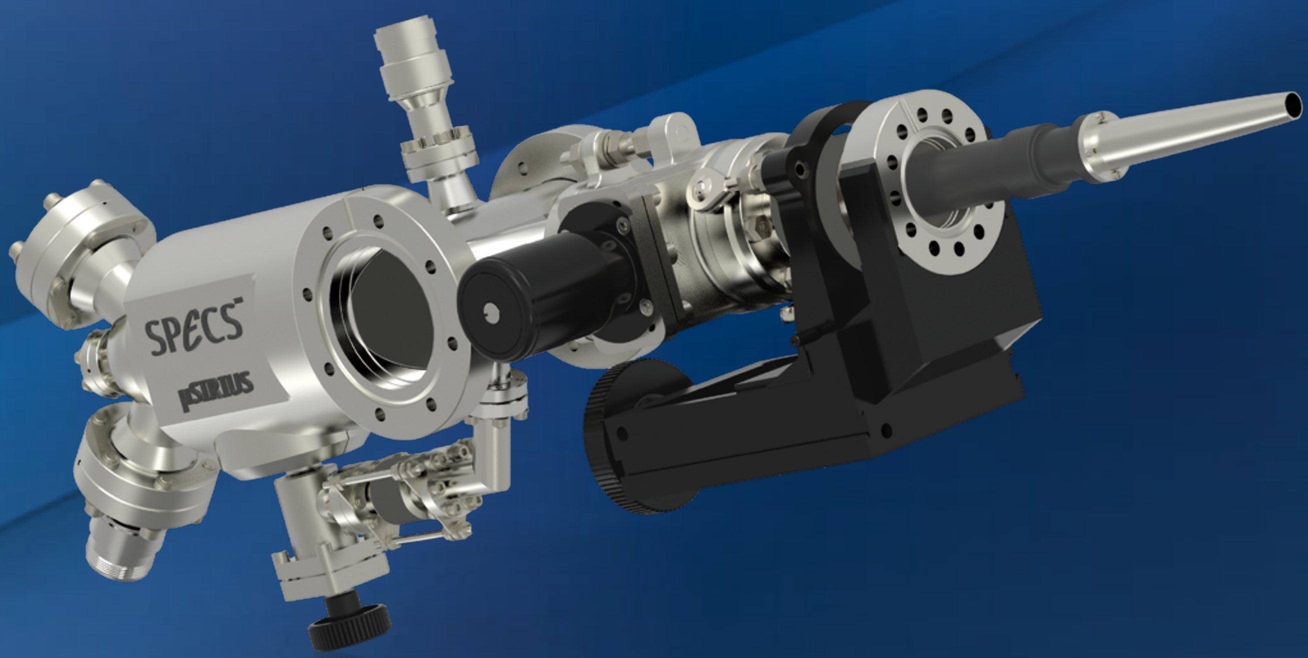
UV Source Series

UV SOURCES FOR ULTIMATE INTENSITY AND STABILITY

KEY FEATURES

- Variable excitation lines
- Small spot focussing optics (optional)
- Polarizer (optional)
- UV monochromator (optional)
- Automated operation



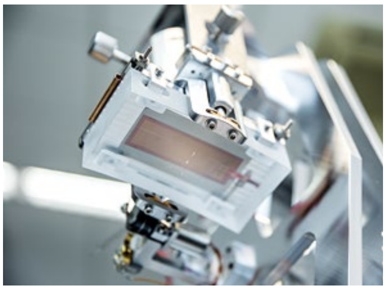
SPECSGROUP

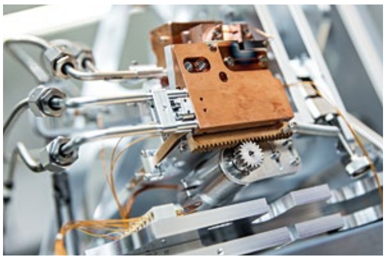
SPECS™

Innovation in Surface Spectroscopy
and Microscopy Systems

Innovative components and systems for groundbreaking new surface analysis tools – that's SPECS.

Our headquarter is situated in the center of Germany's capital Berlin with subsidiaries in Hünstetten, Switzerland, USA and China. SPECS has attracted a talented team of scientists and engineers who have dedicated their knowledge and experience to the development, design, and production of instruments for





surface science, materials research, and nanotechnology for almost 30 years. In order to continuously improve performance and to make available latest developments, we are in contact with numerous scientists, users and customers from all over the world. Reliable quality control (ISO 9001 certified) and excellent fast service, both remote and on-site, ensures maximum uptime and long-term operation and reliability of SPECS instruments over many years.

