NEWSFLYER FALL 2020

Scienta Omicron Company Update

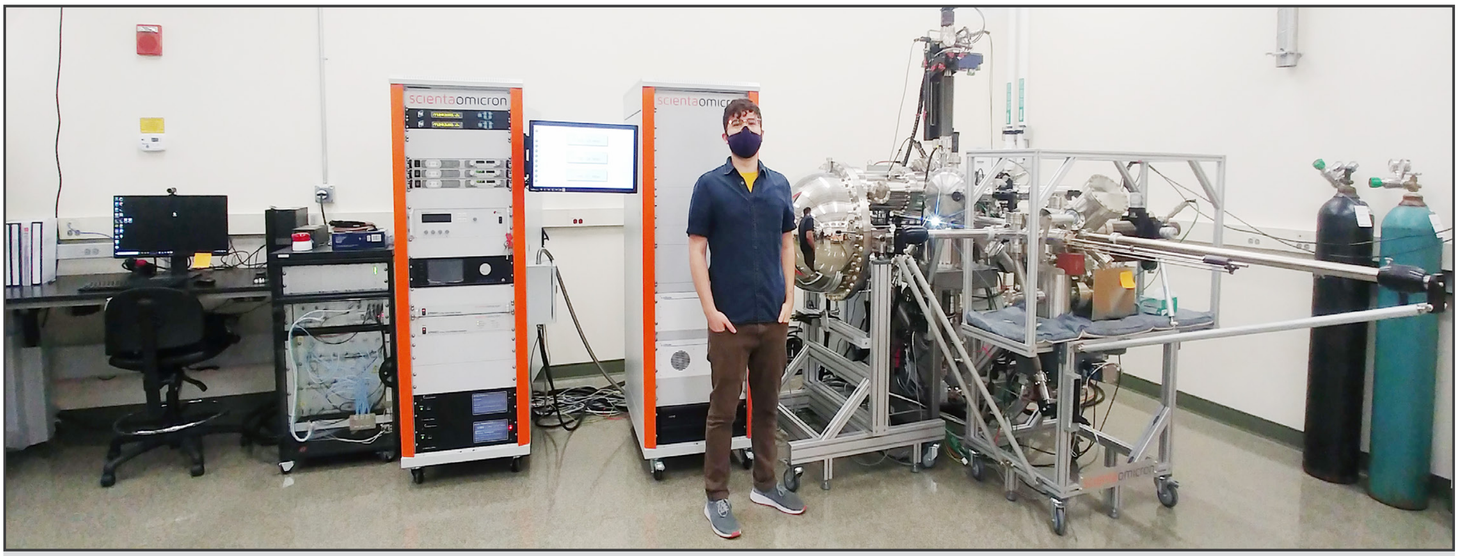
Message from CEO Johan Åman

Over the past six months the global COVID-19 situation has caused our company to work differently and change operational process, but we are pleased to report that progress has continued well despite the uncertainty of the time period.
I would like to take this opportunity to share some highlights of the past six months. We have:

- Completed the first ever remote installation of a system, a **Lab10 MBE** in Canada
- Shipped our first **DA20 Electron Analyser** for **ARPES** and **XPS** to a customer in Japan
- Successfully merged Sigma Surface Science expertise and products into our product and service offerings
- Shipped and installed the first HAXPES Lab in North America at Binghamton University
- Shipped the first **LT SPM Lab** built and tested in the recently founded SPM and XPS Business Unit in Taunusstein, Germany
- Provided more online and remote Service Support Sessions than ever before

We thank you, our customers, for your unrelenting support and resilience over the past six months.
We are proud to be part of the international research community and look forward to continuing to support you to meet your research goals into the future.

CEO Johan Åman.



Dr. Matthew Wahila next to the first shipped and installed HAXPES Lab in North America at Binghamton University.

