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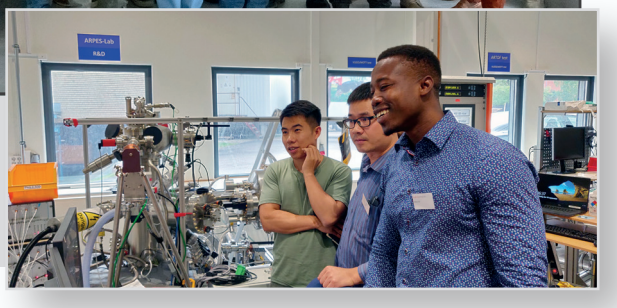
Fall 2019 News

Scienta Omicron - Superior Technology

Please visit our IOP Webinar NanoESCA



Our worldwide service team - coming from USA, India, China, Japan, Canada, Germany, and Sweden - meeting for a seminar in Sweden and Germany. In total the team has more than 400 years of experience in Nanoscience.

Content

Services team grows ever stronger

Satisfaction survey springboard to key improvements

Scienta Omicron is currently performing a customer satisfaction survey and the feedback so far has been really positive. Along with very good ratings we have also received constructive feedback, which we take seriously and are acting on. We have learned that our customers are continually looking for shorter installation times, easier communication methods and quicker responses.
The demands on research do not slow down!
As part of our training and improvement programs we held our annual global service meeting in September. Service teams from around the world visited both our factories in Germany and Sweden for advanced training, team networking and knowledge sharing to better improve our communication and overall service capabilities.

Scienta Omicron has more than 25 people in its global service organization, already the largest in the market. We continuously invest in growing the services force in size and capability. Our global reach ensures we are close to our customers, providing rapid response via phone, email or on-site, while providing support in our customer's native language.

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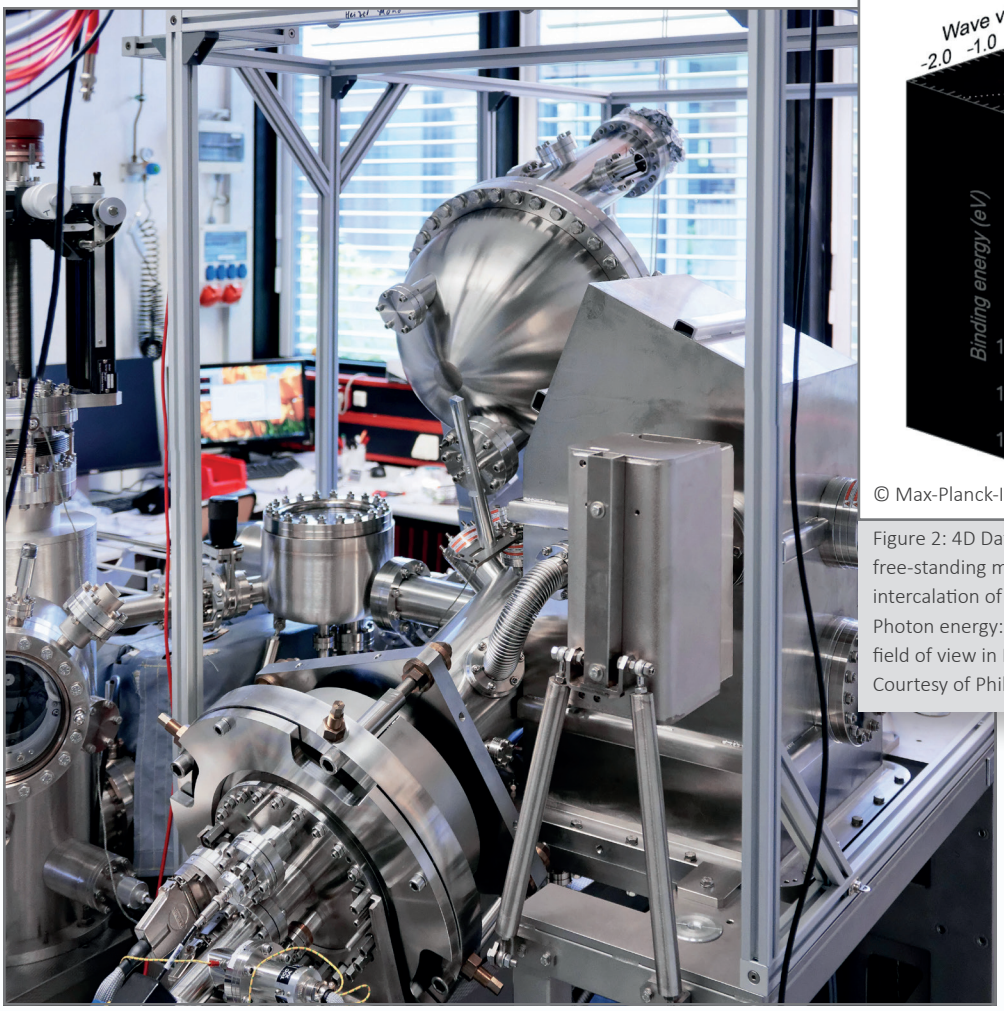
Installed at MPI Stuttgart...

