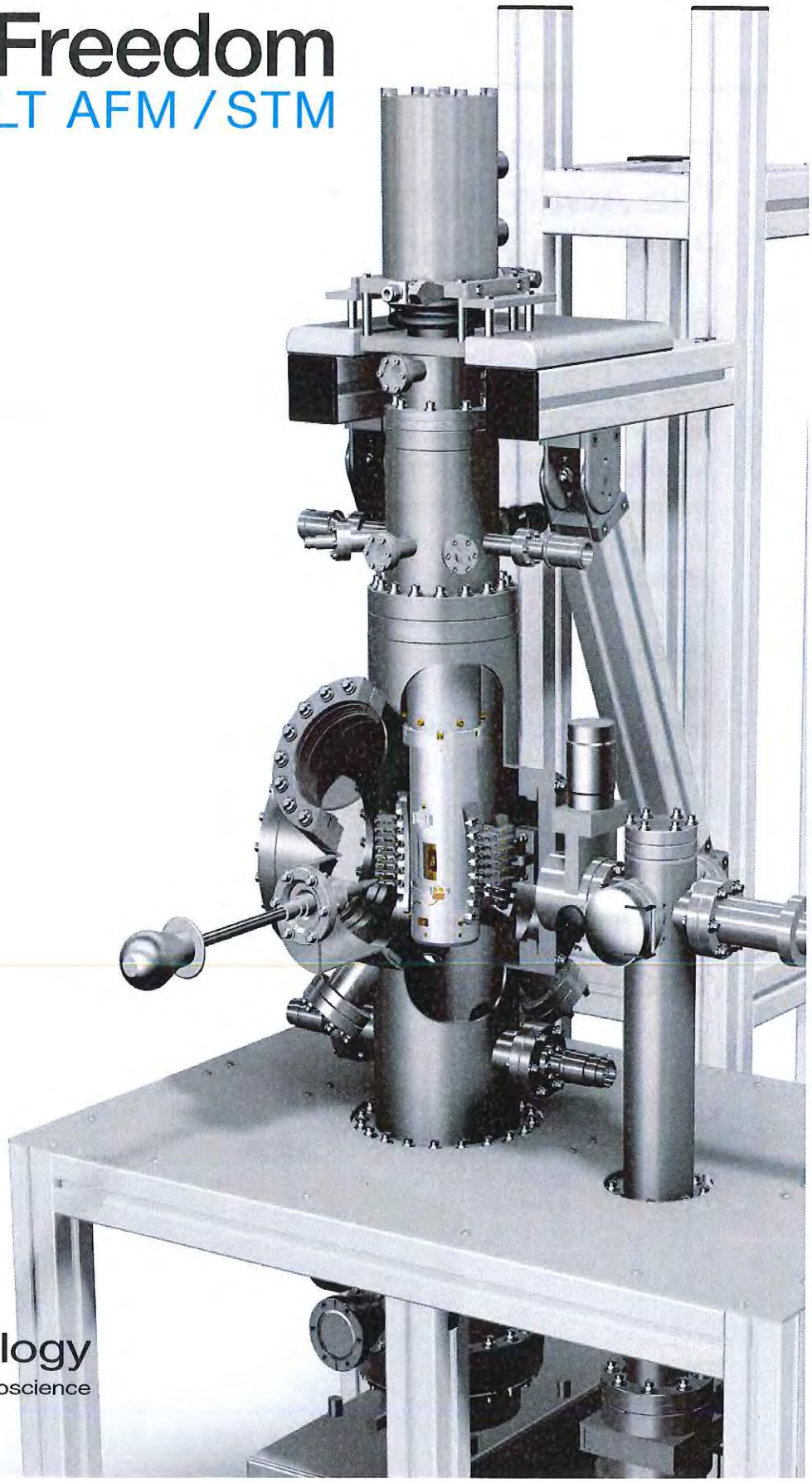
PanScan Freedom

Cryogen-Free LT AFM / STM



RHK Technology

Imaging the Future of Nanoscience

PanScan Freedom
Cryogen-Free LT AFM / STM

Introducing The Award Winning PanScan Freedom

RHK introduces the award winning PanScan Freedom, the world's first closed-cycle cryogen-free system for stable low temperature performance, unprecedented low drift, exceptional spectroscopy performance, and atomic resolution in a surprisingly compact, simple, and affordable package.

PanScan Freedom enables you to explore tomorrow's materials and make discoveries that will keep your laboratory first in science.

Not just remarkable... revolutionary.

Only from RHK.

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All the Advantages of LT
None of the Constraints

LHe-Free

Cryogen Cost-Free

Interruption-Free

Hassle-Free

Atomic Resolution 9-400 K

XY Drift As Low As 0.2Å/Hr

Z Drift As Low As 0.2Å/Day

Superb STS

Cryogen-free SPMs have been the dream of scientists for many years. Most scientists assumed that a cryogen-free SPM could never reach the level of performance of the older generation of previous designs due to the high vibration and acoustic noise of the helium-free cryostats.

RHK's devotion to engineering excellence is embodied in the PanScan Freedom, which truly delivers all of the advantages of LT with none of the constraints.
The PanScan Freedom frees you from the spiraling costs of liquid helium, risks of ruined experiments due to cryogen supply, hassles of dewar switch-out and transfer hoses, and safety concerns of liquid cryogens. Now you can enjoy all of the benefits of LT measurements securely, safely, and confidently, with low total cost of ownership.

The worlds first cryogen-free, ultra low drift, vibration free, low temperature SPM now at 9K