The Newly Installed HAXPES Lab at Hyogo/SPring-8 in Japan

'Beamtime' Available for Industrial Companies

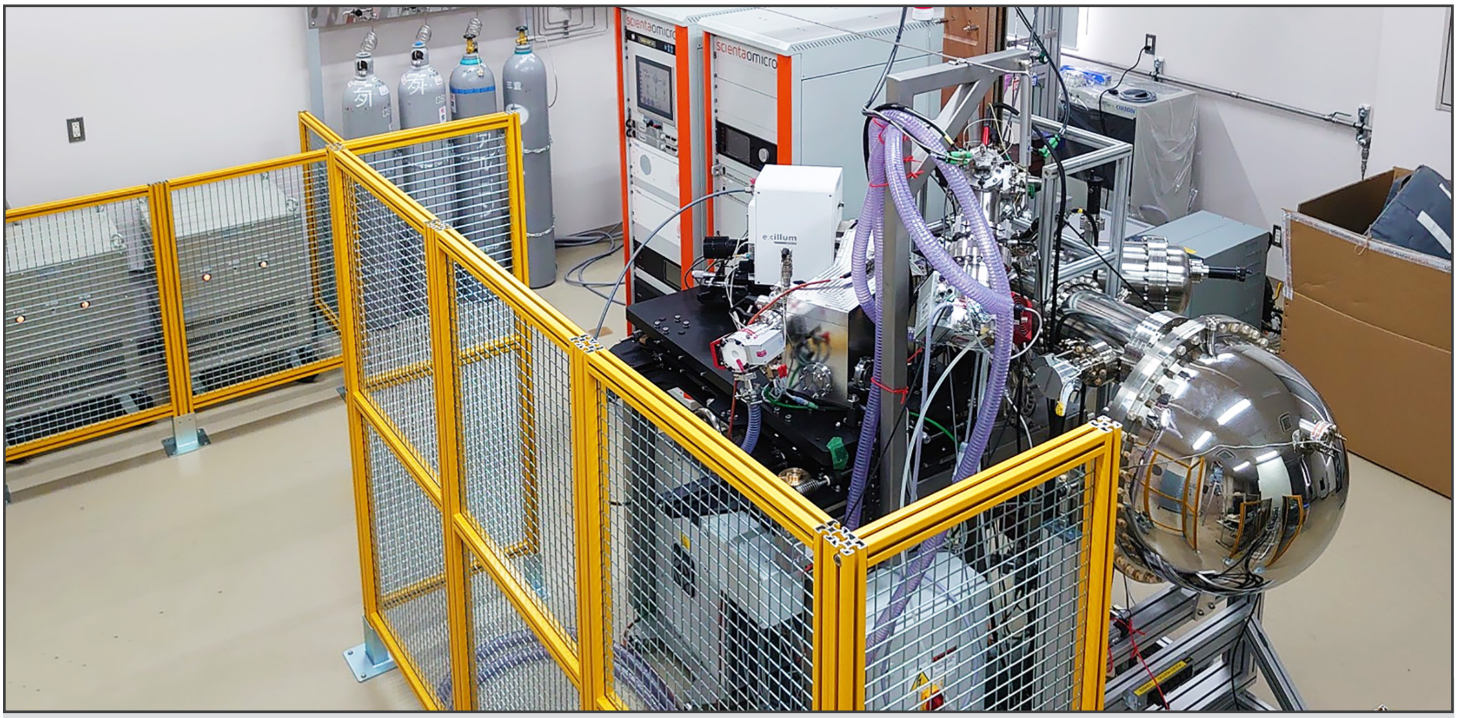
The recently installed Hard X-ray Photoelectron Spectroscopy Lab, HAXPES Lab, at Hyogo Science and Technology Association in Japan will support a wide variety of both fundamental and industrial research applications. The **HAXPES Lab** will enable research into a variety of areas all without the need for a synchrotron end station including, semi-conductors, rubber, batteries, organic materials, and steel.

Kazushi Yokoyama, Director of the Synchrotron Radiation Research Centre says:

> *"We aim to provide an advanced tool in the form of the HAXPES Lab for researchers from industrial companies to use to research and analyse new materials such as metals, electric devices and polymers. The HAXPES Lab will help our research group with chemical states analysis, for instance, heterojunction's interface between substrates, coated materials, and contaminants."*

The **HAXPES Lab** system is located at SPring-8, a synchrotron radiation facility in Hyogo, Japan, and access is open for industrial partners of the facility. 'Beamtime' will soon be available to book by the hour by private industry and customers. A database of HAXPES Lab reference measurements is being populated to help users plan experiments.

The Hyogo HAXPES Lab Hero,
Synchrotron Radiation Research Centre,
Created by Reon Sakura.



The HAXPES Lab at the Hyogo Science and Technology Association.

