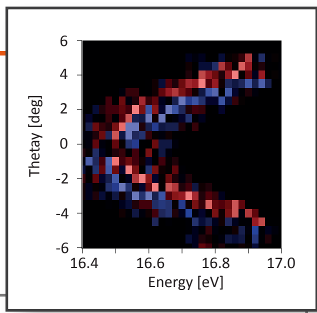
Fall 2018 News

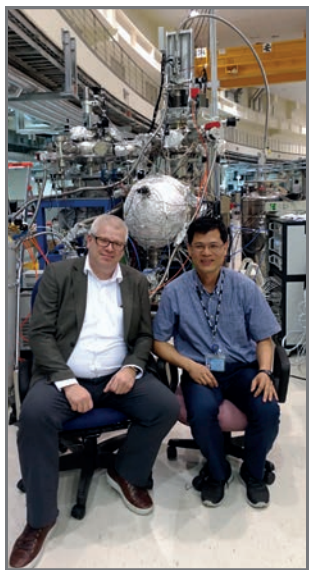
Scienta Omicron - Superior Technology

Spin-Resolved ARPES

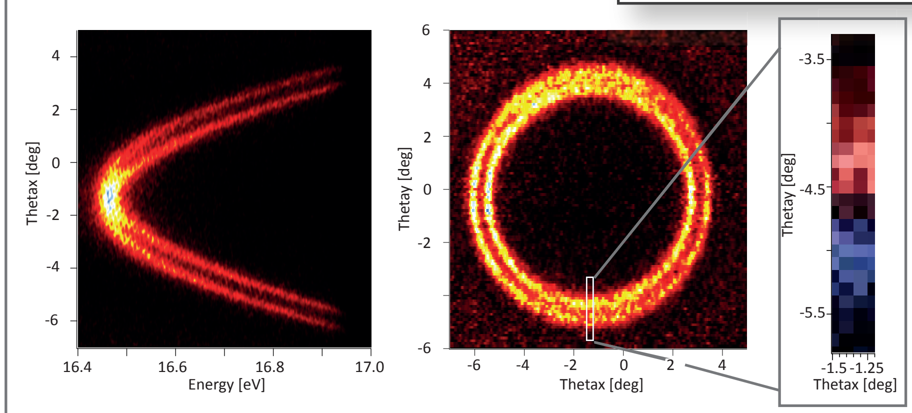
Highlight from Taiwan



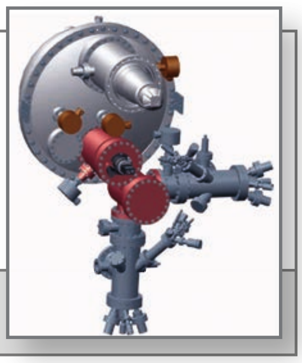
Prof. Lin of the National Tsing Hua University has a new ARPES system based on the Scienta Omicron DA30-L analyser with a 2D Ferrum VLEED spin detector and the VUV5k UV source. The system was recently installed and already shows excellent results.
Test measurements were made using a LHe cooled Au(111) sample. In these data the DA30-L ARPES mapping and Spin mapping modes were utilized to take advantage of the analyser's deflection capability. All data was therefore acquired with fixed manipulator/sample position. The complete ARPES data cube was acquired in 10 min and the displayed cuts to the right show the ThetaX/ThetaY Fermi surface map and ThetaX energy cut. Both show clear separation of the spin bands in the surface state. The high resolution spin resolved data from the indicated position in the ThetaX/ThetaY map was acquired with maximum resolution settings in 2h. The two spin directions indicated with red and blue are clearly separated with excellent resolution and statistics. A full energy/ThetaY overview was recorded in only 1h.



Prof. Lin, NTHU, and Dr. Wiell (left), Scienta Omicron, in front of the Spin-ARPES system.



The system provides state of the art ARPES data and the high efficiency of the spin detector is sufficient to allow both high resolution and fast overview (see insert) spin resolved measurements.

