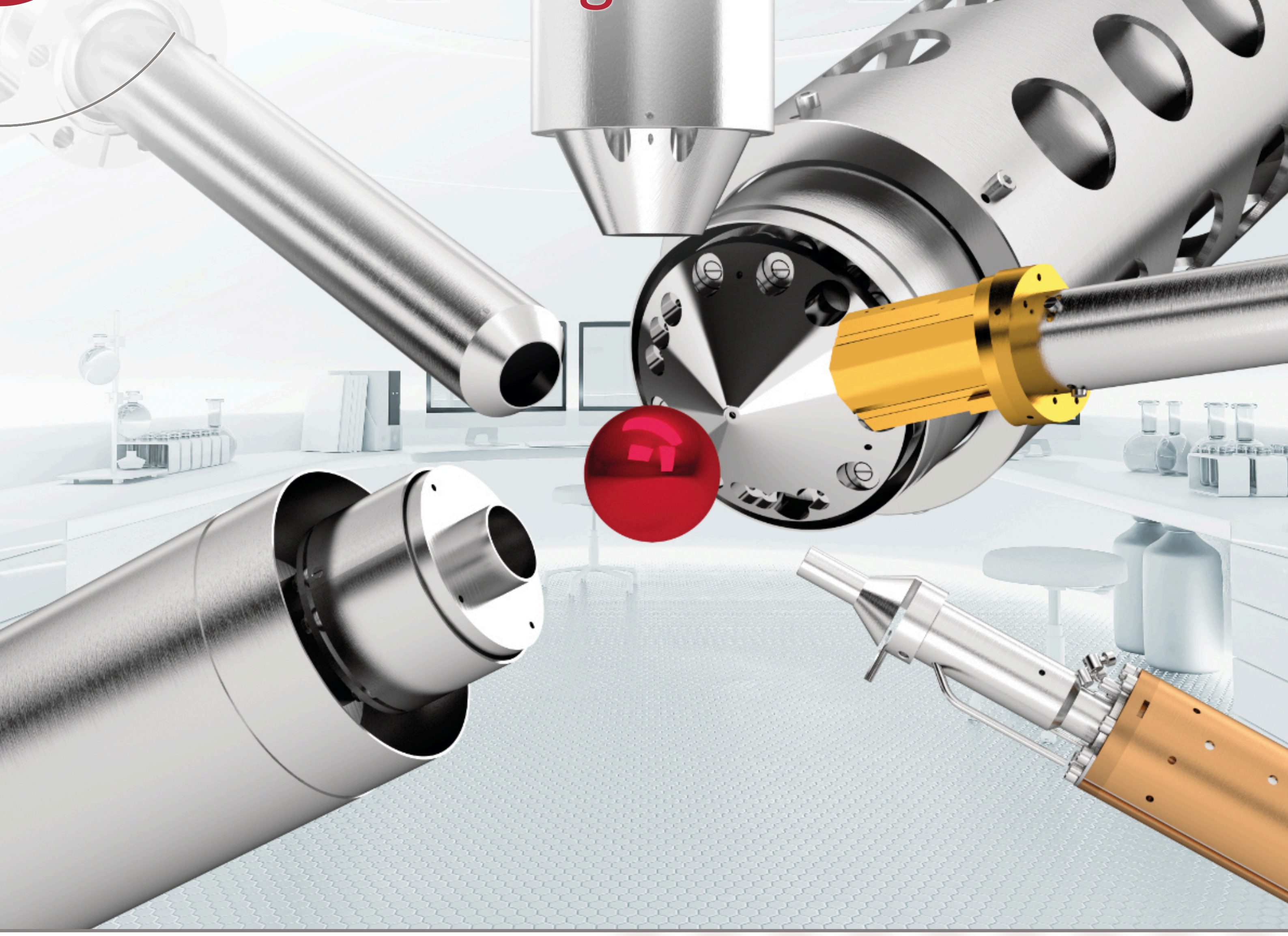
FOCUS Scientific Instruments

Product Catalogue 2023



- E-Beam Evaporators
- Ion Sources
- VUV Light Sources
- Photoemission Electron Microscopes
- Spin Filters

FOCUS

THE EFM SERIES

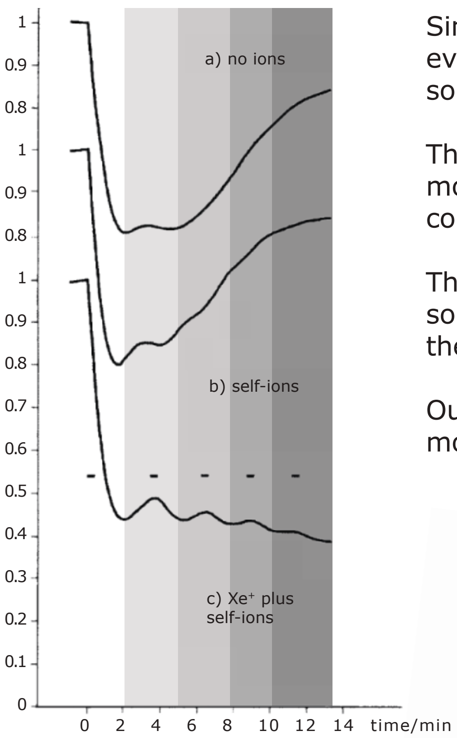
UHV E-BEAM EVAPORATION

Since 1990, FOCUS manufactures the widespread and well known EFM evaporators (Evaporator with Flux Monitor). With more than 2000 devices sold world wide, we are the No. 1 brand in the market.

These UHV e-beam evaporators are dedicated to ultra-pure sub-monolayer and multilayer thin film growth under ultra high vacuum (UHV) conditions.

The product family includes the legendary EFM 3 as well as much more sophisticated solutions like the EFM 3i for ion-beam-assisted deposition or the EFM 4 for large samples.

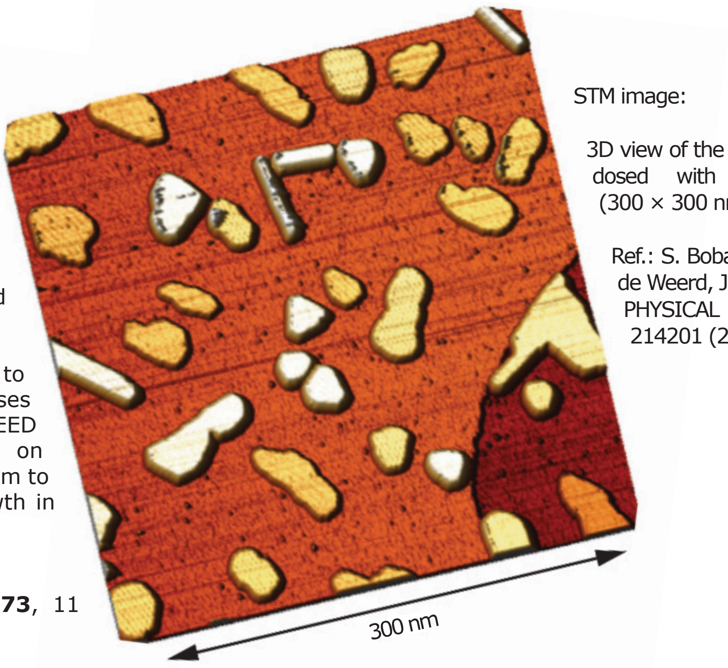
Our evaporators are also successfully used for the deposition of organic molecules.



Above: EFM 3i - Ion Beam Assisted Deposition (IBAD)

The EFM 3i is specifically designed to facilitate layer by layer growth in cases where it does not occur naturally. RHEED oscillations monitor the growth of Co on Cu(111) starting with a) a neutral Co beam to a strongly improved layer by layer growth in c) using self-ions and Xe^+ ions.

