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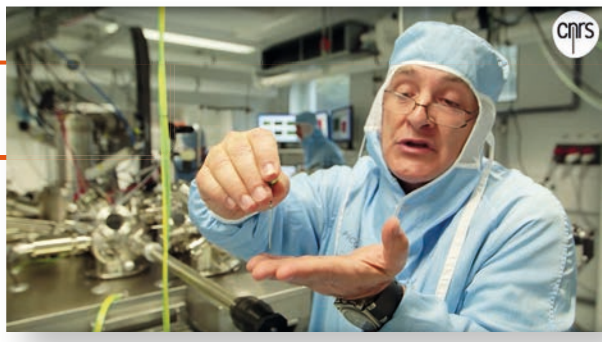
Fall 2017 News

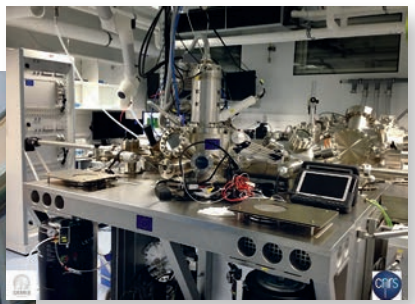
Scienta Omicron - Superior Technology



Prof. Christian Joachim, Picolab Toulouse, France

The ‘Nanocar Race‘ in Toulouse

An international scientific experiment within the LT NANOPROBE



The LT NANOPROBE system in the Picolab in Toulouse.

The race teams in the remote control room.

Nanocars have competed for the first time ever during an international molecule-car race in April 2017 in Toulouse (France). The vehicles, which consist of a few hundred atoms, were powered by electrical pulses during the 36 hours of the race, in which they had to navigate a racecourse made of gold atoms, measuring a maximum of 100 nanometers in length. They squared off beneath the four tips of a LT NANOPROBE located at the CNRS Centre d'Elaboration de Matériaux et d'Etudes Structurales (CEMES) in Toulouse. The race, which was organized by the CNRS, is first and foremost a scientific and technological challenge.

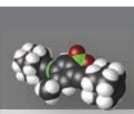
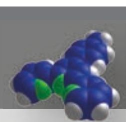
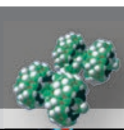
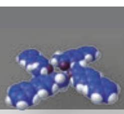
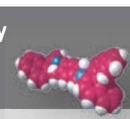
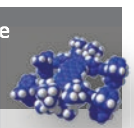
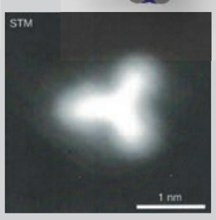
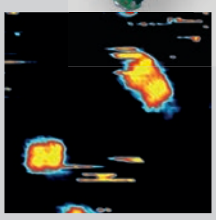
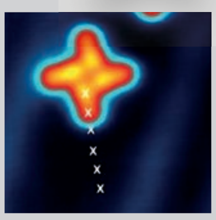
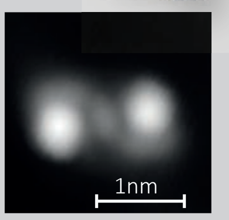
Beyond the competition, the overarching objective was to advance research in the observation and control of molecule-machines. More than just a competition, the Nanocar Race is an international scientific experiment that has been conducted in real time, with the aim of testing the performance of molecule-machines and the scientific instruments used to control them.

The use of such molecular machinery - activated individually or in a synchronized fashion - will be seen in the future: atom-by-atom construction of electronic circuits, atom-by-atom deconstruction of industrial waste, and capture of energy.

The Nanocar Race was a unique opportunity for researchers to implement cutting-edge techniques for the simultaneous observation and independent manoeuvring of such nano-machines.

The nanocar race organisation began in 2013 as part of an overview of nano-machine research for a scientific journal, when the idea for a car race took shape in the minds of CNRS senior researcher Christian Joachim (now the director of the race) and Gwénaël Rapenne, professor of chemistry at Université Toulouse III - Paul Sabatier.

The next Nanocar race is already in discussion.

