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NanoESCA II

- High Resolution PEEM
- Full Field ARPES and µARPES
- Small Area Spectroscopy
- Excellent Energy Resolution < 50meV
- Aberration Compensated Energy Filter
- State of-the-art detector technology
- LHe Cooled Sample Stage

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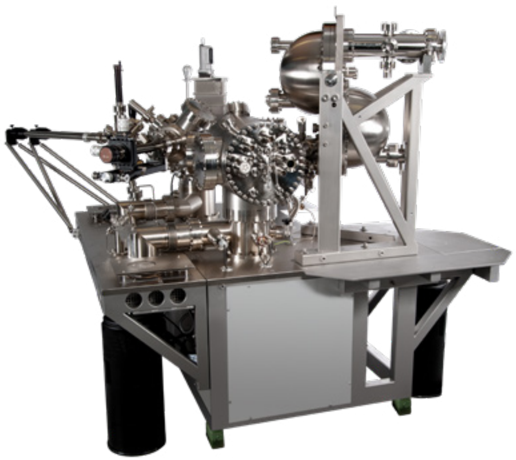
for forefront photoemission research on micro and nano scales. One application for high resolution micro area spectroscopy is µARPES on localized 2D materials with outstanding momentum resolution using laboratory excitation sources. Since more than 2 decade PEEM has been established as key technology for photoe-

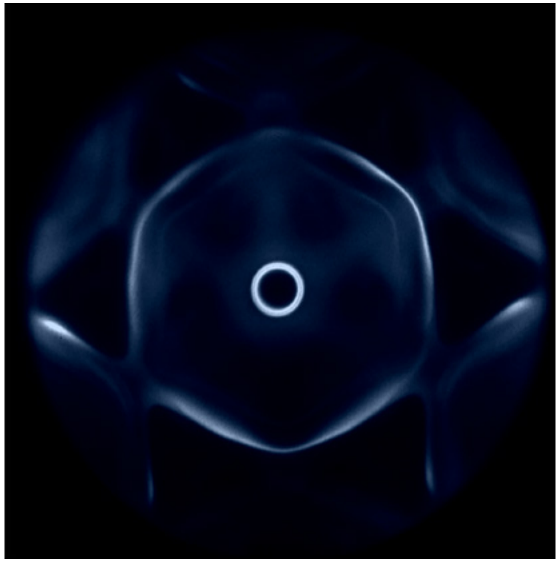
Introduction

NanoESCA II is the technical refinement of the NanoESCA I which won the prestigiuos R&D 100 award in 2007.
NanoESCA II is - simply said - the ultimate PEEM instrument.

NanoESCA II combines high spacial resolution and excellent spectroscopy performance in a single instrument allowing for forefront photoemission research on micro and nano scales. One application for high resolution micro area spectroscopy is µARPES on localized 2D materials with outstanding momentum resolution using laboratory excitation sources.
Since more than two decades PEEM has been established as key technology for photoemission research on the micro and nano scale. However spectroscopy PEEM has always been limited to applications where energy resolution is not a critical parameter. NanoESCA II changes this situation allowing spectroscopy on the micro and nano scale with outstanding spectroscopy performance.
For latest information like e.g. specifications please click here:
www.ScientaOmicron.com/nanoesca



Introduction



NanoESCA II is a unique combination of the convenient to use electrostatic FOCUS IS-PEEM and the patented Imaging Double Energy Analyzer (IDEA). The IDEA is a high transmission aberration compensated energy filter allowing for high resolution spectroscopic imaging in real space and k-space with energy resolution below 50 meV.