Ref.: J.Kirschner, H.Engelhard and D. Hartung , Rev. Sci. Instrum., Vol. **73**, 11 (2002)



STM image:

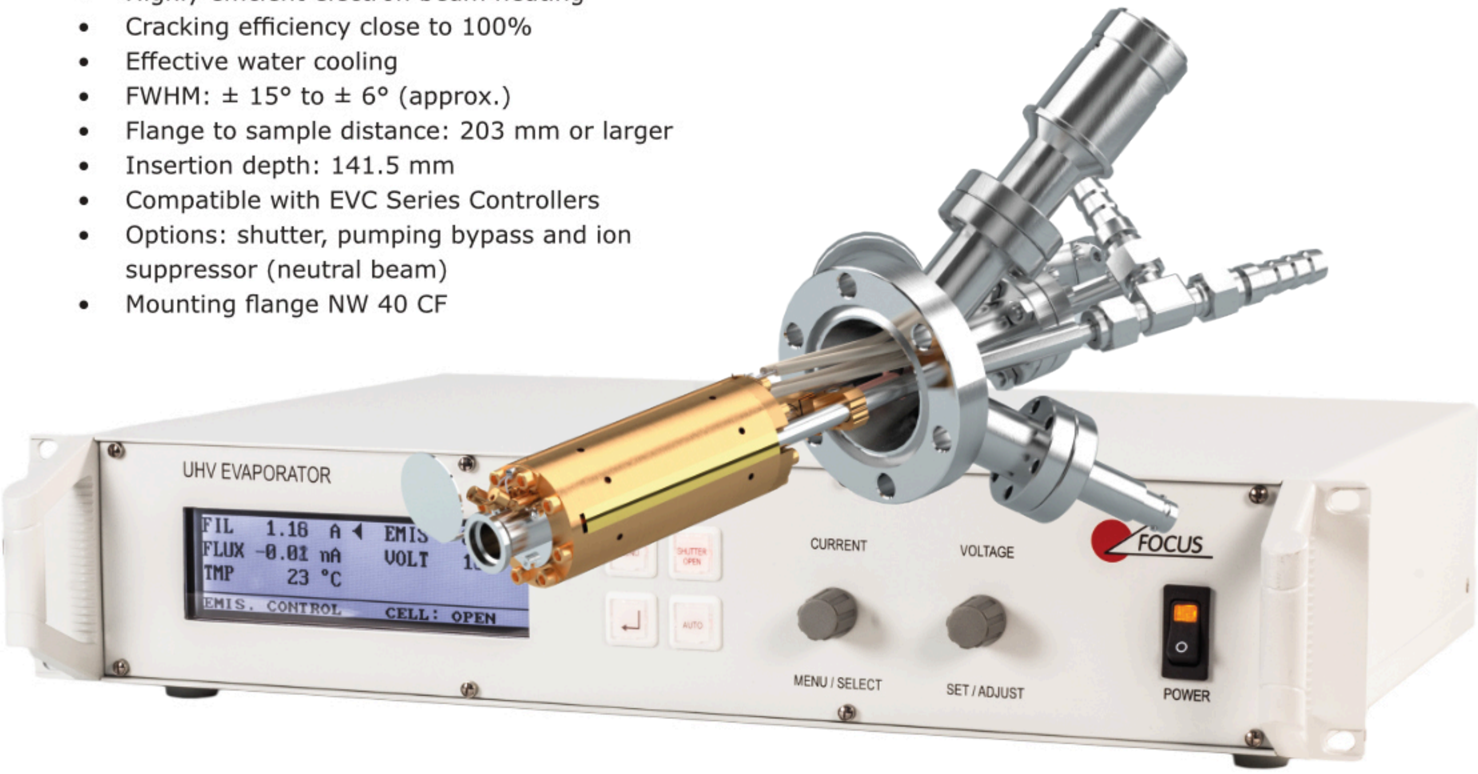
3D view of the $Al_{13}Co_4(100)$ surface dosed with 2.6 ML of Bi (300 × 300 nm^2).

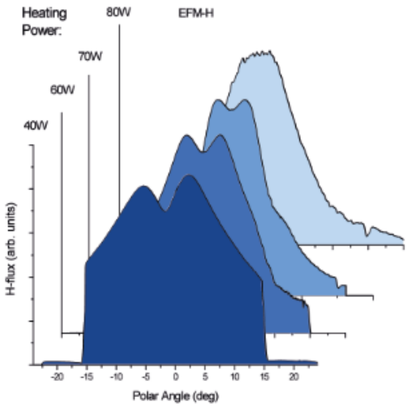
Ref.: S. Bobaru, É. Gaudry, M.-C. de Weerd, J. Ledieu, V. Fourneé, PHYSICAL REVIEW B **86**, 214201 (2012)

EFM-H

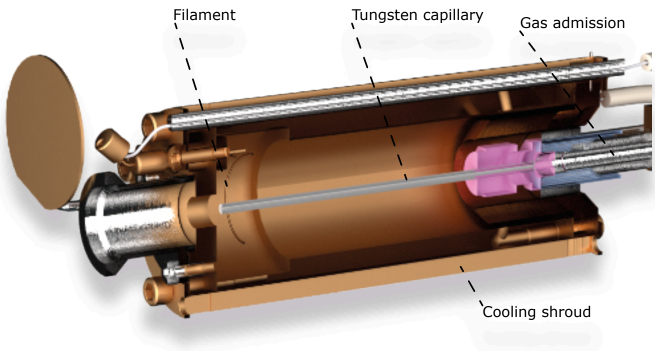
HYDROGEN ATOM BEAM SOURCE

- Highly efficient electron beam heating
- Cracking efficiency close to 100%
- Effective water cooling
- FWHM: ± 15° to ± 6° (approx.)
- Flange to sample distance: 203 mm or larger
- Insertion depth: 141.5 mm
- Compatible with EVC Series Controllers
- Options: shutter, pumping bypass and ion suppressor (neutral beam)
- Mounting flange NW 40 CF





The EFM-3H is carefully designed to deliver a sharply defined beam profile. By adjusting the heating power, different spot profiles can be selected.



Schematic cross section of EFM-H

The EFM-H (as thermal gas cracker) is a source to provide atomic hydrogen based on the design of the EFM 3. A flange NW 16 CF on the rear side is used for hydrogen inlet, including a pumping by-pass to clean the piping prior to H_2 disposal.
It is ideal for cleaning and etching semiconductor surfaces (such as Si, GaAs, Ge or InP), for surface passivation, for improvement of thin film growth and other similar applications using atomic hydrogen.

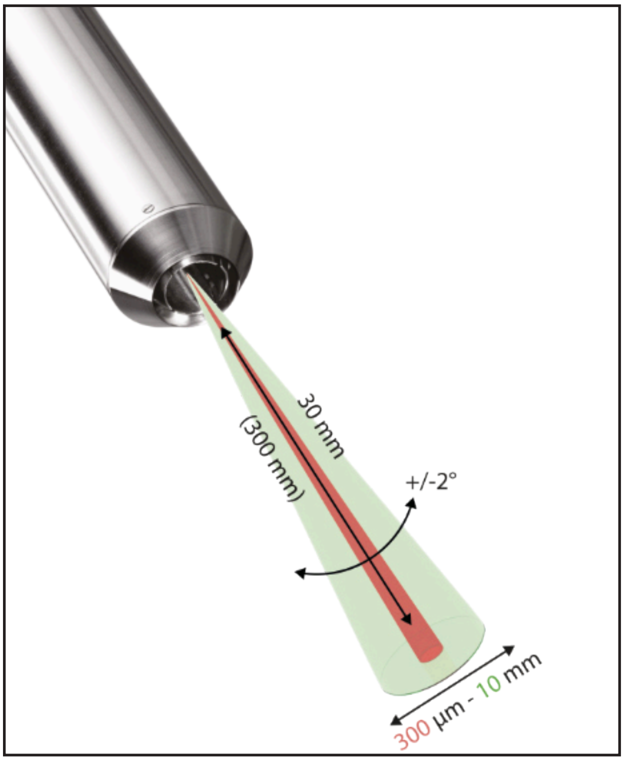
The EFM-H features a cracking efficiency close to 100%, a smooth, flat and sharply defined spot profile, a low background pressure due to its efficient water cooling and a low power consumption, demonstrating the outstanding performance of the EFM-H.

The EFM-H is compatible with all EVC power supplies and cable sets.

FDG 15

FOCUSED HOT FILAMENT ION SOURCE

- The FDG 15 is a hot filament ion source for ultra clean sputtering or depth profiling between 10 eV and 5 keV (optional)
- Effective differential pumping (10^{-8} mbar in operation)
- Ion focusing optics with spot sizes < 300 µm to 10 mm (at 50 mm working distance)
- Integrated port aligner for source alignment
- Controlled by the the power supply front panel or via a TCP/IP interface
- An ease of use LabVIEW™* – based PC software
- Beam current regulation
- Optional high current @ low energies e.g. for sputtering of semiconductors (< 100 eV) or charge neutralization in ESCA (< 10 eV)