A new NanoESCA for momentum microscopy and imaging XPS



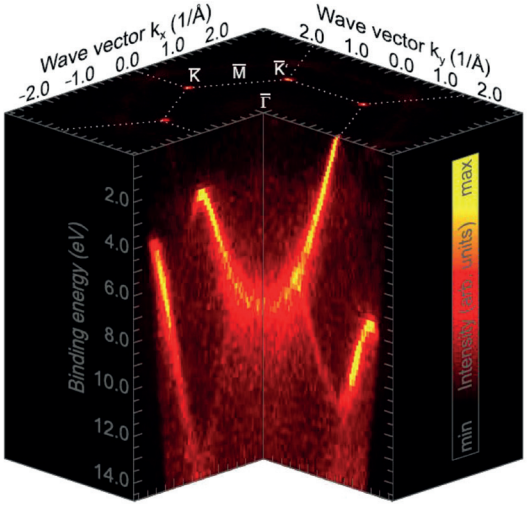


Figure 2: 4D Data-Cube measured with the NanoESCA on quasi-free-standing monolayer graphene on SiC obtained via hydrogen intercalation of the (6√3 x 6√3)R30° carbon buffer layer. Photon energy: 40.81 eV (He II) from non-monochromated HIS14, field of view in Real-space: 40 µm, total acquisition time: 10 min. Courtesy of Philipp Rosenzweig, MPI für Festkörperforschung,

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

Since summer 2019 the Max-Planck Institut für Festkörper-forschung in Stuttgart has a powerful new analysis tool in the group of Prof. Ulrich Starke [1] (see figure 1). The NanoESCA system is equipped with an HIS 14 VUV source and a micro-Focus 350 monochromated X-ray source, which allows for using the full potential of the NanoESCA from k-space microscopy (micro-ARPES) to imaging spectroscopy with ultra-high lateral resolution.

The research group of Prof. Starke investigates the atomic structure of surfaces and thin films of technologically interesting quantum materials with the goal of a fundamental understanding of growth, interface formation and crystal formation at the atomic scale. A particular topic is epitaxial graphene on silicon carbide surfaces.

Figure 2 shows first results measured with the k-space mode of the NanoESCA system from a very defined spot on the sample. The imaging X-ray spectroscopy capability will be used to identify the chemical composition of the surface, which gives crucial additional information about the exact conditions of the local sample spot from where the band structure was acquired.
Scienta Omicron wishes Prof. Starke and his team much successful research with this new instrument.

References:
[1] https://www2.fkf.mpg.de/ga/

Installed at Meiji University, Tokyo...

Japanese scientists at the forefront of HAXPES

Japan has been a leader in Hard X-ray Photoelectron Spectroscopy (HAXPES) for many years. Multiple experimental setups, including the world class beamlines at SPring-8, have supported the HAXPES technique.

Today the field of HAXPES is expanding at an unprecedented rate, as predicted by Wolfgang Drube in 2011 when he stated that 'HAXPES is the ESCA of the future' (Svensson et al., Hard X-ray Photoelectron Spectroscopy, Ed. Woicik, Springer, 2016). This increasing popularity has led to an oversubscription of HAXPES beamlines at synchrotrons around the world.

For HAXPES to flourish there is a need for more experimental facilities. One solution is to enable HAXPES by using laboratory excitation sources. Again, Japanese scientists are at the forefront. Prof. Ogura of Meiji University has installed the HAXPES Lab, equipped with a 9.25 keV monochromated excitation source and EW4000 analyzer, making his research group one of the few in the world that can perform HAXPES measurements directly in their laboratory. As shown here, the HAXPES Lab is being actively used to investigate of the origin of electrical characteristics of indium-gallium-zinc oxide (IGZO).