UV Source Series

ULTIMATE PERFORMANCE AND RELIABILITY

Characterization of the electronic structure of new materials by valence state spectroscopy

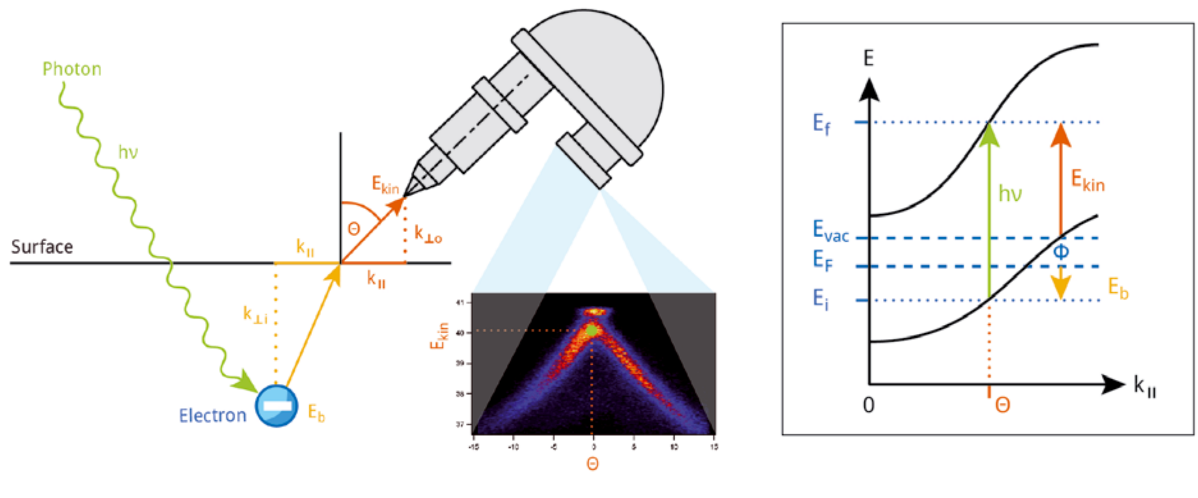
Ultraviolet and Angle Resolved Photoelectron Spectroscopy (UPS, ARPES)

Photoelectron spectroscopy (PES) is one of the most powerful and most frequently used spectroscopic techniques in solid state physics, physical chemistry and materials science. Using the photoelectric effect, PES provides a material sensitive and non-destructive probe for modern scientists to examine the chemical composition (XPS or ESCA) and the electronic structure (UPS and ARPES) of matter.

By illuminating a sample with light of a certain photon energy (hν), electrons are released from a solid, using the photon energy to overcome their binding energy (E_b) and work function (Φ). The remaining energy provided by the photons is transferred into the kinetic energy (E_{kin}) of the photoelectrons. The surface breaks the geometry, affecting the momentum conservation such, that only the parallel wave component k_{II} is conserved after crossing the surface.

Finally the electrons can be analyzed in an electron analyzer with respect to their E_{kin} (or E_b) and to Θ representing k_{II}. On this basis, a 2D distribution of the electrons for given E_b and k_{II} is measured, directly reflecting the electronic band structure of the material. Such experiments in laboratory environments require intense, small spot UV light sources of high stability for optimum performance.

SPECS offers a series of small spot UV sources fitted to various demands, starting from flexible and robust UV sources for economic application to highly sophisticated UV sources for different gases and photon energies with monochromators for highest performance and energy resolution.



Angle resolved photoelectron spectroscopy

Focus™

EXPERTS FOR UHV-COMPONENTS AND MOMENTUM MICROSCOPY

HIS 13

Ease of operation, robust design and a high intensity make the HIS 13 a preferred excitation source for UPS.

High Intensity UV Source

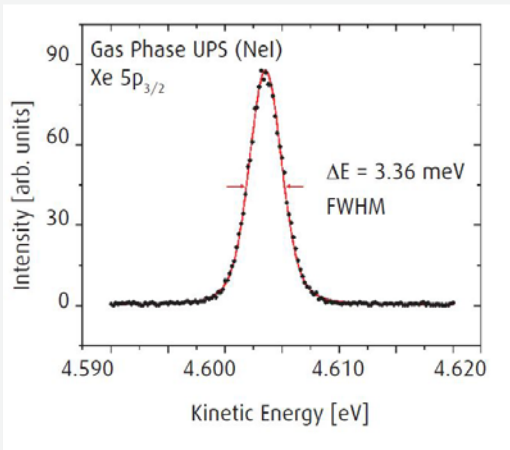
The HIS series is widely acknowledged as the preferred excitation source for ultraviolet photoelectron spectroscopy (UPS) due to its user-friendly operation, robust construction, and high intensity. Among the various models, the HIS 13 stands out as a versatile and reliable base configuration, ensuring straightforward handling, dependable performance, and seamless integration. Light is generated through a high-voltage discharge of the target gas, which facilitates effortless ignition, exceptionally stable output, and an extended source lifespan. Additionally, the quartz optics allow for operation with a diverse range of samples and analyzer technologies.

Build to Expand

The HIS 13 serves as the base model for a wide array of available options, including a polarizer, multiple pumping stages, focusing mirrors, and monochromator configurations. As a result, the HIS 13 is an ideal choice for expanding experiments and provides an accessible entry point into UV photoelectron spectroscopy.

Performance

Next to substantial photon flux density, the HIS 13 ensures optimal spectroscopic cleanness with edge resolution less than 2 meV, tested by gas phase photoemission spectroscopy using Ne I on a Xe target gas.



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 operated with Ne.