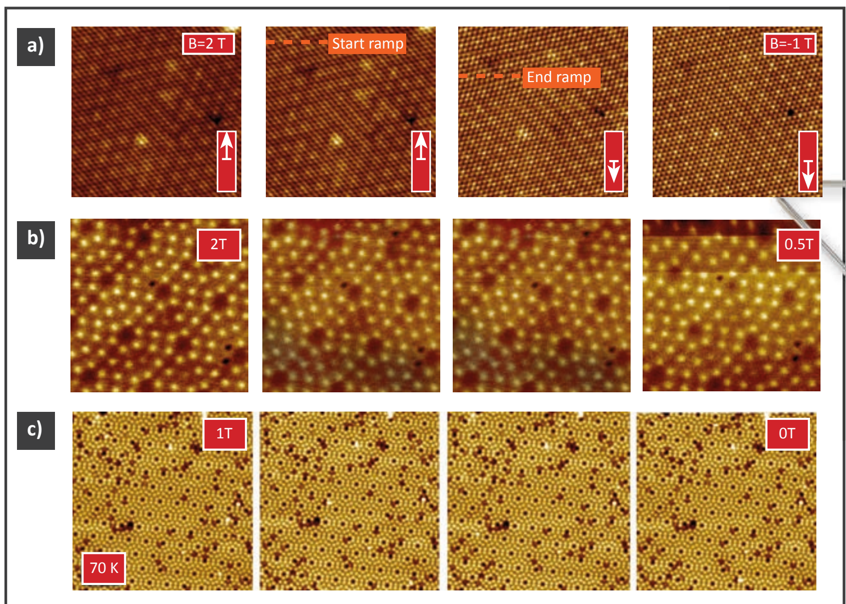


Key equipment: VUV5k and DA30-L equipped with a 3D Ferrum VLEED detector system. (see insert)

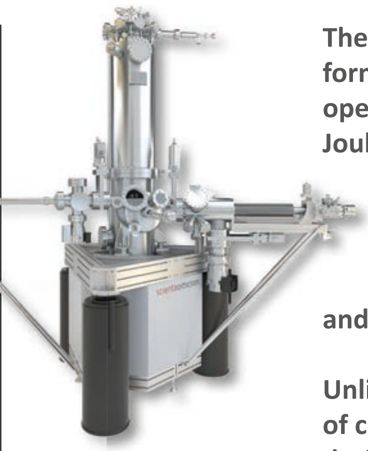
Data courtesy: Prof. Dengsung Lin, Department of Physics, National Tsing Hua University, Taiwan

TESLA JT SPM

Continuous SPM imaging during magnetic field variation



Three series of pictures (4 across each row) of STM and QPlus AFM images from various surfaces under different imaging conditions.
a) Continuous STM on $NbSe_2$ at T = 1K with magnetic field variation from B_z = 2T to B_z = -1T.
b) Continuous QPlus AFM on Si(111) 7x7 at T=1K with magnetic field variation from B_z = 2T to B_z = 0.5T.
c) Continuous STM of Si(111) 7x7 at T=70K with magnetic field variation from B_z = 1T to B_z = 0T.



3D Model of a TESLA JT SPM TriLeg system.

The new TESLA JT SPM continues to prove its extraordinary performance and versatility under various operating conditions and opens up the route to new experiments. The cryostat includes Joule-Thompson (JT) cooling, allowing for temperatures down to 1K. The superconducting UHV-magnet generates magnetic fields up to 3T. This cryostat design ensures the lowest possible He consumption. A He volume of only 11 l provides 5 days of uninterrupted measurements even while operating the magnet and varying its field strength.