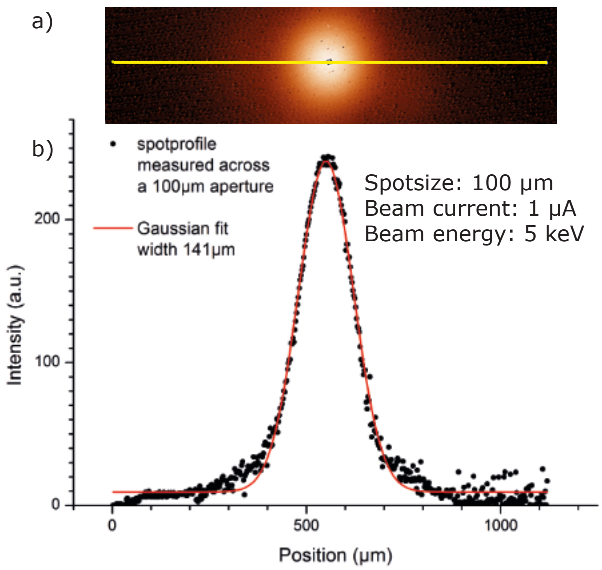


FDG 150

FINE FOCUSED SCANNING ION SOURCE

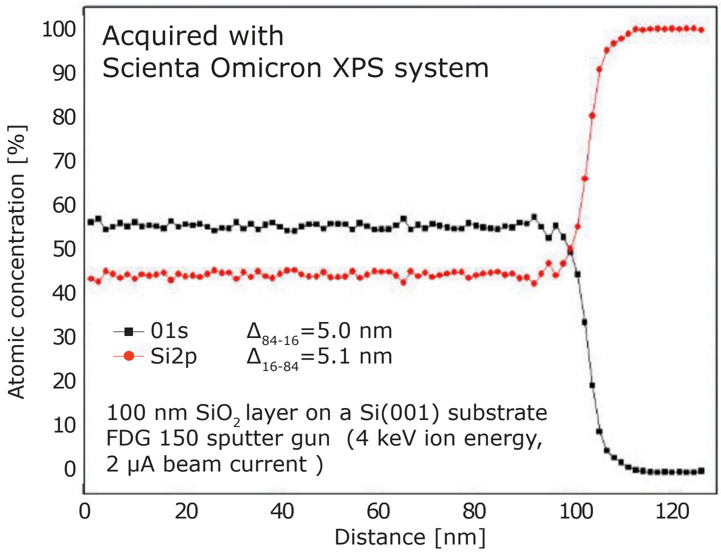
In addition to all features of the FDG 15, the FDG 150 provides even higher focussing capabilities and ion beam scanning up to a range of 10 mm x 10 mm with Keystone Correction.
It is a high performance UHV Ion source for depth profile analysis with XPS and Auger Spectroscopy. It is also used for sample cleaning, for sensor cleaning in scanning probe microscopy and for the excitation in ISS/LEIS instruments.

The source is equipped with a stable beam current regulation for ultimate depth resolution in depth profile analysis. It can be operated at energies as low as 5 eV to be used for charge neutralization with ESCA applications and the beam diameter can be focused down to less than 150 µm.



a) Image of the argon ion spot scanned across a 100 µm aperture.

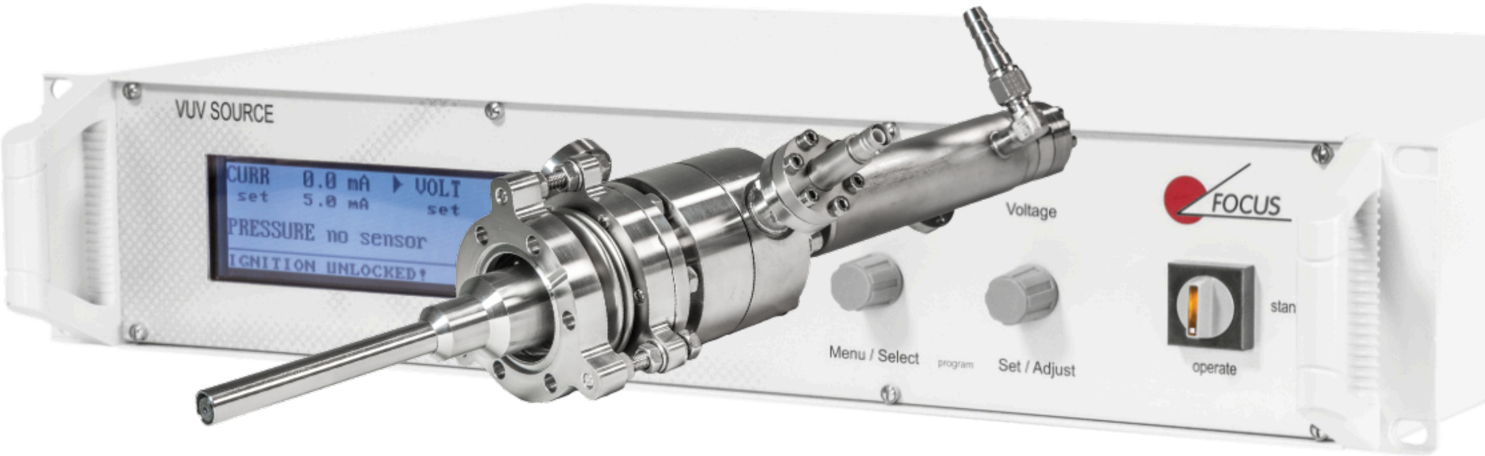
b) Cross section along the yellow line of a) showing a spot profile corrected by aperture width which results in a 100 µm spot diameter @ 1 µA beam current.



XPS depth profiling through a 100 nm SiO_2 layer on Si (001): The cross-over position of the Oxygen peak (O1s) and Silicon peak (Si2p) intensities indicates the thickness of the oxide layer.

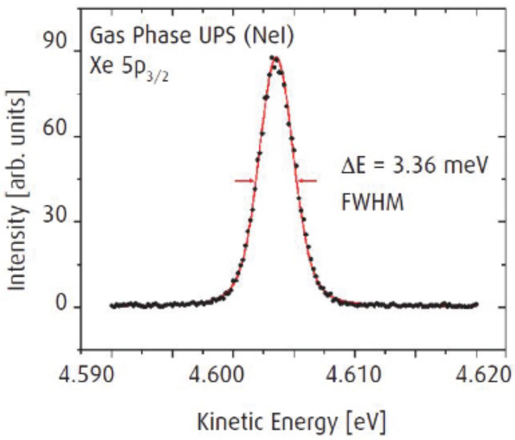
HIS 13

HIGH INTENSITY VUV-SOURCE



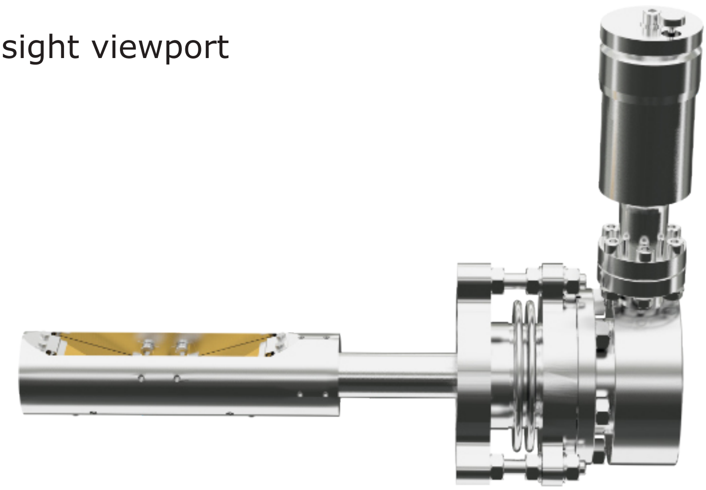
Ease of operation, robust design and a high intensity make the HIS 13 a preferred excitation source for UPS. The source is available with multiple options such as a linear polarizer, third differential pumping stage or an attenuator to tune light intensity. More than 350 installed units stand for reliable quality. The VUV source power supply with up to 300 mA discharge current, integrated pressure gauge display and fast electronic ignition supports ease of operation and optimized source brightness.

- Long lifetime due to filament free design
- Ease of operation
- Robust design
- Discharge regulation
- Precise alignment with line of sight viewport
- Large range of options

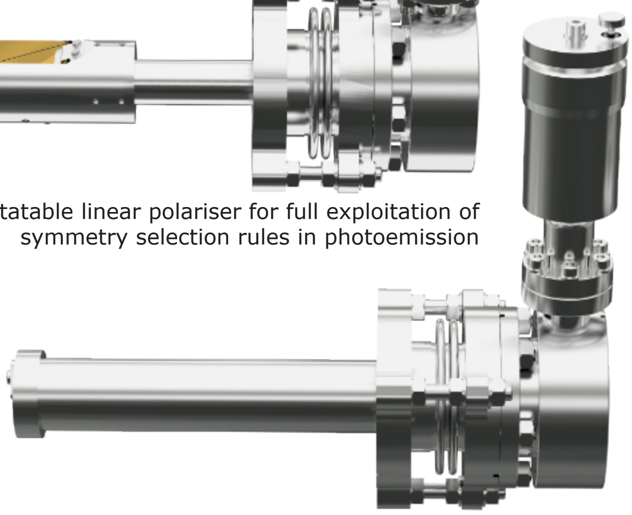


The line width of the gas phase spectrum is dominated by the Xe Doppler broadening and the analyser resolution. It proves a line width less than 2 meV of the HIS 13.