Features

- Long lifetime due to filament free design
- Ease of operation
- Discharge regulation
- Precise alignment with line of sight viewport
- More than 300 installed units

HIS 14 HD

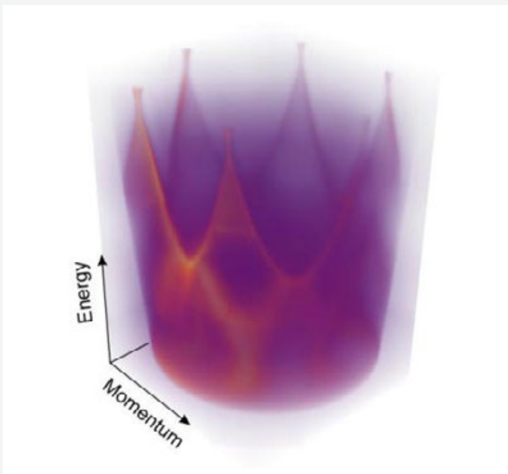
Highi Densitiy UV Source fur UPS, ARPES, PEEM and µ-ARPES

The HIS 14 HD lamp builds upon the HIS 13 model by incorporating an additional focusing mirror. This mirror creates optimal conditions for high-resolution Angle-Resolved Photoemission Spectroscopy (ARPES), achieving a spot size of 180 µm. This enables high angular resolution with traditional ARPES analyzers while simultaneously delivering a photon density that facilitates efficient angular resolved photoemission spectroscopy.

With a generous working distance of 70 mm, the HIS 14 HD is fully compatible with the acceptance angle and working distance requirements of high-performance ARPES analyzers. Additionally, the optical viewport located at the back of the source allows users to monitor discharge conditions and provides a direct line-of-sight to the sample, ensuring precise beam spot alignment.

For those needing greater flexibility in integration with existing instruments, a specialized version, the HIS 14 200, is available, offering an extended working distance of 180 mm.

HIS 14 HD UV source with focussing mirror



Graphene/SiC aquired with HIS 14 HD and a NanoESCA
Courtesy Philip Rosenzweig, Max-Planck-Institut für Festkörperforschung in Stuttgart

Features

- Ease of use
- Easily retrofittable
- Focussing optics
- Precise alignment with viewport

HIS MONO

VUV Monochromator

The HIS Mono is designed to work seamlessly with the HIS 13 and 14 HD models. To achieve optimal performance, it features a unique reflection zone plate design that effectively separates satellite emission lines while ensuring high transmission rates. This design significantly enhances spectral purity by eliminating unwanted "ghost" peaks from the spectrum. The available lines include He I and II, along with a mirror for optical or laser alignment. Additionally, its compact design facilitates easy upgrades to existing systems.

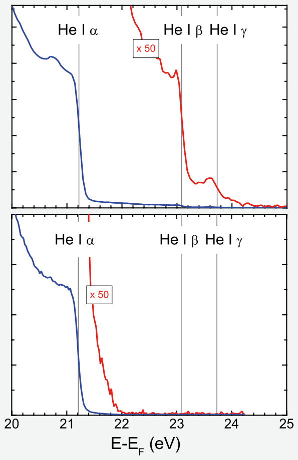
Features

- Dispersive element with 20% transmission for He I and II
- Patented zone plate arrangement
- Precise alignment with line of sight viewport using LED
- Operating pressure down to 10^{-10} mbar range
- To be combined with HIS 13 & HIS 14 HD
- Integrated pumping port

Photoelectron spectra of W (100) using FOCUS CSA

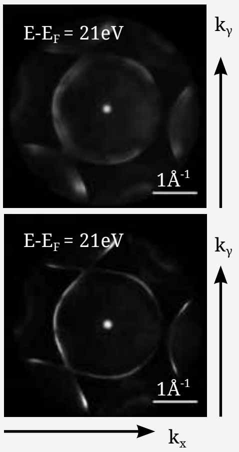
without monochromator

with monochromator

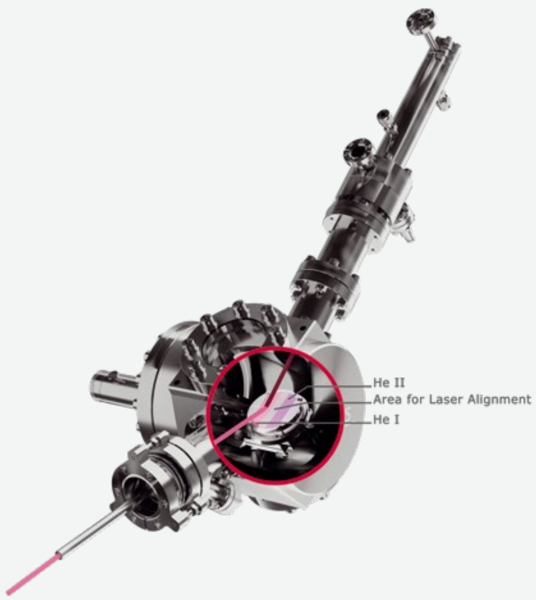


top: Satellites He I-β and γ present
bottom: no satellites

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



top: shadow-structure visible due to HE I-β
bottom: band-structure due to HE I-α solely



HIS Mono operational principle and results

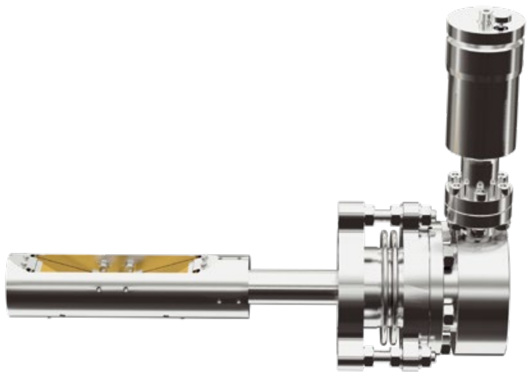
Accessoires

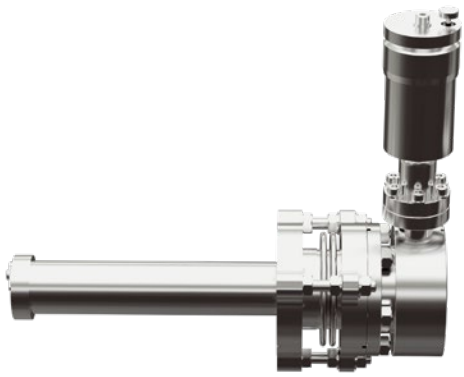
Polarizer

To effectively apply selection rules in photo-emission and spin-sensitive measurements, a polarizer is essential. The polarizer add-on consists of a three-mirror optical element designed specifically for the HIS sources.