Position	**1st** 	**1st** 	**3rd** 	**4th** 	**Fairplay** 	**Best image** 
Vehicle						
University/ Country	Uni Graz / Rice Univ. Austria / USA	Univ. Basel Switzerland	Ohio University USA	TU Dresden Germany	MANA / NIMS Japan	CEMES-CNRS France
Team Leaders	Leonhard Grill & James Tour	Remy Pawlack	Saw-Wai Hla & Eric Masson	Francesca Moresco	Waka Nakanishi	Gwenael Rapenne
Surface	Ag(111)	Au(111) (shared)	Au(111)	Au(111) (shared)	Au(111) (shared)	Au(111) (shared)
Propulsion mechanism	Dipolar	Inelastic	Dipolar	Inelastic	Inelastic	Inelastic
Driving distance	150nm 1.5 hours	133nm 6 hours	43 nm 29 hours	11nm First hour	1nm First hour	25nm by pulling (not allowed)
Incidents	-	-	-	Molecule was stuck on a defect; Molecule destroyed	Motor blocked	Molecule jumped on the tip

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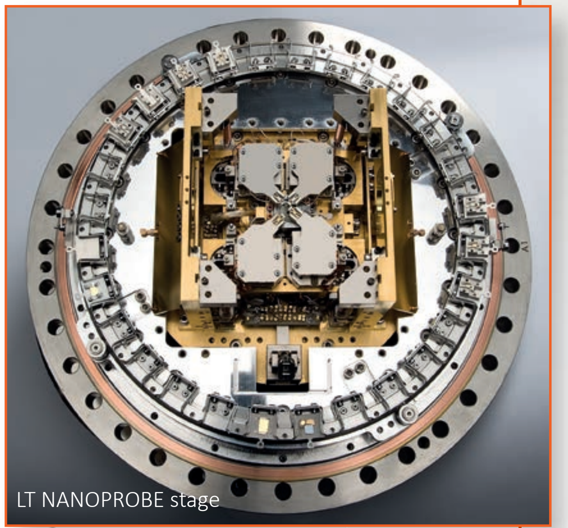
The new MATRIX 4 for the LT NANOPROBE

Compact controller for 4 SPM's

The MATRIX 4 controller for the LT NANOPROBE follows a modular and compact concept which makes customisation possible - strictly along the needs of our customers. The base controller includes fully independent STM operation of the four individual probes, including STM imaging, feedback, 3D coarse positioning and easy access to all signal lines. Each probe can be equipped and upgraded for QPlus AFM using the newest PLL technology developed together with Zürich instruments. The latest software version facilitates ease of use and control of all four probes by one PC, including software controlled tip and sample coarse positioning, Vernissage data browsing and many more functionalities.

Simultaneous and independent operation of all four probe at a performance level resolving and manipulating individual molecules has been demonstrated during the Nanocar race at CEMES in Toulouse (http://nanocar-race.cnrs.fr).