Unlike other SPM designs, the TESLA JT SPM is uniquely capable of continuous STM or QPlus AFM imaging and spectroscopy maps during magnetic field variation, all while keeping the tip at the same location with atomic scale precision! The accompanying series of images are from videos taken while varying the magnetic field and prove this precision for both STM and QPlus AFM measurement modes.
Beyond this the TESLA JT SPM – in contrast to conventional approaches – gives access to a large temperature range. Potential applications include investigations of molecular and atomic structures and their behaviors in both static and dynamic magnetic field conditions at various temperatures.

MATRIX 4
with new QSpeed™ AFM Mode

The new QSpeed™ AFM mode paves the way for stable and high speed QPlus[1] imaging with large scan ranges and high corrugations. QSpeed™ is based on a tuned oscillator technique which has recently been advanced by Udo Schwarz's group at Yale University through which it is licensed [2].

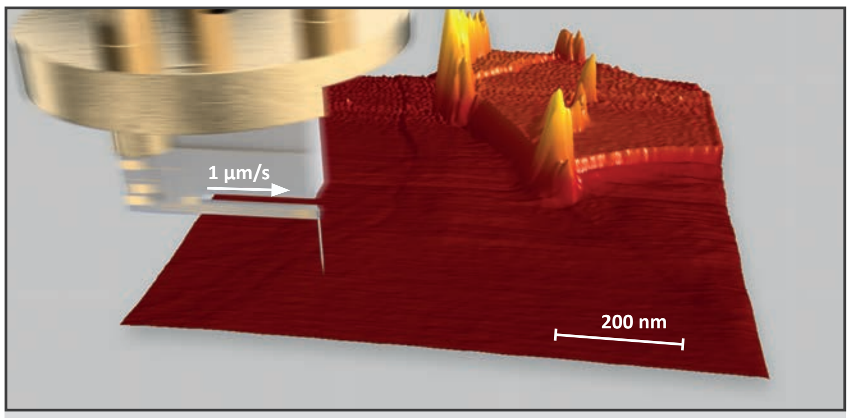
The method overcomes limitations of conventional frequency modulated QPlus AFM with slow scan speeds, where single survey images on the scale of 100 nanometers can take many hours. In addition, the high likelihood of tip crashes on corrugated samples has been dramatically reduced and therefore allows using QPlus AFM technology in a much broader field of applications and with maximum simplicity for less experienced users.

The first results using QSpeed™ with MATRIX 4 show undisturbed images with a surprisingly high scan speed of up to 5µm per second in a VT AFM operated at room temperature in Scienta Omicron´s R&D lab.

Although the Si(111) surface was contaminated with weakly bound clusters of several nanometres size, scans were completed with no major tip modification or tip crash (Fig. 1).

The QSpeed™ AFM mode will be available for all MATRIX 4 controllers using Scienta Omicron's new Zurich Instruments powered PLL AFM controller.

(1) Giessibl F.-J. Science, 1995, 267(5194): 68-71
(2) Tuned-Oscillator Atomic Force Microscopy, licenced from Yale University, O.E. Dagdeviren et al., Nanotechnology 27 (2016) 065703, patent pending.



Fast survey scan on contaminated Si(111) sample using QSpeed™ with a QPlus sensor. The 1 x 1 µm scan was recorded with a scan speed of 1 µm/s at room temperature within 13 minutes. The new mode allows scanning the tip over large particles without tip crash or dirt pick up.

QSpeed™ offers:

- User friendly & simple QPlus operation - for all user levels
- Fast operating QPlus AFM at low- & room-temperatures
- Survey scans on surfaces with high corrugation
- Studying large scale ordering effects
- Ultimate resolution on molecules

Atomic-scale rewritable memory using scanning tunnelling microscopy techniques*

Prof. Wolkow and his co-workers at the University of Alberta in Edmonton, Canada have created the most dense, solid-state memory in history using scanning probe microscopy techniques.
Such devices are created by atom manipulation in combination with efficient error correction/editing based on machine learning methods. These new techniques have been used to control the tip for automated error-free device fabrication in a Scienta Omicron LT STM at 4 Kelvin.
The patterns are written by hydrogen lithography with atomic precision into a hydrogen-passivated Si(100)-2×1 surface. In a second step dangling bond structures are created and corrected by hydrogen repassivation if necessary.
Hydrogen lithography and hydrogen repassivation unlock a wide range of new possibilities including the creation of hundreds of precisely placed identical qubits for quantum computation and the realization of room temperature, stable, atomic-scale memory.