Attenuator

Highly sensitive samples, such as organic molecules, may suffer from beam damage induced by photo emission experiments. To enhance the lifetime of sensitive layers, the intensity can be reduced with an attenuator by a factor of 10 or 100.





Differential Pumping

In addition to the base differential pumping, a 3rd and 4th differential pumping stage can be added to the source. In this way, the operational pressure during measurements can be significantly lowered into the 10^{-10} mbar regime.

HIS 14 HD Ar-MONO

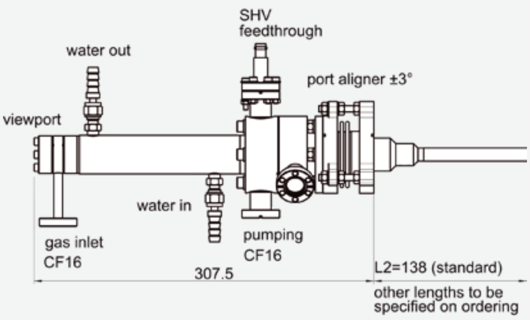
- Ar I radiation: two strong lines with small difference of 0.21 eV
- Ar I α radiation with a photon energy of 11.62 eV is transmitted and Ar I β radiation is suppressed by a heated LiF window
- Regulated heating electronics
- Retractable for standard use with He radiation
- For HIS 13 and HIS 14

Specifications

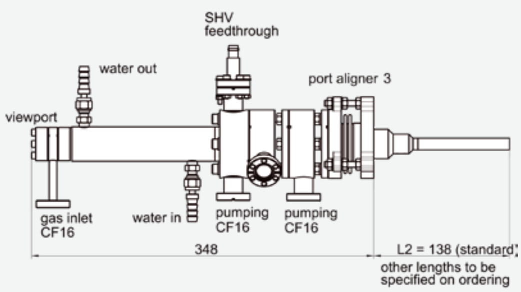
Technical Data

	HIS 13	HIS 13 (Mono)	HIS 14	HIS 14 Mono
Gases	He, Ne , Ar, Kr, Xe, H	He I, He II	He, Ne , Ar, Kr, Xe, H	He I, He II
Photon Flux Density	$3.2x10^{11}$ ph/(s*mm^2)	$1.2x10^{11}$ ph/(s*mm^2)	$4x10^{12}$ ph/(s*mm^2)	$8x10^{11}$ ph/(s*mm^2)
Operating Pressure	$5x10^{-8}$ to $1x10^{-9}$ mbar			
Spot Size	1.1 mm (10 mm dist.)		<180 µm	
Working Distance	50-100 mm		70 mm	
Mounting Flange	DN40 CF (DN63 CF)		DN63 CF (DN100 CF)	
Insertion Depth	138 mm - flexible		203 mm	
Bakable	Up to 250°C			
Optics	Quartz Capillary (0.8, 1.2, 1.7 mm)		Focussing Mirror	
Differential Pumping	2 stages default, 3 and 4 stage available			