Measured with
Scienta Omicron EA 125



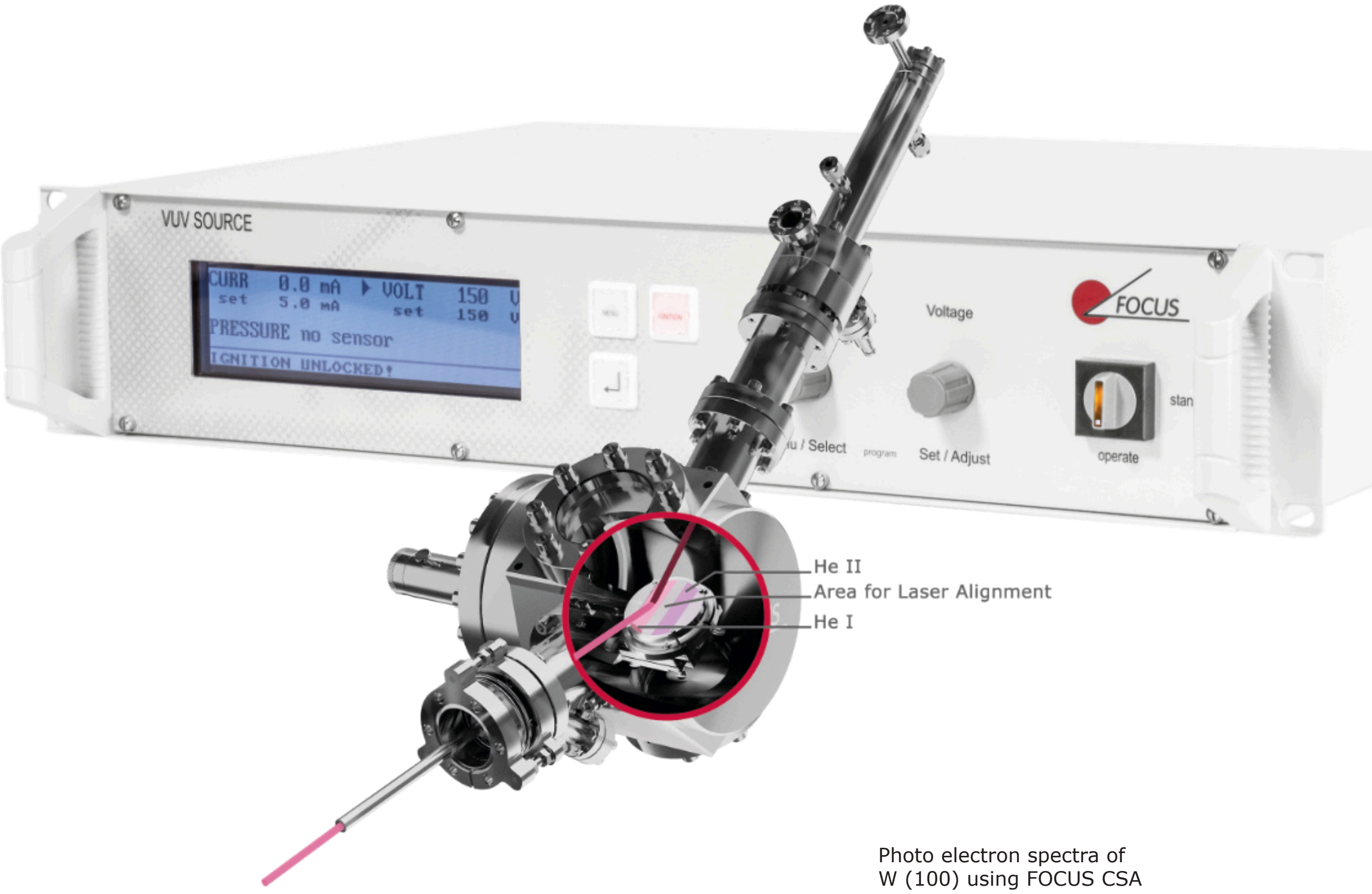
Continously rotatable linear polariser for full exploitation of symmetry selection rules in photoemission



Attenuator for HIS 13/14 for VUV-sensitive samples. Variable reduction of photon flux by a factor 10 or 100.

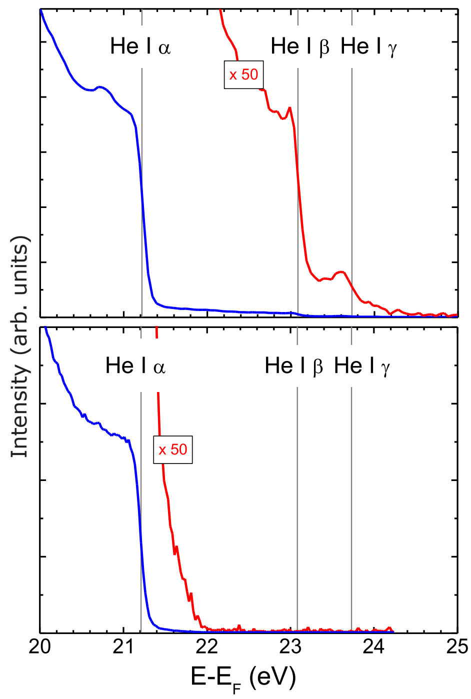
HIS 13 MONO

MONOCHROMATIZED VUV SOURCE



- Dispersive element with >20 % transmission for He I and II
- NW 40 CF mounting flange
- Ease of operation
- Cost effective removal of either HeI or HeII incl. satellites

Photo electron spectra of W (100) using FOCUS CSA



Top: Satellites He I-ß and y present
Bottom: No satellites

Gefördert durch:

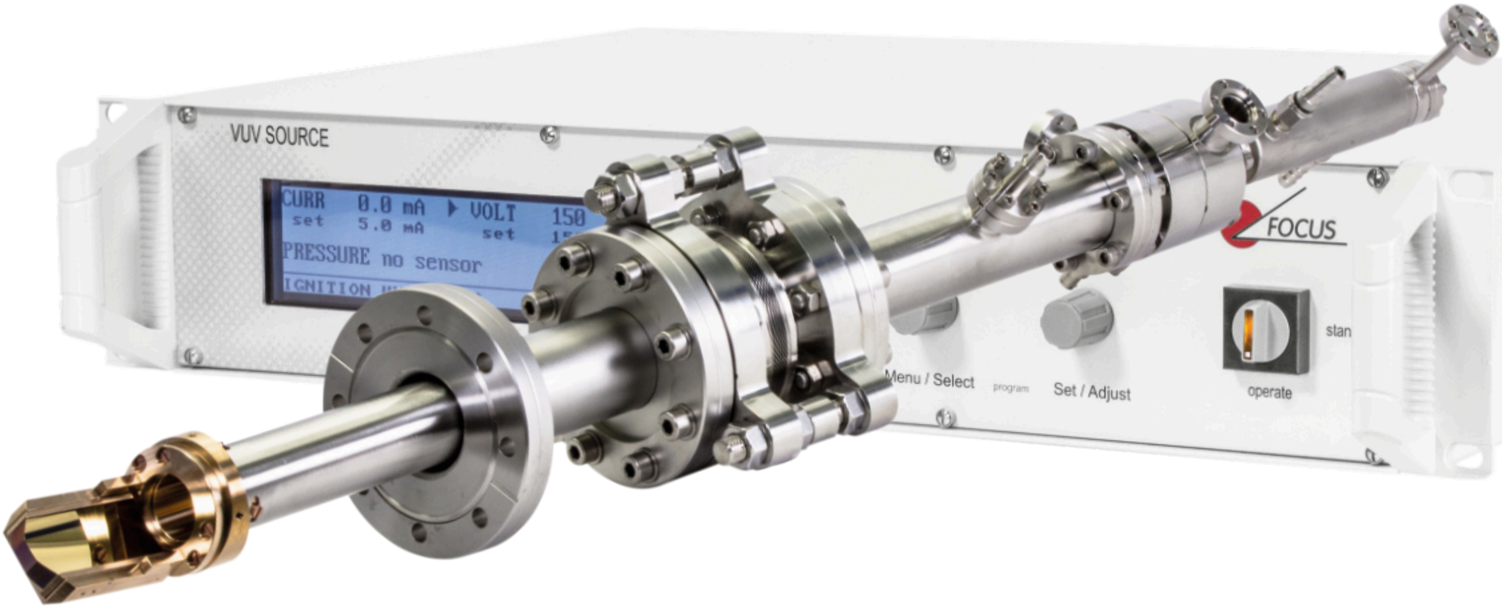
Bundesministerium für Wirtschaft und Energie

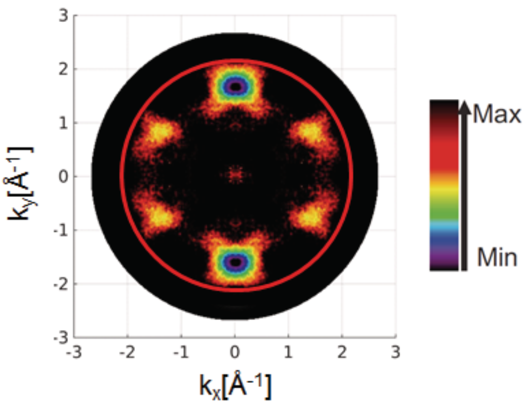
aufgrund eines Beschlusses des Deutschen Bundestages

HIS 14 HD
FOCUSED VUV-SOURCE

The HIS 14 HD fine focused high photon density VUV-source is the ideal photon laboratory source for ARPES and PEEM with < 180 µm spot size, ca. 70 mm working distance and a 50 times higher flux density compared to a non-focused source. The photon flux for He I is up to 1.1 x 10^{13} ph/s/mm².