LT NANOPROBE stage

Left: LT NANOPROBE system


MATRIX4 LT NANOPROBE CONTROL

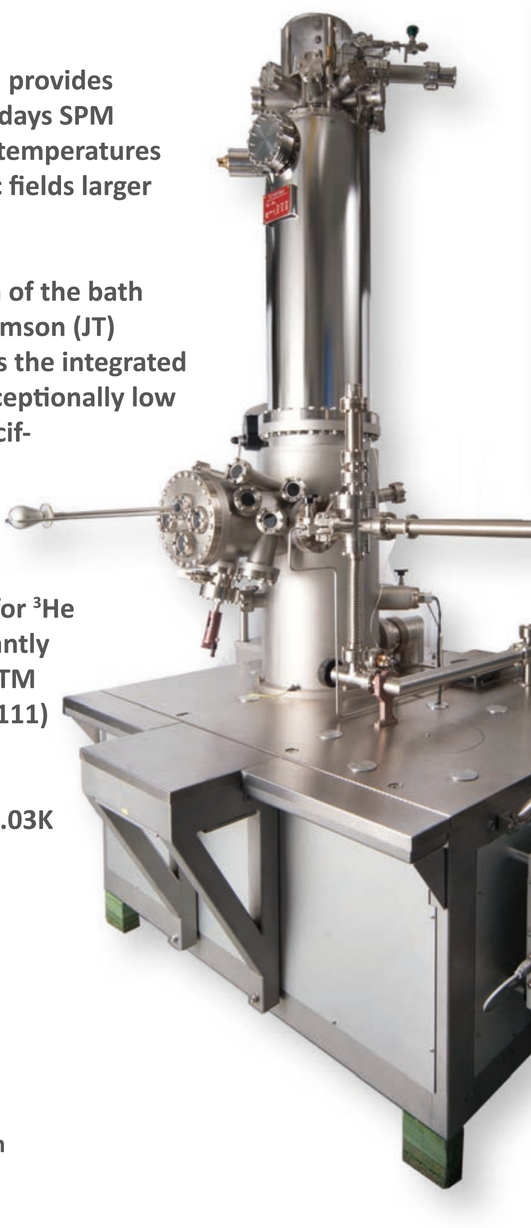
TESLA JT SPM

Demonstrating atomic resolution STM on Au(111) at T= 1.03K

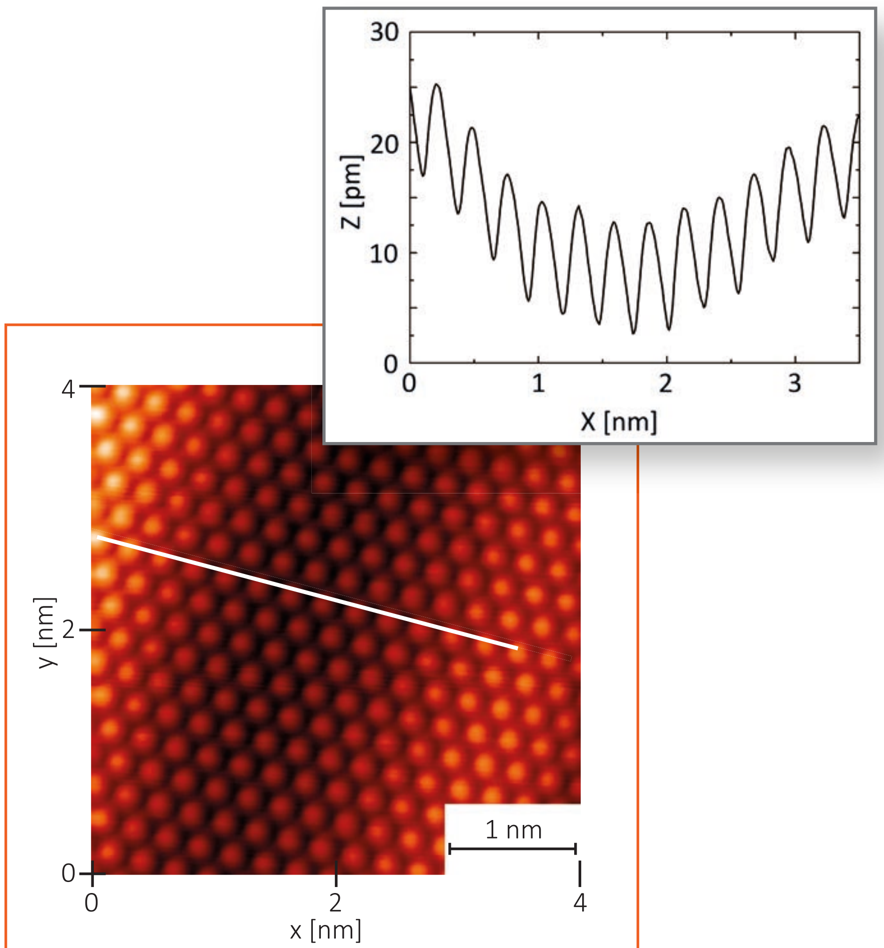
The new TESLA JT SPM provides access to more than 5 days SPM measurement time at temperatures T < 1.4K with magnetic fields larger than B > 3T.

Careful thermal design of the bath cryostat and Joule Thomson (JT) cooling stage as well as the integrated dry magnet lead to exceptionally low LHe consumption, specifically during magnet operation.

The external JT Helium supply allows for ^{3}He operation and significantly lower temperatures. STM measurements on Au(111) prove the exceptional stability of the system. A temperature of T = 1.03K has been achieved by optimised thermal coupling.