NanoESCA at MPI Stuttgart Contributes to New Study of High-Mobility Graphene on Ge/Si Substrates

Micro-ARPES for Future Device Engineering

As reported in the Scienta Omicron Fall 2019 newsletter, the Prof. Ulrich Starke group at the Max-Planck-Institut für Festkörperforschung in Stuttgart has extended their instrumental capabilities by the addition of a new NanoESCA momentum microscope [1]. One of their research focuses is epitaxial graphene on silicon carbide (SiC) surfaces. Figure 1 shows an impressive example of a high quality 4D data cube, measured in the micro-ARPES mode of the NanoESCA. The sample is monolayer graphene on SiC and was prepared by sublimation growth in an argon atmosphere. A very helpful feature of momentum microscopy for such studies is the ability to capture the full angular space of photoelectrons simultaneously, i.e. all Dirac cones of graphene at the Fermi energy in one shot.

This same operational mode was also extremely practical in a recently published study on high-mobility graphene on Ge/Si (100) substrates, a joint effort between the Prof. Ulrich Starke group, researchers in Chemnitz, Frankfurt (Oder), Göttingen, and Lund [2]. The charge carrier mobility of this material combination was found to be very high due to a quasi-charge neutrality of the graphene layer. The latter hosts 48 Dirac cones (due to four Ge facets and two rotated graphene domains), all of which were probed simultaneously by the NanoESCA momentum microscope. Future studies on device structures of this material will especially benefit from the combination of the real- and momentum-space capabilities of the NanoESCA.

References:
[1] https://www.fkf.mpg.de/6700262/30_nanoESCA
[2] J. Aprojanz, Ph. Rosenzweig et al., ACS Appl. Mater. Interfaces 12, 43065 (2020). https://doi.org/10.1021/acsami.0c10725

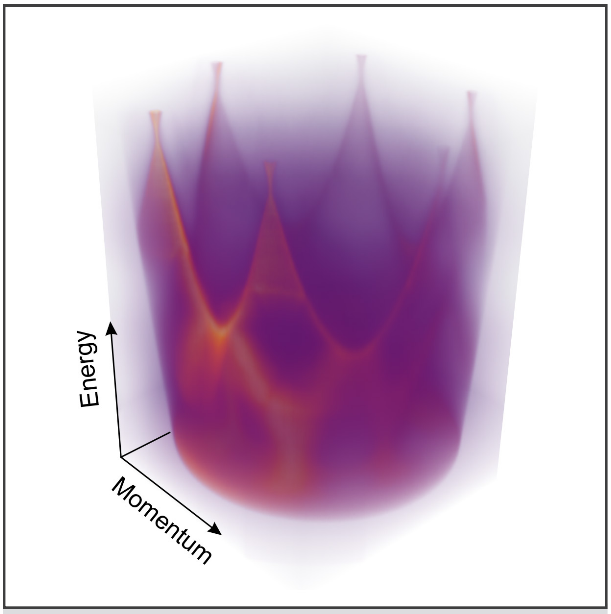


Figure 1: This 4D data cube of monolayer graphene on SiC was acquired with the Stuttgart NanoESCA momentum microscope and He I excitation. The six Dirac cones are very sharply pronounced. The data set ranging from the Fermi level down to almost 6 eV binding energy was acquired at room temperature on a 30 µm FOV with a 100 meV analyzer resolution. Monolayer graphene on SiC was prepared in the group of Ulrich Starke at the Max-Planck-Institut für Festkörperforschung in Stuttgart by sublimation growth in argon atmosphere, reproducibly yielding large-area, homogeneous samples with a sharp electronic band structure. Courtesy of Philipp Rosenzweig, MPI für Festkörperforschung, Stuttgart.