Operation with chamber pressure in the 10^{-10} mbar range is possible when using the optional third pumping stage. The source is mounted on a NW 63 CF flange and comes with the VUV-source power supply.

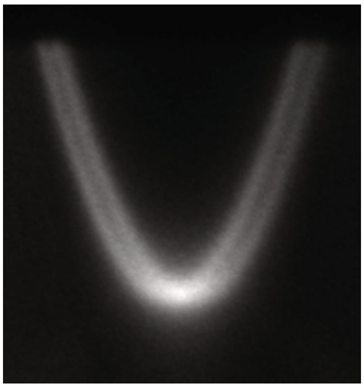




k_x-k_y map of the HOMO of NTCDA on Cu(111)

Dwell time 45 min, recorded with Elmitec SPE-LEEM/PEEM III

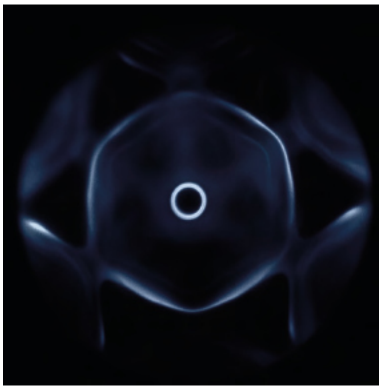
Courtesy:
Prof. Christian Kumpf,
FZ Jülich GmbH, PGI-3



Au (111) surface state with Rashba Splitting He I excitation (21.2 eV)

Dwell time 50 s measured with PHOIBOS 100 (SPECS GmbH)

Courtesy:
Dr. L. Dudy, M. Scholz, Universität Würzburg



Fermi surface (k_x-k_y-map at 21.2 eV) of Au(111)

Dwell time 100 s, recorded with FOCUS NanoESCA (FOCUS / Scienta Omicron)

Courtesy:
Konrad Winkler, Scienta Omicron

FOCUS HIS 14 HD MONO

MONOCHROMATIZED VUV SOURCE

The HIS 14 HD Mono is the ultimate source for UPS, ARPES, PEEM and Micro-ARPES. It combines the high photon density of the VUV source HIS 14 HD with a highly efficient dedicated monochromator. This makes it an excellent excitation source for ARPES and Momentum Microscopy applications.

Gefördert durch:

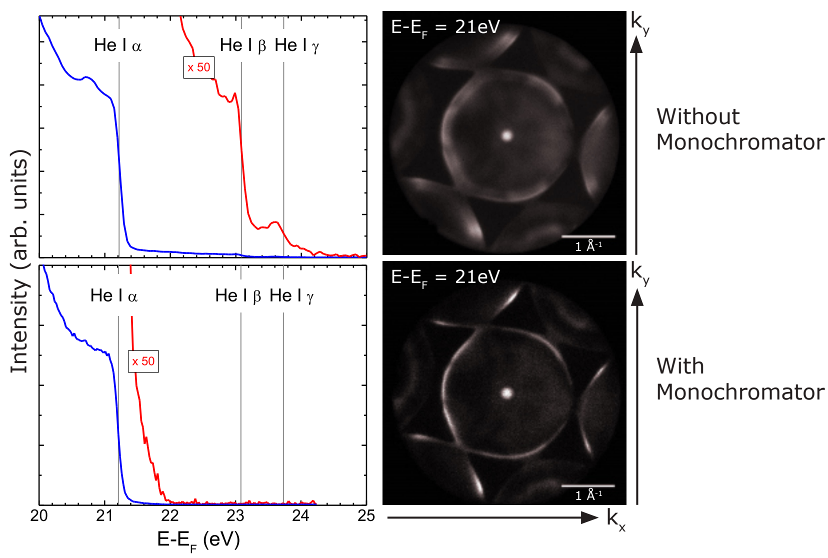
Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

- Dispersive element with 20 % transmission for He I and II
- Photon flux
  He I: > 1x 10^{12} Photons/s/mm²
  He II:> 2x 10^{11} Photons/s/mm²
- Spot size down to < 180 µm (ø 0.8 mm light capillary)
- Working distance 70 mm
- Ease of operation
- Operating pressure down to 10^{-10} mbar range (with third pumping stage)

Photo electron spectra of W (100) using FOCUS CSA

Momentum microscopy of Ag (111) using FOCUS IEF-PEEM



Top: Satellites
He I-β and γ present

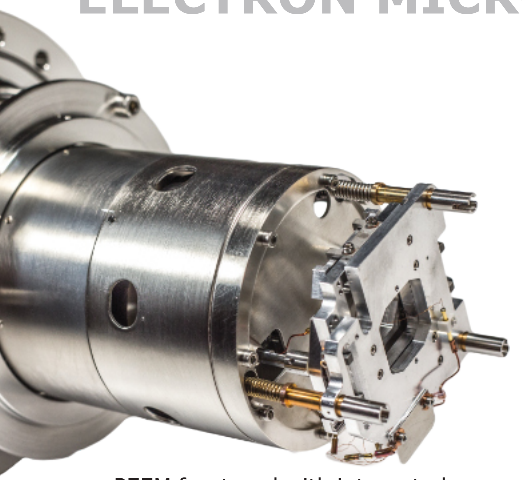
Bottom: No satellites

Top: Shadow-structure
visible due to He I-β

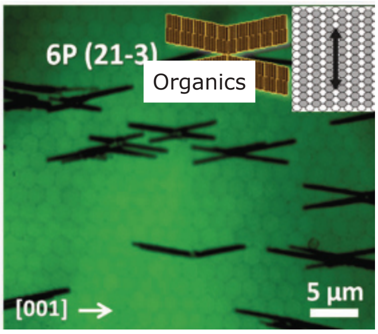
Bottom: Band-structure
due to He I-α solely

FOCUS IS-PEEM

PHOTOEMISSION ELECTRON MICROSCOPY



PEEM front-end with integrated sample stage (IS-PEEM)

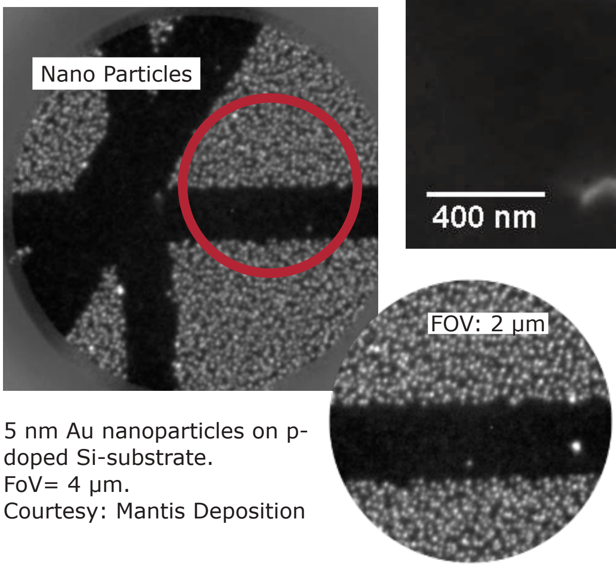


PEEM image of self-assembled p-sexiphenyl (P6) Nanostructures that form when P6 is deposited on Cu (111). Typical height of the nanostructures are in the range of 50-500 nm.
Ref.: A.J. Fleming, M. Ramsey, Phys. Chem. Chem. Phys. **13**, 10, (2011)

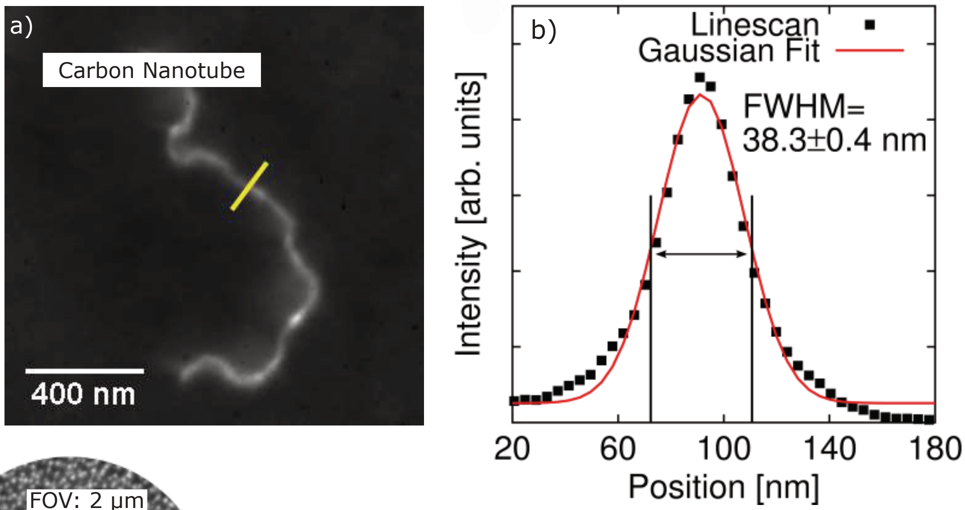
The FOCUS IS-PEEM is a Photoemission Electron Microscope with integrated sample stage (IS) for unsurpassed stability and precise sample positioning via remote controlled piezo drives. The variable contrast aperture and the stigmator/deflector makes it a very versatile microsope for laboratory and synchrotron applications.