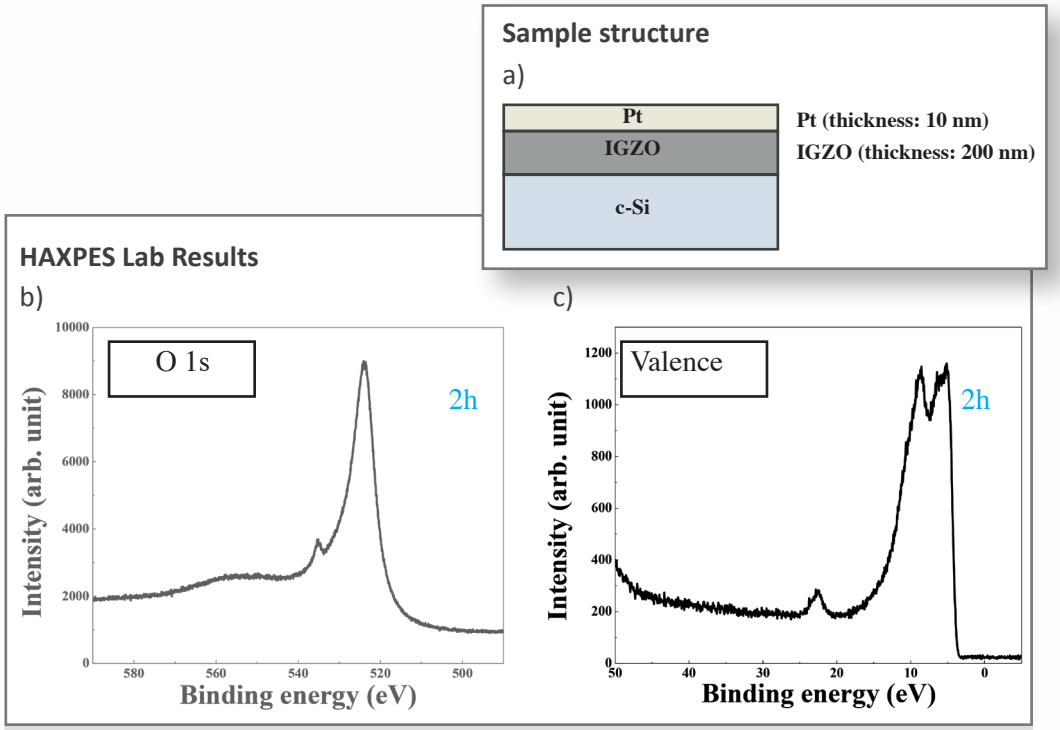


Figure 1: a) An IGZO sample investigated by HAXPES Lab. b) O1s and c) valence band spectra recorded with HAXPES Lab. By varying the material mixing ration and deposition parameters of the sample the origin of the electrical characteristics of IGZO can be understood.

Quantum jamming transition to a correlated electron glass

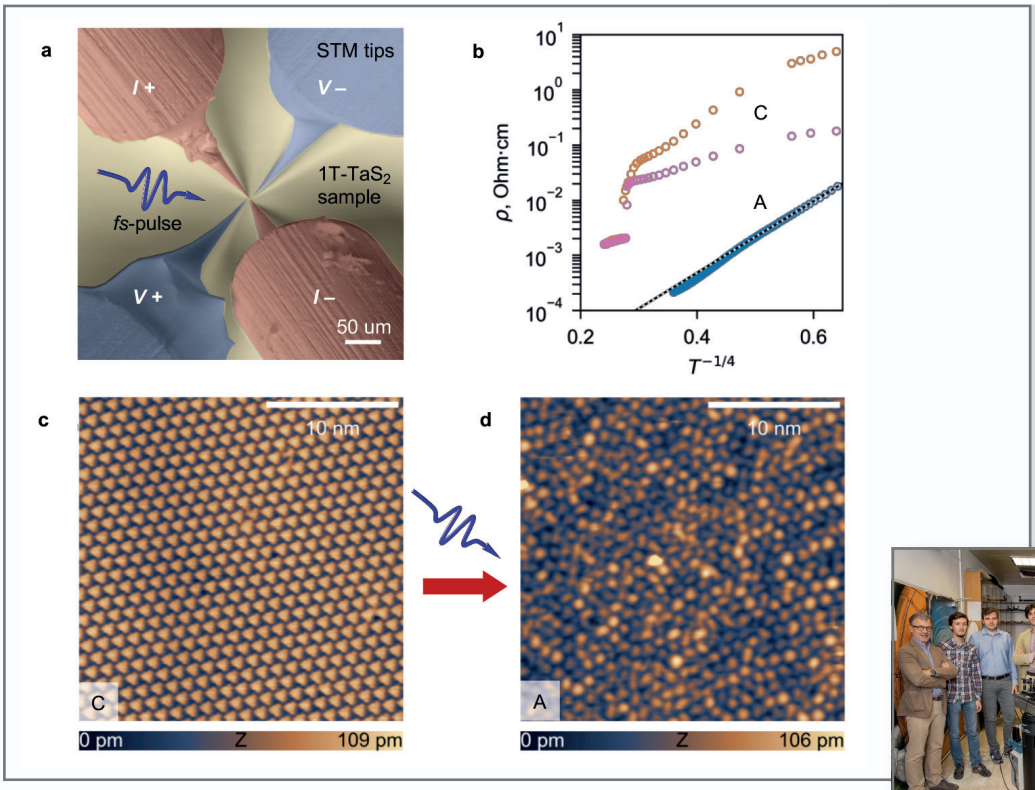
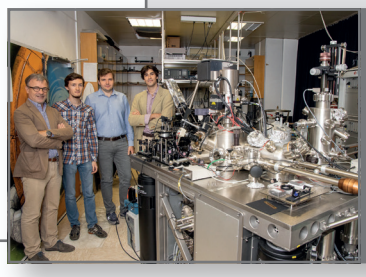