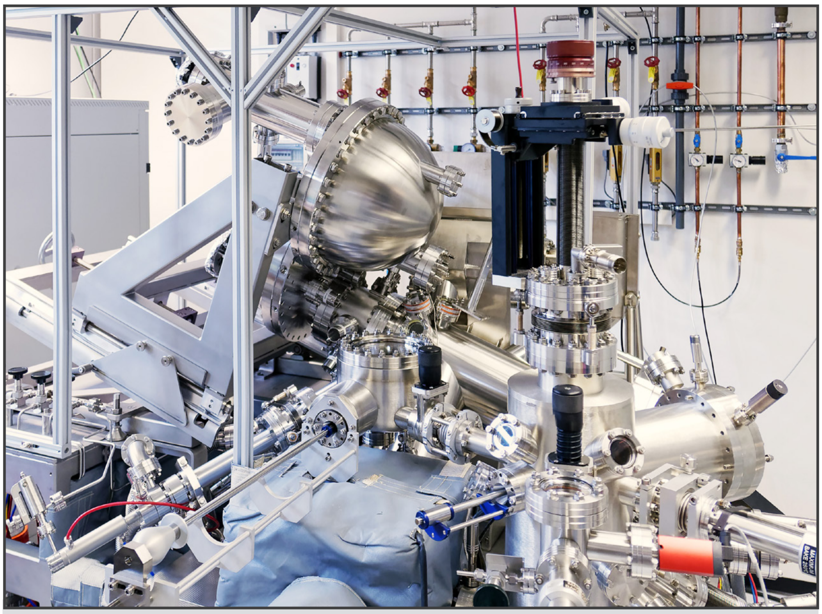


Figure 2: The NanoESCA installation at the MPI für Festkörperforschung (Stuttgart), group of Prof. Ulrich Starke [1]. The NanoESCA system is equipped with a preparation chamber, a HIS 14 VUV source, a monochromated X-ray source and a LHe cooled 4 axis manipulator.

nanoARPES Characterisation of Functioning and Tunable Devices

Effect of Gate Voltage on Twisted Bilayer Graphene

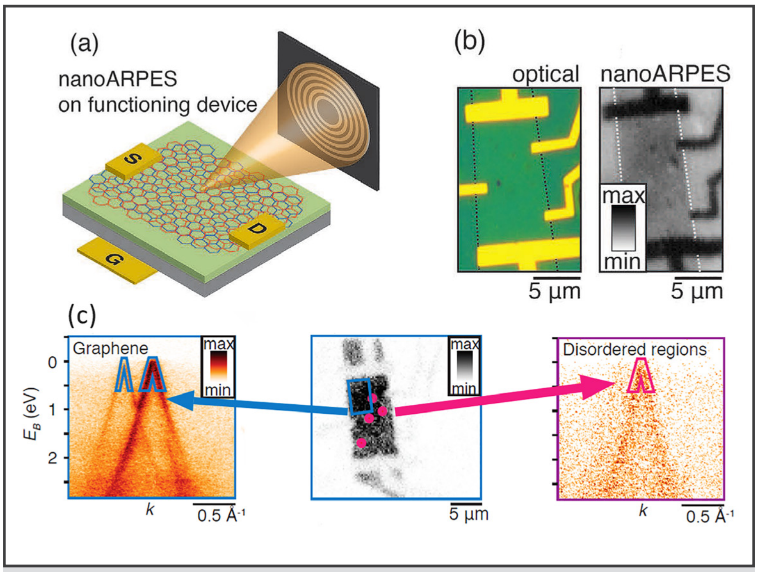
In their recent paper, A. J. H. Jones and S. Ulstrup et al. explore engineering properties of quantum materials by placing a singularity of the density of states near the Fermi energy. Using ebeam lithography for structuring and formation of electrical contacts, a device consisting of twisted bilayer graphene (twBG) on a stack of hBN and graphite was formed. The device was wire bonded to a chip package and introduced to the nanoARPES branch of the I05 beamline at the Diamond light source.

With nanoARPES, such devices in the micrometre scale become accessible and even tiny spatial inhomogeneities the sub-µm domain can be characterised including the twist angle. Given the large twist angle, the mini Brillouin zone of the superlattice is large enough to detect and identify band structure features, specifically the van Hove singularity (vHs) and a small gap. The authors demonstrate how an applied gate voltage can shift this vHs and allows positioning relative to the Fermi energy.

