RHK Technology
Imaging the Future of Nanoscience

RHK PanScan LT Scanner
RHK R9*plus* Controller
RHK Technical Collaboration

6 CASE STUDIES

INTEGRATION OF THE RHK PANSCAN SPM SCAN HEAD INTO CUSTOMERS' HOME-BUILT SYSTEMS

Six research groups are highlighted that utilized RHK's PanScan SPM head to overcome the challenges of time, funding, and unique requirements. They successfully built custom UHV SPM systems as varied as cryogen-free, LHe bath, and even 300 mK -- plus high magnetic fields. Cutting-edge results were achieved and published in high-impact journals.

Massachusetts Institute of Technology
Integration with Janis 300 mK cryostat with 8T magnet

Columbia University
Integration with four new and existing LHe cryostats

University of Science and Technology of China
Integration with customer-built 4K cryostat

Clark University
Cryogen-free SPM built in stages – From ambient to RT UHV to Cryogen-Free UHV

State University of New York
Integration with Cryo Industries 4K cryostat

Ohio State University
Integration with two existing UHV and cryogenic systems

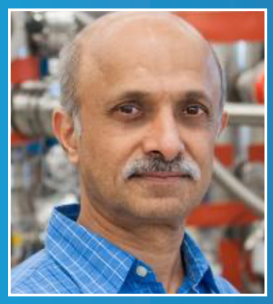
About RHK Technology
34 years of SPM instrumentation leadership

RHK Technology
Imaging the Future of Nanoscience

A CASE STUDY

RHK CUSTOMER SUCCESS

RHK PanScan SPM integrated with Janis 300 mK cryostat with 8T magnet



Dr. Jagadeesh Moodera
Senior Research Scientist, Physics Dept.
Plasma Science and Fusion Center (PSFC)
Massachusetts Institute of Technology
Cambridge, MA

OVERVIEW

As a Senior Research Scientist at a world-renowned university, you've set your sights on a ground-breaking experiment to detect Majorana fermions on a metal surface. This will require a highly stable STM that can operate at millikelvin temperatures with the ability to be rotated precisely inside of a 5T in-plane magnetic field.

No commercial STM had this capability, so a custom instrument would need to be developed. Which supplier do you choose to meet the complex challenges you know are ahead in a difficult, high-risk task? And why do you think they can rise to the occasion and ensure your success?

Dr. Moodera had learned about RHK's cryogenic scan head and R9 Controller from his own experience at the American Physical Society's March meeting. A live demonstration of the PanScan Freedom, a cryogen-free system was underway at RHK's booth, producing remarkable atomic resolution results without the need for special system isolation against ambient noise and vibration.

> *"The real time demo of atomic scale imaging of a topological insulator surface at the APS March meeting, in that essentially street level setting with the cryogenic compressor running is simply awesome. All these physicists walking by and tapping on it did not make any difference… It is very impressive!"*

While RHK's PanScan and R9 Control looked very promising, for a mK system many more challenges loomed ahead. Dr. Moodera still needed to select a mK cryostat package. And the mK cryostat design required a specialized transferable scanner mounted at the bottom of a very tall cryostat. Janis Research was selected to provide his mK cryostat. The superconducting magnet was provided by Cryomagnetics.

RHK and Janis agreed to work together, utilizing their many years of experience to design a system with unique capabilities that did not compromise the performance of the scanner or cryostat. While keeping the core PanScan head essentially standard, RHK built a unique mounting

and transport system to securely anchor the head inside of the magnet at the base of the cryostat.

RHK also designed a mechanism to enable unlocking the scanner from the base, raising it up and mounting it into a second stage inside of the load lock. This second operating position allows the quick exchange of the probe and sample at room temperature and the ability to verify room temperature operation before returning the scan head to the bottom of the cryostat. Eliminating cooling cycles with imperfect tips or samples greatly increases productivity as well as saves large amounts of helium.

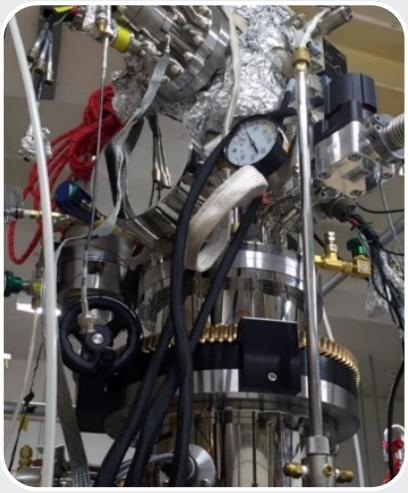
All RHK elements were designed to be compatible with the Janis mK cryostat construction and geometry. Both inter-operated as designed to reach and maintain 350 mK temperatures while imaging. This customized joint-effort system has been installed and tested, is fully operational, and delivered strong imaging performance in Dr. Moodera's lab at MIT. The images below are excerpts of his published research.

> *"Having worked with an STM for a couple of years, I can clearly appreciate the magnitude of this fantastic accomplishment by RHK Technology. I am totally confident in our choice…a custom built mK STM/nc-AFM from RHK"*

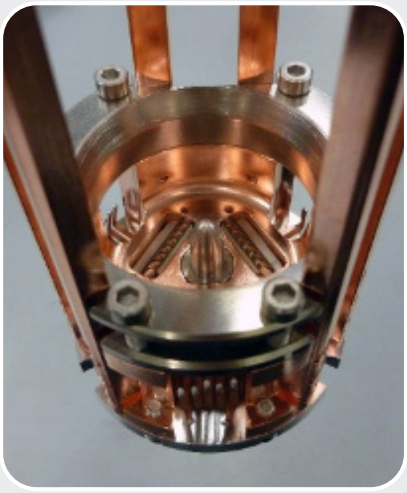
Dr. Moodera is now working with RHK to expand the capability of his STM system by modifying the scan head to incorporate novel capabilities for advanced scanning operation. RHK is providing the scan head drawings and technical support to enable them in highly challenging future experiments. .

SYSTEM

Customized PanScan STM head installed in 300 mK He^3 cryostat from Janis Research Company. Scan head transferrable in-situ to load lock for sample/tip exchanges and testing probe and sample before cooling down to mK base temperature for imaging. Cooled scan head can be rotated within magnetic field. Overall design ensures high stability and low noise of the system even without any internal vibration isolation.



Top flange assembly of cryostat showing rotation stage



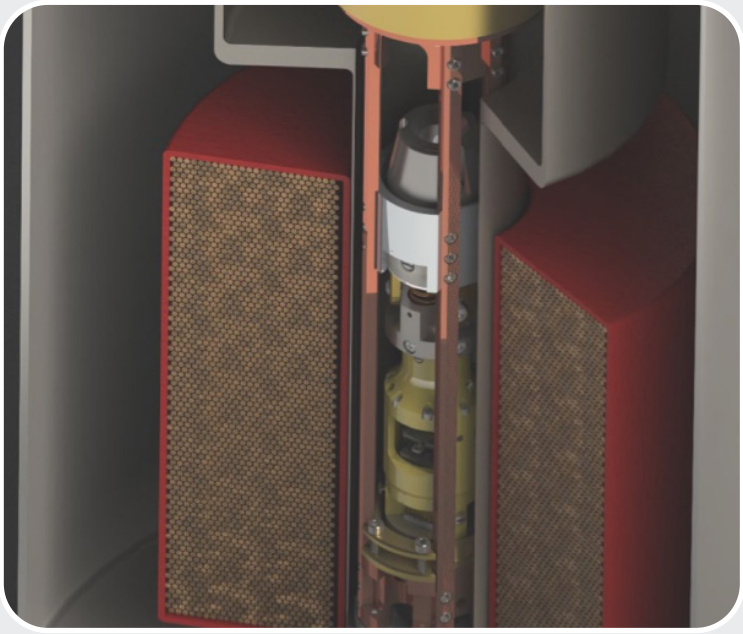
Receiving stage in bottom of cryostat

Bottom view of scan head showing pluggable connections.

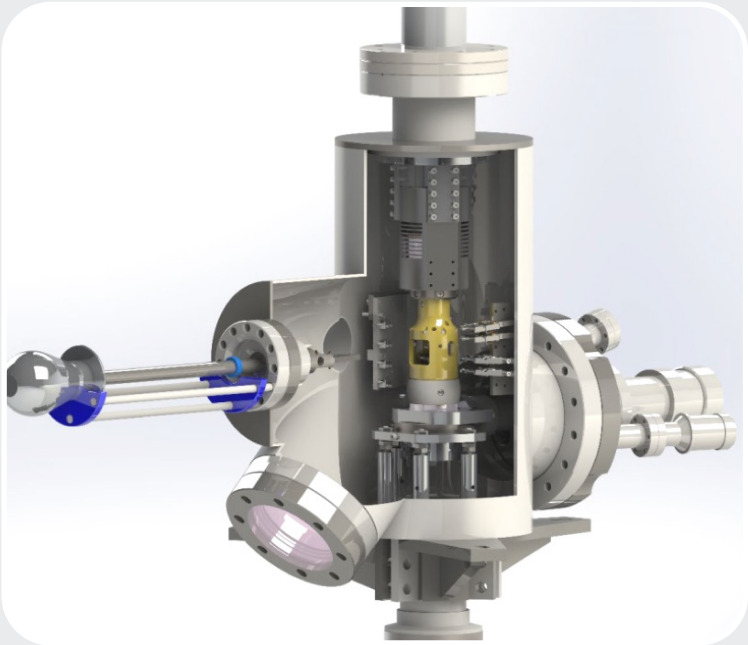
RHK PanScan mK-magnet SPM (cutaway views):

Image shows position of scan head in load lock and cryogenic positions along with raise/lower and locking mechanism.