PanScan Freedom
Cryogen-Free LT AFM / STM

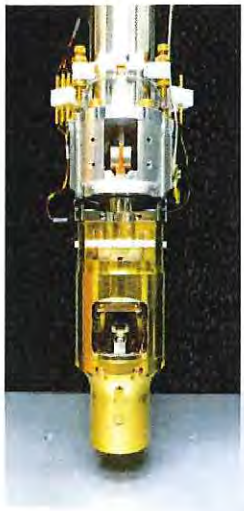
Devotion to Engineering Excellence

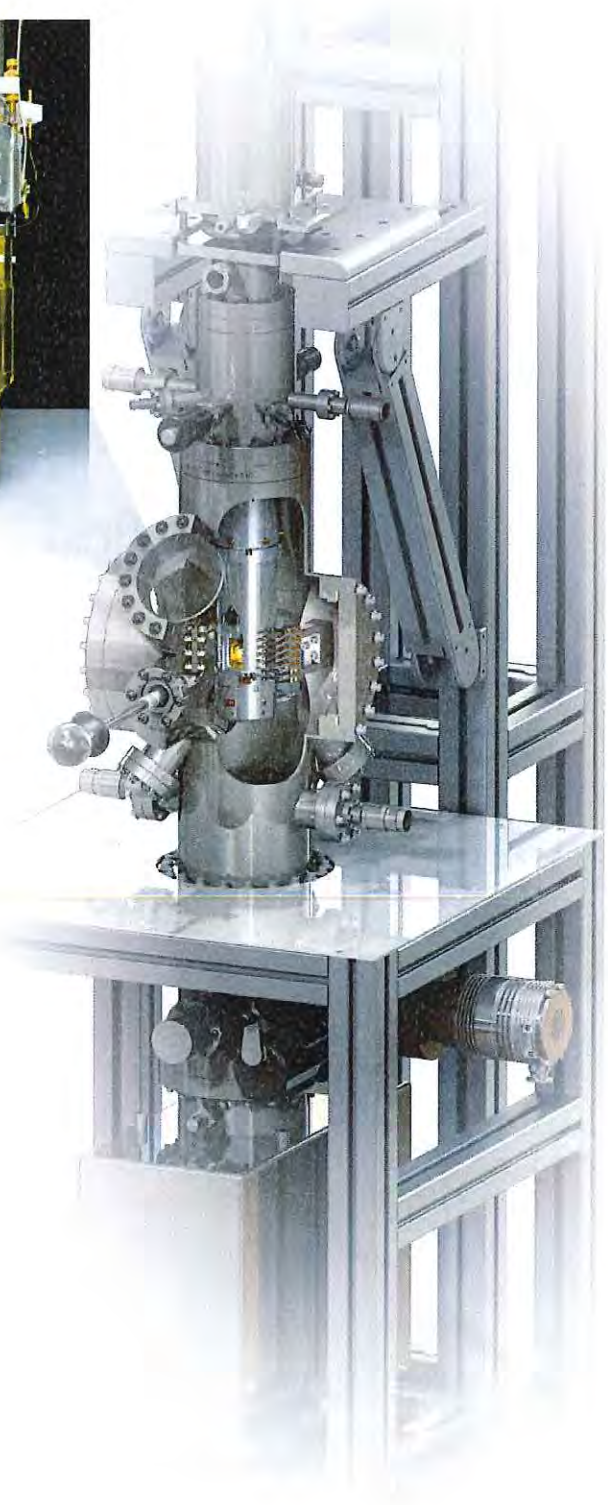
RHK's dedicated staff of the industry's most experienced scientists and engineers have been working for years to optimize every component of the PanScan Freedom.

The advantages are clear: lowest noise, lowest drift, superb STS, ultimate convenience, experimental flexibility, and increased productivity. All this while eliminating the cost of budget-busting liquid helium.

RHK has worked closely with Advanced Research Systems to develop a custom closed-cycle cryostat system with a uniquely low level of vibration at the cold finger. PanScan Freedom utilizes an advanced multi-stage vibration isolation system with a highly optimized vibration damping system. The extreme stability of the scan head developed in collaboration with Dr. Shuheng Pan rejects the remaining vibration coming from the cryostat and the surrounding environment.

Less Than $1/Hour In Operating Costs Including Electricity And Maintenance





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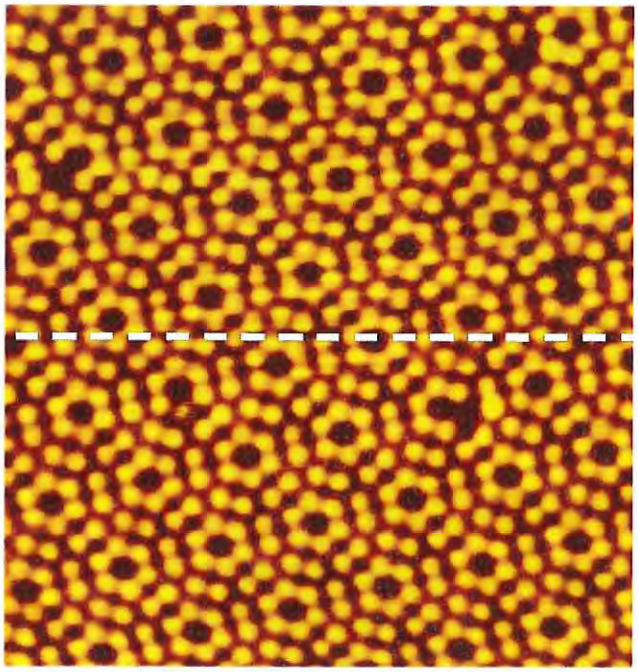
No Degradation of Performance While Cryostat is Running

Closed-Cycle ON



Closed-Cycle OFF

CCC stability at 18K Si image courtesy of B. Choi (RHK)

Extraordinary performance in a tiny footprint. No large pits or soundproofed rooms are needed for excellent results. Will even work well in noisy rooms with large floor vibrations. The Pan Scan Freedom is perfect for researchers that would have never previously considered a cryogenic SPM due to the high cost and complicated operation. The PanScan Freedom's ease of operation and low cost of ownership will provide a dramatic improvement in all STM, spectroscopy and AFM measurements. Lower noise, more stable tip and sample, and dramatically lower drift to greatly improve productivity.

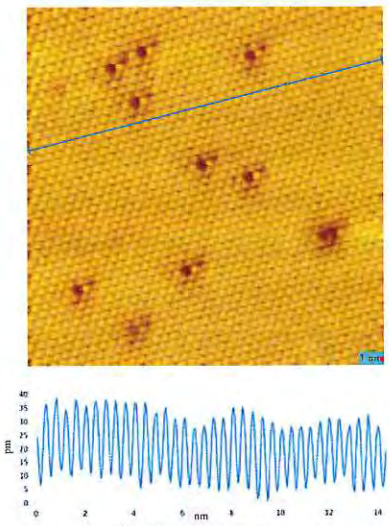
Image Virtually Anywhere

The compact, rigid, symmetric design of the PanScan Freedom enables ultra low noise <1 pm imaging performance, with the cryostat running. Even noisy environments do not degrade performance, which was proven running the PanScan Freedom live on the exhibition floor during AVS 2014, APS 2015, DPG 2015, AVS 2015, and APS 2016.