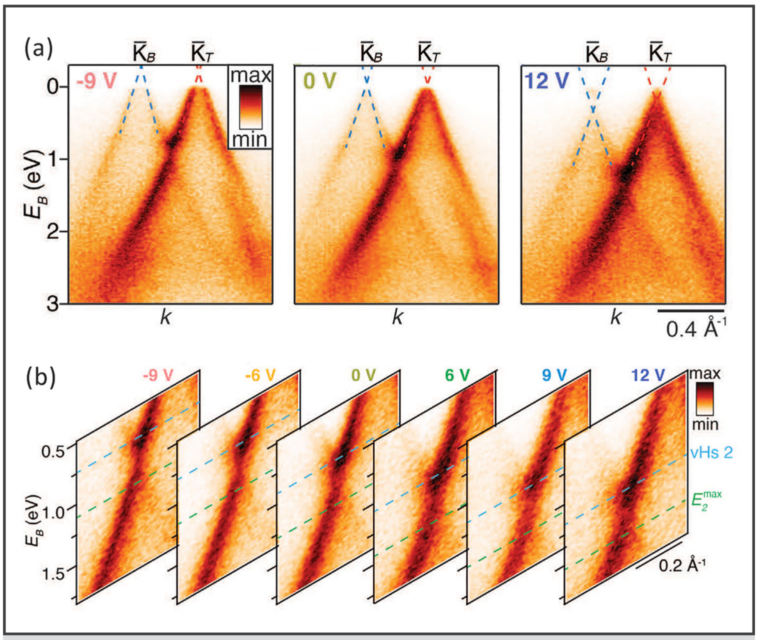
These results encourage further electron transport studies where the vHs energy is tuned with electrical doping in combination with fully resolved (E,k) band structure measurements.

Professor Katoch contributing author stated:
“It is crucial to bridge the gap between the electronic transport and band structure measurements to obtain a comprehensive understanding of electronic properties of emergent quantum materials. In this direction our work provides a deeper insight into the electronic band structure of fully functional mesoscopic sized twisted bilayer graphene device.“

About nanoARPES using the DA30-L:
The measurements for this paper were acquired at the I05 beamline at the Diamond light source where a Fresnel zone plate focused 60 eV light down to a 690 nm spot on the sample. A piezo electric stage scanned the sample at 250 nm increments relative to the spot while a DA30-L acquired the photoemission spectra at each position (E, k). The DA30-L deflector mode was used to obtain (E, k_x, k_y)-dependent photoemission intensity.



nanoARPES of twisted bilayer graphene. (a) Overview of the nanoARPES experiment. (b) Device region by optical microscopy (left) and by integrated ARPES intensity (right). (c) Region specific spectra can be extracted and can be used to reconstruct band structure sensitive images. Adapted and cropped from original.

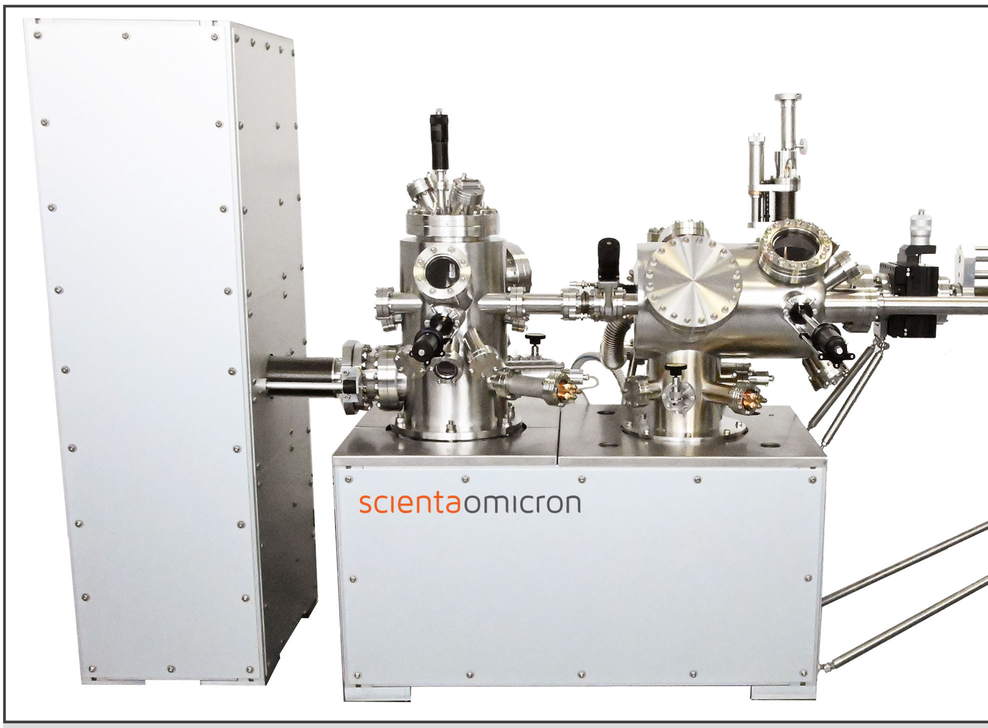


Influence of the gate voltage on the band structure. (a) Influence of gate voltage on the dirac cone positions and (b) the position of the van Hove singularity. Adapted and cropped from original.