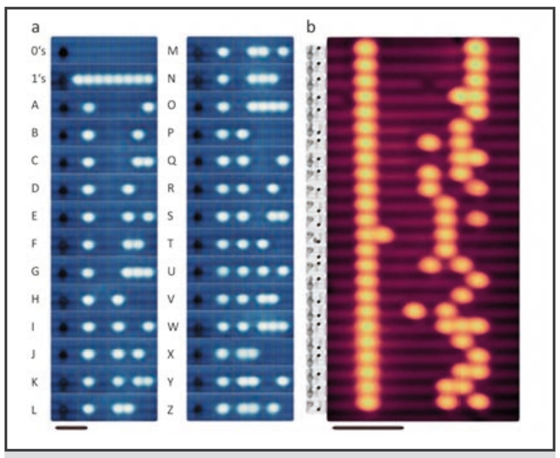


Fig.1: 8-bit and 192-bit atomic rewritable memories.
The 192-bit array was written in 250 seconds into a hydrogen-passivated Si(100)-2×1 surface.

* 'Lithography for robust and editable atomic-scale silicon devices and memories' (doi:10.1038/s41467-018-05171-y) - appears in the current issue of Nature Communications.

Microsoft and University of Copenhagen open Quantum Materials Lab

Microsoft has officially opened the doors to a brand-new Quantum Materials Lab at its Lyngby site in Copenhagen where, together, researchers and engineers from the University of Copenhagen and Microsoft are poised to develop the materials underpinning the first scalable quantum computer in the world. Microsoft's collaboration with public universities also extends to include the Technical University of Denmark, a neighboring institution to the new Microsoft Quantum Materials Lab.
Peter Krogstrup, Microsoft Scientific Director and Professor at the Niels Bohr Institute at the University of Copenhagen, leads the team at the Quantum Materials Lab and aims for a global breakthrough in quantum computing. Scienta Omicron is proud to be part of this challenge. The recently installed LT NANOPROBE is one of the key instruments in the new lab, enabling in-situ analysis of qubit material quality and prototype circuits with atomic-precision positioned, electrical SPM probes.

Peter Krogstrup: 'The LT NANOPROBE will be used in conjunction with the other equipment in the Microsoft Quantum Materials Lab to understand materials properties in order to tackle a central challenge in quantum computing: quantum state decoherence.
The Lab will approach this fundamental problem by developing customized hardware that is designed to fabricate complete quantum networks while keeping all processing steps in an ultra-clean environment.'

Bristol NanoESCA Laboratory

Rapid successes made by one of the most advanced surface analysis instruments in UK