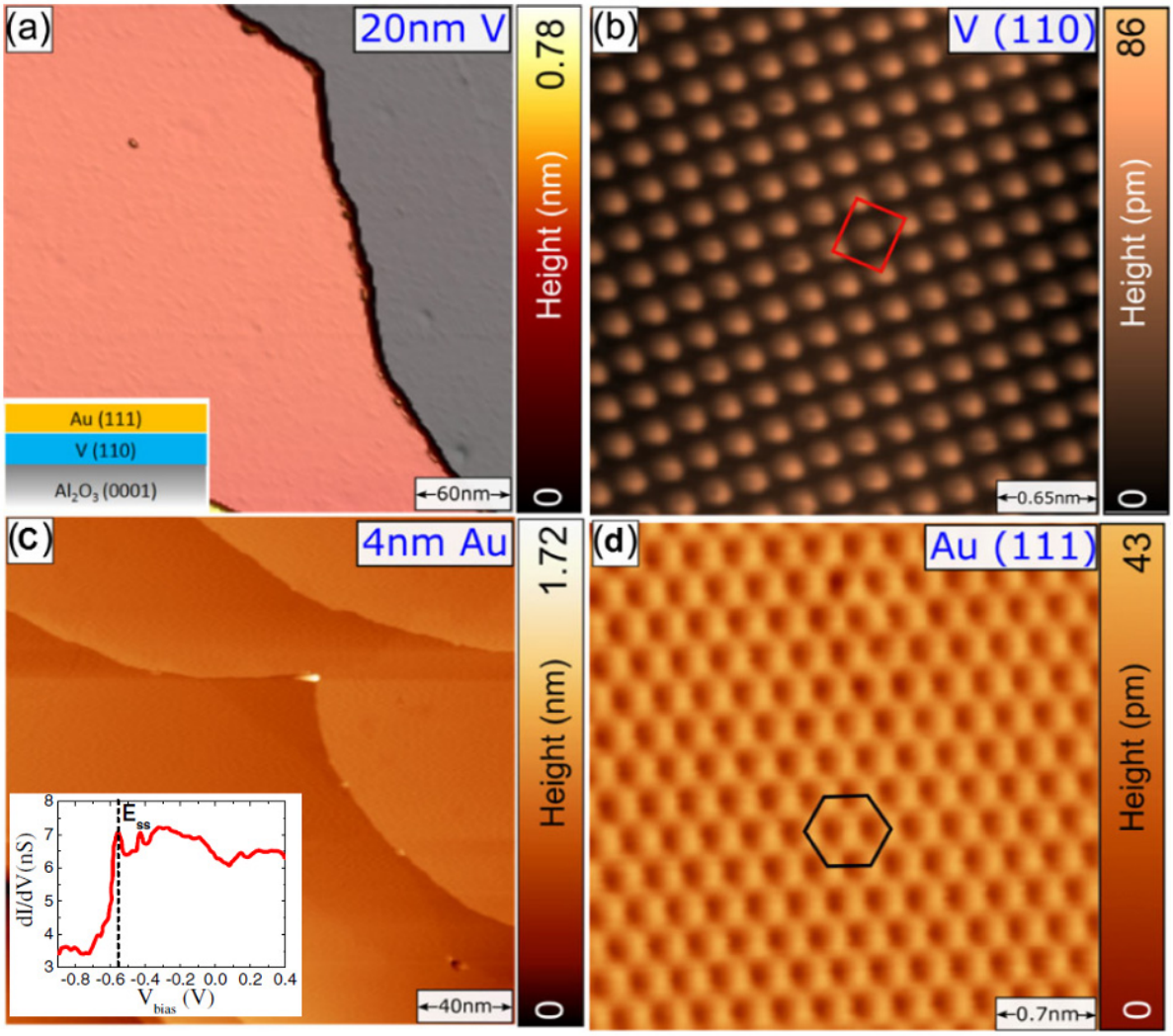
RHK PanScan:
Ready to scan at 350 mK in 8T magnetic field. Solid atomic resolution with high resolution spectroscopic imaging without internal vibration isolation.



PanScan Load Lock Details:
Interior view of load lock showings pincer-grip wobble stick along with in-situ storage racks for spare tips and samples.

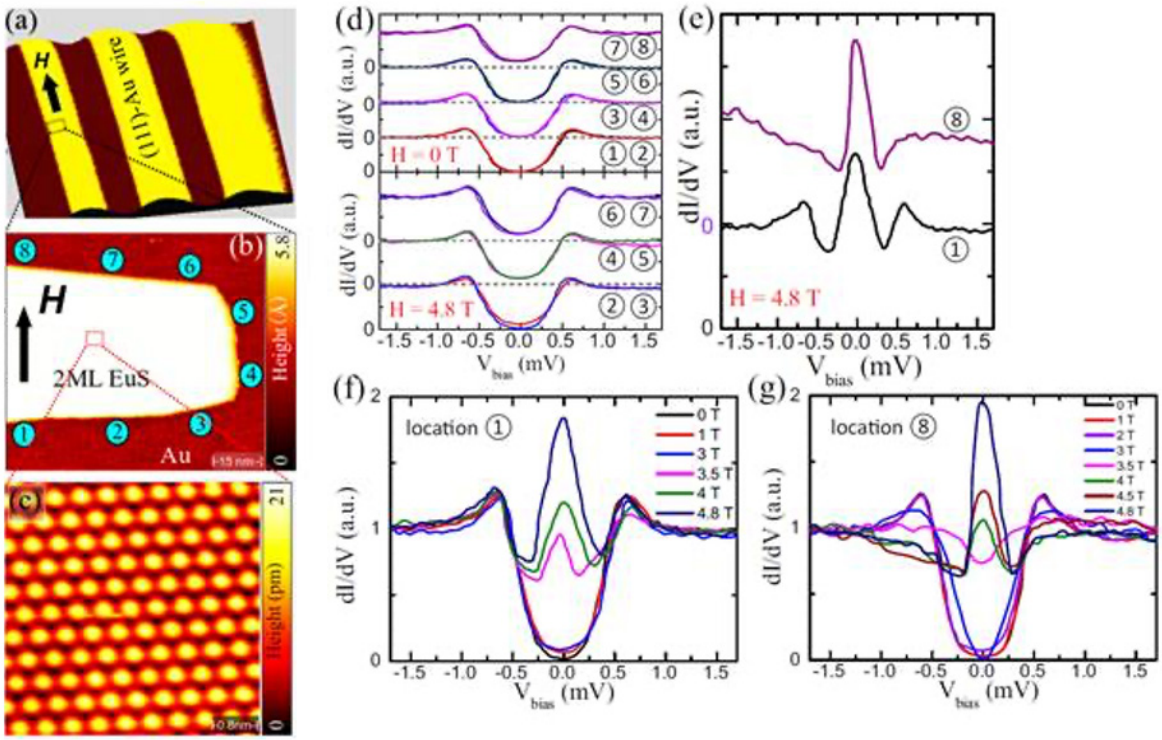


RESULTS



(a) Large scale image of 20 nm V film on sapphire substrate.
(b) Atomic image of V(110) surface.
(c) Large scale image of 4 nm Au grown on V surface. (Inset) dI/dV spectrum showing the edge of the surface energy band.
(d) Atomic image showing hexagonal atomic lattice of Au(111).

Superconductivity in the Surface State of Noble Metal Gold and its Fermi Level Tuning by EuS Dielectric. *Physical Review Letters* PHYSICAL REVIEW LETTERS **122**, 247002 (2019)



Topographic and spectroscopic data on a Au(111) nanowire with a 2 ML EuS overlayer. The topological transition is demonstrated as the magnetic field is increased in the direction of the nanowires, the superconducting gap is shown filling in until a pair of Zero Bias Peaks (ZBP) appear, a clear signature of Majorana Zero Modes (MZM). Data acquired at 380 mK.

(A) The STM topography image of a Au(111) nanowire array with two MLs of EuS deposited over it.
(B) Zoomed-in STM topography image of a relatively large EuS island sitting at the edge of the Au nanowire.
(C) The atomically resolved EuS surface in the marked region.
(D) Comparison of the dI/dV tunneling spectra under both H = 0 T and H = 4.8 T. A slight filling in of the gap is seen at positions 2 through 7 in the 4.8-T field.
(E) Sharp Zero Bias Points (ZBP) emerges for H = 4.8 T at positions 1 and 8.
(F and G) The evolution of the dI/dV spectra at position 1 and 8 as a function of the strength of the applied field.

Signature of a pair of Majorana zero modes in superconducting gold surface states
Proceedings of National Academy of Science PNAS April 21, 2020 117 (16) 8775-8782

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A CASE STUDY

RHK CUSTOMER SUCCESS

- RHK PanScan SPM integrated in Cryo Industries 4K Liquid Helium cryostat
- Two PanScan RHK SPMs replacing old scan heads in existing cryostats
- Custom PanScan SPM system optimized for fiber probes

Dr. Abhay Pasupathy
Columbia University

OVERVIEW

Dr. Abhay Pasupathy joined Columbia University in 2009. As a postdoctoral researcher, Dr. Pasupathy had experience with designing and building his own scan probe instruments. As a new professor, Dr. Pasupathy started by building his own STM. In 2011, the opportunity came to expand his laboratory with a new instrument.

Should a complete turnkey system be chosen, a safe path, or a homemade, system customized to his exact requirements? The chosen path must be suitable and flexible enough for the demands of two realms of research: first, experimental quantum materials research on two-dimensional materials and heterostructures; and second, integrating scan probes with light of various sorts and developing new probes for spatially resolved transport measurements, and more. There was much at stake.

Dr. Pasupathy decided to pursue a hybrid approach, where the system was designed in-house, but various parts were sourced externally. The cryostat selected was from Cryo Industries of America to minimize liquid helium consumption. Dr. Pasupathy chose RHK and its PanScan SPM scan head with the R9 Controller for the best mix of performance, capabilities, flexibility, and support for this unique home-built platform. RHK's many years of experience and reputation gave him the confidence that they would be able to support him as the system was being assembled and in the coming years. That confidence has paid off as the system has been the platform for multiple PhD students and several publications.

Dr. Pasupathy Says,

> *"Both the hardware and the electronics provided by RHK have been reliable for several years, and RHK staff have been generous with their time and effort in helping us achieve new functionality on a regular basis"*

Early last year Dr. Pasupathy needed to replace a non-working scan head that had been built years earlier by one

of his students who was no longer with the group. To keep the group's research moving forward, a fast delivery was required. He had to decide between building his own scan head or selecting a commercially available instrument. Due to the group's nine years of productive service of their first RHK PanScan head, they selected another PanScan head for the job. Although the standard PanScan head could fit into the existing space, RHK collaborated with Dr. Pasupathy to customize the scan head design. To optimize the precision to which the probe could be positioned over the sample surface, the optical path through the scan head was enlarged, providing enhanced resolution with their high NA microscope. Even with a customized design, RHK was able to deliver the customized scan head on time and to specification.