Reference:
A. J. H. Jones, S. Ulstrup et al, Adv. Mater. 2020, 32, 2001656,
https://doi.org/10.1002/adma.202001656
https://arxiv.org/pdf/2006.00791.pdf

INFINITY SPM

Next Generation Low Temperature SPM



INFINITY SPM Lab

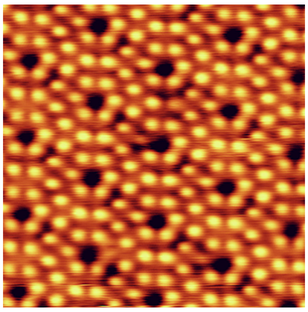
- Excellent SPM pm-stability due to Two-Chamber Concept
- Very Small Drift
- No Helium Consumption
- Temperature: 9 K to 420 K
- ‘Infinite’ Measurement Time
- Quiet Working Environment
- User Friendly & Easy Handling

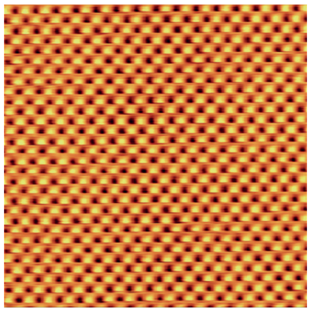
Small Footprint, Low Noise INFINITY SPM with integrated Pulse Tube Cryostat and customised preparation chamber.

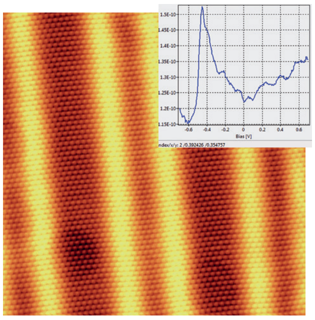
The INFINITY SPM is a low-temperature SPM for high-resolution STM, QPlus® AFM, and spectroscopy experiments. A pulse tube cryostat cools the UHV SPM to a temperature of typically below 9 K.
Thus, handling liquid Helium or liquid Nitrogen is no longer necessary, making the instrument safer and easier to use. For optimum mechanical decoupling, the pulse tube cooler is placed in a separate high vacuum chamber with acoustic shields. **This unique two-chamber design of the INFINITY SPM is the key to picometer stability in a temperature range from <10 K to 420 K.**

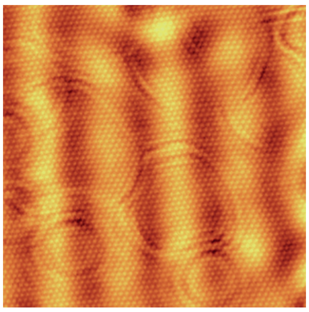
The integrated high-quality pulse tube cryostat with long-term maintenance cycles requires very little service efforts, allowing the instrument to stay cold for years. The excellent SPM stability and low thermal drift of the INFINITY SPM are at the same pm-level as conventional bath cryostat SPMs. Beyond that, the Infinity-QPlus® option is characterised by a very low spectral amplitude noise density, enabling highest resolution QPlus® imaging and spectroscopy.

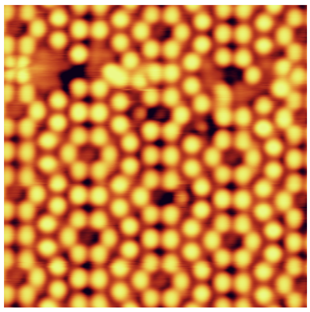
The INFINITY SPM is the first commercial instrument of a new generation of low temperature SPMs that has all the advantages of a Low Temperature SPM, but is independent of liquid Helium.