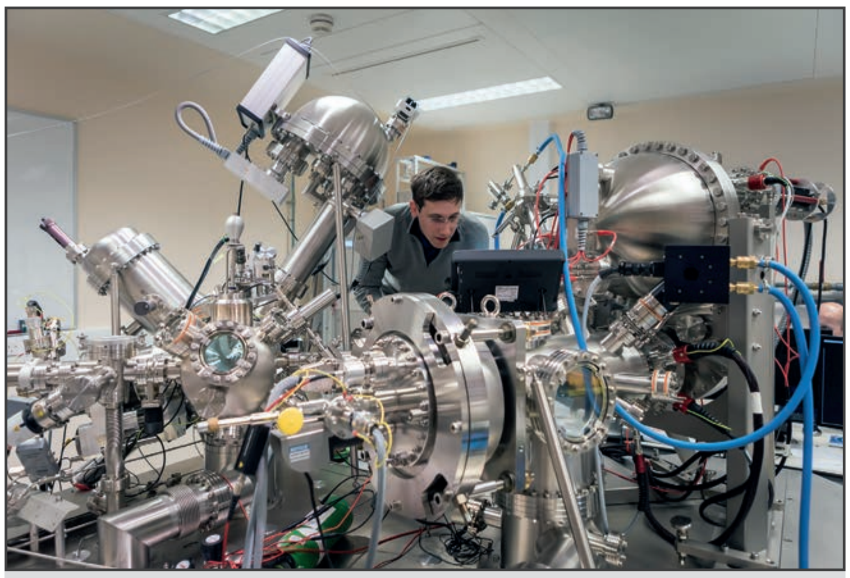


Figure 1: Mattia Cattelan working in the Bristol NanoESCA Laboratory. On the right hand side you see the NanoESCA system with its liquid helium cooled microscope sample stage, on the left hand side an extended preparation chamber with a separate XPS setup and a high resolution LEED.

Shortly after its installation the Bristol NanoESCA Laboratory [1] (see figure 1) started its operation in the beginning of 2017 and since then spawned a lot of scientific attention for its unique capabilities to surface science researchers in the UK working on advanced materials for Energy, NanoBio and Quantum photonics. The publication list of the lab is rapidly growing, covering already 4 published and 3 submitted journal papers. ‘At least another 5 are really close to submission‘, stated Mattia Cattelan, who is the specialist responsible for scientific analysis with the NanoESCA system.

The Bristol NanoESCA Lab is organized as user-facility, which has allowed a wide range of advanced materials to be investigated with the machine, including Graphene, Diamond, noble metal catalysts, CZTS photovoltaics, Uranium Crystals and thin Films, Topological Insulators, 2D Heterostructures, Nanoalloys, and Transition Metal Dichalcogenides (TMDC).

A nice example of the measurements performed in Bristol on TMDCs is shown in figure 2, exploring the differences in the band structure of VSe_2 along various high symmetry axis with intriguing resolution. The use of full-wavevector ARPES (at the Fermi surface) notably improved the acquisition times for such complicate experiments [2].

Neil A. Fox, head of laboratory, says: ‘Of specific interest to University researchers and synchrotron users is the NanoESCA capability to offer energy filtered PEEM with a lateral resolution of 13 nm, image field of view can vary from 1100 µm to 3 µm, and micron-scale-Angle-Resolved-Photoemission Spectroscopy (µ-ARPES) from mono-crystal domains as small as 3 µm with an energy resolution of 21 meV at 29 K. This capability makes the Bristol NanoESCA highly complementary to the techniques offered on beamlines I05 (NanoARPES), and I09 (TOF momentum microscope) at the Diamond Light Source (DLS).
Since the NanoESCA is a laboratory-based beamline utilizing focused light sources, it can operate throughout the year and offer a pre-analysis service to help researchers from industry and academia to prepare sample materials for UHV analysis and obtain preliminary data to help target more detailed analysis at DLS. This would be especially useful to industry users who pay significant amounts of money for beamtime access. This pre-analysis service will also be used to leverage industry and user support for future expansion of the Bristol NanoESCA capability involving the funding of additional tuneable light sources by EPSRC or DLS‘.