Compact TESLA JT SPM head



Atomic resolution STM on Au(111) at T= 1.03K. Individual atomic corrugation approx. 7pm, height variation due to herringbone visible. Scan range 4 x 4 nm, U_{GAP} = 200 mV, I_{SET} = 2.0 nA, Loop gain: 1%. Insert: Line profile

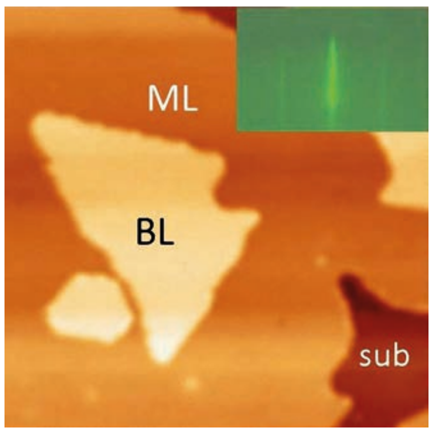
MBE Growth with Lab10 MBE System

Synthesis of two-dimensional materials by Lab10 MBE

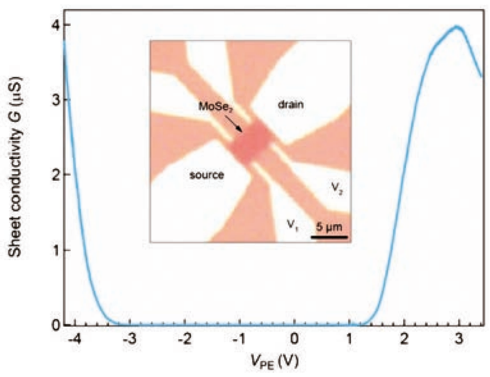
Two-dimensional materials, like graphene and transition metal dichalcogenides (TMDCs), attracted a lot of attention recently, caused by atomic-scale thickness, semiconducting character, strong spin-orbit coupling and promising electronic properties. They are potential candidates for a wide range of applications, like flexible electronics, sensing, spintronics and optoelectronics.

For practical applications, the controlled growth of these materials with high quality over a large area is mandatory. A high potential technique to fulfil the needs of large-area synthesis of 2D materials is molecular beam epitaxy (MBE).
Successful MBE growth of two different TMDCs was demonstrated using Scienta Omicron's Lab10 MBE systems. Monolayer WSe_2 was grown by Prof. Mao Hai Xie's group in Hongkong [H.J.Liu et al., 2D Mater. 2 (2015), 034004] and analysed by STM and STS. Figure 1) shows WSe_2 grown on highly oriented pyrolytic graphite (HOPG) with a partial coverage of bilayer domains and holes of the exposed substrate. The inset shows a typical RHEED pattern, the streaky pattern indicates layer-by-layer growth mode.

1)



2)



Another 2D material which has attracted a lot of attention is $MoSe_2$. The group of Andras Kis at EPFL Lausanne [M.-W. Chen et al, ACS Nano, 2017, 11 (6), pp 6355–6361] reported the growth of atomically thin $MoSe_2$ on GaAs(111)B substrates. MBE-grown $MoSe_2$ films were integrated in electrolytically gated transistors and showed ambipolar electrical transport (Figure 2).

The Lab10 MBE has been proven as a powerful system for the MBE growth of 2D materials. It can be modified, to match the vision of individual customers. Furthermore, it can be interfaced with a multitude of Scienta Omicron analysis systems, like XPS, ARPES and SPM, to facilitate the development of novel materials.

HAXPES Lab demo system

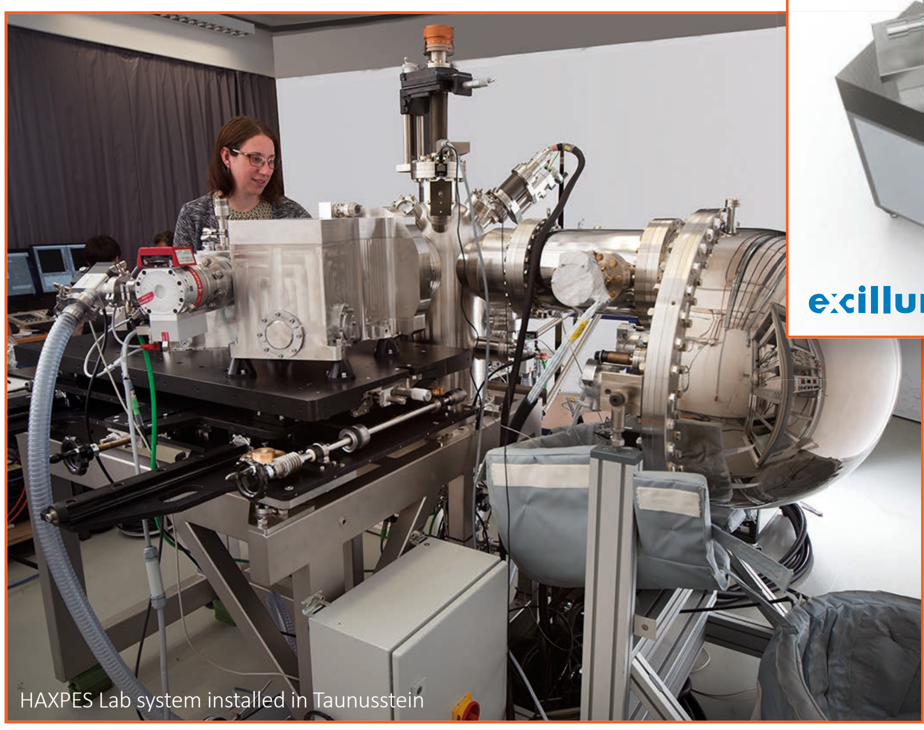
About to open a window to the bulk in home labs