Si(111)7x7: QPlus® at 9.6 K


NaCl(001): QPlus® at 9.7 K


Au(111): STM at 9.6 K


Corresponding dI/dV map on Au(111) at U=-480mV and 9.6 K


Si(111)7x7: STM at 8.6 K

LT SPM

TERS with Sub-Molecular Resolution

Optical spectroscopy techniques, like near-infrared, Tip Enhanced Raman Spectroscopy (TERS) or low-temperature fluorescence, provide detailed information about the chemical and environmental structure of organic systems. In this article we focus on our new setup for advanced optical experiments at helium temperature in an ultra-high vacuum environment. With highest efficiency for light collection and the possibility to adjust the lens focus (in-situ) with respect to the STM/QPlus® tip, TERS measurements with highest lateral resolution (sub-molecular) become possible. Moreover, the optical setup is fully compatible with proven measurement modes like STM, STS, IETS, QPlus®, etc and does not at all compromise the excellent performance, stability or hold time (> 65 hours) of the LT STM.

To ensure best optical conditions, the optical integration offers:

- Highest detection efficiency provided by the numerical aperture (NA) of NA > 0.4.
- Angle of incidence optimized to 30°.
- Three piezo-motors for adjustment of the lens in the full temperature range from 4.5 K to 300 K.

In combination with the proven performance of the LT STM, this modification allows a broad range of new and exciting experiments.

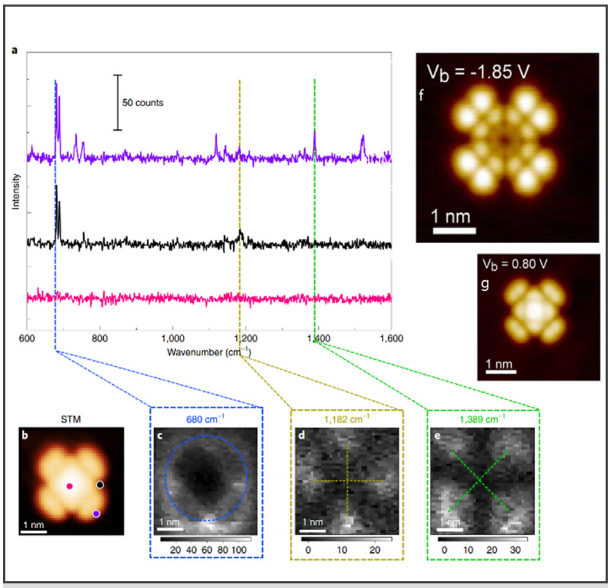
3rd Generation Universal Low Temperature SPM platform. Key characteristics: Highest SPM stability, Long Hold time, excellent QPlus performance, lens setup for TERS measurements.

TERS EXPERIMENTS by Imada and Kim et al., Nature Nanotechnology 15, 105–110 (2020)

Instrument: Customized LT-SPM

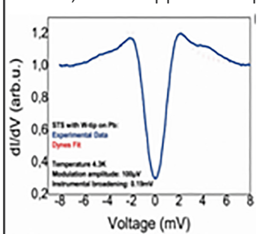
In their fascinating publication, Hiroshi Imada and Yousoo Kim et al. report on single-molecule STM-TERS Raman spectroscopy with sub-molecular resolution and have investigated the intrinsic vibrational and electronic structure of a single CuNc molecule! The authors observe three different STM-TERS spectra (a) at positions indicated in the STM topography (b) and have performed high-resolution single-molecule TERS mapping of the CuNc molecule on NaCl (c-e) for different wavenumbers (mapping parameters: V_{bias}=1V, I_t=50pA; TERS maps: 40×40pixels, 1Å per pixel, 1s exposure time per pixel). The TERS maps show three distinct patterns that represent vibrational modes with three kinds of vibrational symmetries. The maps can be explained by considering the correlation between the original symmetry of the molecule and the plasmonic nanocavity.

From the high resolution STM topography images of the CuNc molecule taken at 10 pA, it can be clearly seen that the overall performance and stability of the LT STM is not affected at all by the TERS setup (f and g).

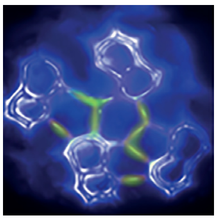


High Resolution STM and TERS measurements with sub-molecular TERS contrast on a single CuNc molecule.

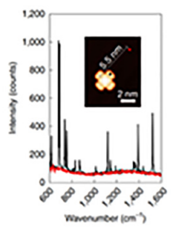
LT STM, some supported experiments:



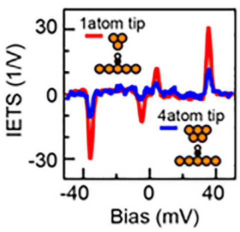
STM/STS, e.g. dI/dV on superconcuctors



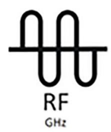
QPlus®, e.g. high resolution molecular imaging by Qiu et al.