[1] http://www.bristol.ac.uk/physics/facilities/nanoesca/
[2] M. Cattelan and N. A. Fox, Nanomaterials 2018, 8(5), 284

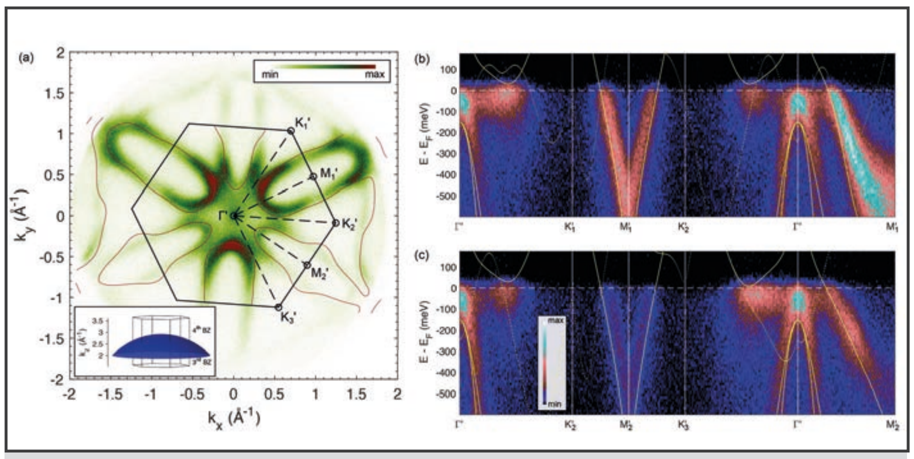


Figure 2: (a) Momentum microscopy image of the VSe_2 Fermi level. These images were acquired at different kinetic electron energies to measure a full momentum and energy resolved data cube, which makes it easy to analyze and compare the band-structure of the material along various high symmetry axis (b,c). Submitted to PRL. Courtesy of J. Laverock.

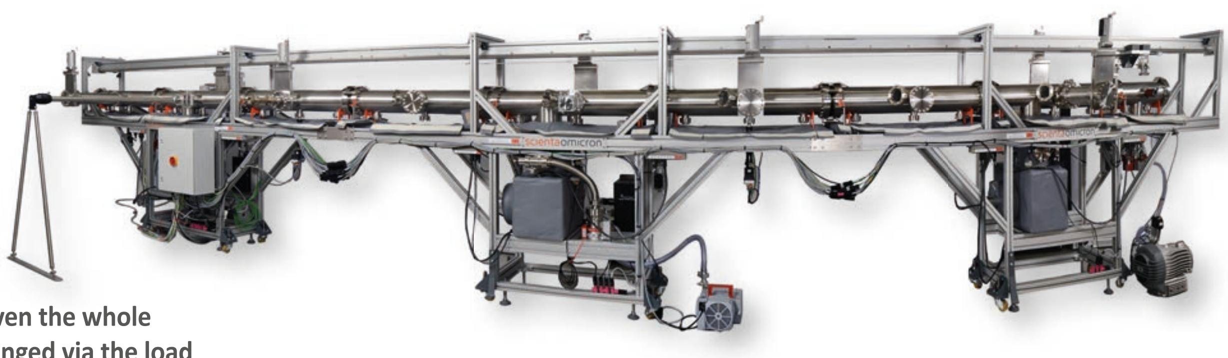
A Versatile Backbone for UHV Cluster Systems

New Linear Transfer Line

This newly designed transfer line removes length restrictions, providing for cost-effective, high quality expandability. Composed of independent, movable 3 m long segments, the linear transfer line (LTL) efficiently connects new and existing growth and analysis modules, maximizing lab space for materials innovation platforms.

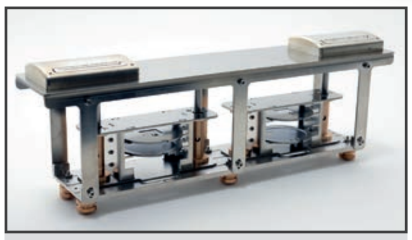
Optimized pumping and quality design ensure true UHV conditions while providing a high degree of configuration flexibility. Gate valves can separate LTL sections, minimizing cross-contamination and isolating subsystems for servicing. Multiple LTLs can then be easily extended or integrated with rotary distribution chambers.

The trolley accepts multiple sample plates or wafer carrier rings (e.g. six 2“ carrier rings).