Figure 1:
a) The pseudocolor image is taken in-situ from above with a scanning electron microscope. The tips colored red and blue are used for current injection and voltage sensing, respectively in the four-probe resistivity measurements.
b) The 4-tip resistivity in the ground (C) state and the photoexcited (A) state measured in-situ with ohmic contacts. The T-dependence of the A state resistance is consistent with variable range hopping.
c) Raw STM image of the ground state (C) exhibiting a regular lattice of polarons.
d) Raw STM image of the photoexcited hyper-uniform state (A) formed after a single 30 fs pulse at 4.2 K shows an amorphous structure.



Dragan Mihailovic, Yevhenii Vaskivskyi, Yaroslav Gerasimenko, Michele Diego (left to right) with the LT NANOPROBE. Photographer: Marjan Verč, IJS

Ultrafast lasers provide a new approach to tailor the properties of quantum materials and open access to the emergent states of matter forming exclusively under non-equilibrium conditions. After being exposed to a femtoseconds-long optical pulse, most materials revert to their original state, but in some cases a metastable excited state can form while the system is still out of equilibrium. In the past two decades, a variety of such states, demonstrating e.g. transient switching from insulator to metal or even superconductor, with lifetimes ranging from picoseconds to months, have been discovered in correlated systems. However, all of these states have usually been closely related to their neighbors on equilibrium phase diagrams, and finding drastically new states has turned out to be elusive.

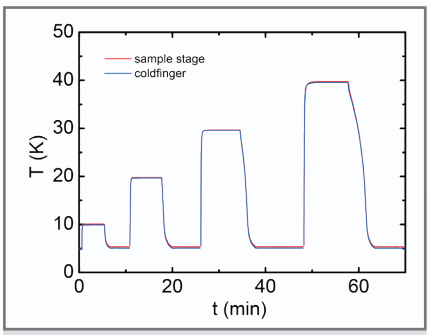
In their recent work [1] the group from Jozef Stefan Institute in Slovenia has shown how controlled ultrafast optical excitation can lead to the formation of a peculiar hyperuniform electronic configuration in a prototypical layered transition metal dichalcogenide (see Figure 1). Hyperuniformity is a 'hidden' order mostly characteristic of the classical jammed systems, and until now has never been observed for charged fermions. The mechanism of its formation is related to dynamical localization of electrons due to their mutual interactions in a quench caused by the ultrafast optical pulse.

The LT NANOPROBE design offers flexible ways to introduce femtosecond laser pulses for switching in-situ within an STM[2] enabling real-space studies of the emergent metastable states. The four tips are indispensable, because they may be used for the measurement of the temperature-dependence of four-probe resistance of the photoinduced metastable states on a microscopic level (see Figure 1b). STM imaging confirms that the metastable state is indeed present over the whole area between the tips. Precise tip positioning gives further insight into the dimensionality of the optically switched area and mechanisms of transport. The LT NANOPROBE combined with ultrafast laser excitation forms a versatile new research platform for the study of photo-induced metastability.

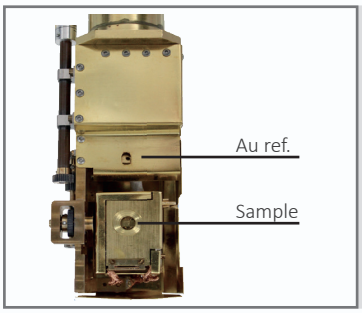
References:
[1] Ya. A. Gerasimenko et al., Nature Materials (2019), to appear in the October issue; DOI: 10.1038/s41563-019-0423-3
[2] Ya. A. Gerasimenko et al., npj Quantum Materials 4, 32 (2019).