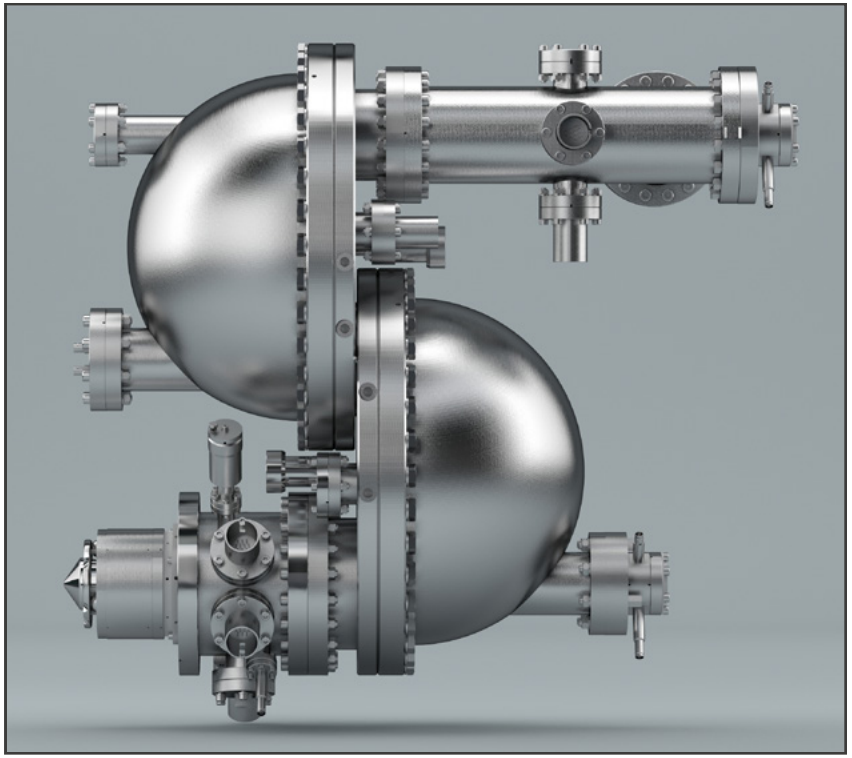
NanoESCA II is also equipped with a new 2D imaging detector allowing for true electron event counting as required for low intensity applications. An optional a LHe-cooled sample stage with eucentric rotation and a new high brightness VUV lab source are also available, delivering unparalleled performance under laboratory conditions or at synchrotron beam lines.

One example for the angle resolved UPS performance is the Fermi surface map of Au(111) recorded in a single shot from an area < 20 µm. The k-resolution was estimated to 0.01 Å^{-1}.

System configuration

NanoESCA Analyzer:

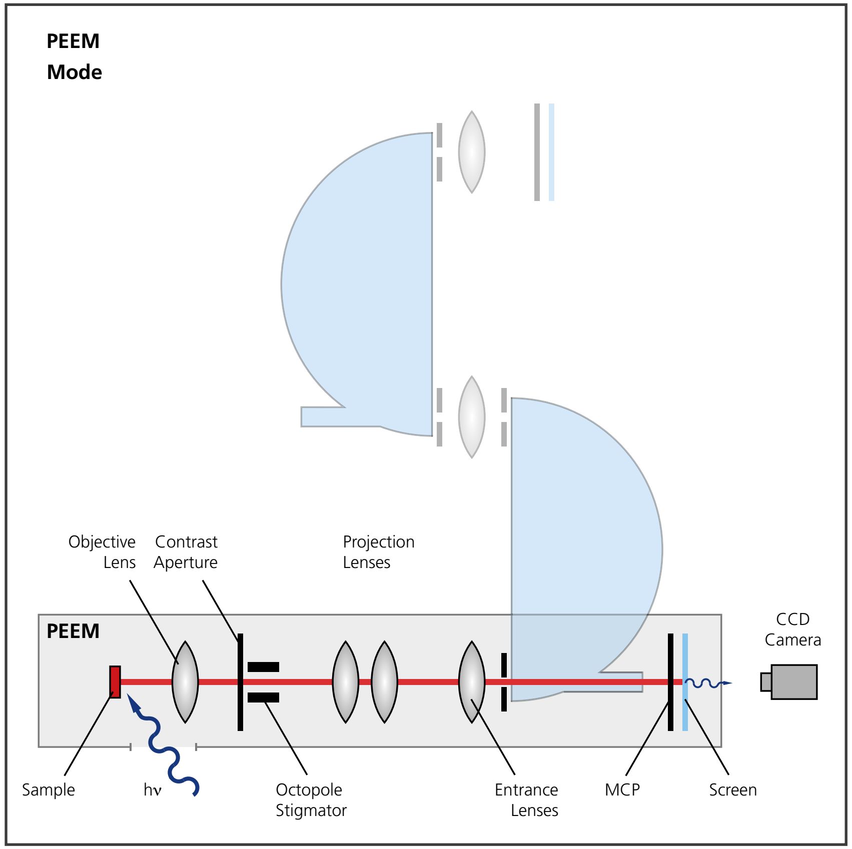
The NanoESCA instrument has three main building blocks: an electrostatic PEEM as entrance lens (FOCUS PEEM), the aberration compensated energy filter (IDEA) and the projective zoom lenses which allow operation of the instrument from survey mode with a large filed of view to very high magnification.