Topography contrast, work function contrast, chemical contrast and magnetic contrast can be used for surface sensitive real-time imaging of any reasonably flat and conducting surface ranging from molecules, nanotubes, graphene to cluster and magnetic samples.

The ease of use of an operator-friendly software helps users to operate the PEEM at its full performance level with excellent scientific results.



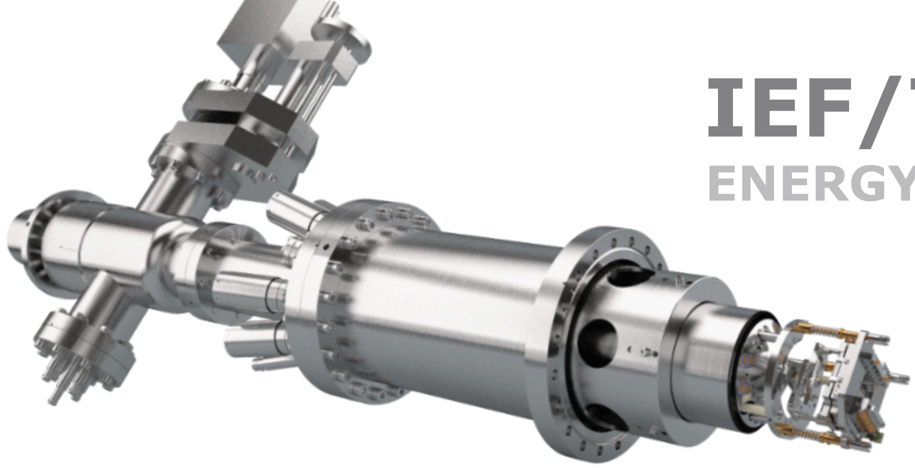
5 nm Au nanoparticles on p-doped Si-substrate.
FoV= 4 µm.
Courtesy: Mantis Deposition



a) PEEM measurement showing the image of an isolated Carbon Nano Tube (CNT) at highest magnification.

b) Line profile of the intensity along the yellow line in a) together with a Gaussian fit.

Ref.: A. Neff et al., American Journal of Nano Research and Application, Special Issue: Advanced Functional Materials. 2, 6-1, (2014)

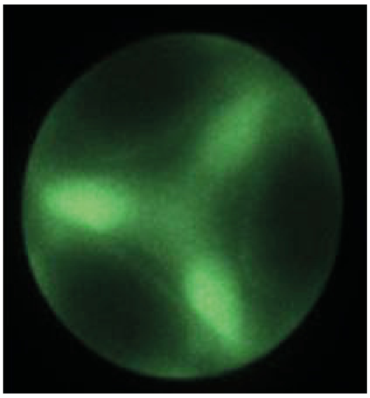


IEF/TOF-PEEM

ENERGY FILTERED PEEM

The Imaging Energy Filter (IEF) makes the FOCUS PEEM a powerful tool to measure work function maps (with lab sources) as well as element specific maps (with synchrotron, X-ray micro-spectroscopy) of conductive samples. For time/energy resolved measurements paired with a pulsed excitation source the FOCUS PEEM can be equipped with a Time-of-Flight (TOF) energy filter. These energy filters can be combined in one instrument for maximum versatility.
The PEEM with IEF and/or TOF is available with angular imaging optics. Such a Momentum Microscope acquires k-space images/momentum maps from precisely defined regions on the sample.

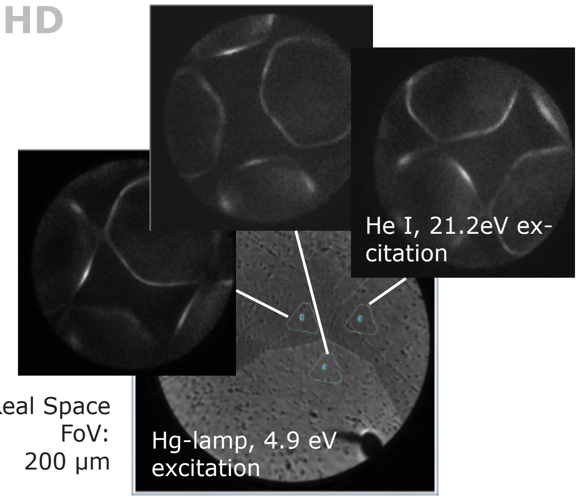
IEF PEEM & VUV LAB SOURCE HIS 14 HD



Left: Imaging of the d-band region of Ag(111), He I excitation (HIS 14 HD, 21.2 eV), $E-E_F$ = 15.5 eV, dwell time 5 s, FoV = 20 µm

Right: µ-ARPES of polycrystalline silver. The navigation in the real space is accomplished by use of the iris micro aperture defining the region of interest before switching to k-space imaging.

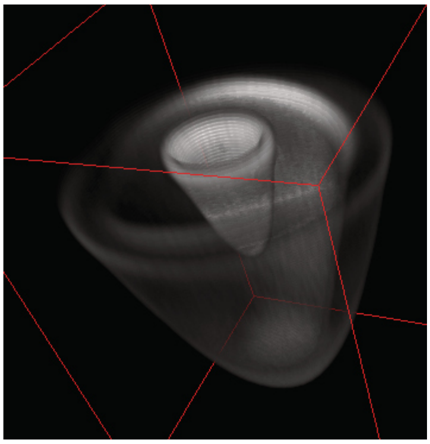
Because of their different crystallographic orientations the single grains deliver different momentum patterns.



Real Space FoV: 200 µm

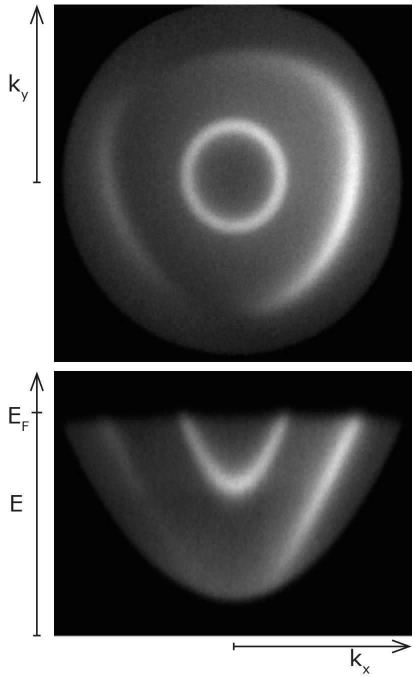
TOF PEEM & PULSED LASER

The complete k-space of the photoemission from a Au (111) surface (at room temperature), has been excited with a pulsed 210 nm laser (80 MHz rep. rate, 200 x 200 µm², 17 µW). One can see the surface state and direct sp-sp transitions.



3D representation of a complete $E-k_x-k_y$ data cube.

- Real space FoV: about 25 µm
- k-space FoV: ±0.575 Å^{-1}
- drift energy: 20 eV
- energy range: 4.3 eV to 5.9 eV (E_F)