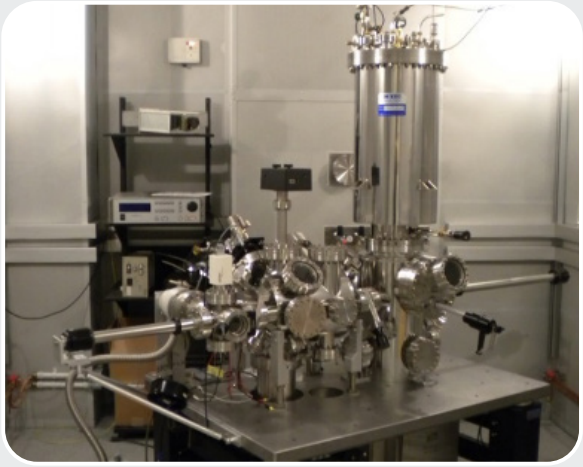
Just before Christmas of last year another student-built scan head reached the end of its useful life, again requiring a make or buy decision. Dr. Pasupathy again decided to select RHK's PanScan head as they were able to deliver it within a coupe of weeks including a customized vibration isolation stage designed to interface with their existing cryostat.

> *"Twice last year RHK met their delivery promises of a new PanScan head which prevented costly downtime."*

Currently, Dr. Pasupathy has begun a collaboration with other members of the physics and engineering communities at Columbia University. They required an SPM scan head that is optimized for for light injection and collection from the tip/sample junction. This system had the unique requirement for in-situ exchange of optical fiber-based probes. Other requirements included the ability to build the system around an existing flow cryostat to keep the costs within the limited budget as well as a quick delivery allowing data to be generated in time for the project review. Again Dr. Pasupathy chose RHK to supply the heavily customized PanScan scan head, integrated into a customized vacuum chamber along with the R9plus control system.

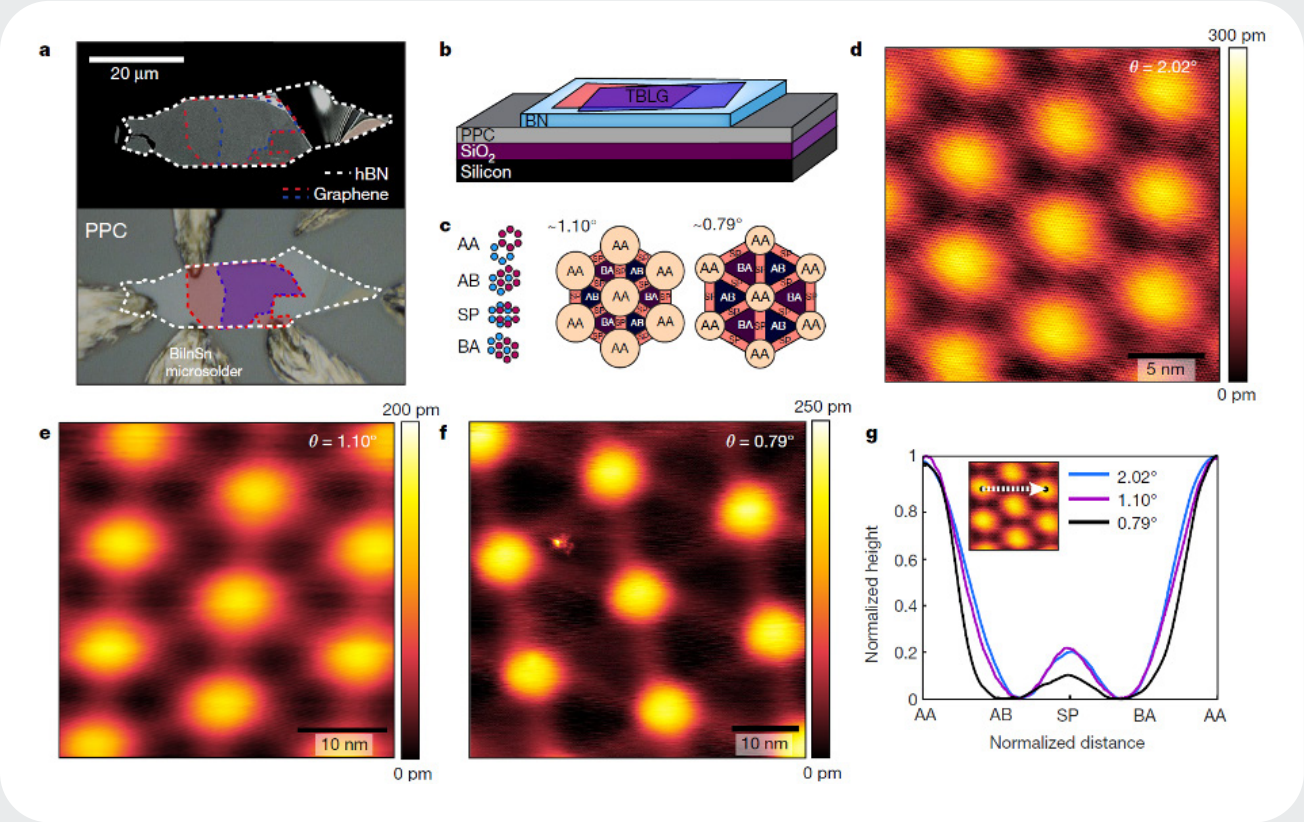
> *"RHK partnered with us to develop a microscope to meet our unique experimental requirements. They listened closely to our needs and offered suggestions for a design that limited the risk of a completely new design while keeping within our budget and delivery constraints. When this system is delivered it will be the fourth RHK SPM in our lab."*

SYSTEM



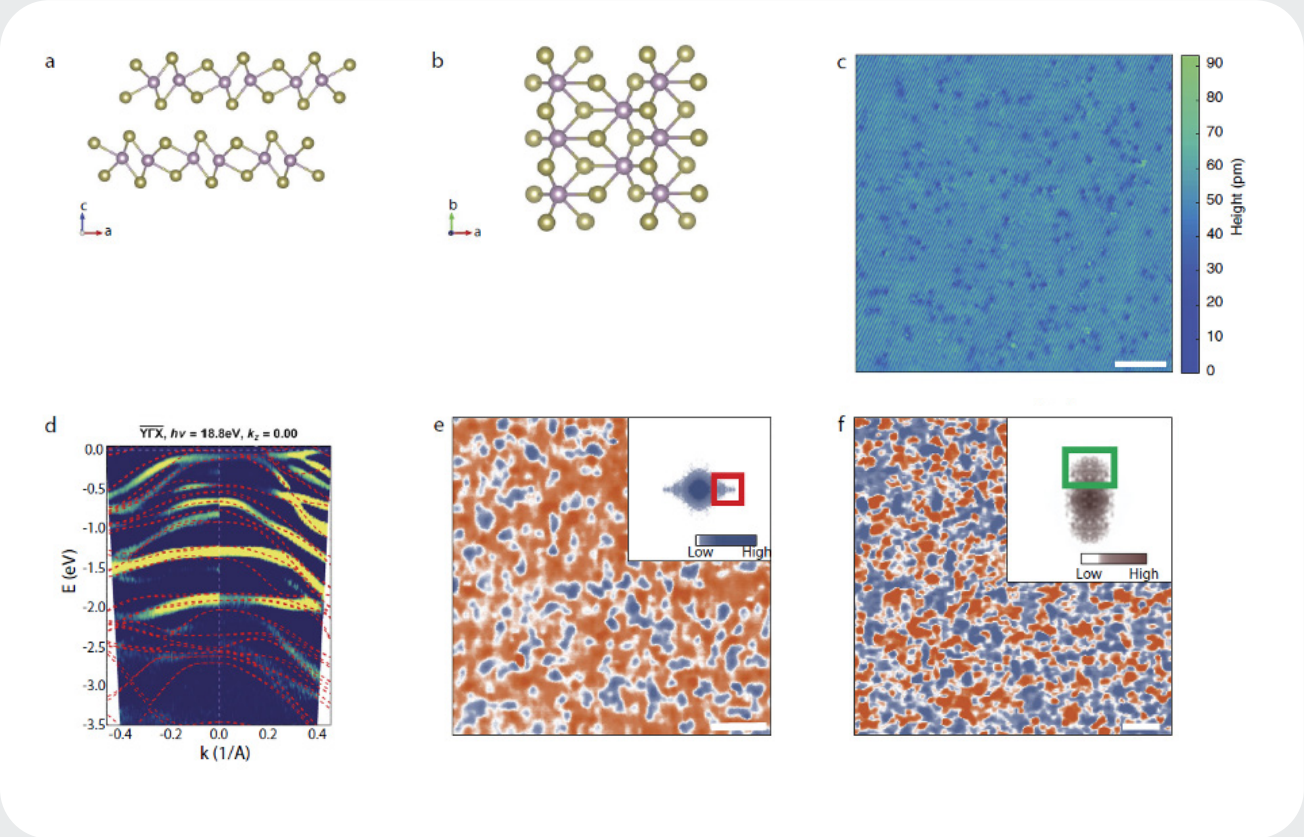
Customer-built system incorporating the RHK PanScan SPM in a Cryo Industries LHe cryostat.

RESULTS



Atomic insights on TBG structure near the magic angle.
(a) Optical images of sample. **(b)** sample schematic **(c)** schematics of areal-space moiré patterns **(d-f)** Atomic STM images at three twist angles. **(g)** Normalized spatial height profiles

Size dependence of electronic property in CVD-grown single-crystal graphene
Nature 10.1038/s41586-019-1431-9



Td-$MoTe_2$

(a-b) Ball and stick models. **(c)** Atomic resolution with rows parallel to the crystals' *b*-axis. **(d)** 2D cut of band structure (ARPES). **(e)** dI/dV map at -35 meV **(f)** dI/dV map at 50 meV.