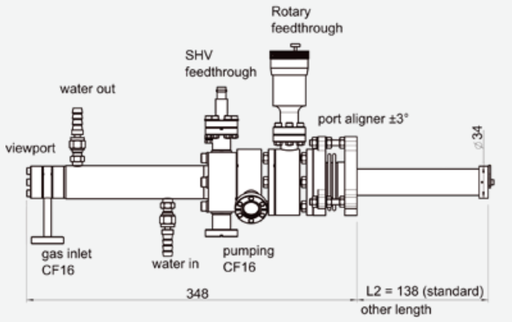
Dimensions



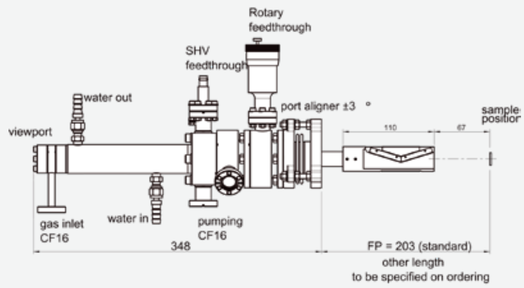
HIS 13 Standard



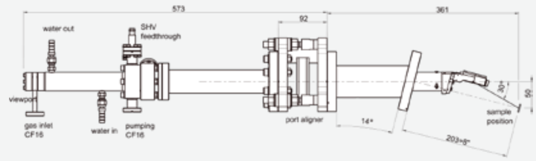
HIS 13 add Pumping



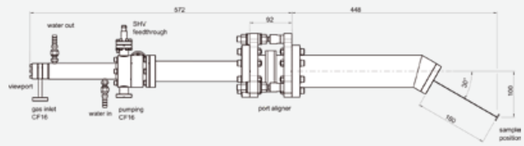
Attenuator for HIS 13



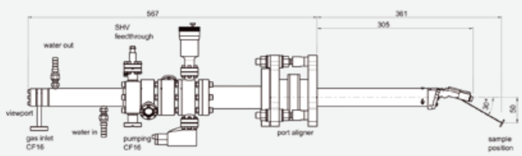
HIS 13 w. Polarizer



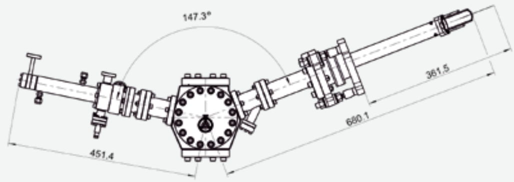
HIS 14 HD



HIS 14 HD 200



HIS 14 Ar Mono

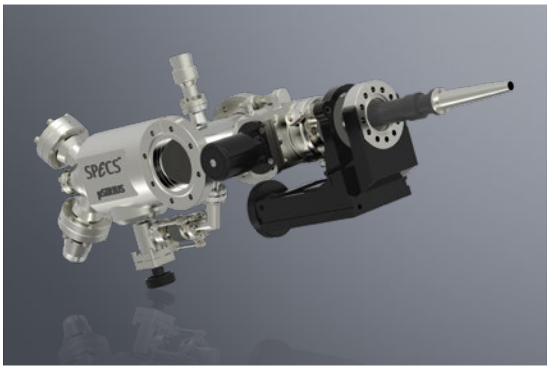


HIS 14 Mono

µSIRIUS

Duoplasmatron UV Source

A new generation of the SPECS UV source improves the performance of the well-established duo plasmatron light source UVS 300, keeping its unique features for small spot analysis for ARPES and UPS. Using an optimized design it is possible to control the plasma generation with much higher precision than before. As a result a brilliant and bright UV source has been designed, named after the brightest star in the sky, Sirius. The main item of the µSIRIUS is the newly designed and fully 3D printed discharge chamber. The water cooling is now imprinted in the discharge housing. That reduction of size allows us to increase the quality of the magnetic field on the duo-plasmatron discharge area.
The body is designed entirely for a full UHV operation of the source. Hence, the bake out capabilities and gas purity of the source are increased. A new type of filament on industry standard lifetime guarantees extreme long life performance of the source (> 5.000 hours). The new design has an optical viewport through the complete UV source, which allows aligning of the source with an external laser pointing device.



Unsurpassed small spot optics

The µFOCAL 100 focusing capillaries is designed for optimal performance with the new SPECS µSIRIUS. This new generation of optics aims at highest photon flux densities for unrivaled ARPES performance and highest count rates. The combination of a real point source, such as the µSIRIUS, yields maximum focusing of all emitted photons onto the sample without the need for artificial confinement of the emission spot. The smaller the focus gets, the higher the local photon flux density and hence the higher the performance of the new generation of SPECS small spot hemispherical analyzers.
The smaller the spot size, the higher the angular resolution achievable by electron analyzers. The ASTRAIOS 190 ARPES analyzer benefits from a maximum photon flux density within its acceptance area and from a significantly increased angular resolution. The KREIOS series analyzers benefit from the high photon flux desnity for µARPES applications as a higher flux density is available under the real space selection apertures. Hence, both imaging quality and aquisition time are strongly improved.

Features

- On the other hand, in the thermally excited
- High photon flux density
- Optimal focusing to 100/300 µm
- Adjustable He I / He II ratio
- Long filament life time
- Fully UHV compatible
- All noble gases

ETC – Versatile Focusing Optics

The ETC capillary is a long time established standard, offering an excellent price to performance ratio. The elliptical design of the capillary allows a spot size down to 300 µm and a continously adjustable spot size. The spot size fits all SPECS analyzers for best performance in different fields of application. The ETC optics are compatible with vacuum housings for near ambient pressure application and for integration into the SPECS LEEM/PEEM P90.

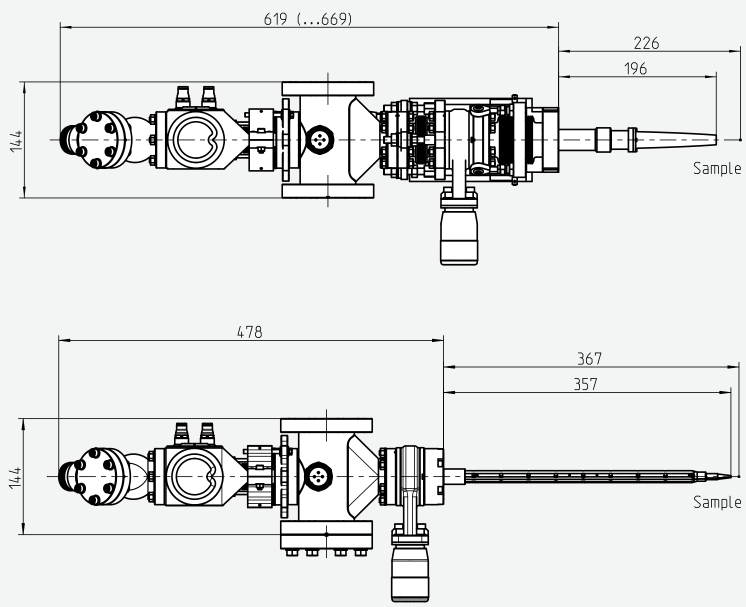
COSCON Power Supply

The source is controlled up by a new generation of power supplies, driving the source at higher power for outstanding performance. The SPECS COSCON series is a fully remote controllable power supply standard, now available for UV sources. It is controlled either via SpecsLab Prodigy or via its own web interface. A full integration into measurmenet automation is available for the COSCON SUVS. For stand-alone operation it is supplied with a compact and versatile touch screen for operation in front of the system.