ARPES manipulators

Advances for high resolution and temperature dependent studies



Closed cycle manipulator temperature ramps and precision using PID control.



The manipulators feature two sample positions.
One primary stage featuring the 5- or 6-axis motion, and one secondary 4-axis stage usually occupied by a reference pin (for evaporating with Au).

1 BAR XPS

For studies of industrially relevant catalytic reactions

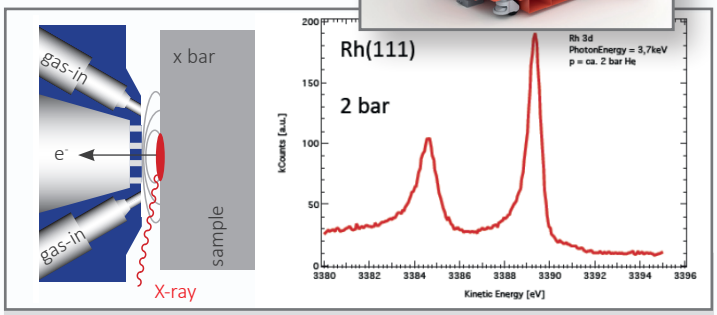


Figure 1: The Scienta Omicron Bar XPS design was developed by Anders Nilsson and Peter Amann at Stockholm University. Bar XPS uses the virtual gas cell design, which creates a high local pressure area around the sample of > 1 bar (a), (b) shows a Rh 3d spectra recorded at 2 bar He pressure. The insert shows a schematic figure of the system.

The advancement of cryogenic manipulator technology for ARPES has been fast in recent years. Open cycle 4-axis manipulators are now guaranteed to reach temperatures better than 3.5K, and the temperature increase for the 6-axis version is only 2K, with guaranteed specification <5.5K.

Even more impressive progress has been made for closed cycle, dry ARPES manipulators: The ultimate temperatures are now almost on par with the open cycle, <4K for 4-axis and <6K for 6-axis with manual azimuth. These now truly support the high resolution ARPES systems by giving temperature broadening contributions in the 1 to 2meV range.

Closed cycle technology brings great advantages for temperature dependent studies. The PID temperature control allows fast and precise ramping. The stability of the set temperature is excellent and the cool down to base temperature is equally easy and fast. Cool down time from room temperature is realized in only 4 h for the CC version.

The full manipulator range is available as part of an ARPES system or as stand-alone components.

It is estimated that up to 90% of chemical products are produced via catalysis. Many heterogeneous catalytic reactions occur at high pressures and temperatures.
To study these types of catalytic reactions, researchers at Stockholm University have constructed an instrument capable of measuring XPS under conditions of > 1 bar of pressure in the vicinity of the catalytically reactive surface.

Peter Amann and Anders Nilsson, et. al. present the instrument, which consists of a HiPP analyser, in the Review of Scientific instruments article 'A high-pressure X-ray photoelectron spectroscopy instrument for studies of industrially relevant catalytic reactions at pressures of several bar'.
The performance of the instrument is demonstrated by measuring bulk 2p spectra from a copper single crystal at He pressures of up to 2.5 bar and C 1s spectra in gas mixtures of CO + H_2 at pressures up to 790 mbar.

The capability of the instrument opens up the possibility of operando studies of heterogeneous catalytic reactions under industrial manufacturing conditions. This 1 Bar XPS system solution is now available from Scienta Omicron.