Temperature-driven topological transition in 1T'-$MoTe_2$

Nature NPJ Quantum Materials 10.1038/s41535-017-0075-y

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A CASE STUDY

RHK CUSTOMER SUCCESS

RHK PanScan SPM integrated with Cryo Industries 4K Liquid Helium Cryostat

Dr. Shengyong Qin
Professor
Department of Physics & Hefei National Lab for Physical Sciences at Microscale, University of Science and Technology of China (USTC)
Hefei, China

OVERVIEW

Dr. Qin's journey to LT SPM Nanoscience started when he earned his Ph.D. at the University of Texas at Austin and during subsequent years of hands-on experience at Oak Ridge National Laboratory and RHK Technology, Inc. Finally, Dr. Qin moved back to China for a professorship at USTC in Hefei. While his direct experience at RHK was certainly advantageous, now he has achieved his own UHV LT SPM published results on the other side of the world.

From his direct experience at RHK, Dr. Qin knew the deep advantages of PanScan and the R9 control system. Now on his own, he selected these as the core components of his own USTC system. Dr. Qin said,

> *"The RHK Pan scan head provides very high stability while maintaining simple design to allow integrating into different custom systems, and R9 controller wins with its low noise level and expansion flexibilities."*

His research interests led him to the 4 K temperature range, which required a LHe bath cryostat. He moved forward to integrate a home-built bath cryostat with his RHK PanScan head and R9 Controller to reach the desired 4 K operating range. He explains,

> *"We have a home-built LT-STM system with RHK Pan scan head and R9 controller. The Pan scan head design is very simple with great mechanical stability: the scan head was mounted directly to the bottom of the liquid He Dewar, and everything runs smoothly without any vibration noise issue. The Pan scan head has a very compact design which gives it great flexibilities in being integrated into different systems under various circumstances. The tip/sample exchange mechanism is reliable and reasonably easy to operate which is also a big advantage. The R9 controller is capable of providing low noise spectroscopic measurements with its built-in lock-in, and the R9 software provides users plenty of expansion capabilities as well."*

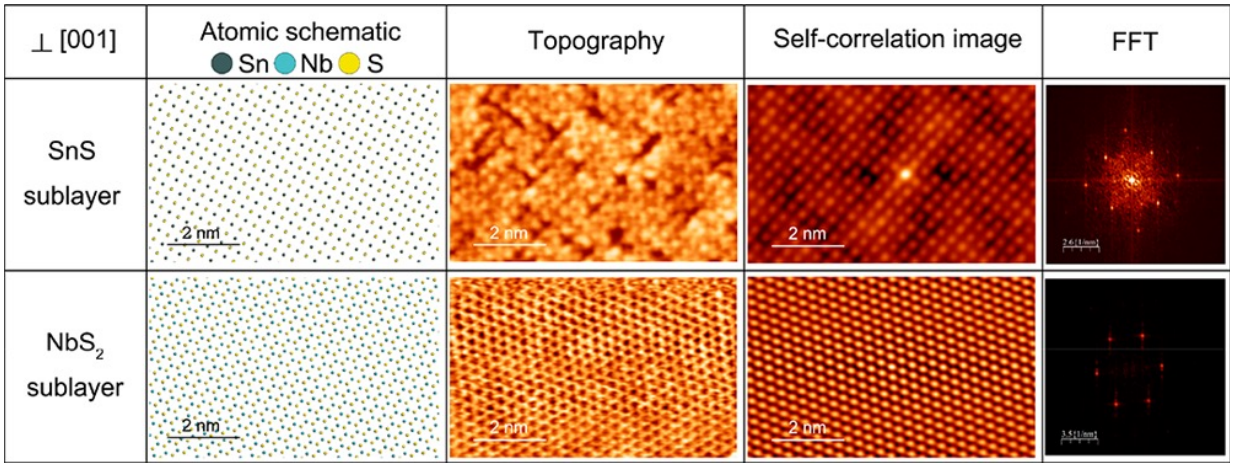
Dr. Qin has multiple publications in high impact journals. He continues to pursue deeper lines of scientific LT SPM accomplishments at USTC. His PanScan and R9 comprise the core of his very capable LT research system. Recently, he purchased another PanScan head and RHK's latest controller, the R10 for cryogenic STM/AFM studies. firsthand that solid tech support for his PanScan hardware and R9 software is close at hand and responsive to his needs.

SYSTEM

PanScan STM head integrated into a home-built LN2/LHe cryostat at 4 K with no internal vibration isolation. System controlled by R9.

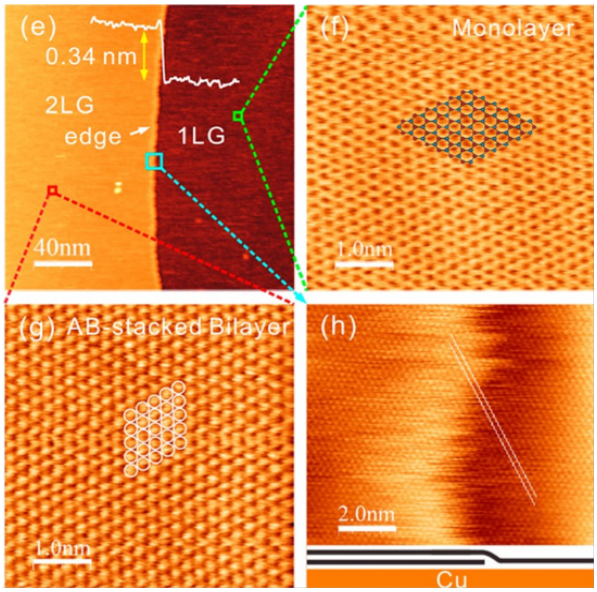
RESULTS

PanScan STM head integrated into a home-built LN2/LHe cryostat at 4 K with no internal vibration isolation. System controlled by R9.



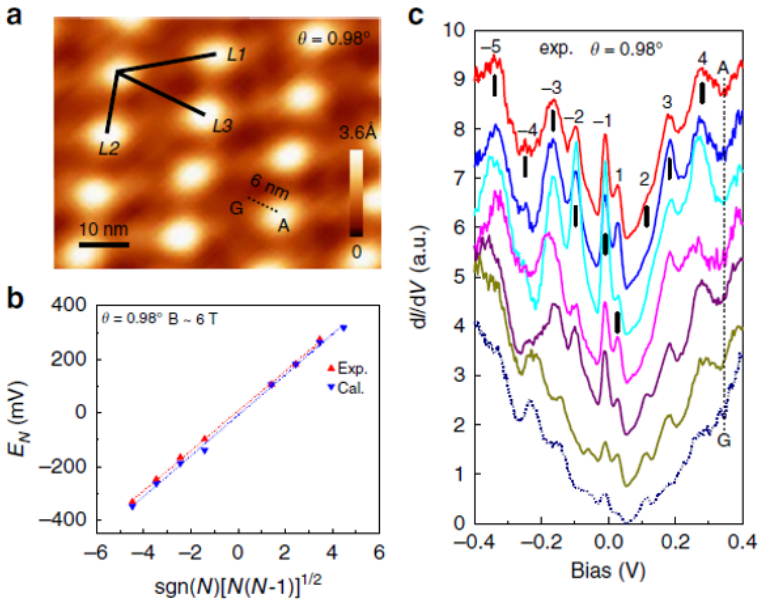
STM morphology. Atomic schematic, STM topographies, FFT, and self-correlation images of each sublayer of NbS_2.

Monolayer Behavior of NbS_2 in Natural van der Waals Heterostructures
Journal of Physical Chemistry Letters 2018, 9, 6421-6425



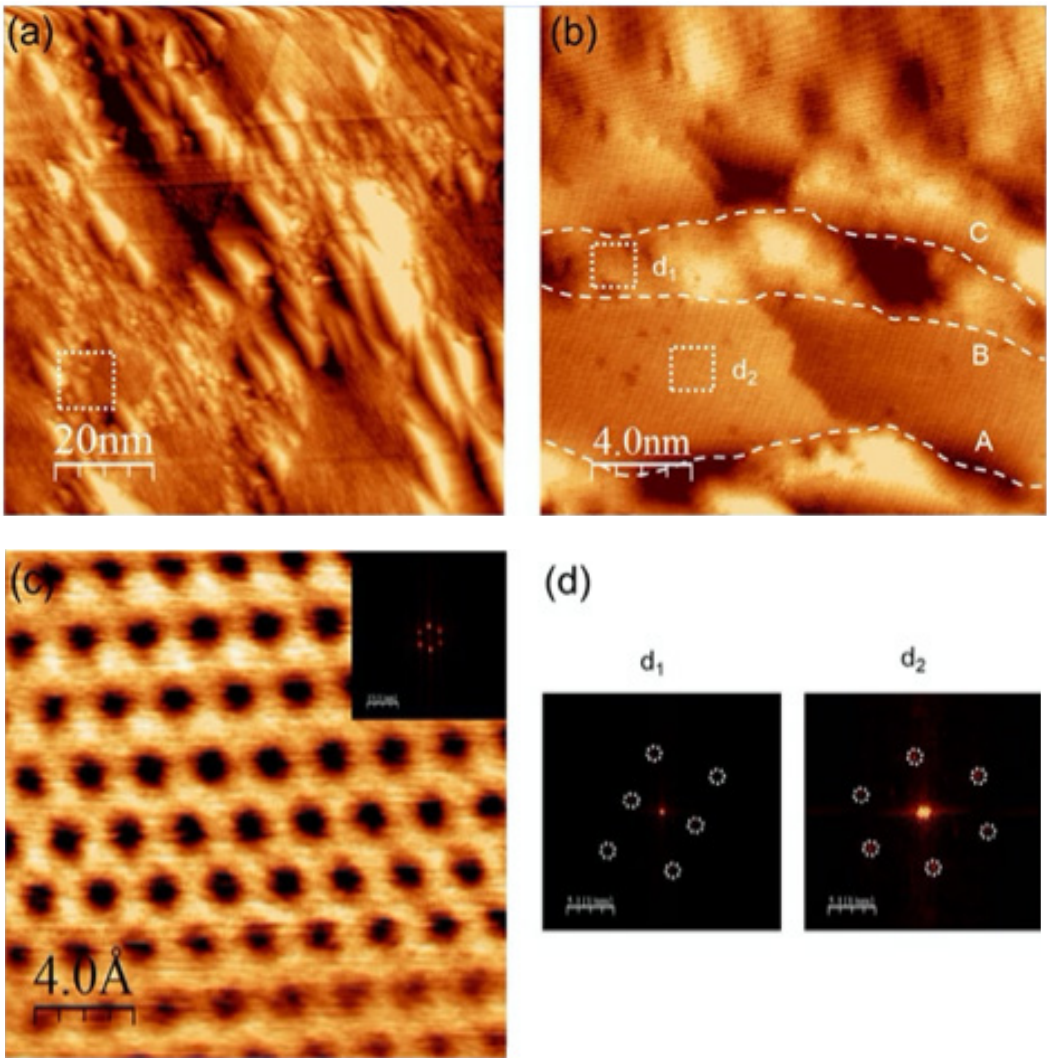
Step and atomic resolution images of graphene