Technical Data

Specification	µFOCAL 100	ETC
Gases	He I and He II, Ne, Ar, Kr, Xe possible	He I and He II, Ne, Ar, Kr, Xe possible
Photon Flux Density (He I)	$> 1 \times 10^{15}$ photons/s*mm²	$> 1 \times 10^{14}$ photons/s*mm²
Spot Size	100 µm	300 µm
Spot Shape	Gaussian	n/a
Mounting Flange	DN35CF	DN35CF
Insertion Depth	196 mm	357 mm
Operating Pressure in AC	$< 5 \times 10^{-8}$ mbar	$< 5 \times 10^{-8}$ mbar
Lifetime	> 5.000 h	> 5.000 h
Monochromator Version	yes	yes
Bakeable	150 °C	150 °C

Dimensions



Top: µSIRIUS Small Spot (µFOCAL); Bottom: µSIRIUS Focused (ETC); all in top view

TMM 304

Toroidal Mirror Monochromator

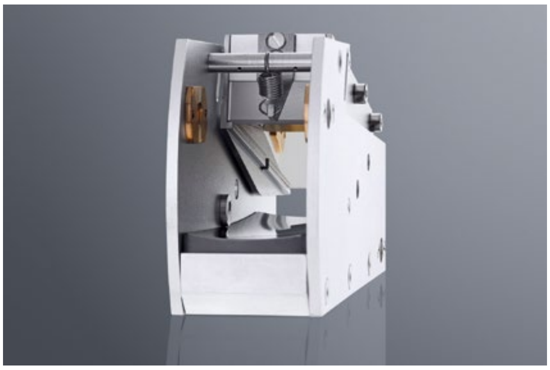
The TMM 304 is a toroidal mirror monochromator for laboratory UV sources, compatible with the µSIRIUS. It can be equipped with two cassettes which are optimised for specific wavelength. Switching the cassettes can be performed without braking the vacuum. The light is guided towards the sample by a focusing the new µFOCAL 100 or ETC capillary resulting in small spot sizes and high photon flux densities.
In combination with a high performance differential pumping system UPS measurements under excellent UHV conditions can be performed. It is optionally available with a rotary stage to change the polarization in-situ. The rigid frame is retractable for easy mounting and operation and offers ultimate stability and precision at the same time.

Cassettes

Cassettes consists of a matched grating/mirror pair. Each cassette is optimized for a particular wavelength. Cassettes are available for He I and He II, as well as for Xe (with 1.200 and 2.400 lines/mm). The degree of polarization is > 80 %. An optional polarizing cassette is also available with a resulting degree of polarizaten exceeding 90%.

Frame

The TMM 304 can be ordered with a fixed or rotatable frame. Both versions come with a z-retract, a rotation base and a tilt for easy beam alignement. The rotatable frame provides an additional motorized rotation around the beam axis to switch between s- and p-polarized light, without braking the vacuum.

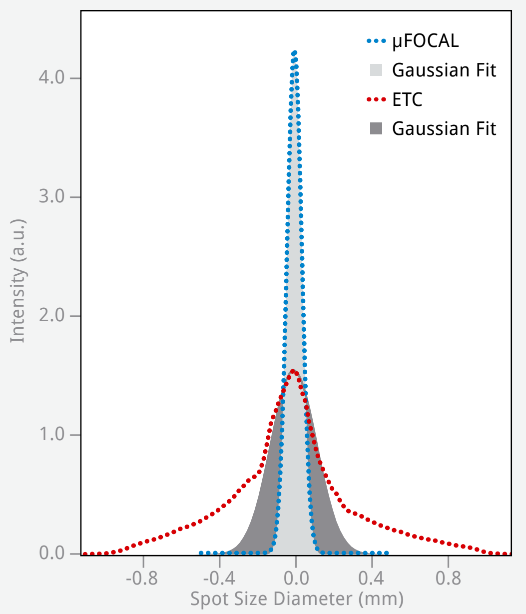


Features

- Two cassettes installed
- High photon flux
- Cassettes for He I, He II, Xe and polarizer
- Advanced differential pumping
- µFOCAL 100 or ETC for small spot size and high photon densities
- Rotatable frame for changing polarization of UV light

Spot Size

The new µFOCAL 100 optics yield spot sizes better than 100 µm. The spot size of a UV source is linked to the ARPES performance and its small spot capability. The µFOCAL 100 optics provides a spot size (FWHM) of < 100 µm and the ETC of < 300 µm when combined with the new µSIRIUS source. The plot below shows factory test measurements done on the different optics, for the µFOCAL 100 (blue) and ETC capillary (red). The measured beam profile is marked with the dotted line and the Gaussian fit of the main component is a solid line. The new µFOCAL 100 optics characterization demonstrates the almost perfect Gaussian peak shape, providing optimal conditions for high performance APRES analysis. The ETC capillary can reach a peak FWHM of < 300 µm. Allthrough based on a broad background, the main photo-emission intensity will come from a defined area in the center. Hence the SPECS small spot analyzers benefit from from the aligned spot size and field of view of 300 µm, respectively.