System configuration

Unfiltered PEEM Mode:

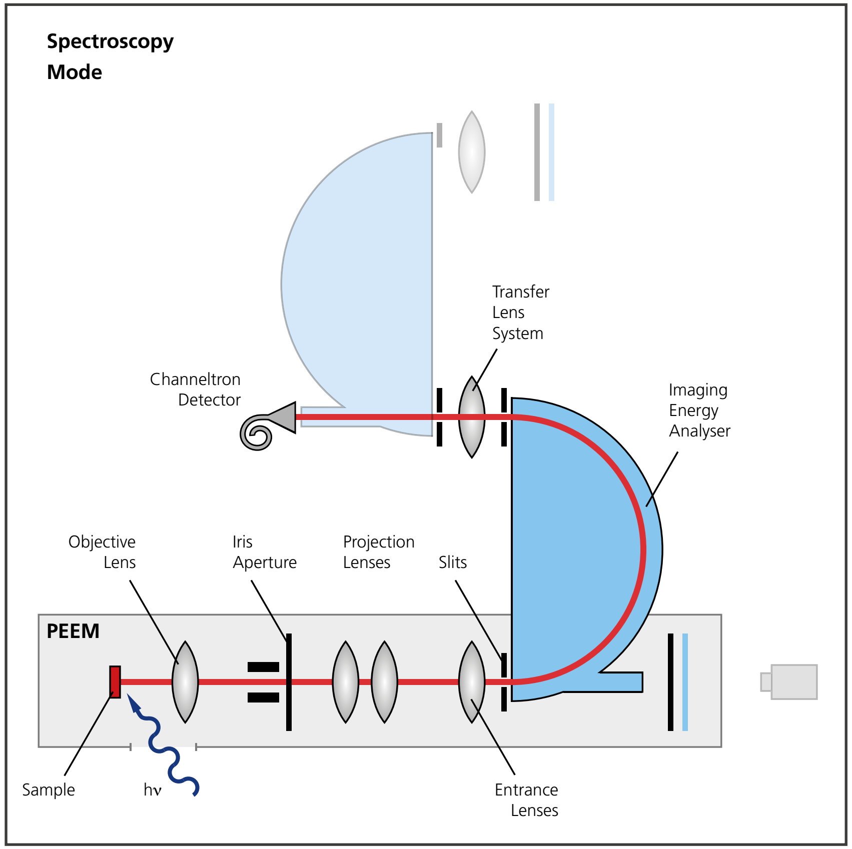
The entrance lens of the NanoESCA is an electrostatic PEEM which can be operated in non-energy-filtered PEEM mode. The PEEM consists of an immersion objective lens with exchangeable and adjustable contrast apertures, an electrostatic octopole stigmator and projective lenses. A continuously adjustable iris aperture at the first intermediate image plane which can be used to select a defined field of view for local spectroscopy. A first imaging detector allows observation of the unfiltered PEEM image (Fig. PEEM mode). This mode can be operated with magnification as low as 1:20x allowing for very large field of views (several 100 µm) for survey and navigation purposes.



The PEEM mode also allows very high magnifications > 7000x for high resolution PEEM and total yield measurements.