Chemical Vapor Deposition Growth of Bernal-Stacked Bilayer Graphene by Edge-Selective Etching with H_2O
Chemistry of Materials 2018, 30, 7852-7859



Electronic properties and pseudo-magnetic field behaviors of twisted bilayer graphene (TBG)

Large-area, periodic, and tunable intrinsic pseudo-magnetic fields in low-angle twisted bilayer graphene
Nature Communications (2020) 11:371



STM images of graphene on Cu substrate showing hexagonal lattice (d2) and rhombic moiré patterns (d1)

Size dependence of electronic property in CVD-grown single-crystal graphene
Materials Research Express 5, 075005

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A CASE STUDY

RHK CUSTOMER SUCCESS

A Cryogen-free SPM built in stages – Ambient to RT UHV to Cryogen-free

Dr. Michael Boyer
Associate Professor and Chair of Physics
Clark University
Worcester, MA

OVERVIEW

Dr. Boyer faced a tough situation as he joined the Physics Department at Clark University. He had to navigate through a new Assistant Professor faculty position and successfully pursue his interests in Experimental Condensed Matter Physics and STM studies, all while being tightly limited on funding and short on time. What's the smart approach, and how best to proceed?

First he searched for affordable commercial STMs that could be built in stages, given limited startup funds. Initially RHK's Beetle-walker ATM350 got his attention as UHV-ready and somewhat adaptable for cryogenics. Then he found RHK's PanScan to be more flexible and fully designed for chilled tip and sample research. It was similar to a unit he built in stages as a grad student.

Recognizing that PanScan enables a convenient path for system building from ambient to UHV and then to cryogenic, his decision was made. He started with an RHK atmospheric PanScan in an airbox and an R9 Controller. This economical yet very capable Kit produces meaningful results out of the box.

Dr. Boyer says,

> *"I appreciated the flexibility on the part of RHK to work within the constraints of my start-up budget, allowing me to begin my experiments with a state-of-the-art STM system with the ability to add capabilities (e.g., vacuum system, cryogenics, etc.) at a later time as funding becomes available."*

Dr. Boyer next upgraded his PanScan atmospheric set-up to vacuum. This step enabled a wider range of research topics and more published papers. Then it was time to make a big advance: his next system upgrade would be the crucial step to LT.

By design, Dr. Boyer and RHK together had been coordinating plans to upgrade to an LT PanScan Freedom system. With the groundwork already in place, he was able to make the move to 9 K tip and sample without duplicating hardware or wasting funds.

Having mapped out the evolution of his expanding system, he published papers in peer-reviewed journals based on research at each phase of his step-by-step journey to a PanScan Freedom UHV LT system. Dr. Boyer says,

> *My experience with RHK has been very positive. Working directly with an RHK engineer, I was able to customize an STM system for the types of experiments that I want to conduct.*

Now, with his fully equipped PanScan Freedom closed-cycle cryogen-free STM and R9 controls, he doesn't ever need to allocate precious funding for LHe or suffer through frustrating downtime waits for cryogen supply and dewar replacements. He can concentrate on a full range of LT condensed matter physics research.

As he expands his research further into UHV LT, Dr. Boyer confronts new questions on hardware and control topics. As before, he turns to RHK for deep support. He knows firsthand that solid tech support for his PanScan hardware and R9 software is close at hand and responsive to his needs.

> *Everyone at RHK has been extremely responsive to questions I have had, spanning from questions about software functions, the ability to customize measurements, electronics, hardware, and inquiries for new system components and upgrades.*

Dr. Boyer's planning and execution has paid off. He is now the Chair of the Physics Department at Clark. He says,

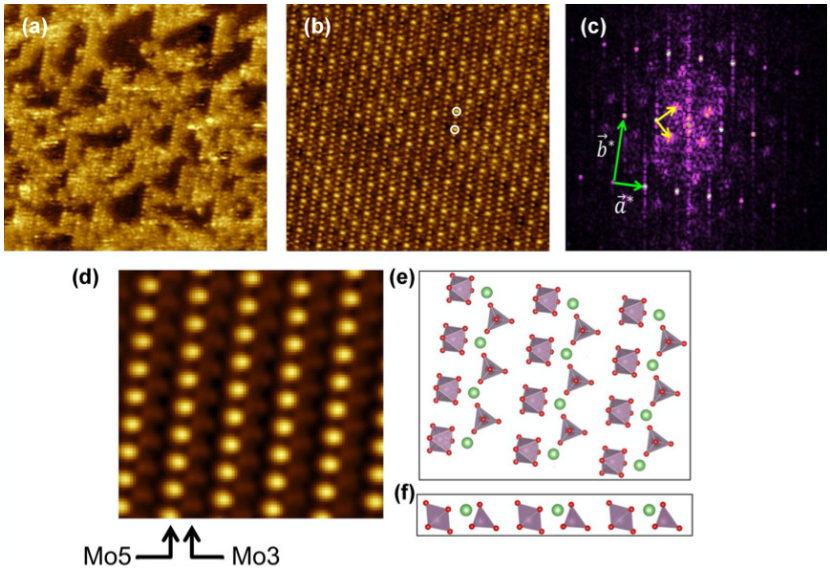
> *I have and will continue to highly recommend RHK to other researchers looking to construct a high-quality STM system and who would like to work with a company which is very responsive to their questions and needs.*

SYSTEMS & RESULTS

Dr. Boyer Boyer's evolving PanScan configurations over time:

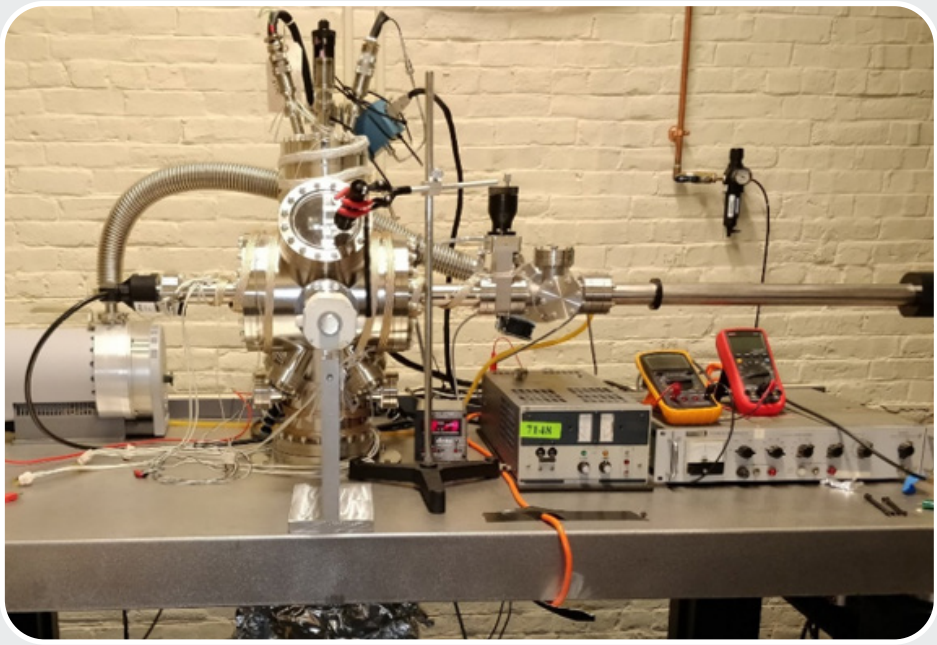
1. PanScan STM head and R9 Controller originally used in air.
2. Later upgraded to UHV.
3. Now fully outfitted to a RHK PanScan Freedom complete system with Advanced Research Systems (ARS) closed-cycle cryogen-free LHe at 9 K.
4. With his RHK Freedom, Dr. Boyer has zero LHe expense.