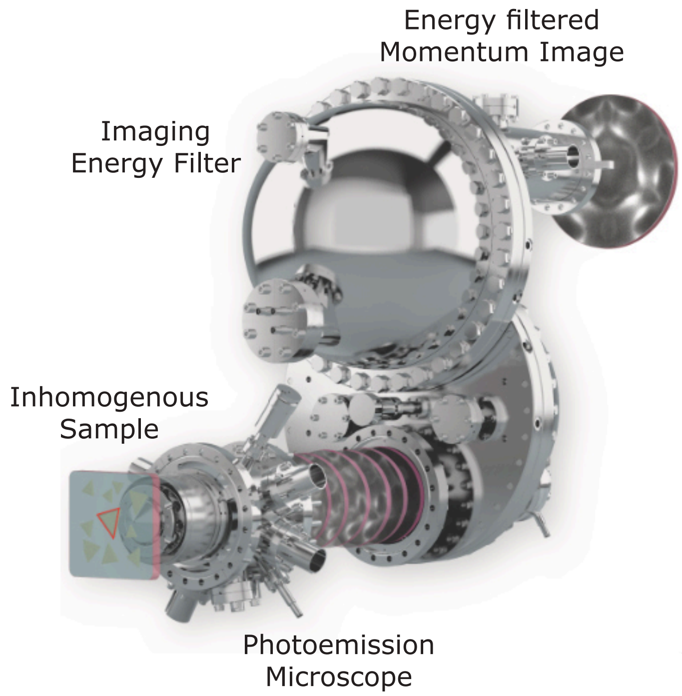


k_x-k_y image near to the Fermi energy E_F

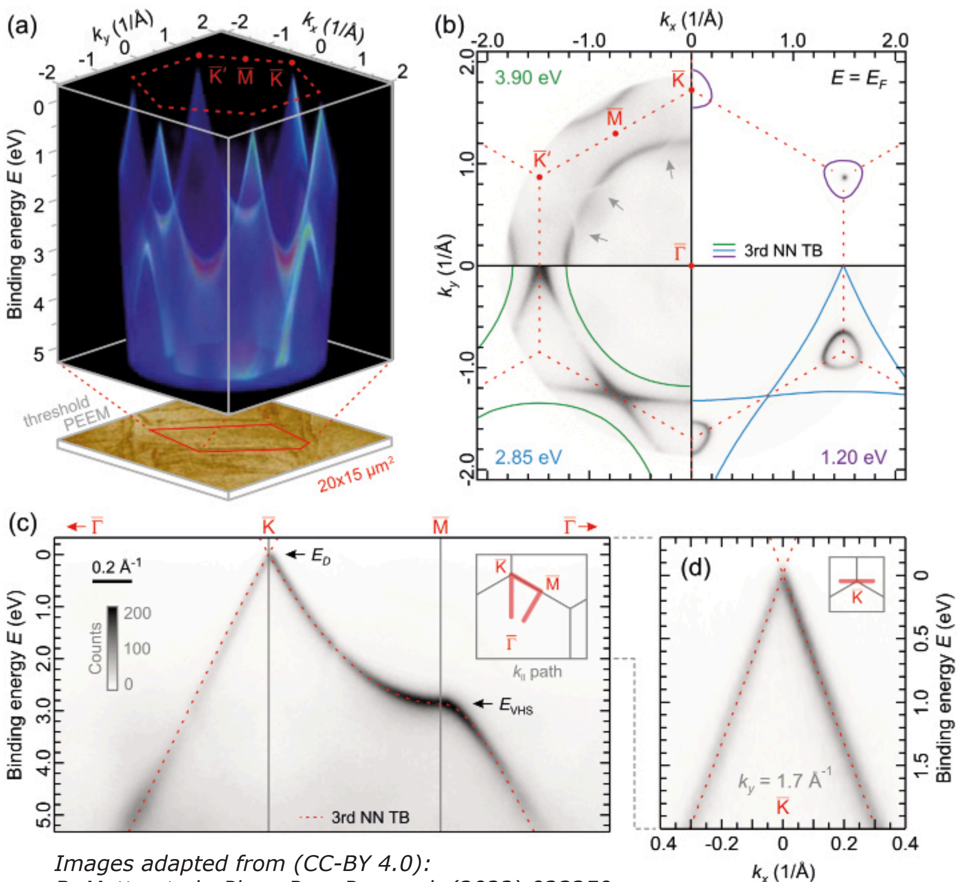
$E–k_x$ image with a sharp parabolic emission horizon.

NanoESCA · MARIS
NEXT-GENERATION PHOTOEMISSION MICROSCOPY

- Momentum and Real-Space Imaging Spectroscopy
- Easy sample navigation with live-view
- Lateral resolution < 35 nm in Real-Space
- Momentum-Space Resolution < 5 mÅ^{-1}
- Excellent Imaging Energy Resolution < 25 meV
- Energy filtered microscopy for strong chemical contrast in UPS and XPS
- Precise sample region isolation for micro ARPES
- Full Brillouin zone snap-shot of a constant energy cut due to 180° angular acceptance



MOMENTUM MICROSCOPY ON GRAPHENE

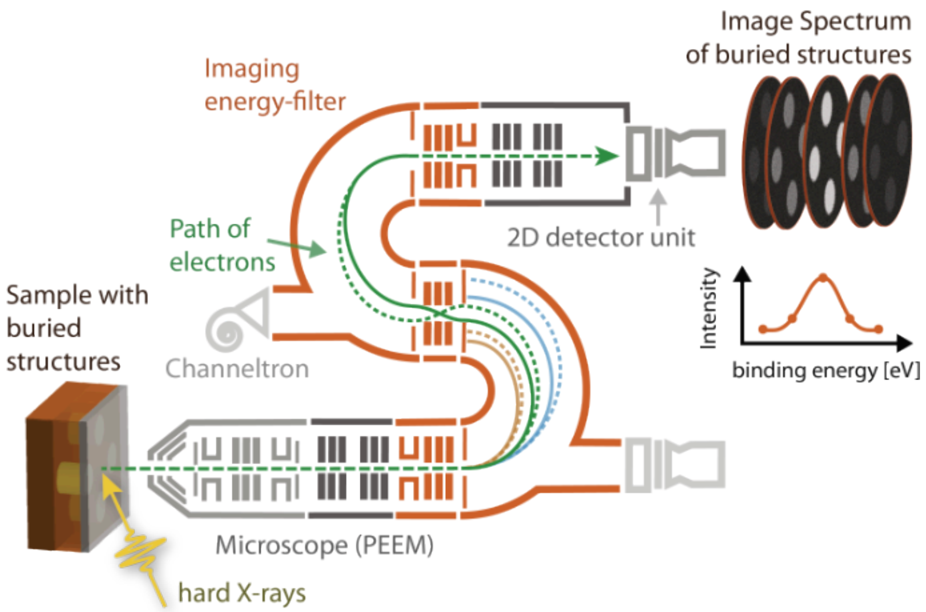


Images adapted from (CC-BY 4.0):
B. Matta et al., Phys. Rev. Research (2022) 023250

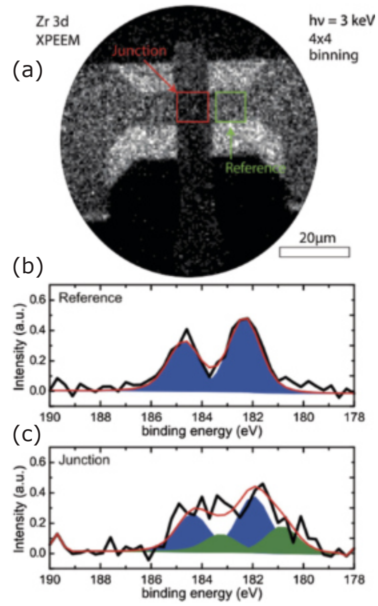
By acquiring energy filtered momentum images step by step across the valence band, one gets a 4D stack of ARPES data (a). Constant energy cuts (or momentum images) of four different energies are showing, how the band structure is evolving from the Fermi level to higher binding energies (b). Energy dispersion curves along different high-symmetry directions (ΓKMΓ) can also be extracted from the data stack (c).
A symmetric cut through the Dirac cone at K, perpendicular to the ΓK-direction is shown in (d).

HAXPEEM & XTOF

BULK-SENSITIVE HARD X-RAY MICROSCOPY



The HAXPEEM is a NanoESCA with optimizations for imaging the high energetic photoelectrons excited by hard x-ray synchrotron sources. This allows to perform bulk-sensitive photoemission microscopy with an increased information depth.



With this approach it becomes possible to do chemical resolved imaging microscopy through cover-layers with sub-micrometer resolution. The data is e.g. important to understand the switching behavior of novel devices: The chemical changes of the active layer can be examined in-situ through the top electrode.
The spectromicroscopic image (a) shows the Zr 3d intensity of a ZrOx ReRAM device. The spectra of a pristine reference field (b) can be compared to a switched junction field (c) and the chemical differences can be analyzed.

Images adapted from (CC-BY 4.0):
C. Kalha et al., J.Phys.: Condens. Matter 33 (2021) 233001

XTOF - EFFICIENCY BOOST

For pulsed sources with high photon energies, the XTOF concept can increase the measurement efficiency by up to a factor of 10. The double-hemispherical energy analyzer is used as band pass pre-filter for the time-of-flight (TOF) filter. This avoids spectral overlaps of very fast or very slow electrons with the core level of interest in the TOF detector. The TOF detector measures the energy window passing the pre-filter in parallel, which makes a significant improvement in measurement time. The instrument can as well be used as normal NanoESCA with non-pulsed sources.