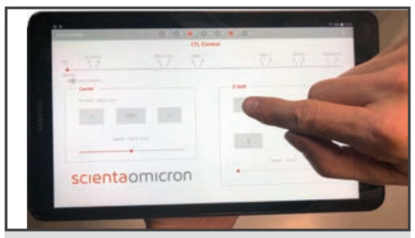


A robust magnetic coupling mechanism between the driver and the sample trolley maintains connection as the trolley passes through flange connections and gate valves. Samples, and even the whole trolley, are easily exchanged via the load lock segment.

The integrated MISTRAL system monitors and controls pumps, gauges, pneumatic valves and heater controls, including bake-out recipes and remote monitoring. Optional motorization integrates convenient control from a tablet PC or the system control touch screen.



Removable multi-sample trolley



Tablet PC with control software

scientaomicron

NEWS from HAXPES Lab

New publication & Webinar

We are very happy to announce that our paper ‘A novel laboratory-based hard X-ray photoelectron spectroscopy system‘ is now published in: Review of Scientific Instruments 89, 073105 (2018); (https://doi.org/10.1063/1.5039829). It is open access for everyone to download. In the paper you can read about our HAXPES Lab, a home lab system for HAXPES measurements using GaKα radiation.

Parallel a HAXPES webinar is available here: https://physics-world.com/a/haxpes-measurements-in-your-own-laboratory/

Product Configurator

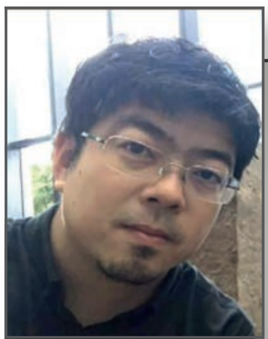
Available for Lab10 MBE systems

A digital product configurator is now available for the Lab10 MBE system – a research system for innovative material development under UHV conditions. It enables the direct and quick configuration of a Lab10 MBE system tailored to the customer needs with immediate visible feedback, based on real-time 3D technology.

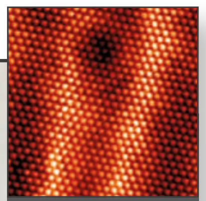
Modifications to the system can be made with one mouse-click, thus parallel configurations can be designed in seconds. Please contact our sales team to create your individual configuration!

Excellent Performance

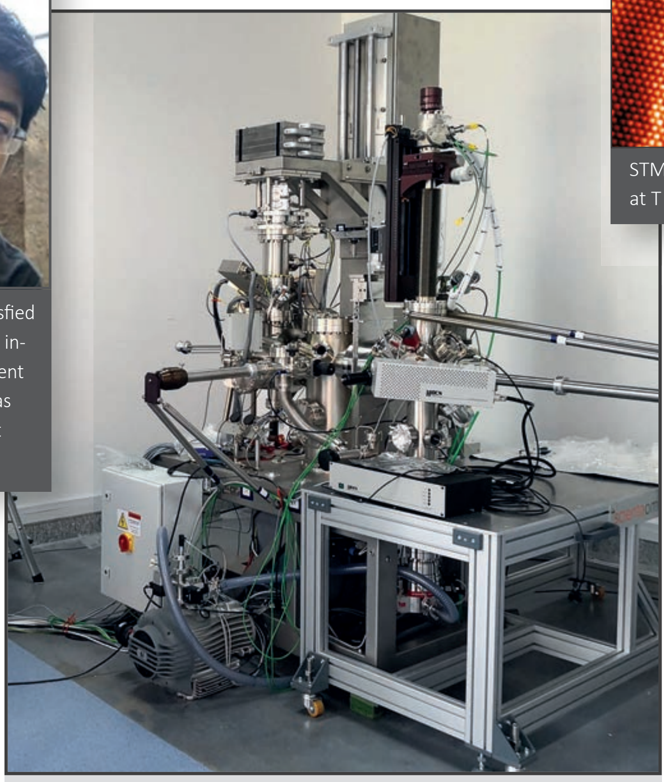
Fermi Dry Cool^{TM} - Installed in China



Prof. Ma: ‘I am very satisfied with both, the seamless installation and the excellent performance - which was achieved in such a short time.’