ATM PanScan STM in air



Origin of a superlattice observed in $Li_{0.9}Mo_6O_{17}$ by scanning tunneling microscopy.
Physical Review **B 93**, 045430 (2016)

PanScan STM in UHV at Room Temperature

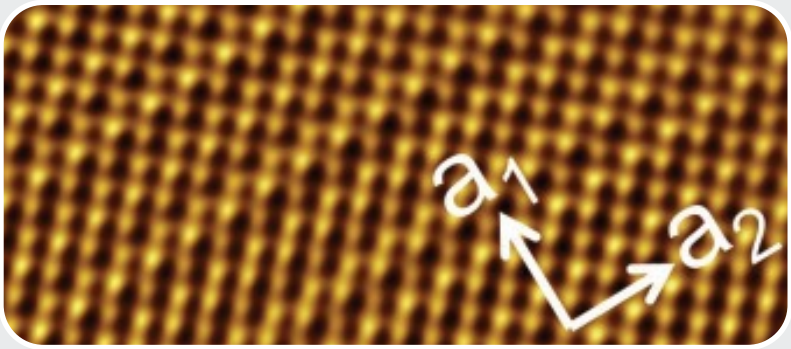


Dr. Boyer Boyer's UHV RT PanScan

PanScan STM in UHV at Room Temperature *(Continued)*

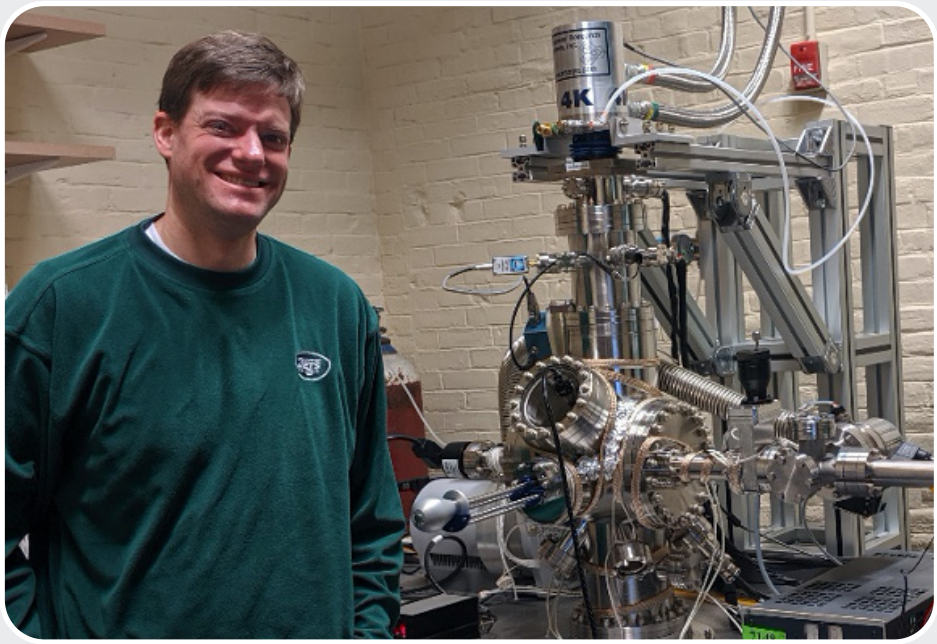
Multiple charge density wave states at the surface of $TbTe_3$.
Physical Review B 94, 205101 (2016)

Other publications:
Interplay of charge density wave states and strain at the surface of $CeTe_2$.
Physical Review B 101, 245423 (2020)



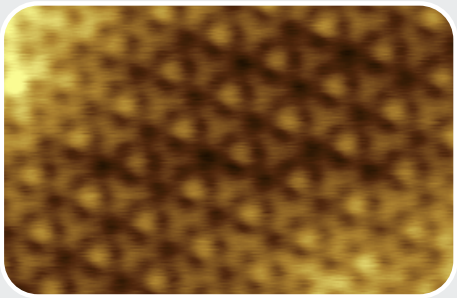
PanScan Freedom STM in UHV at 9K

Freedom 9 K closed-cycle cryo,
Vibration isolation, shields



Dr. Boyer with his complete Freedom 9 K
closed-cycle cryo-free PanScan-R9 system

$TiSe_2$ at 9K
Atomic resolution image acquired during installation
of upgrade to PanScan Freedom LT



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A CASE STUDY

RHK CUSTOMER SUCCESS

RHK PanScan SPM integrated with Cryo Industries 4K Liquid Helium Cryostat

Dr. Pegor Aynajian
Associate Professor, Physics
SUNY Binghamton University
Binghamton, NY

OVERVIEW

If you've chosen your preferred supplier of a 4 K LHe bath cryostat for a lab-built LT STM system, now what's the best choice of a scan head to mate with it for your research goals? And how can you get support for key components from different suppliers, when overall performance and research success depend on everything working just right together?

This was the situation confronting Dr. Aynajian when he joined the Physics Department at Binghamton University. His intended nano-research at SUNY-Binghamton required variable temperature starting as low as 4 K. A LHe-bath cryostat was a necessity. To get the whole package he needed within his budget, a thoughtful approach of mix-and-match plus do-it-yourself was required for the bath cryostat, scan head, and control electronics and software.

Dr. Aynajian chose Cryo-Industries of America to provide his 4 K cryostat. His decision was based on Cryo-Industries crucial combination of key features: suitability of overall design for a university lab-based self-builder/researcher; adequate 4 K hold-time; adaptability of mounts to accept a 3rd party scan head; and US-based production, service and support.

Discussing his choices, Dr. Aynajian commented,

> *With a limited start-up budget, going for a million-dollar machine was not an option.*

Now he needed to make a final decision on the scan head and control system. The RHK PanScan scan head had attracted Dr. Aynajian's attention. As he explained,

> *…it was compact, isolated from the environment by a spring/magnetic damping system, and - most importantly - customizable to enable the lateral movement of the sample as well as the possibility of introducing multiple samples simultaneously.*

There were additional factors, too. He added,

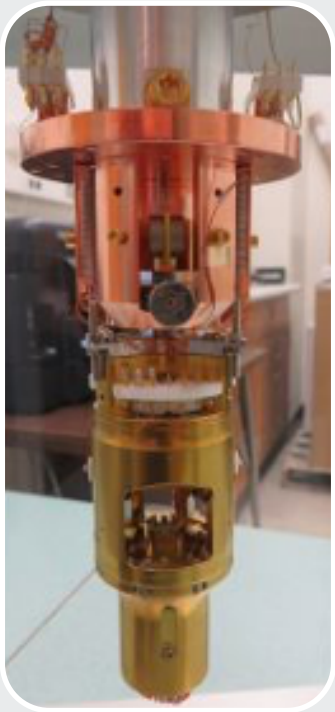
> *RHK not only provided build-your-own options, but also highly experienced engineers who helped in solving the technical details to ensure a successful integration and operation of the system.*

Likewise, he knew the optimal choice for the best scan head Control System would be RHK's R9, due to its perfect compatibility with the RHK PanScan as well its broad flexibility and readily accessible depth of capabilities for the challenging range of experiments he planned. This matched pair of LT scan head and electronic controls, both built, supported, and serviced by a single US company, provided him the proof of performance and track record to be confident in his choices. RHK agreed to build custom mounting to mate the scanner and cryostat, and to advise and assist with wiring.

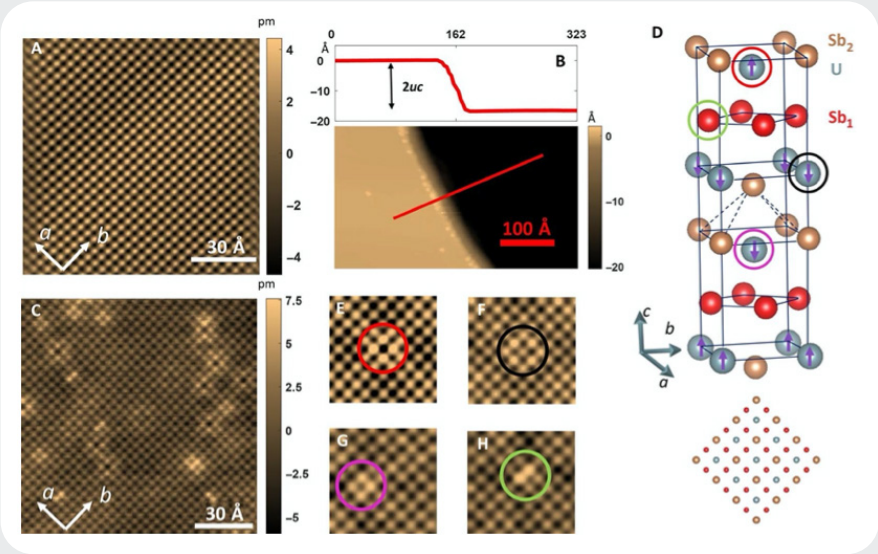
Now he could concentrate fully on his PanScan 4 K LT STM research. Dr. Aynajian is producing many published results. He is happy with his choices and the crucial support and service he received. A few of his results and images are displayed below.

SYSTEM

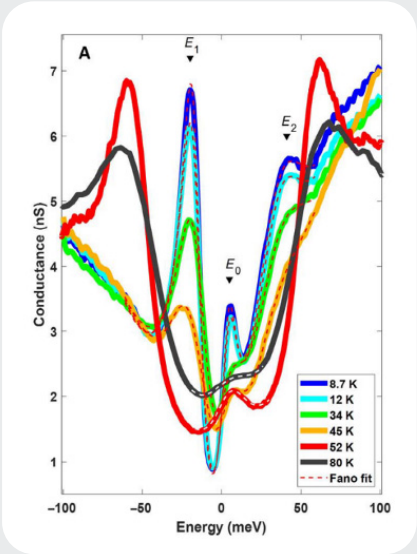
RHK's PanScan STM head and vibration isolation system (shown below), installed using an RHK-designed and built custom mount into his Cryo-Industries of America LHe 4 K bath cryostat, and controlled by RHK's R9 system. Dr. Aynajian's 4 K system is operating great and continues to produce published results.



RESULTS

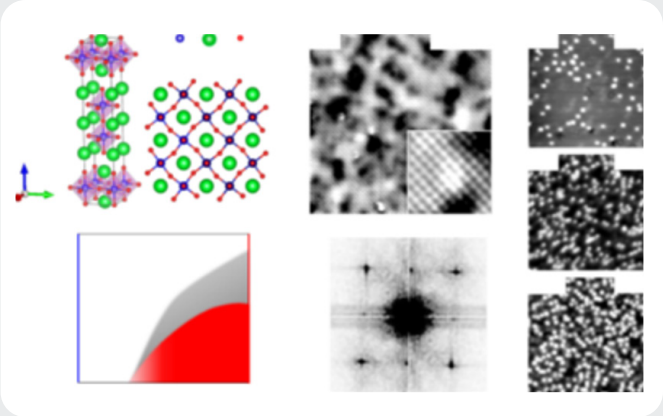


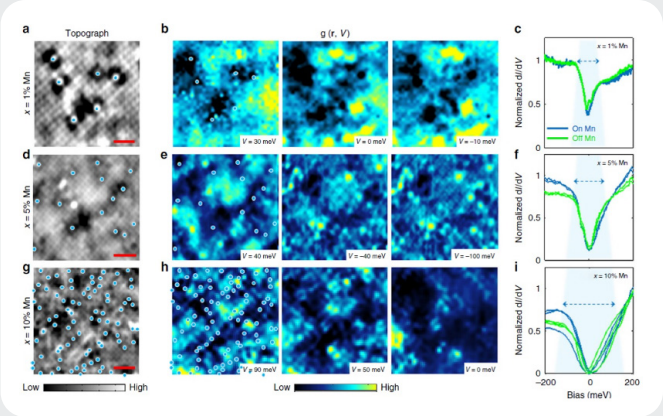
Atomic structure of $U_{1-x}Th_xSb_2$ showing four distinct types of defects resulting from Th substitution of U atoms.