System configuration

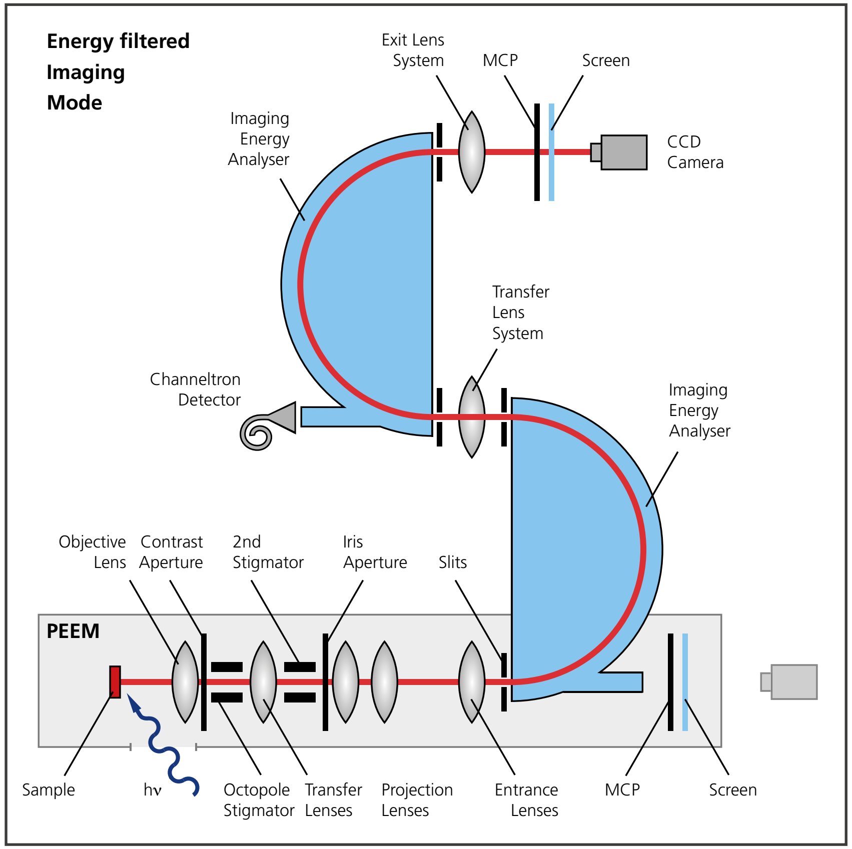
Small Area Spectroscopy:
A channeltron detector is situated at the exit of the first hemisphere. This detector can be used for local spectroscopy from preselected areas. By means of the PEEM entrance lens and together with the iris aperture at the first imaging plane local areas on a sample can be identified and precisely defined. Photoelectrons from the preselected area are energy filtered by the first hemisphere and detected by the channeltron for small area spectroscopy. This mode provides fast and accurate spectroscopy results in real space or k-space. It is also often used to identify the energy position of a peak for detailed analysis in imaging mode.



System configuration

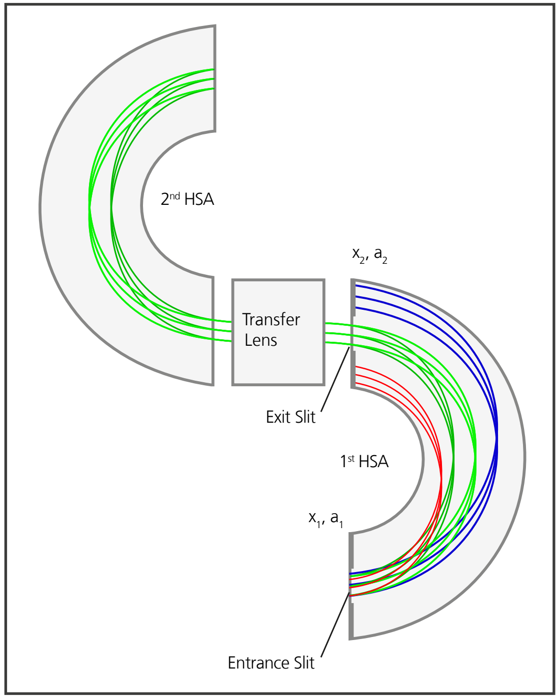
Energy Filtered PEEM Imaging:
The core part of the NanoESCA instrument is the aberration compensated energy filter. It is a patented design based on two hemispherical analysers allowing for PEEM operation with ultimate energy resolution in real space and k-space (Electron optical scheme).

The energy filter is situated between the PEEM front lens and the projective lenses at the exit. While the PEEM acts as a first magnification stage and retards the electrons to the pass energy of the energy filter the projective lenses act as second magnification stage which is followed by a second imaging detector.



The accessible electron energy range for the NanoESCA is 0 -1800 eV. Optionally the energy range can be extended up to 10 keV.

System configuration



Electron optical scheme: The scheme of the aberration compensated energy filter includes two hemispheres and a transfer lens, electron trajectories are overlayed. The trajectories follow the Keplers law of planetary motion: electrons starting at the entrance slit position are focused onto the exit slit of the IDEA conserving all literal and angular parameters independent of energy, start angle and start point because both hemispheres together build up complete Kepler orbitals.

The scheme illustrates electron beams of different energies (indicated by different colors) entering the first hemisphere (1st HSA). The central transfer lens projects the image from the exit of the first analyzer onto the entrance of the second analyzer.

The second hemisphere (2nd HSA) completes the Kepler potential and corrects the aberrations introduced by the 1st HSA. This can be seen e.g. for a green off-axis trajectory. This patented energy filter offers minimized aberrations induced by the energy filter hence allowing for excellent imaging conditions, superior transmission and ultimate energy resolution (< 50 meV).

