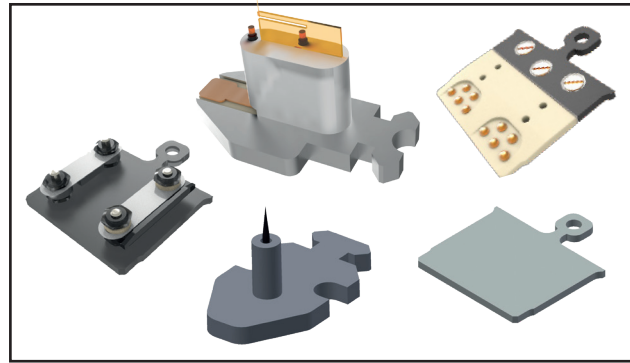
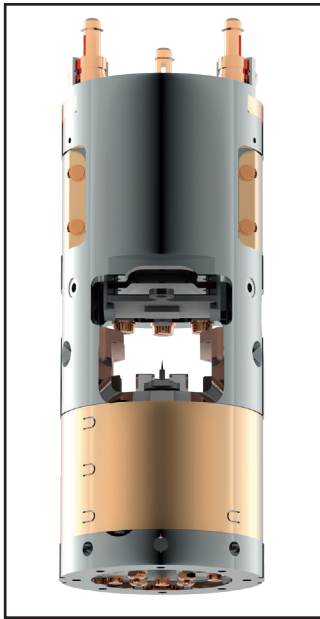
The TRIBUS SPM has a 3D (X/Y/Z) motor for tip and sample navigation, is extremely mechanically stable and offers numerous access ports for optical observation, in-situ sample and probe exchange and evaporation onto the sample/substrate. An effective thermal shielding in combination with the compact design and short mechanical loops, and a high symmetry within the STM head are responsible for a very low relative drift between sample and measurement probe. Up to 10 additional electrical contacts to the sample extend the range of possible measurement modes.

The proven Omicron flag style sample plate design ensures the compatibility with existing SPM instrumentation and transfer systems.

As an option, a superconducting coil for vertical fields of ± 5 T can be offered for the POLAR SPM. The UHV compatible dry magnet is mounted at the bottom of the helium cryostat. In combination with tip/sample preparation (heating, ion etching, evaporation...) the POLAR facilitates a wide range of SPM operation modes including STM, QPlus® AFM, Spin Polarized Tunneling as well as related spectroscopy (STS, I/V, dI/dV, df(V), force spectroscopy, IETS, experiments).