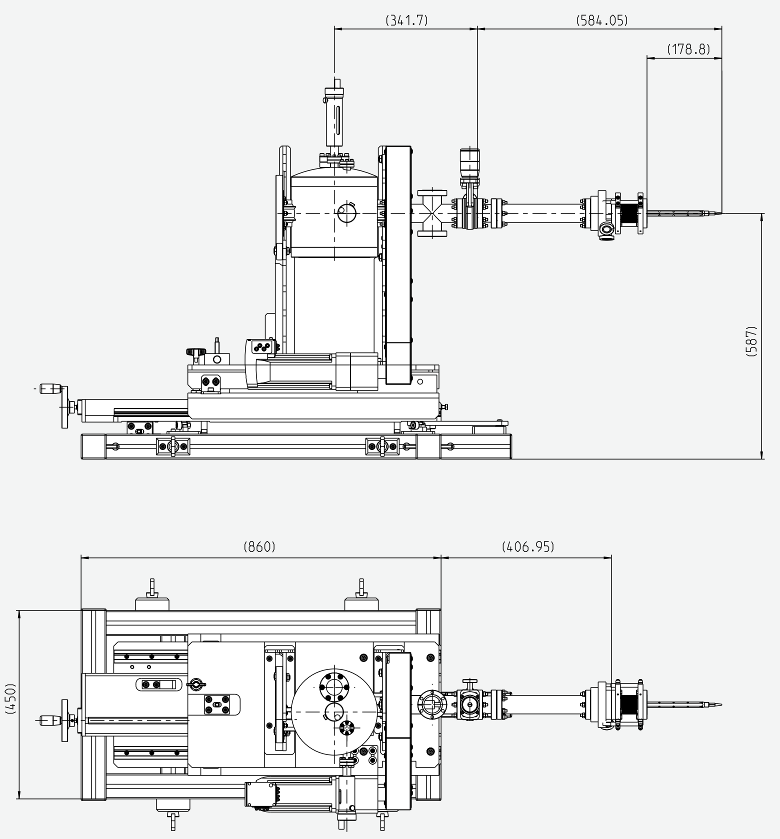


Spot sizes better than 100 µm.

Technical Data

Specification	µFOCAL 100	ETC
Line width	< 1 meV	< 1 meV
Photon Flux Density	> 1 × 10^{14} photons/s*mm²	> 1 × 10^{13} photons/s*mm²
Spot Size	100 µm	300 µm
Mounting Flange	DN35CF	DN35CF
Operating Pressure in AC	< 5 × 10^{-10} mbar	< 5 × 10^{-10} mbar
Bakeable	150 °C	150 °C
Rotatable Frame Available	yes	yes

Dimensions



TMM 304 Monochromator

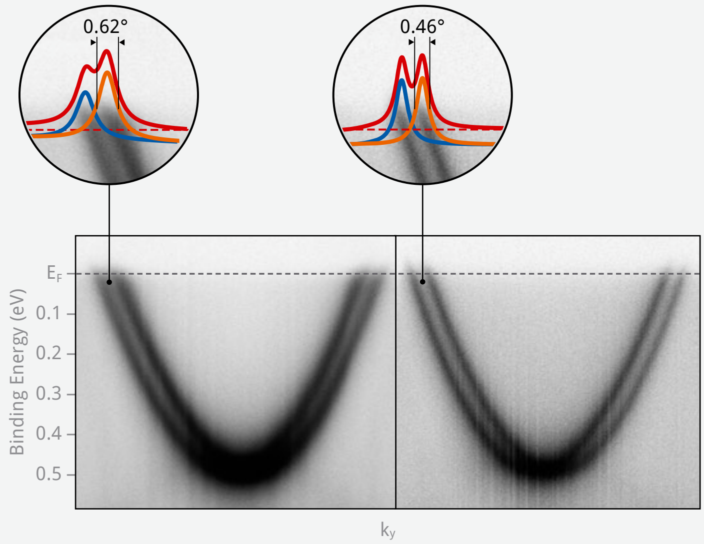
Applications

ARPES

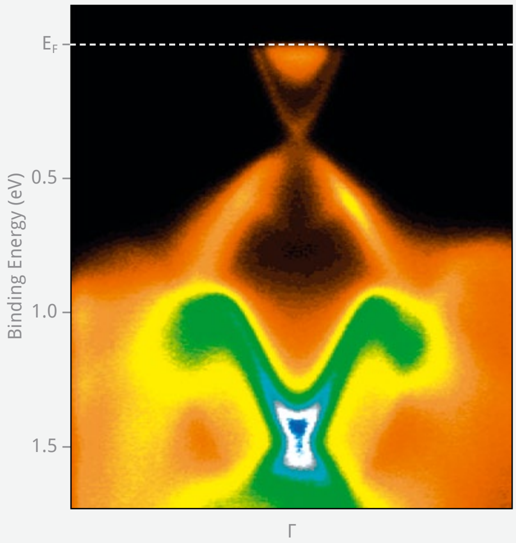
The smaller the spot size, the higher the angular resolution achievable by the analyzer. The below shown application shows the Au(111) surface state, acquired subsequently on the same sample with the same PHOIBOS 150 2D-CMOS analyzer. The left panel show the µSIRIUS predecessor UVS 300 with ETC optics (500 µm spot), the right panel shows the same dataset acquired with the µSIRIUS µFOCAL 100 (100 µm spot). The angular broadening of the Au(111) Rashba splitting depends directly on the spot size of the source on the. Going from 500 µm to 100 µm lowers the FWHM from 0.62° to 0.46°, showing a significant performance boost.