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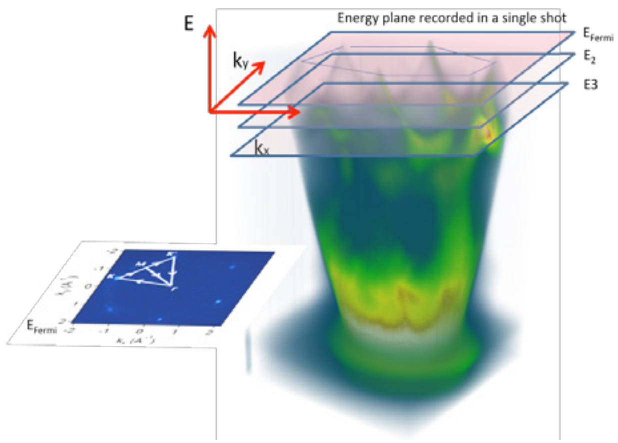
Small area ARPES

The k-space electron optics enables the NanoESCA II to be used for k-space / momentum analysis from a microscopic area on the sample. This analysis is independent of the size of the photon beam. The k-space mode allows to image $k_{||}$ with a very large acceptance of more than ± 3 Å^{-1} at a given energy without any rotation of the sample. In contrast to conventional ARPES NanoESCA II records data with a fixed $k_{||}$ acceptance independent of the kinetic energy.

This measurement scheme is illustrated by the semi transparent 3D band structure plot of graphene recorded with He I light excitation (0-15 eV binding energy) where the six peaks are the Dirac points. The complete data set was recorded by scanning of the energy, without any mechanical rotation of the sample. At each energy a full slide of k_x and k_y parallel was recorded with a diameter of 4 Å^{-1} in a single shot; see e.g. the constant energy cut at the Dirac point (insert).

One advantage of this method is its simultaneous access to all angles in a single shot experiment allowing for analysis of features at large k vectors with ease.



An iris aperture situated in the intermediate image plane of the microscope allows to record k-space data from local areas < 10 µm e.g. on small islands of 2D materials.

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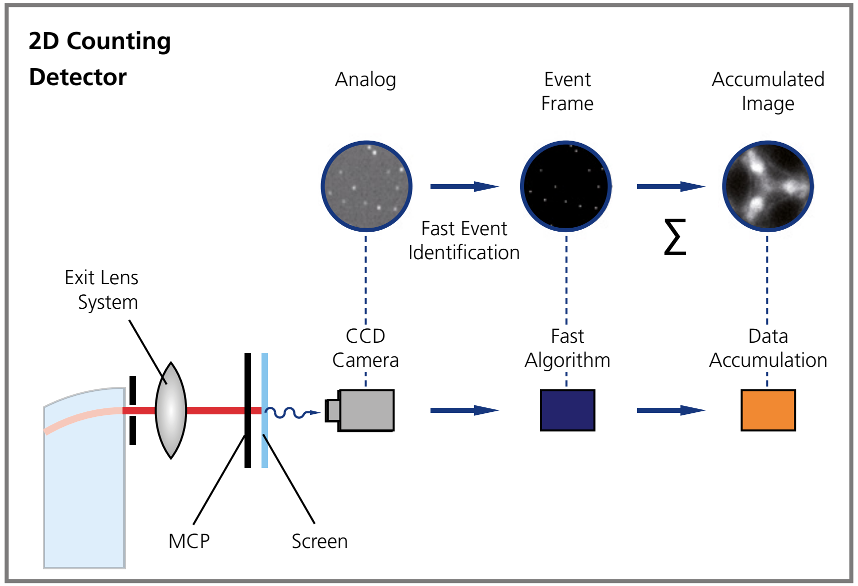
Detector