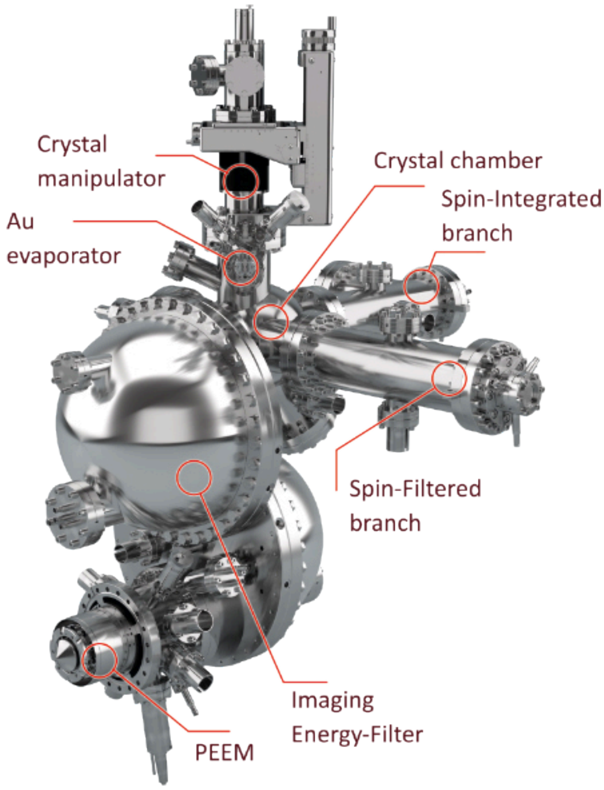
N. Weber, German Patent DE 10 2017 009 299 C5 (2017)
G. Schönhense et al., Rev Sci. Instrum. 91, 123110 (2020)

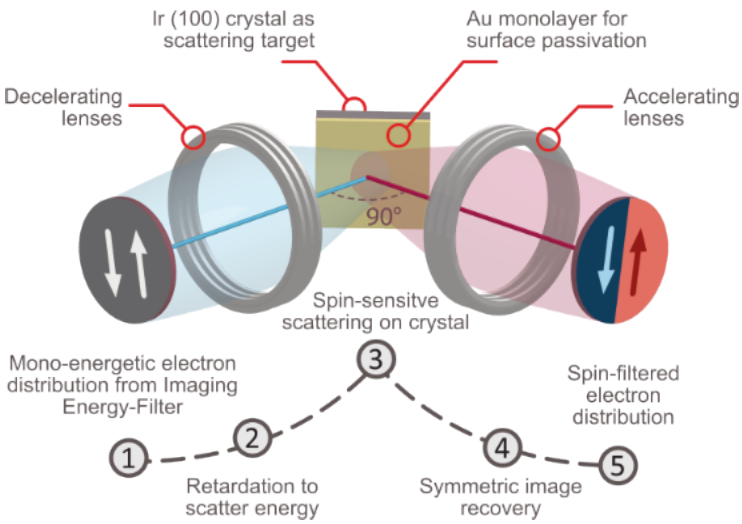
IMAGING SPINFILTER

HIGHLY EFFICIENT SPIN DETECTION FOR MICROSCOPES

The instant spin filtering of a microscopy image takes the efficiency of spin related research to a new level. In combination with a NanoESCA analyzer, spin structures in real space (e.g. magnetic domains) as well as in momentum space (e.g. electronic band structure) can be examined.

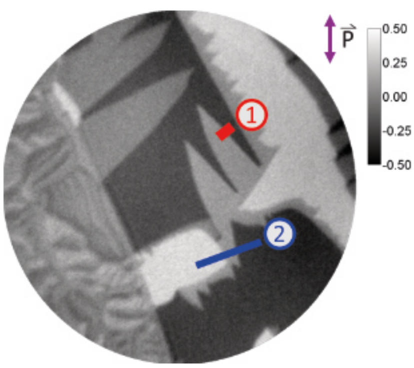
The monochromatic image delivered by the NanoESCA is a prerequisite for the defined kinetic electron energy needed for the spin-sensitive scattering process at the Au/Ir crystal. The Au passivation of the Ir surface keeps the scattering conditions stable for weeks.



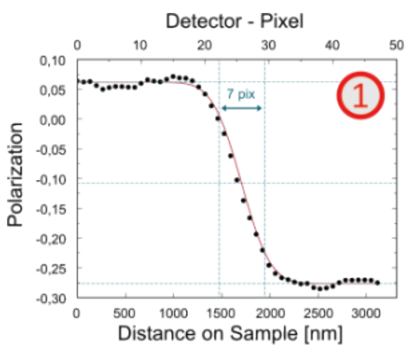


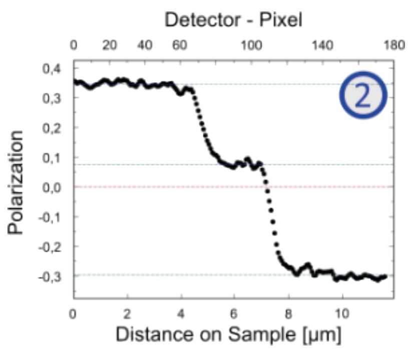
Each Au/Ir crystal is pre-characterized to find the optimal conditions for a high single point figure-of-merit (with Spin sensitivity > 60% and Reflectivity >1%). The parallelization of the spin detection due to the imaging approach makes the detector four orders of magnitude more efficient than single-point detectors.

MAGNETIC DOMAINS ON POLY-IRON



The spin filtered PEEM image of a poly-crystalline iron sample shows a strong spin contrast for different magnetic domains.





The line profiles show the spin polarization of different domains. The edge resolution reveals 142 resolvable image points along the diameter which corresponds to more than 10^4 parallel detection channels for the detector.

FERRUM

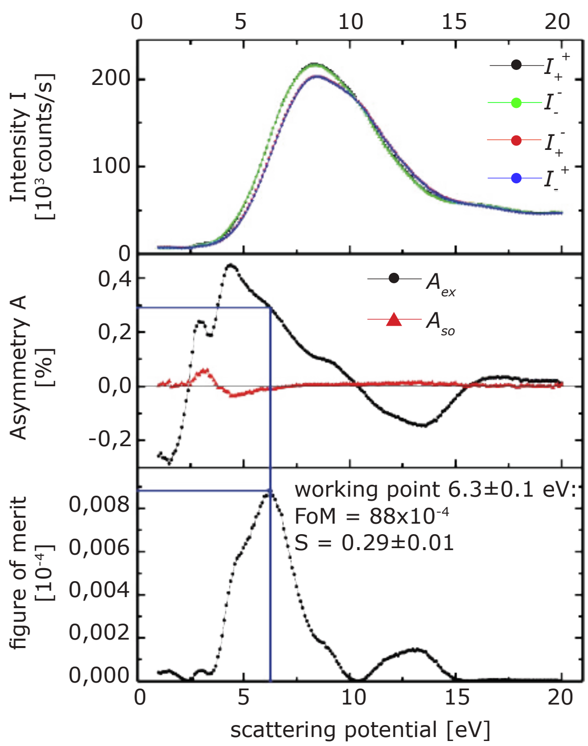
EFFICIENT SPIN DETECTION FOR ARPES

Spin and angle resolved photoelectron spectroscopy (SARPES) provides a high simultaneous sensitivity to the spin, momentum and energy of electrons. It is a powerful method for directly probing the spin polarization of surfaces and electronic structures of novel materials.

The spin polarization detector FERRUM has a high figure of merit (FoM) of 8.8 x 10^{-3}. This allows for much shorter integration times of spin-resolved ARPES compared to former spin detectors.

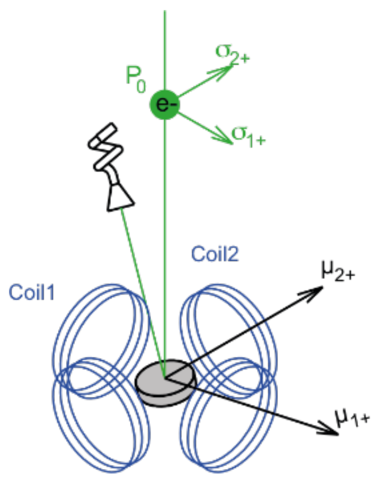
The integration time for a given signal to noise can be reduced by more than one order of magnitude compared to conventional Mott– or SPLEED detectors. In addition the operation of the FERRUM is straight forward and does not require expert knowledge.

The FERRUM can be used with all kinds of electron analysers. Together with an optional spin rotator it allows for measuring all three spin components without sample rotation.



Polarized secondary electrons excited with He I (21.2 eV) from a magnetized iron film are used to characterize the FERRUM and prove a figure of merit of 8,8 x 10^{-3}.

Ref.: M.Escher et al. e-J. Surf. Sci. Nanotech., **9** (2011)



Working principle of the FERRUM

Incoming electrons are scattered spin-dependent at a magnetized thin iron film on W(100).

The scattered electrons are measured with a channeltron.

Magnetic coils switch the magnetization of the iron film in order to measure subsequently two orthogonal spin components in both directions.

FOCUS GmbH develops and manufactures scientific instrumentation for Materials Research and advanced Electron Beam and Laser Welding systems. We are situated in Hünstetten, Germany and are close to Frankfurt airport. Since our formation in 1990, we have worked closely with the research community to collaborate on new innovative products. A dedicated team of electronic engineers, software engineers, designers and physicists ensures that a FOCUS product will exceed the expectations of high technology operators now and into the future.

Our Scientific product portfolio includes our pre-eminent EFM electron beam evaporators, ion sources, UV light sources and photoemission microscopes. We also manufacture spin detectors which are integrated into the FOCUS NanoESCA and alternative OEM analysers.

Our Powerbeam product line consists of both Micro Electron Beam Welding and Laser-in-Vacuum Welding systems. These turn-key solutions provide a unique control of beam power and spot size to address challenging welding and surface modification task in the micrometer range. Both operations are also available via our Job Shop Service center for small batch manufacture or proof of concept.

All our products, whether electronics, software or the hardware are developed, manufactured, and tested in-house. This focus on integrated solutions allows us to prioritize intelligent control concepts to optimize ease of use with even the most complex of technologies.

We support our customer community via in-house workshops, conference/trade fair presentations and with regular news updates at **www.focus-gmbh.com** .

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