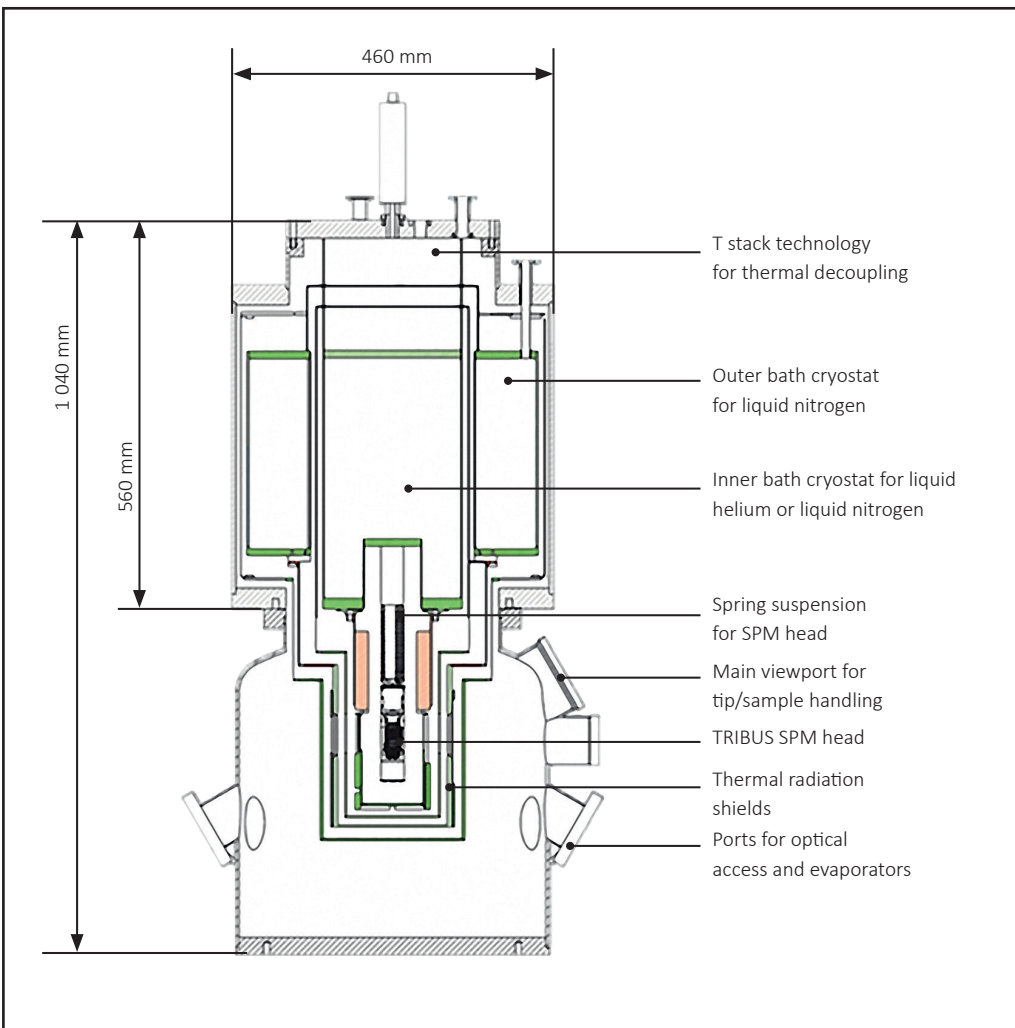
POLAR UHV SPM system including customised preparation chamber with LEED, evaporators, tip and sample preparation stage



Sensors and Samples

- In-situ tip/sample exchange via wobble stick
- Secure tip/sample handling
- QPlus® sensors and STM tip carriers
- Standard flag style sample plates:
 - For metal single crystals
 - For direct current heating (Si samples)
 - Sample plates with tapped holes
 - Various materials available
 - Sample plate with 4+1 & 10+1 electrical contacts
 - TVS sample plates for variable temperature operation

The POLAR SPM employs the TRIBUS SPM head with 3D coarse motion for tip/sample, high intrinsic stability, easy tip and sample exchange, and optical access.



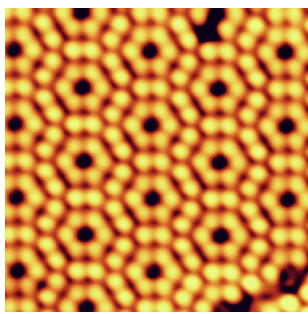
Electrical contacts and temperature variation of the sample

In addition to the main sample potential, the sample acceptor stage can have up to 10 additional electrical contacts. These contacts may be used for customised experiments or for use with the TVS sample plate for continuous variation of the sample temperature during analysis. The electrical contacts are protected against sample transfer damage.

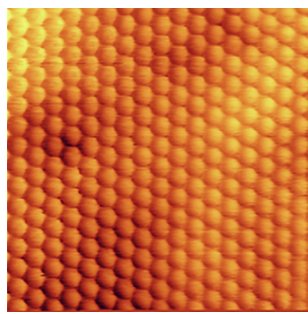
Optical Access for CCD Camera and Evaporators

- Thermal shield with windows for optical observation
- Direct evaporation into SPM
- Angle between evaporator and sample surface: 30°
- Evaporation from either rods or crucibles...

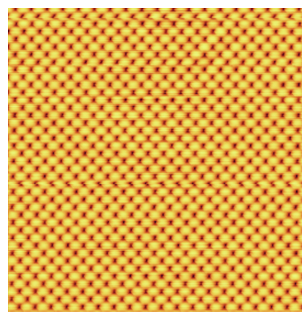
Schematic Design of the POLAR SPM
The rigid and compact cryostat has a height of less than 60 cm.