PanScan Freedom
Cryogen-Free LT AFM / STM

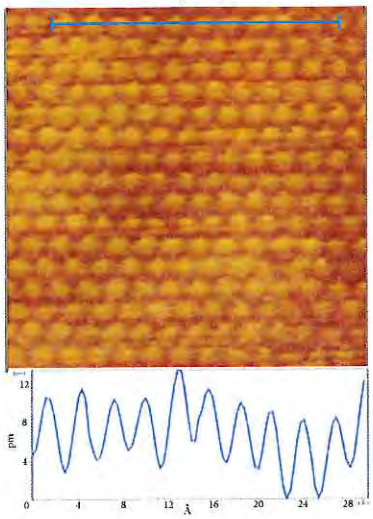
Exceptional Low-Noise

In doped Bi_2Se_3
STM image @ 18 K

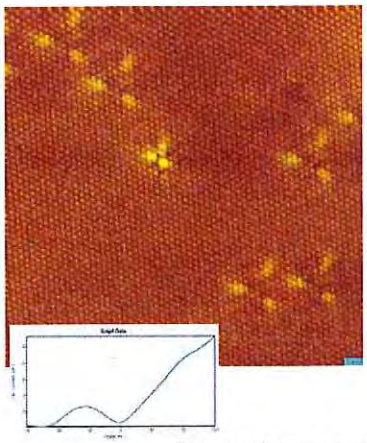


V_b=115 mV, I_t=0.3 nA, 15x15 nm

Au (111)



V_b=25 mV, I_t=01.5 nA, 3x3 nm

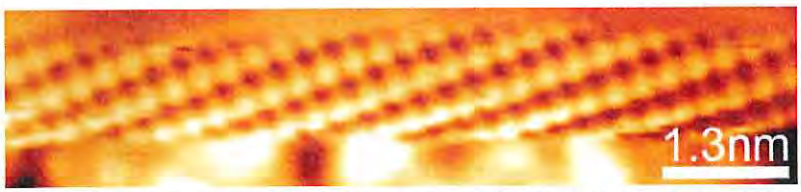


Topographic image (top) and spectroscopy (bottom) of Bi_2Te_3 at 9.3K
20nm x 20nm

Above Image acquired on the showroom floor during the AVS exhibition, November 2014

Proven Performance

Visualization of surface structures with atomic scale resolution is the main function of the SPM. The practical realization of ultra low noise atomic structures has been demonstrated by the PanScan Freedom on a variety of materials from crystalline metals to carbon nanotubes. PanScan Freedom has demonstrated world-class low-noise, low-drift, LT atomic resolution and STS results, all without consuming a drop of LHe. From the quiet of the laboratory to the noisy exhibition floor, PanScan Freedom produces excellent results, and it is ready to deliver the same superb performance in your lab.



Carbon Nanotube imaged at 15K courtesy of G. Nazin Group (Univ. of OR)

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Atomic Resolution in STM and AFM

Superior Versatility

The PanScan Freedom is available with STM only or with both STM and AFM capabilities. AFM-qPlus[1] and STM probes are switchable in vacuum. qPlus[1] sensors include a conductive tip for combined AFM and STM scanning techniques.

Both of these complimentary proximal probe techniques provide atomic resolution. The unique value of AFM is its applicability to a broader range of materials, especially insulators. By utilizing probe holders with the same mounting base, you can easily load both STM and AFM-qPlus probes into the tip storage positions and switch between them in situ.

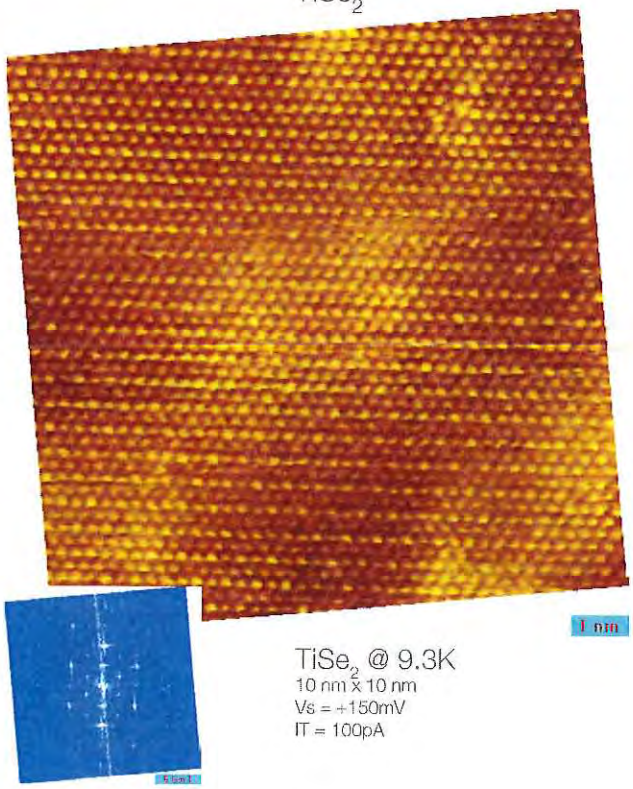
Atomic Resolution 9-400 K

Ultra Low Noise <1 pm

3 Stages of Mechanical Decoupling & Vibration Isolation

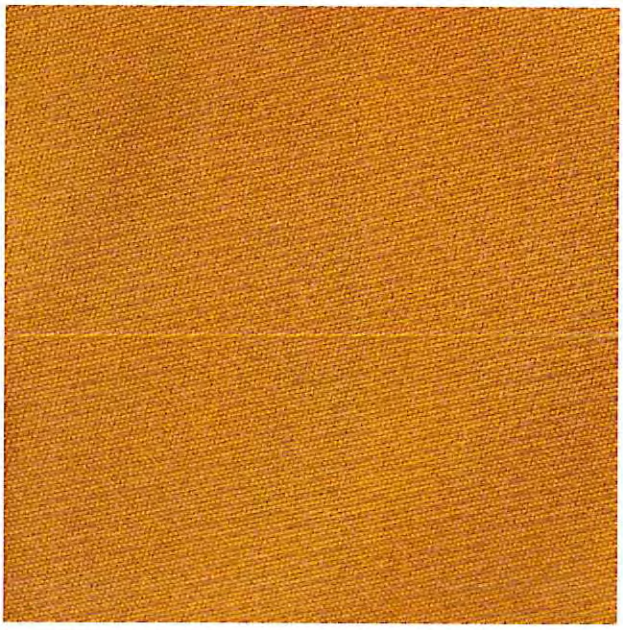
Ultra Stable Scan Head

$TiSe_2$



$TiSe_2$ @ 9.3K
10 nm x 10 nm
Vs = +150mV
IT = 100pA

HOPG (2048 x 2048 pixels)