Electronic states of $U_{1-x}Th_xSb_2$ and their temperature evolution

Orbital-selective Kondo lattice and enigmatic f electrons emerging from inside the antiferromagnetic phase of a heavy fermion
Science Advances | Research Article – Giannakis *et al., Sci. Adv.* 2019;**5**:eaaw9061 18 October 2019





Real space structure of electronic states in $Sr_3(Ru_{1-x}Mn_x)_2O_7$

Emergent charge order near the doping-induced Mott-insulating quantum phase transition in $Sr_3Ru_2O_7$
Nature – Communications Physics | (2019)2:36

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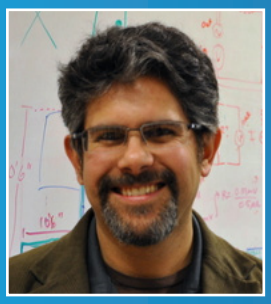
RHK Technology
Imaging the Future of Nanoscience

A CASE STUDY

RHK CUSTOMER SUCCESS

Two RHK PanScan SPMs integrated into existing UHV and cryogenic systems



Dr. Jay A. Gupta
Associate Professor, Physics
Ohio State University
Columbus, OH

SITUATION

Dr. Gupta's scientific research program has been expanding faster than the instrumentation base, prompting him to look for innovative ways to increase productivity and instrument time, within the relatively limited equipment budgets available. Dr. Gupta was able to merge funds from a new DOD DURIP award and from existing awards to upgrade and launch two more SPMs in his group, both based on the RHK PanScan head. The first new head was installed in an existing UHV chamber, while the second replaced a home-built LT-SPM that had fallen into disrepair over the last few years.

CHALLENGE

The short time-frame for these grants puts a premium on high performance solutions that can get up and running quickly, while the more limited equipment budgets (compared to startup funds) required leveraging of existing resources.

KEY QUESTIONS

1. Which UHV SPM supplier has core components – scan head and control electronics – that could solve both challenges at the same time, minimize training, and accelerate progress?

2. Which supplier can Dr. Gupta trust with CONFIDENCE to provide adaptable, proven solutions and technology, and the depth of support essential for tackling both projects quickly?

DECISION

RHK Technology was his firm choice.
Here is Dr. Gupta's view:

> *"The RHK Pan scan head provides very high stability while maintaining simple design to allow integrating into different custom systems, and R9 controller wins with its low noise level and expansion flexibilities."*

> *In the second project, we chose an RHK PanScan head to replace an existing custom-built SPM that had fallen into disrepair in my lab. As the cohort of PhD students who designed and built this STM have long since moved on, we just didn't have the time to maintain the instrument and still make the necessary progress on our funded programs.*

With two RHK PanScan kits – a PanScan STM head and a PanScan AFM/STM head, plus two RHK R9s – Dr. Gupta and his group have been able to achieve these goals. They are efficiently integrating the PanScan heads and R9 Controllers into two different lab systems. And they are effectively obtaining results, with confidence for the long term.

Dr. Gupta goes on to say,

> *[For the first project] RHK was able to provide a 'bolt-on' PanScan stage and flange that was integrated into the chamber and producing images within a week. The optical access ports and small stage size allowed us to integrate an in-situ objective optic to tightly focus light onto the tunnel junction.*

For the second project,

> *The small size of the RHK stage and the compatibility with our existing sample holders and vacuum chamber were big selling points, and the new head was running in air on the table within a few days. The relatively simple wiring requirements allowed us to quickly integrate the stage into the existing UHV chamber, and we have now been imaging samples at room temperature while we complete the redesign of radiation shields that will allow for low temperature measurements. The stability of the instrument has allowed us to image samples remotely and maintain progress even with lab disruptions due to COVID.*

And for RHK, it's ***Mission Accomplished*** on both projects!

SYSTEM

Two PanScan scanners and two R9 controllers for two projects:

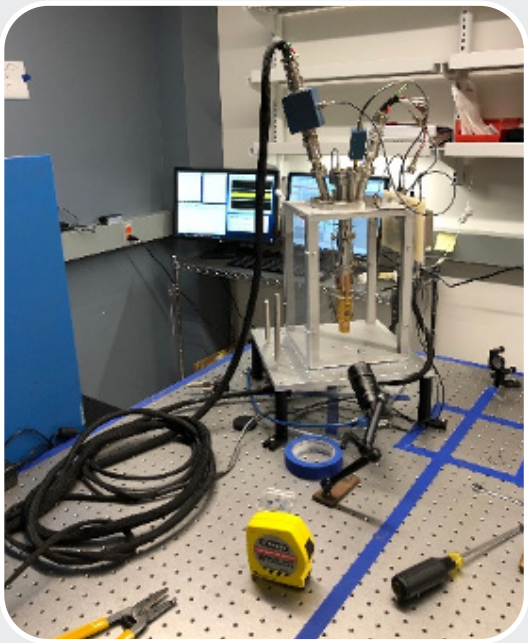
1. DoD DURIP award for custom STM system. Using existing UHV chamber already outfitted with integrated ion pump and load lock. Subsequently designed and built e-beam heater for sample annealing, and added ion sputter gun. Chamber now on optical table with high-intensity laser system to study laser-modified surfaces.

2. Replacement for old custom-home-built LT-AFM/STM that had fallen into disrepair. New PanScan AFM/STM using same sample prep capabilities. Scanner suspended from Janis LHe bath cryostat with base temperature of 7 K.

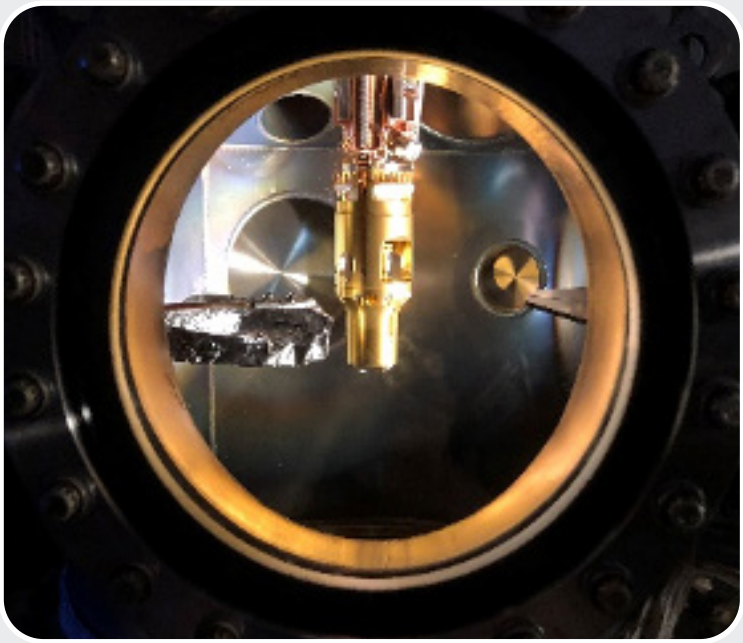
RESULTS

System builds #1 and #2 are shown below with initial results.

PanScan #1: STM (bolt-onto existing UHV chamber)



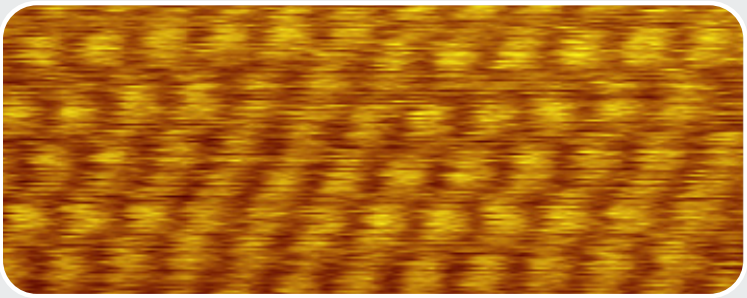
STM and flange in test cabinet on optical table top. Blue lines mark out an optical path under design.



STM integrated into UHV chamber.

Preliminary image of HOPG test sample at RT in UHV.

Note: Imaging is under non-optimized tip and vibration conditions.

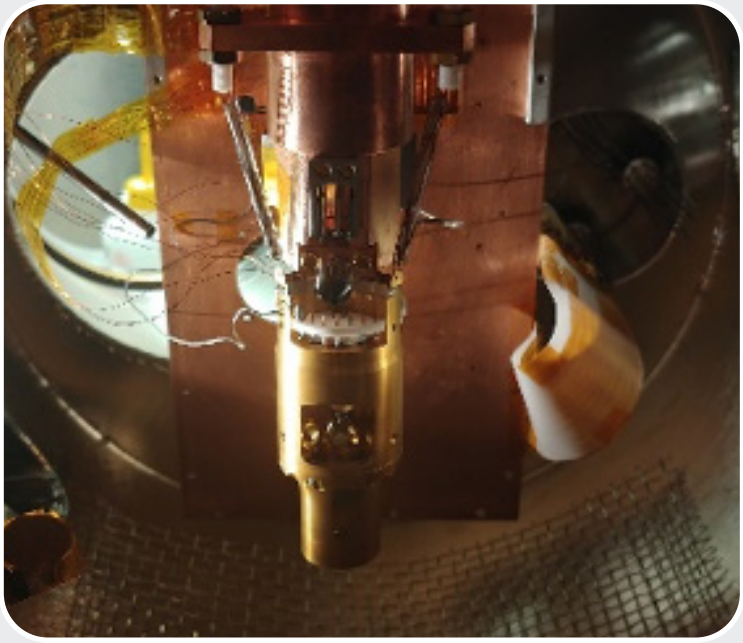


PanScan #1 will be used to study laser/surface interactions and dynamics.
Atomic resolution imaging will be used to probe the initial stages of laser-induced ablation, starting from the single defect level up to fully periodic surface structures.