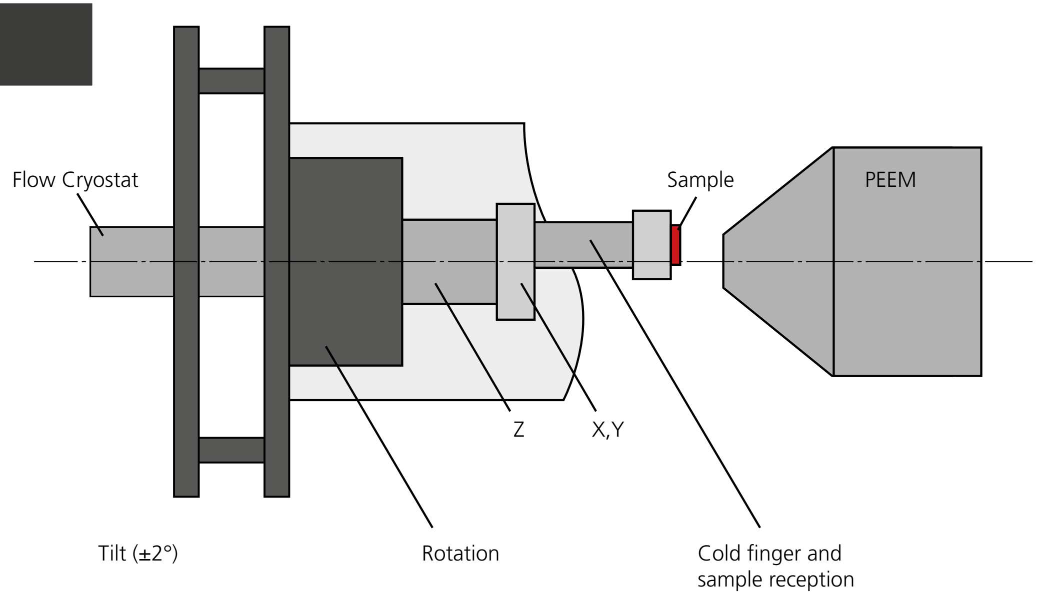
The NanoESCA uses 3 detectors. One channeltron for small area spectroscopy and imaging detectors for energy filtered and non filtered PEEM mode. The imaging detectors consist of a combination of a MCP for signal amplification, a fluorescent screen for signal conversion and a high end low noise, slow scan CCD camera to deliver best image quality.

The imaging detectors can also be operated in a dedicated event counting mode allowing for true single electron detection.
In this mode a fast algorithm identifies and localizes single electron events and converts these events into counts.



As a result the accumulation time for low intensity signals is not limited by the camera anymore. The mode provides an optimum signal to noise ratio for all low signal applications.

Sample Stage



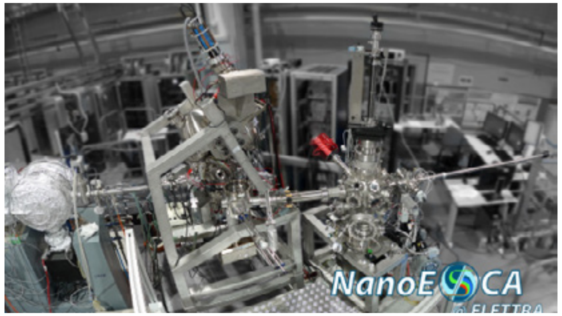
The NanoESCA can be offered with a 2 axis piezo stage for room temperature applications.
Optionally a high precision LHe cooled 6 axis manipulator (X,Y,Z, rotation + 2 static tilt corrections) is available. It allows operation from < 40 to > 600K. The manipulator is motor driven. The rotation around the sample normal is eucentric due to the stacking order of the motions allowing rotation within the field of view of the instrument.

As a result investigation of areas-of-interest at different angles becomes possible without time consuming adjustment procedures. In addition the manipulator was designed for low drift at low temperatures enabling time consuming small area spectroscopy even at LHe temperatures.

Excitation Sources

Laboratory excitation sources: The NanoESCA II is designed to be operated with a number of different excitation sources. The instrument provides several ports which can be individually equipped with e.g. UV and VUV sources like Hg, D2 and a dedicated high brightness He I & II source for microscopy applications (HIS 14 HD). Additionally the NanoESCA allows operation with other light sources e.g. Lasers.

Synchrotron excitation: NanoESCA II has proven performance at a large number of synchrotrons ranging from soft x-ray beamlines e.g. micro spectroscopy beamline in Bessy, ELETTRA, ESRF to a Hard x-ray beamline at PETRA III. The outstanding transmission in energy filtered mode and the superior energy resolution down to below 50 meV turns NanoESCA into a very powerful beam line end station for all PEEM, XPEEM and µ-ARPES related research.



Click here for a link:

https://www.elettra.trieste.it/elettra-beamlines/nanoesca.html

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About Scienta Omicron

Scienta Omicron is the world‘s leading supplier of analytical UHV-instrumentation solutions in nanotechnology research and development. With a team of more than 200 specialists we provide for:

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- **Scanning Probe Microscopy**
- **Thin Film & Tailored Systems**
- **Service & Engineering**

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