AFM-qPlus image[1]

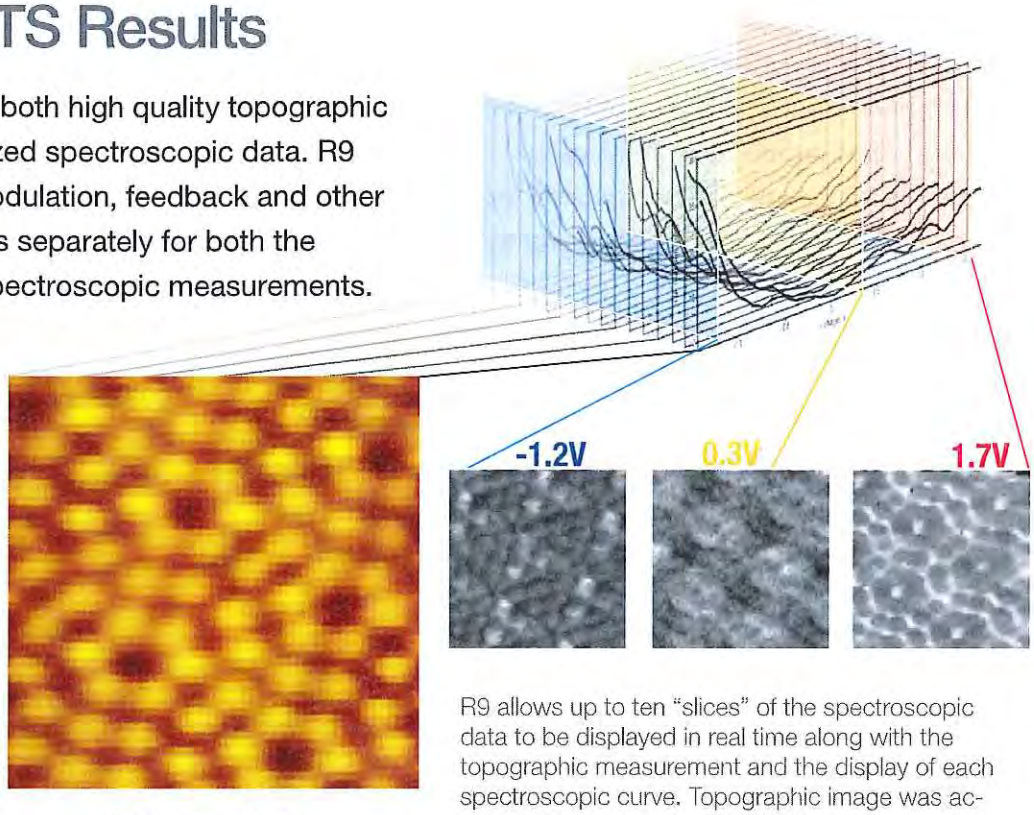
- 80nm x 80nm
- qPlus sensor f_0 = 20.6kHz Q = 5,800
- T = 16K
- Feedback on the frequecy shift Δf = 21Hz (Repulsion)
- Scan speed : 32nm/s

[1]qPlus® is a trademark of Prof. Franz Gießibl

PanScan Freedom
Cryogen-Free LT AFM / STM

Superior STS Results

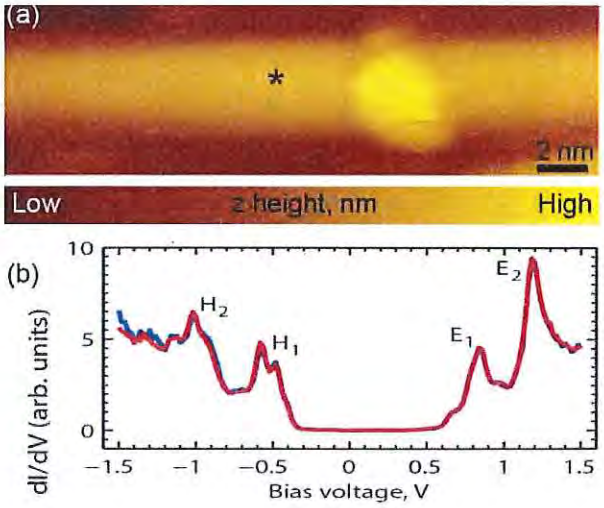
R9 uniquely allows both high quality topographic images and optimized spectroscopic data. R9 adjusts the bias modulation, feedback and other imaging parameters separately for both the topographic and spectroscopic measurements.



Si Image courtesy of B. Choi (RHK)

R9 allows up to ten "slices" of the spectroscopic data to be displayed in real time along with the topographic measurement and the display of each spectroscopic curve. Topographic image was acquired simultaneously with dI/DV spectra on every pixel at 18K VS=1.8 V, IT=0.5 nA.

STS spectroscopy of a single-wall carbon nanotube. (a) STM image of the nanotube. (b) Two STS spectra measured in one sweep from -1.5 V to 1.5 V (red curve) and back to -1.5 V (blue curve). The spectra were measured in the location shown by an asterisk in (a). The peaks observed in (b) are identified as Van Hove singularities associated with the valence (peak H_1) and conduction (peak E_1) bands. Higher order bands H_2 and E_2 are also observed. The STS spectra were obtained by measuring differential conductance, dI/dV, using the lockin-technique with a modulation of 20 mV. Tunneling set point: 1.5 V, 0.1 nA. Acquisition time: 2 minutes per spectrum.



J.D. Hackley, D.A. Kislitsyn, Daniel K. Beaman, Stefan Ulrich, G.V. Nazin, "High-stability cryogenic scanning tunneling microscope based on a closed-cycle cryostat," Rev. Sci. Instum., 85, 103704 (2014).

Extremely Low Drift

The entire microscope, including the probe and sample are held at precisely the same temperature. Eliminating thermal gradients reduces drift to an extremely low level, with X,Y drift to as low as 0.2Å/hour and Z drift as low as 0.2Å/day.