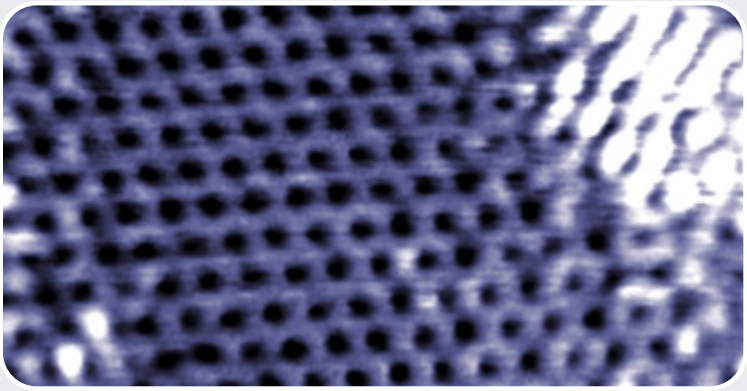
PanScan #2: AFM/STM (replacing existing head in custom-built LT-AFM/STM)

This shows the PanScan head bolted onto the cold plate of a Janis LHe batch cryostat.

While the Gupta group is using the RHK spring suspension and clamping mechanism, they also made a custom support plate to get the height of the stage right for the chamber.
They also made up a wiring harness to go from the STM head to their multi-pin UHV feedthrough.



An STM image of monolayer hBN, taken at room temperature in UHV.
Wrinkles and defects distort the honeycomb lattice in places.



PanScan #2 will be used to study novel magnetic materials using the spin polarized STM technique.
Magnetic skyrmions are analogous to traditional magnetic domain walls. These magnetic skyrmions can be realized in materials down to nanoscale dimensions, which is promising for high-density storage.

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RHK BUILDS FOR A PURPOSE

Your Research, Your Success. Eplore with Confidence

PanScan Powerhouse: Ultra-stable and rigid, unprecedented low drift and low noise, the PanScan provides picometer stability STM/qPlus-AFM functionality, exceptional spectroscopy performance, and fully compatible with cryogenic temperatures and high magnetic fields. It is extremely reliable in demanding settings from ambient to UHV, millikelvin to 400 K. In use by over 70 labs worldwide with hundreds of publications.

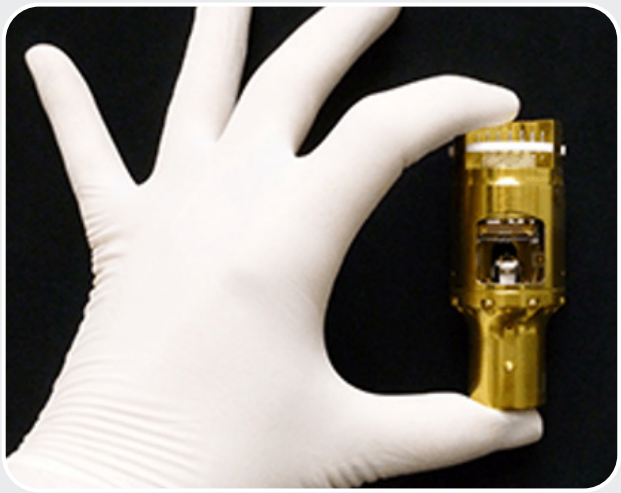
PanScan offers a wide variety of important practical features, such as industry-standard flag-style sample plates; 4 electrical contacts on the sample stage; 5mm XY coarse sample offsets; integrated temperature sensor; internal sample heater for localized temperature control; multiple large opening in the body providing access to the tip/sample junction.

Compact and adaptable, PanScan is available in configurations from just the scan head for integration into a customer's homemade system to complete UHV surface analysis systems.

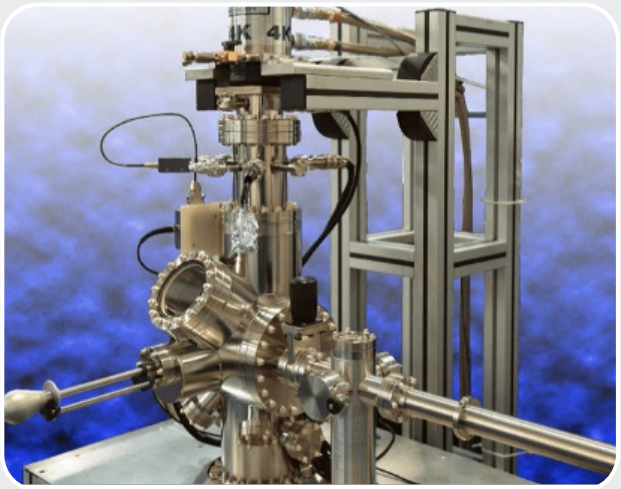
The PanScan Freedom SPM system was the world's first cryogen-free UHV SPM system. With more than thirty systems installed in leading labs around the world, RHK opened the door to high performance cryogenic SPM research for labs without a reliable and affordable source of liquid helium.

The PanScan Freedom never needs liquid cryogens – even running 24 hours a day producing atomic resolution images and lengthy, sophisticated STS data. No wasted time and money tied to LHe. No interrupted or delayed experiments waiting for cryogen refills. No hassles, no risks handling dewars. The PanScan allows you to spend more time on research and achieve better results faster.

Wide optical paths in the PanScan Freedom enable high NA lenses to position the probe over features as small as 2 µm, critical in device, exfoliated and inhomogeneous samples.

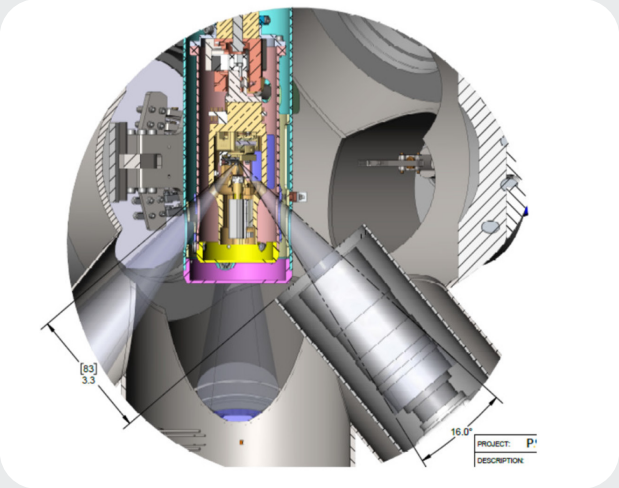


PanScan: Better by Design

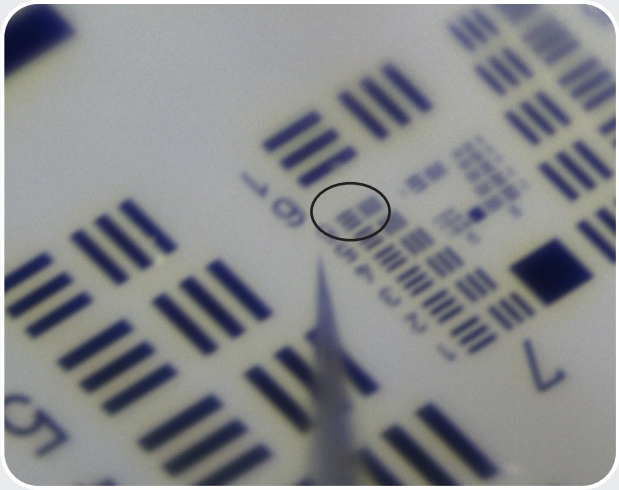


Free Yourself with PanScan Freedom

Wide optical paths in the PanScan Freedom enable high NA lenses to position the probe over features as small as 2 µm, critical in device, exfoliated and inhomogeneous samples.



Ultra-compact design of PanScan enables short working distance of optical objectives

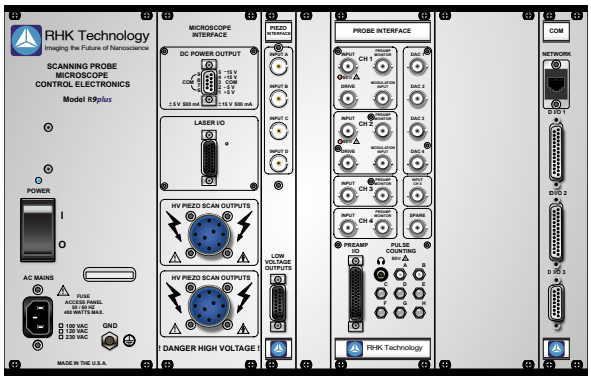


Optical image of tip-sample junction on USAF 1951 test target. Circled feature are 2.2 µm lines/spaces.

RHK R9PLUS CONTROL

Your Research, Your Success.

Explore with Confidence: With the plus Advantage, no Controller is better equipped or more capable to take on any research challenges you face. R9plus provides the ultimate in SPM Control; revolutionary architecture provides the highest signal quality and performance in an elegant one-box design. As you pioneer the frontiers of Nanoscience, count on RHK's R9plus SPM Controller to lead the way.



RHK delivered the world's first commercial STM control system in 1987 and many of the world's leading groups rely on RHK systems. Through eight generations of evolution and refinement, over 1,000 of RHK original "Blue Box" controllers were installed worldwide. Then we revolutionized the field again with the R9 family of one-box integrated controllers. More than 300 are propelling research groups in every field of nanoscience.

RHK delivers compelling value and proven quality to broaden the frontiers of atomic scale research. The company has earned a world-wide reputation as a supplier of superior technology and customer support.

Every day, in university and government labs around the globe, RHK research platforms lead to new discoveries in nanotechnology. Founded in 1981, RHK Technology brings over 25 years of experience to the design and manufacture of advanced UHV SPM instruments. Our installed base continues to grow and now includes over 300 systems and 1,300 Controllers.

RHK'S GLOBAL CUSTOMER BASE & WORLD-WIDE SALES CHANNELS

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