Topological Insulators

Topological insulators are insulating materials with surface states crossing the gap between the (bulk) valence and conduction band. Bi_2Te_3 is a well known example for this kind of materials. The image shows an energy disposal image of the thus described surface state at the Γ point of the Brillouin zone. Its two branches have different spin states, avoiding the opening of a band gap at the touching point of these two bands. The result is a dirac cone like structure. This reference measurement has been aquired on an PHOIBOS 225 2D-CCD at 70 K sample temperature during a factory acceptance test.



Band Map of Au(111) surface state. Left: UVS 300 with ETC Optics. Right: µSIRIUS with µFOCAL 100.



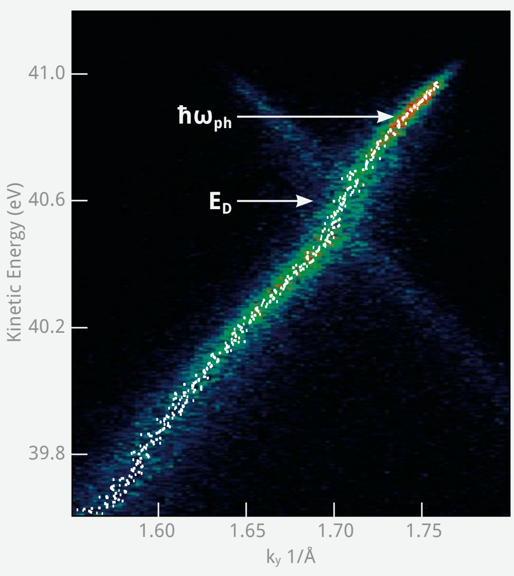
Γ point of Bi_2Te_3, raw data from PHOIBOS 225 2D-CCD with UVLS and TMM 304 at T=70K.

Observing Quasiparticles

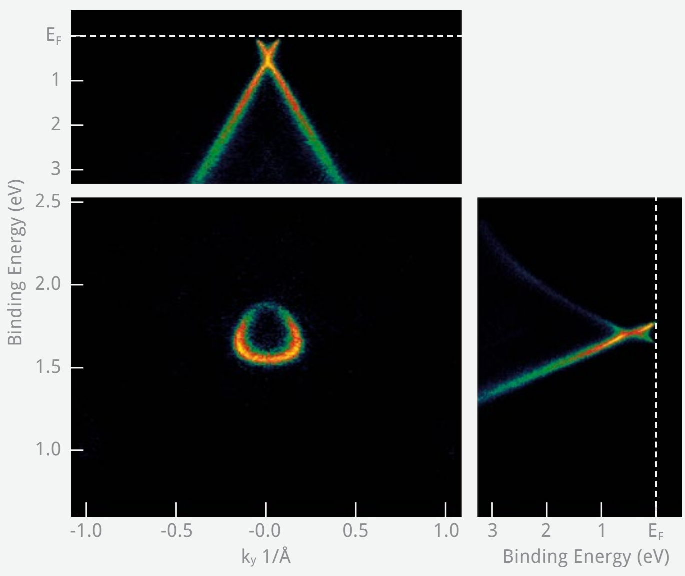
In 2007, Bostwick et al. reported the observation of a plasmaron dispersion, the interaction of the electron with the plasmon wave of a solid, in graphene on SiC. Close to the Fermi level, a kink in the band dispersion is visible, attributed to the electron/plasmon interaction.
Using the ASTRAIOS 190 in combination with the TMM 304 and µFOCAL 100, this result could be reproduced at room temperature using the 100 µm spot size. The band dispersion image is an extraction from a 3D scan acquired within 30 minutes in a ± 10° angular resolved mode. The fit indicates the band intensity maximum.

Small Spot Band Mapping

The band map of the graphene on SiC K-point has been acquired with an ASTRAIOS 190 2D-CMOS at room temperature within 15 minutes. The angular acceptance angle had been set to ± 20°. The plot shows excerpts from a 3D dataset of I (Ekin, kx, ky). The central image ist a constant energy cut, showing kx vs. ky. The side graphs are cuts of Ekin vs. kx and ky respectively across the Ekin, kx, ky – reciprocal space.
The high photon flux density and the small spot size perfectly fits the ASTRAIOS analyzer field of view for maximum intensity and short acquisition times.



Band Dispersion of Graphene on SiC. Close to EF a kink ($\hbar\omega_{ph}$) is visible, which us attributed to the plasmaron quasiparticle.



Band Map of Graphene/SiC K-Point, acquired at Room Temperature with the µFOCAL 100 optics and a TMM 304. Acquisition time 15 minutes.

SPECS Surface Nano Analysis GmbH
Voltastrasse 5
13355 Berlin / Germany
www.specs-group.com

T +49 30 46 78 24 0
F +49 30 46 42 083
E info@specs.com

Version 10.21

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