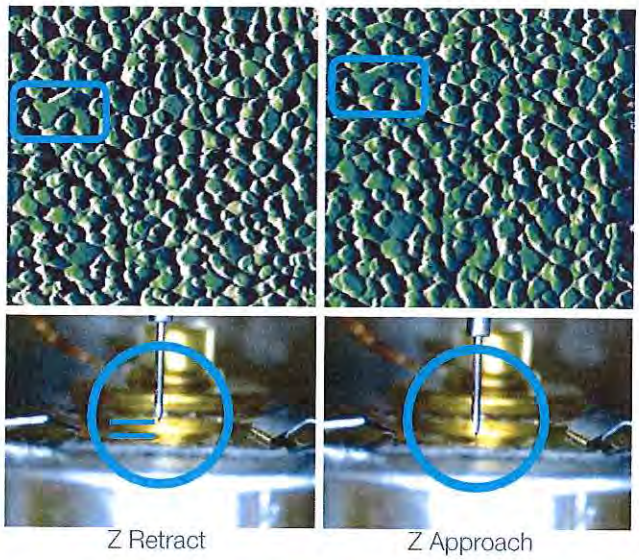
The PanScan Freedom has a symmetric design, which automatically helps compensate for thermal drift. Dual thermal shields fully isolate the scan head from the room temperature of the chamber, helping keep the scan head at a low and steady temperature.

All viewing and evaporation openings in the dual thermal shields can be closed during imaging. This blocks out thermal radiation that would cause uneven heating of the microscope and greatly increase thermal drift. Sapphire windows in thermal shields provide an optical view of the probe/sample when shutters are closed without degrading thermal stability.

Low drift produces superior spectroscopic measurements. Feedback loop can remain open for extended periods without introducing error into measurements.

You can also retract the probe and re-approach and be back to imaging in exactly the same place on the sample.

In the images below, the blue boxes display the same features both before and after retracting the tip by 3 mm.



Z Retract Z Approach

Retract, Re-Approach and Image in the Same Place

Symmetric Design Eliminates Drift

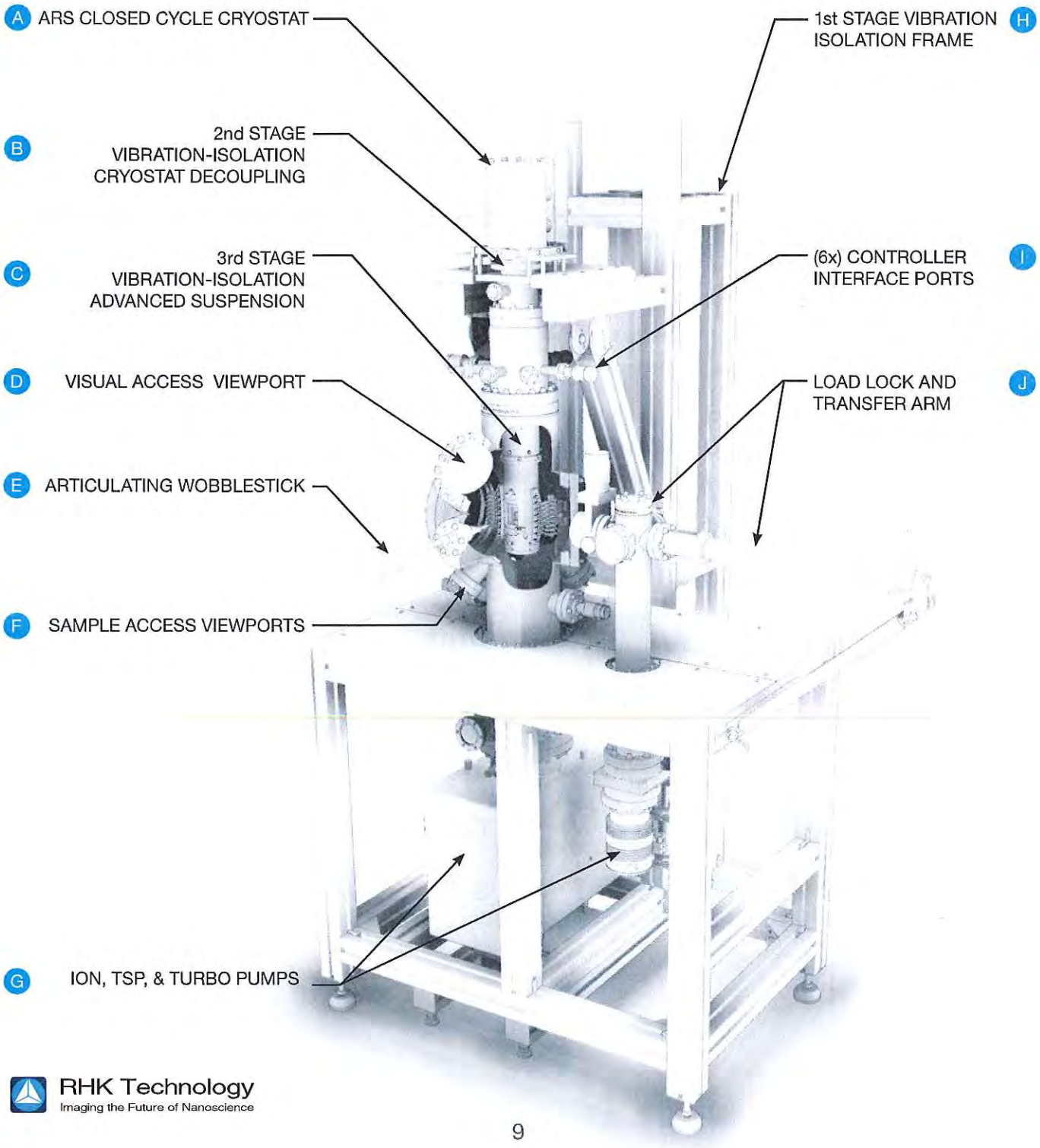
No Thermal Gradients - Probe, Sample, and Scanner All at the Same Temperature