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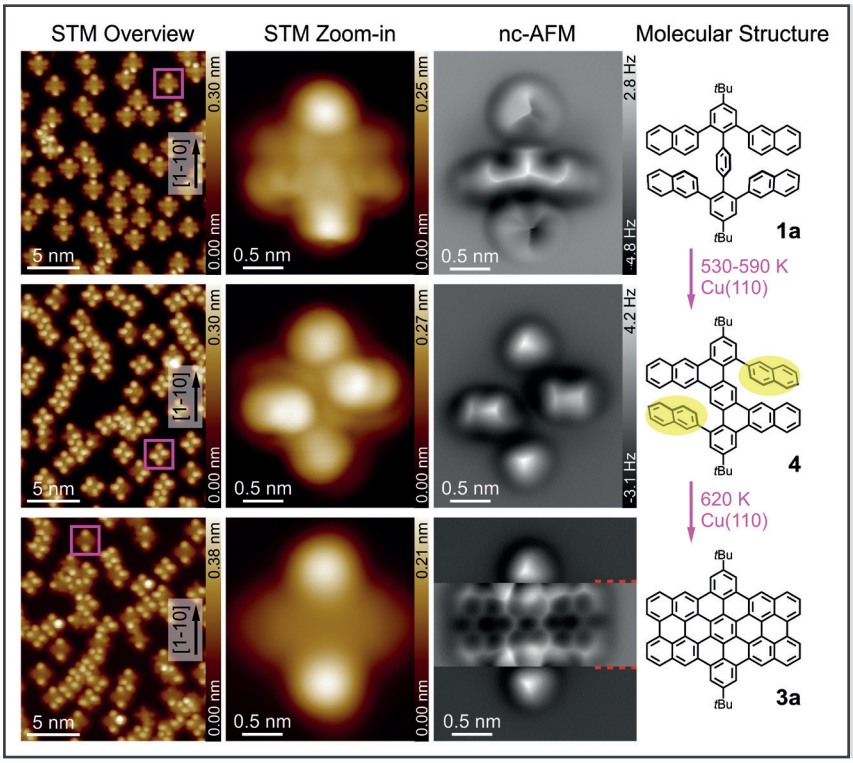
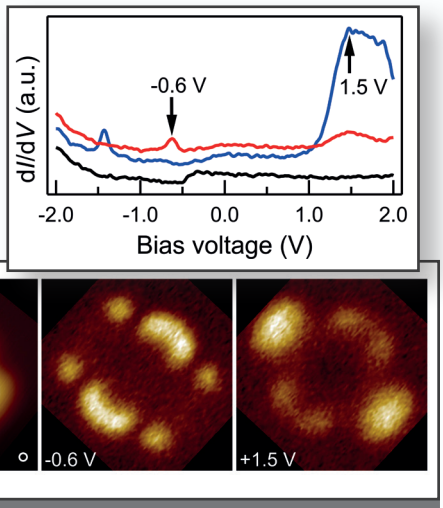
On surface synthesis of Nanographene

A step-by-step analysis through sub-molecular imaging using the LT STM



Exceptionally low thermal drift at T=1 K.
36 hours total acquisition time showing a thermal drift stabilising at 11.2 pm/h.



Scanning tunneling spectroscopic (STS dI/dV) results of the on-surface synthesized dibenzoperihexacenes on Au(111). The measured energy gap between HOMO and LUMO is 2.1 eV.

Nanographenes - which open the energy gap of graphene due to a quantum confinement effect - are regarded as a kind of potential semiconductor material for future electronic devices. Since the electronic properties of nanographenes heavily rely on their size, shape and periphery geometries, it is desirable to produce nanographenes with atomically defined structures. On the other hand, it is also essential to identify the exact chemical structures of the synthesized nanographene products with high-resolution scanning probe microscopy.

Researchers from Prof. Lifeng Chi's group at Soochow University in collaboration with Prof. Muellen and Dr. Natari in MPI Polymer Reseach in Mainz have recently synthesized three different benzo-fused periacenes on metal surfaces with well-designed precursors[1]. The reaction pathways were followed by sub-molecular imaging of the initial, intermediate and final states of the reactants. The related STM (Scanning Tunneling Microscopy) and nc-AFM (Non-Contact Atomic Force Microscopy) images were mostly acquired with a Scienta Omicron low-temperature STM/nc-AFM combined system in Prof. André Schirmeisen's group at Justus-Liebig University, Giessen. It is worth noting that a previous effort in solution with the same precursor 1a unexpectedly provided helicenes. Therefore, the distinct regio-selectivity of cyclodehydrogenation arising from the flattened adsorption geometries and the reduced flexibility of the precursors underpins the formation of nanographenes on surfaces.

The electronic properties of the three nanographene molecules were further investigated by scanning tunneling spectroscopy (STS). Energy gaps of dibenzoperihexacene and dibenzoperioctacene were measured to be 2.1 eV and 1.3 eV, respectively. This work demonstrates good control of the regioselectivity in cyclodehydrogenation reactions on metal surfaces which benefits the synthesis of low-dimensional functional structures including, but not limited to, nanographenes.

1. Zhong, Q. G.; Hu, Y. B.; Niu, K. F.; Zhang, H. M.; Yang, B.; Ebeling, D.; Tschakert, J.; Cheng, T.; Schirmeisen, A.; Narita, A.; Müllen, K.; Chi. L. F.;

Benzo-Fused Periacenes or Double Helicenes?
Different Cyclodehydrogenation Pathways on Surface and in Solution.
J. Am. Chem. Soc. 141, 7399-7406 (2019).