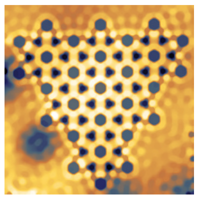
TERS, e.g. high resolution Raman spectroscopy of individual molecules by Imada and Kim et al.



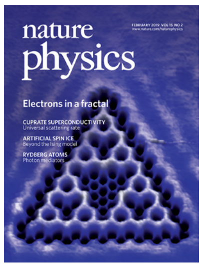
Inelastic tunneling spectroscopy, e.g. by Giessibl et al.



High Frequency time resolved measurements



Manipulation of Atoms and Molecules, e.g. by Swart et al.

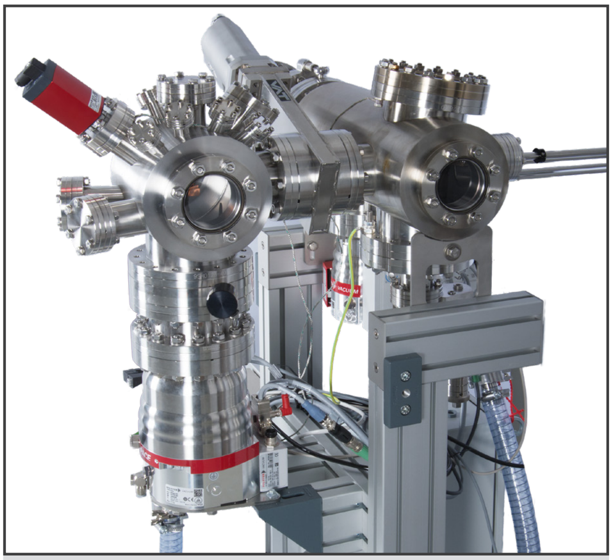


Prototype of ALDcompact Installed

Expanding Deposition Capabilities

Scienta Omicron has recently delivered its first **ALDcompact 10** system to the University of Notre Dame, USA. This new small-footprint module is designed for exploratory work in the field of Atomic Layer Deposition (ALD) process research. To that end, it comes with up to eight independent gas inlets equipped with remotely controlled pulse valves. The hot wall reactor design prevents precursor molecules from condensing/adsorbing on the chamber walls. The **ALDcompact 10** includes a robust sample stage for flag-style sample holders. The core element of the stage is its encapsulated heater, protected against process gas effects and undesired deposition.

The delivered ALDcompact module complements an existing Materials Innovation Platform (MIP), that consists of Molecular Beam Epitaxy (MBE) systems and an in-situ X-ray Photoelectron (XPS) instrument. In this setup, heterostructures can be grown which are not accessible by ALD growth alone. Thin buffer or surface template layers grown by MBE either prevent or control the detrimental formation of amorphous, interfacial oxide layers. The subsequent **ALD** overgrowth results in epitaxial oxide films with high-quality interfaces. Stochiometry of the heterostructure can be verified by in-situ XPS. Information from high-resolution spectra of specific transitions is crucial for the optimisation of the buffer layer. By combining ALD and MBE the technologically important integration of complex oxides with semiconductors becomes feasible.



ALDcompact 10 configured for integration to a Materials Innovation Platform.

Global Service and Support

Great Support for our Customers Secured by Regional Offices

2020 has been a very difficult year filled with uncertainty for the whole world, including the international research community. Scienta Omicron's highest priority has been the health of our staff and customers, meaning that we have necessarily adjusted our Service operations during the COVID-19 outbreak.
We are committed to support our customers to complete research during these strange times. The current situation of limited domestic and international travel has required us to adapt to provide new Service solutions to meet our customer's needs. We have expanded our existing service offering to include more options for remote support, including remote fault-finding sessions, increased email and phone support, and even full system installations.
We can also now offer a wide range of user Training Courses that can be delivered remotely. These sessions take advantage of our large team of specialists, meaning that we can offer training packages covering everything from the basic operational practises and underlying principles, to advanced technical application overviews.
It is our goal to support you, so please contact your local service team if you have any questions about what Service options, we can provide you.

Scienta Omicron service staff member performing product services.