Dual Thermal Shields

Shutters For All Access Ports

PanScan Freedom

Cryogen-Free LT AFM / STM



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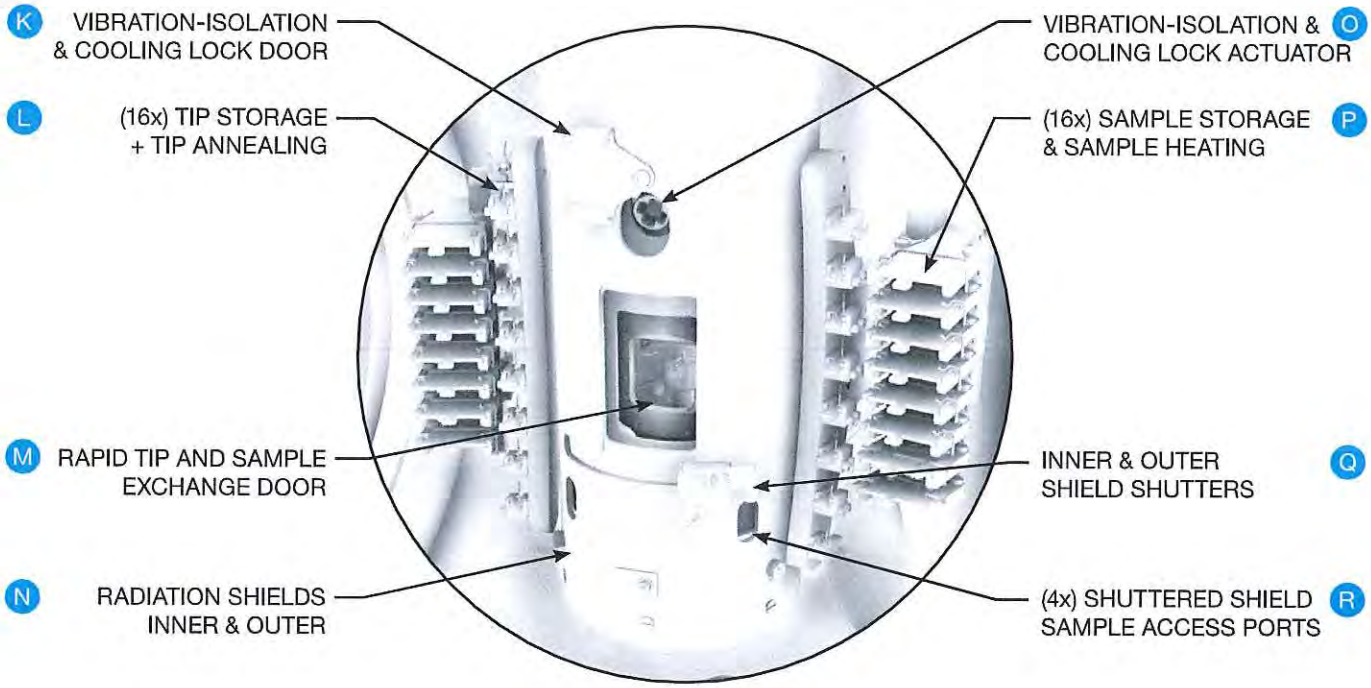
Anatomy and Features



- **A** **ARS Closed Cycle Cryostat:** Capable of reaching temperatures as low as 4K at the coldfinger, without the use of LHe.
- **B** **2nd Stage Vibration-Isolation Cryostat Decoupling:** Separates cryostat helium pump vibrations from scan head.
- **C** **3rd Stage Vibration-Isolation Advanced Suspension:** Decouples scan head from virtually all remaining systemic and environmental vibrations.
- **D** **Visual Access Viewport:** Allows easy accessibility during changing and prepping of tips and samples, as well as while locking and unlocking the scan head.
- **E** **Articulating Wobblestick:** Allows easy manipulation of tips, samples, shutters, and cooling lock.
- **F** **Sample Access Viewports:** (4x) 2¾" CF ports (1⅝" I.D.) For optional in-situ sample prep and other ancillary experimental operations.
- **G** **Ion, TSP, and Turbo Pumps Self Contained:** Enables the small and mobile footprint of the pan scan freedom.
- **H** **1st Stage Vibration Isolation Frame:** The first defense against experiment degrading vibrations
- **I** **(6x) Controller Interface Ports:** Optimized to interface with RHK's R9 control system, with room for customization.
- **J** **Load Lock And Transfer Arm:** Allows for easy installation of new tips and samples without breaking vacuum.
- **K** **Vibration-Isolation & Cooling Lock Door:** Shutter, for cooling lock mechanism, keeps temperatures stable and stays where placed.
- **L** **(16x) Tip Storage + Tip Heating:** Up to 16 storage ports for spare tips, and optional tip annealing port.
- **M** **Rapid Tip And Sample Exchange Door:** Change tips and samples in seconds with direct visual access, easy to use wobblestick, and ample room to eliminate error.
- **N** **Radiation Shields:** Blocks against thermal radiation effecting the scan head with 2 isolating layers.
- **O** **Vibration-Isolation & Cooling Lock Actuator:** Locks the PanScan Scanner to the cold finger with a simple twist of the wobblestick.
- **P** **(16x) Sample Storage & Sample Heating:** Up to 16 storage ports for samples, with 2 positions usable for optional DC and E-Beam heating.
- **Q** **Inner & Outer Shield Shutters:** This 2 stage mechanism allows for closure of the sample exchange door and the 4 shielded sample access ports.
- **R** **(4x) Shuttered Shield Sample Access Ports:** located at 40° off the vertical axis and 90° apart, these allow a direct view of the sample through strategically placed chamber viewports.

PanScan Freedom
Cryogen-Free LT AFM / STM

Members of the PanScan Family

The World's Most Flexible Family of LT SPMs

PanScan
Head

PanScan
UHV RT

PanScan
UHV LT
(Flow Cryostat)

PanScan
Freedom
UHV LT LHe-Free
(Closed Cycle Cryostat)

RHK's PanScan Family includes other PanScan AFM/STM models in addition to Freedom. These range from basic Core Technology Kits for do-it-yourself scientists to turn-key LT systems with LHe/LN_2 flow cryostats. All PanScan models use the same ultra-rigid scan head and R9 controller for optimal results.

Our modular approach provides a simple, direct, and affordable upgrade path for existing models, protecting your investment in research equipment and capabilities over time.

PanScan's unique design and compact size also allow easy drop-in adaptation and integration by home-builders to other chambers and systems already in place in the laboratory.

Explore with Confidence

The *R9* Control System Advantage

R9 Control System, the New Standard in AFM/STM Control Systems.
Over 20 years world's leading researchers have depended on RHK to deliver the highest performance SPM control systems, with more than 1,000 installed. Now, RHK provides the all-new R9, our next-generation platform with dramatic state-of-the-art advantages. All digital Purpose-Built Hardware for lowest noise, highest performance. One-Box Integration for total STM, AFM, even KFM control. IHDL™ for easy drag-and-drop set up of hardware and experiment components that connect and validate automatically. All this and more from the industry's most experienced designers. Not just remarkable...revolutionary.