ARPES-Lab results on disordered TMDCs

Electronic structure determination of small flake samples with VUV spot excitation

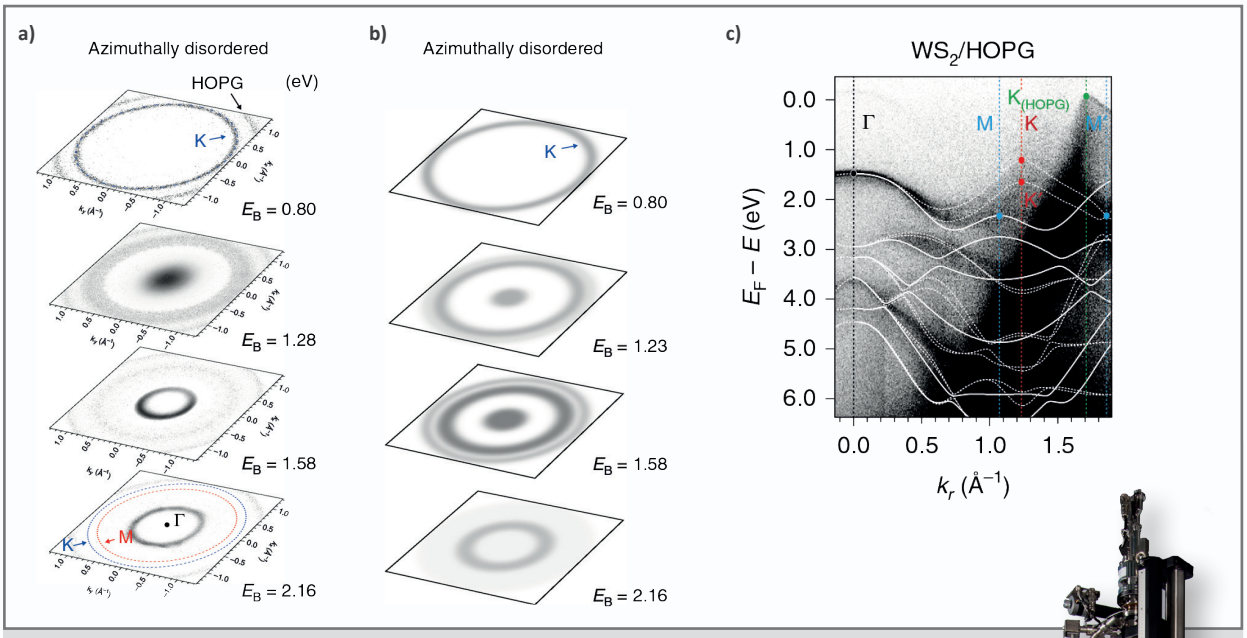


Figure 1: Measured ARPES data from an azimuthally disordered WSe_2 TMDC monolayer single crystal: (a) Experimental and (b) simulated constant energy contour plots of different energy levels below Fermi level from WSe_2 on sapphire, (c) dispersion map from WSe_2 on graphite. (Park et al. and http://creativecommons.org/licenses/by/4.0/)

Transition-metal dichalcogenide (TMDC) monolayers are candidate semiconductors for next-generation nanoscale electronic devices due to their unique electronic and optoelectronic properties. A key for further development and device design is the understanding of the electronic structure of these materials.

Many TMDCs comprise small two-dimensional flakes with azimuthal disorder which prohibits band dispersion observation in ARPES due to angular averaging. However, in the paper 'Electronic band dispersion determination in azimuthally disordered transition-metal dichalcogenide monolayers' Prof. Koch group, Park et al., Communications Physics, 2 (2019) 68, https://doi.org/10.1038/s42005-019-0166-0, propose a method to achieve band dispersion information on such disordered samples by use of theoretical modelling and high precision ARPES including work done with a Scienta Omicron ARPES Lab equipped with a DA30-L analyser and a VUV5k.

Prof. Koch stated: 'With the information disclosed in our paper, we anticipate that research on TMDCs, also beyond the four prototypical ones covered in our work, will be substantially reinforced, as obtaining detailed insight into the electronic structure of 2D powder semiconductors becomes now possible for a significantly wider range of samples and complex structures.'

Figure 2: A Scienta Omicron ARPES Lab is a modular unit that can be adapted to scientific needs by selecting from a range of cryo manipulators (from <3.5K 4-axis to <5.5K 6-axis versions), DA20 or DA30L state-of-the-art ARPES analysers, and a well proven, stable VUV5k He lamp.