We are pleased to see that the final parts of the demo system HAXPES Lab are now being mounted and tested, and during the autumn we will begin welcoming our customers to Taunusstein, Germany to see and test our new true home lab HAXPES instrument.

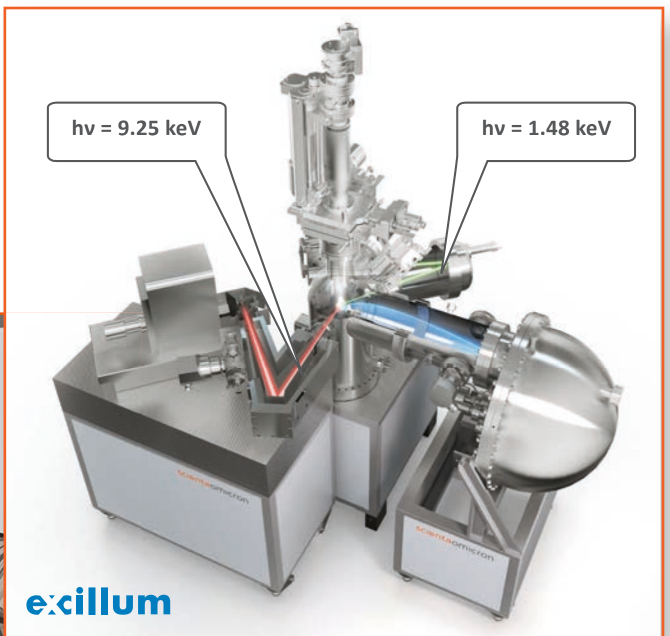
During the recent decades, monochromated Al Kα based X-ray sources have dominated the market for lab-based X-ray photoemission spectroscopy (XPS). The relatively low energy of these X-rays gives valuable surface sensitive measurements.
With HAXPES (hard X-ray photoelectron spectroscopy) the field of photoemission opens a window to the bulk, allowing studies of pure bulk properties of solids, applicable e.g. to the studies of highly correlated systems, nano physics, solar cells, etc.

HAXPES Lab is a system utilizing a 9.25 keV monochromated X-ray source with a Ga-metal jet technique allowing for analysis in the full kinetic energy range up to 9.25 keV. The high photon energy opens new possibilities for bulk measurements with a mean free path of emitted photoelectrons substantially greater than that of photoelectrons emitted by Al Kα radiation.

Using energies of several keV will increase the probing depth to > 100 Å thus opening up possibilities to probe bulk properties.



HAXPES Lab system installed in Taunusstein



3D graphic showing the principle HAXPES Lab design.

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ARPES-Lab:

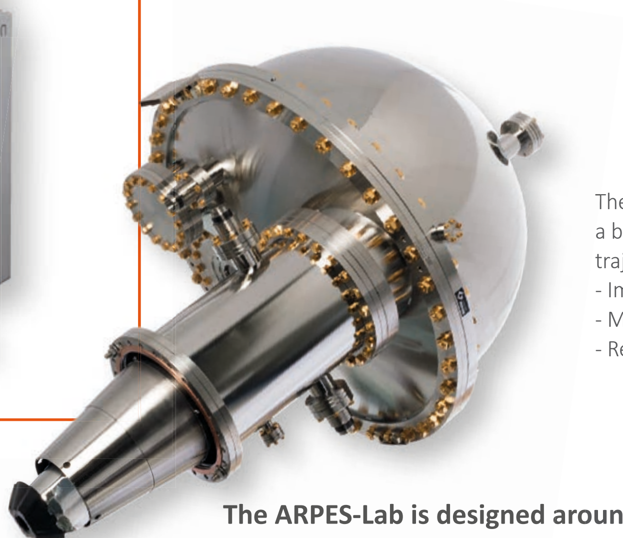
The expert solution for high-end ARPES results