OUTSTANDING EASE OF USE

Integrated one-box solution eliminates multiple modules for every function, and enables simple system re-configuration through software, without a nest of cables which are antennas for noise.

Purpose-Built Hardware, designed and optimized solely for SPM, allows all signal multiplexing, summing, and routing to be handled in the digital domain for ultimate low noise performance.

Supports all SPM operating modes, such as STM, dI/dV spectroscopy, contact and conductive AFM, NCAFM, KFM, without need for external hardware modules.

POWERFUL EXPERIMENTAL FLEXIBILITY

Graphically configure and connect firmware modules to hardware components: PLLs, lock-ins, filters, amplifiers, phase shifters, counters, feedback loops, numerically controlled oscillators (NCO), and more.

Flexibly configure firmware module functionality. For example, a lock-in or PLL can be set to feedback on the fundamental or any integer/non-integer harmonic of excitation signal. Multiple configured lock-ins can operate independently from each other or track multiple harmonics of any input signal.

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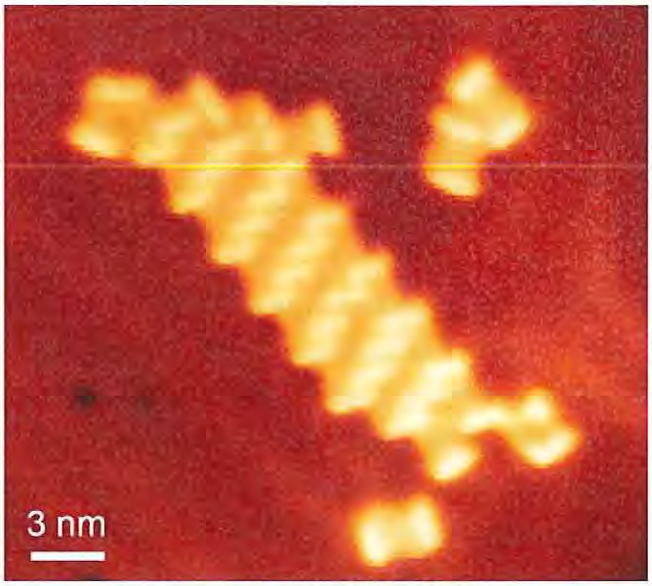
PanScan Freedom
Cryogen-Free LT AFM / STM

Voice of the Customer

Professor Miquel Salmeron said, "I was really impressed by your PanScan Freedom working so smoothly in the noisy environment of the AVS exhibit! The stability was superb and I loved immensely the closed circuit of He gas. This is so cool and so great at a time when getting liquid He is not an easy thing (not to speak of the cost). I wish I had money right now to buy one!"

"I am amazed by the quality of images that your new PanScan Freedom SPM can deliver in a noisy exhibition room. The cryo-free feature makes it much more affordable than conventional cryogenic SPMs. This new microscope should be a dream platform for many customers who have a small budget but a high passion for quality SPM work.", said An-Ping Li (Senior Research Scientist, ORNL)

Professor Vidya Madhavan said, "The topographic images that you obtained on the first day you received my In doped Bi_2Se_3 sample were equal in quality to the published results that we obtained using our commercial bath cryostat STM. It is amazing that such results could be obtained with a closed-cycle cryostat. That you could get equally good results with the system running just sitting on the floor in the exhibition hall during the AVS conference is nothing short of remarkable! Your system is definitely on my wish list for a future purchase."



Adsorption of DDQT molecules on Au(111) in the intermediate coverage regime. STM image [set point 100 mV, 5 pA] of a large area featuring a finite-sized 2D crystal of DDQT with individual DDQT dimers in the vicinity.

Coverage-Dependent Self-Assembly Regimes of Alkyl-Substituted Thiophene Oligomers on Au(111): Scanning Tunneling Microscopy and Spectroscopy

Dmitry A. Kislitsyn, Benjamen N. Taber, Christian F. Gervasi, Stefan C. B. Mannsfeld, Lei Zhang, Alejandro L. Briseno, and George V. Nazin (J. Phys. Chem. C 2015, 119, 26959–26967)

Images and data graciously provided by George Nazin, University of Oregon, Eugene, Oregon.

PanScan Freedom
Technical Specifications

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PanScan Freedom

Models: STM or AFM-qPlus

Temperature: 9K - 400K

Drift: XY drift as low as 0.2Å/hour
Z drift as low as 0.2Å/day

Cooling rate: Ambient to 18K, 6 hours
Sample exchange 1 hour

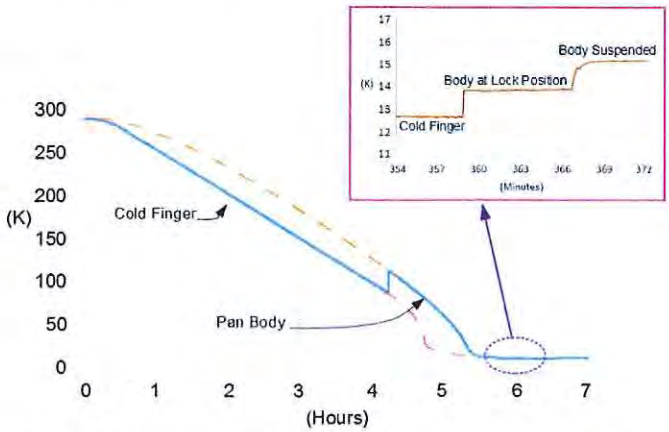
Preamplifiers: Separate AFM & STM

AFM-qPlus™[1]: Scan rates up to 4 µm/sec.

Cost to operate: Approximately $1 per hour
Including electricity and annual maintenance

Exchange: Probe and Sample independently exchangeable in-situ

PanScan Freedom cooling curves:
Tip and sample cooled to same temperature.