STM on Au(111) at T = 9.5K.



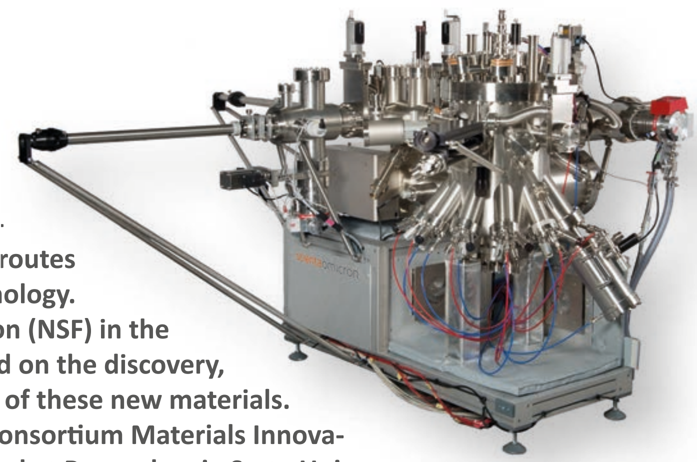
The Fermi DryCool^{TM} System with optical access connect to an IR Spectrometer for surface photo chemistry applications.

Scienta Omicron’s DryCool^{TM} technology promises exceptional mechanical stability in the pm range as well as thermal drift outperforming SPM´s with conventional cooling techniques, while paving the way for measurements with unlimited measurement time at no helium consumption and cost.

The system for Prof. Zhibo Ma at the Dalian Institute of Chemical Physics of the Chinese Academy of Science has been customized for his specific requirement including an IR spectrometer for surface photo chemistry integrated on an additional bench connected to the Fermi DryCool^{TM} system. The system has been thoroughly tested at our Labs in Germany and successfully installed by our excellent Chinese service team within only 2 weeks installation.

2D Layered Materials

EVO-50 MBE system for NSF in USA



Recent advancements in two-dimensional (2D) layered materials have created exciting opportunities in fundamental materials research and routes to disruptive high-impact technology. The National Science Foundation (NSF) in the USA, created a program focused on the discovery, development, and deployment of these new materials. The Two-Dimensional Crystal Consortium Materials Innovation Platform (2DCC-MIP) housed at Pennsylvania State University is one of two such programs presently funded. Led by professors Dr. J. Redwing, Dr. V. Crespi, and Dr. N. Samarth, 2DCC-MIP engages in transformational research for bulk crystal and thin film (2D) chalcogenide growth.

Realizing the full potential of these 2D material requires atomic-level mastery at wafer-scale synthesis. To that end, the heart of the research is the synthesis capabilities of a Scienta Omicron EVO50 Molecular Beam Epitaxy (MBE) system integrated with unique in-situ diagnostic capabilities. In developing synthetic capabilities and hybrid MBE techniques these researchers are developing and exploiting new material nucleation and growth kinetics control. The 2DCC-MIP aims to revitalize the science of crystal growth in the U.S.

‘A truly unique aspect of the 2DCC is that it will offer a user-oriented facility that tightly integrates the state-of-the-art in all three critical areas: synthesis, characterization and modeling,‘ said Samarth.

The 2DCC-MIP‘s current capabilities enable it to immediately deliver samples to the wider community of crystal researchers. Within a year, according to Redwing, the facility will be open to train external users. The research activities of these external users and those of the 2DCC-MIP in-house team will together create a community of researchers poised to make transformational gains in the accelerated discovery and deployment of chalcogenide 2D materials. Scienta Omicron is proud to take such a significant role in this transformative materials science research.