- Comprehensive ARPES solution by market leader
- Expert integration of the best technologies
- Smart system and measurement automatization
- Competent support for configuration and design
- Fast help by world-wide service teams

Angular resolved photoemission spectroscopy (ARPES) is a powerful technique to understand the electronic structure of materials and what can influence their physics and chemistry. The band-structure of the valence band and the Fermi level is the key to understanding electron transport, band-gap phenomena and spin-related effects. The progress of new technologies in e.g. informatics, batteries and solar cells depends more than ever on a precise understanding of the inherent abilities of complex material systems.

The key to precise ARPES measurements is the ideal choice of powerful components like analysers, light sources, manipulator and vacuum chambers as well as the perfect combination to a synergetic system which guarantees the best overall performance of the method.

ScientaOmicron is the well-known market leader for ARPES components with decades of experience in systems design. The ARPES-Lab product merges this expertise to a world-leading turn-key measurement system which generates the best performance out of the best technologies.
The comprehensive system approach from one manufacturer furthermore enables a superior software control concept reaching from the vacuum control to a measurement automation which allows scientists to concentrate on their fast and world-leading results.



The DA30-L hemispherical analyzer measures the full 3D surface cone of a band-structure without any sample tilts by deflecting the electron trajectories perpendicular to the analyzer entrance slit, which allows for:
- Improved momentum detection accuracy
- Matrix element effects are avoided by keeping sample fixed
- Reliable measurement on a fixed sample point

The ARPES-Lab is designed around the popular DA30-L hemispherical high-resolution analyser with its unique deflector concept. For wide-range Brillouin zone scans the motorized sample manipulator is integrated into the measurement (SES) and system software (MISTRAL). The software driven adjustment of the manipulator allows for:
- Precise sample movement during scans
- Automatic movement of the sample between different measurement positions (ARPES, LEED, etc.)
- Security interlocks for manipulator movement

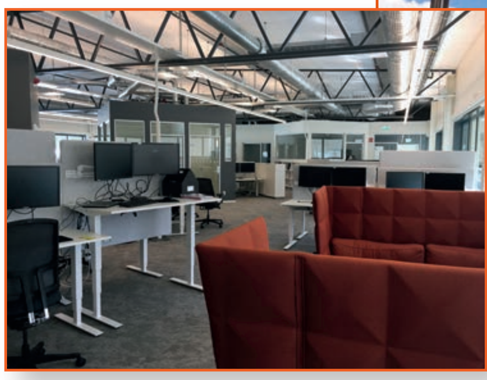
All manipulators (4, 5 or 6 axis) reach very low temperatures to allow for high energy resolutions. The monochromatized VUV light sources are optimized for high flux densities and small beam spots on the sample to improve angular resolution and measurement times. Additional XPS sources are available for chemical core level analysis.

The system is perfected with magnetic shielding optimized for the analyser of choice and a pumping system dedicated to low working pressures even when working with He-discharge lamps. Sample preparation and spin filter options are available for extending the scientific possibilities.

The ARPES-Lab is prepared to be upgraded with components and extendable to multi-technique surface science systems with in-situ-growth and scanning probe microscope capabilities.

New facility in Uppsala

Modern and efficient for further developments



The high demand for Scienta Omicron's electron spectroscopy products has rendered the opportunity to relocate the operation to a larger, purpose-built factory. During July 2017 the move took place, and since August the operation has been up and running in the new environment.

The new facility, like the old one, is located in Uppsala and features two floors: A ground floor dedicated to state-of-the-art production with flow line assembly, clean room areas and modern logistics for production of electron analysers and light sources along with test facilities both for customer systems and R&D projects, and an upper floor with Activity Based Workspace to give an ideal environment for continued innovation and technology leadership. The new, modern Scienta Omicron factory includes the full range of disciplines, from R&D and sales, to production and service.

The space is also shared with the Scienta Scientific headquarters team and our sister company Scienta Sensor Systems.