PanScan Scanner

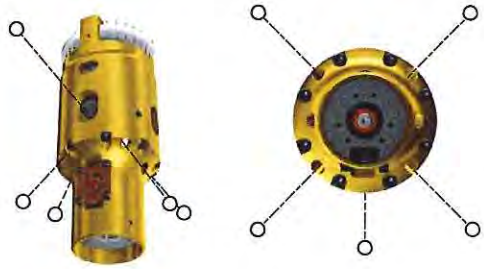
Scan Range XYZ: 8 x 8 x 1.5 µm @RT ±215V
5 x 5 x 1 µm @RT ±150V
2 x 2 x 0.5 µm @ 9K ±215V
1.25 x 1.25 x 0.25 µm @9K ±150V

Coarse Offset XYZ: 5 x 5 x 8 mm

Sample Size: 10 x 10 mm

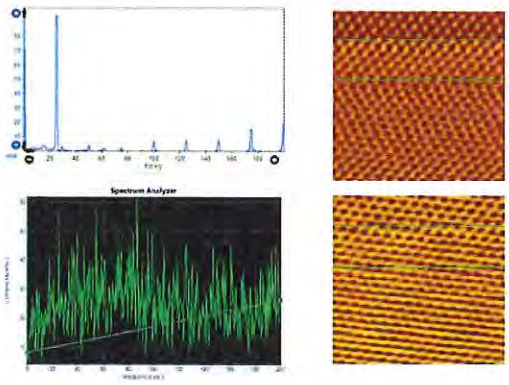
Contacts: 4 to sample (standard)

Tip/Sample access: (in-situ) 5 standard ports for evaporation & optical access



Low-Frequency Vibrational Testing:

The PanScan Freedom was subjected to external vibrations, from 10 Hz to 50 Hz. The top plot shows accelerometer results for a 25 Hz stimulus, generating 30 um/s RMS velocity. Neither the primary excitation peak nor the higher harmonics were observed in the tunneling current spectrum (bottom plot) or in the resultant atomic lattice images.



[1]qPlus® is a trademark of Prof. Franz Gießibl

Product Specifications and descriptions in this document subject to change without notice.

Ultra low noise <1 pm with cryostat running

Proven <1 pm performance on the exhibition floor during AVS 2014, APS 2015, DPG 2015, AVS 2015, APS 2016.

LHe-free

Eliminate the cost of budget-busting liquid helium. Many researchers run their existing microscopes with LN_2 due to the high cost of LHe.

Cryogen cost-free

Approximately $1 per hour including the cost of electricity to run the cryostat and the scheduled maintenance for the compressor and cold head.

Interruption-free

Can maintain cryogenic temperatures indefinitely. Allows unlimited experimental flexibility. Never run out of liquid helium in the middle of a measurement again.

Atomic resolution 9-400 K

XY drift as low as 0.2Å/hour

Entire microscope, including both the tip and sample can be held at the same temperature from 9K to room temperature. Elimination of thermal gradients keeps drift over full temperature range extremely now.

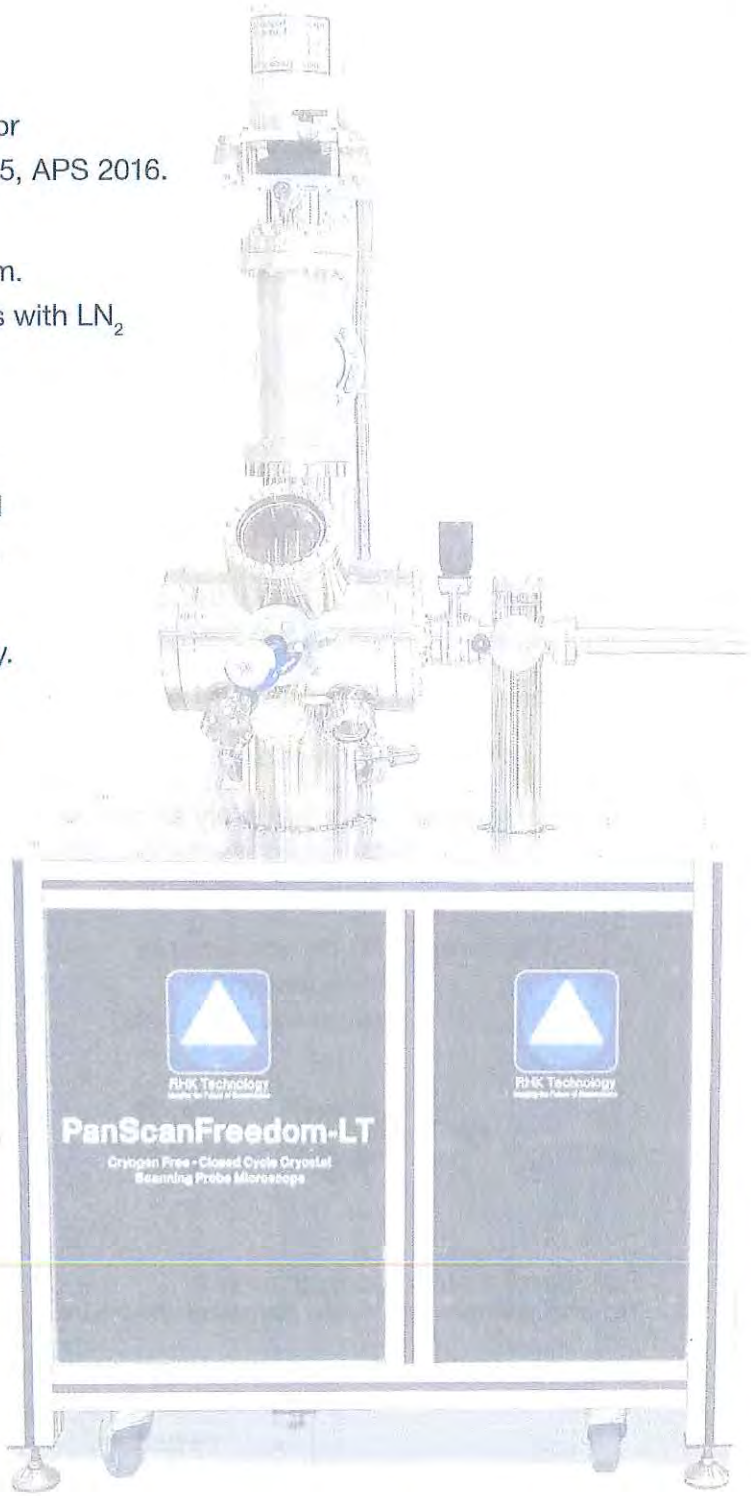
Z drift as low as 0.2Å/day

Low drift produces superior spectroscopic measurements. Feedback loop can remain open for extended periods without introducing error into measurements.

Superb STS

Provide spectroscopic measurements from single I/V curves to full spectroscopic maps. Indefinite hold time allows an unlimited number of spectroscopic measurements to be made without having to stop and re-fill a helium reservoir.

Hassle-free tip and sample exchange



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