Gas Reaction Cell GRC 1300

Bridging the pressure and temperature gap

For scientists working on gas/surface interactions, real world reaction conditions are typically far from those achievable in a UHV system.
Scienta Omicron's new Gas Reaction Cell GRC 1300 helps to close this gap. An inert heating element heats samples up to 1300 K, even in oxidizing gas atmospheres of up to 5 bar.
The cell comes with a vacuum chamber that can easily be integrated to most UHV systems.

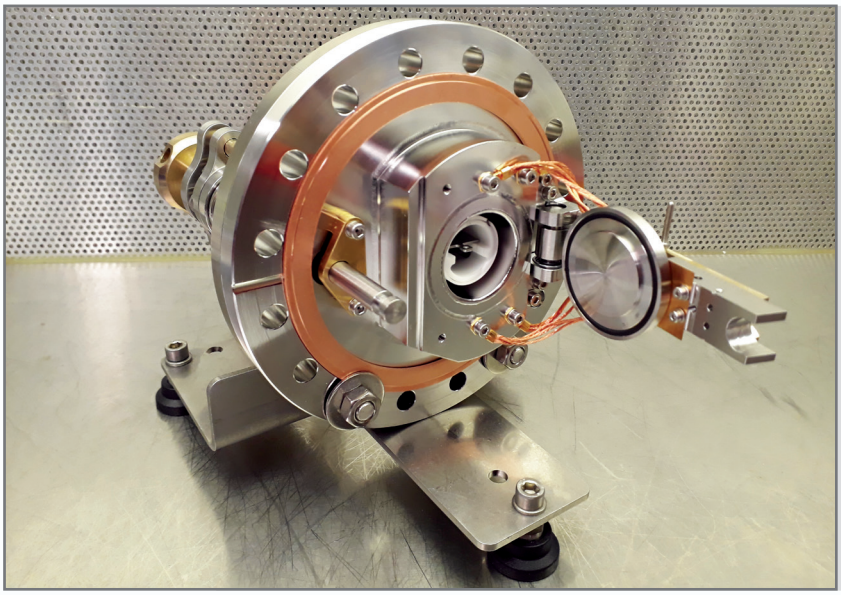
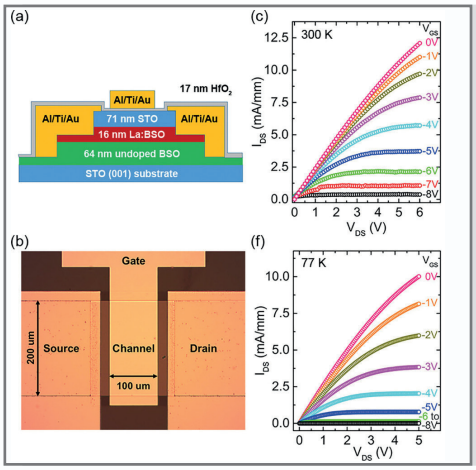


Figure 1: The GRC 1300 heats samples up to 1300 K in an oxidizing 5 bar gas atmosphere in static or flow-through conditions for gas chromatography.

PECASE Award

Prof. Jalan receives Presidential Early Career Award for Scientists and Engineers

Scienta Omicron congratulates Professor Bharat Jalan of the University of Minnesota as a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE). This is the highest honor bestowed by the United States government on outstanding scientists and engineers in the early stages of their independent research careers. The White House, following recommendations from participating agencies, confers the awards annually. Prof. Jalan has been using an EVO50 MBE system since 2012 to grow thin films and heterostructures by employing hybrid molecular beam epitaxy (MBE). The current focus of the group is on the perovskite-based quantum materials and their heterostructures (specifically, titanates and stannates) with particular emphasis on their synthesis with excellent control over stoichiometry, dimensionality, and strain.



Perovskite-based alkaline-earth stannates are highly suitable candidates for transparent conductors, power electronic devices, and high electron mobility transistors. These materials are grown using a radical-based MBE approach and characterized, in particular, for material properties that are strongly coupled to device performance.

One project is focused on Perovskite-based alkaline-earth stannates. This material class possesses wide to ultra-wide bandgaps that make them highly suitable candidates for transparent conductors, power electronic devices, and high electron mobility transistors. Additionally, perovskite structures bring with them exceptional flexibility with regard to compositional tuning and structural compatibility.

His lab will expand with the installation of a new Scienta Omicron Dual-EVO MBE systems in early 2020. Some of his key research which contributed to this prestigious award can be found on his website: https://jalan.cems.umn.edu.

Prof. Bharat Jalan, Dept. of Chemical Engineering and Materials Science, Univ. of Minnesota, Twin-cities