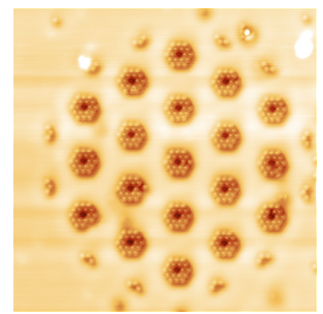
STM: Si(111)7x7 at T = 4.7 K
(Raw data)



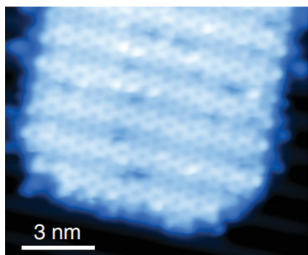
STM: Au(111) T = 4.45 K
(Raw data)



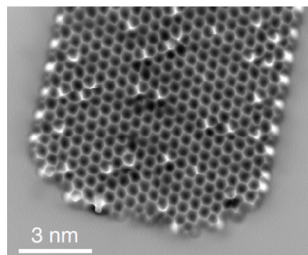
STM: Pb(100) at T = 4.5 K
Data courtesy of Thomas Gardenier and Ingmar Swart, Univ. of Utrecht, NL



STM: Manipulation of CO molecules on Cu(111) 4.5 K
Data courtesy of Jesper Moes, Thomas Gardenier and Ingmar Swart, Univ. of Utrecht, NL

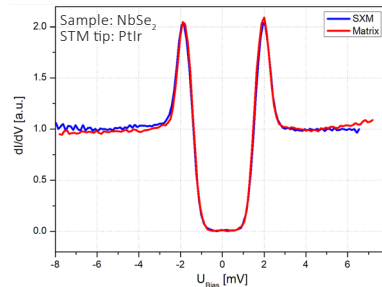


Low High

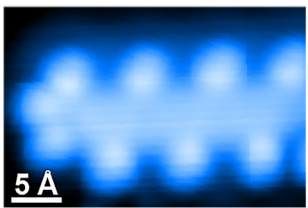


-9.1 Hz 0.6 Hz

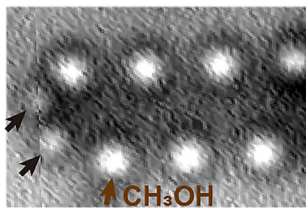
Study of the formation of 2D ice islands on a reconstructed Au(100) surface: High resolution STM image (left) and corresponding QPlus-AFM image (right)
Data courtesy of Jing Guo and Ying Jiang et al., Beijing, CHINA, DOI: 10.1103/PhysRevLett.129.046001



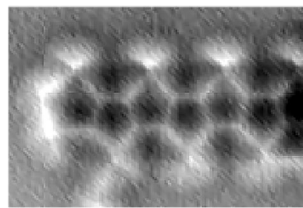
STM/STS at T = 1.49 K with POLAR 1 K pot: NbSe₂, A_{mod} = 100 μV_{rms}
Right image: STM topography on NbSe₂
Right spectrum: corresponding I-V spectra



5 Å Low High



-24.0 Hz



-19.3 Hz

High resolution QPlus® and STM on water-methanol chains at T < 5 K
Left: STM image of a 1D water-methanol chain
Middle and right: Corresponding QPlus® AFM frequency shift images at different tip sample distances showing the internal geometric structure of the molecule.

Data courtesy of Jia Dong, Pu Yang, Chen Zhang, Duanyun Cao, Ying Jiang, and Jing Guo; Beijing, CHINA, DOI: 10.1021/acs.jpcc.1c10296

Technical Data

Min. SPM temperature	< 5 K, or < 1.7 K with optional 1 K pot
STM	atomic resolution on Au(111) at T < 5 K
QPlus®	atomic resolution on NaCl or Si(111) 7x7 at T < 5 K
Drift	< 0.2 nm/h
Holding time for LHe	> 200 hours
Magnetic field	B _z = ± 5 T

Options:

- QPlus® AFM operation
- 4 or 10 additional sample contacts
- STM tip preparation tool
- Customised preparation chamber
- Superconducting 5 Tesla magnet
- 1 K pot for T < 1.7 K

Typical Applications:

STM, STS, QPlus®-NC-AFM, I(V), dl/dU, dl/dz, IETS, atom/molecule/nanoparticle manipulation, df(z), df(U), SP-STM,...

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