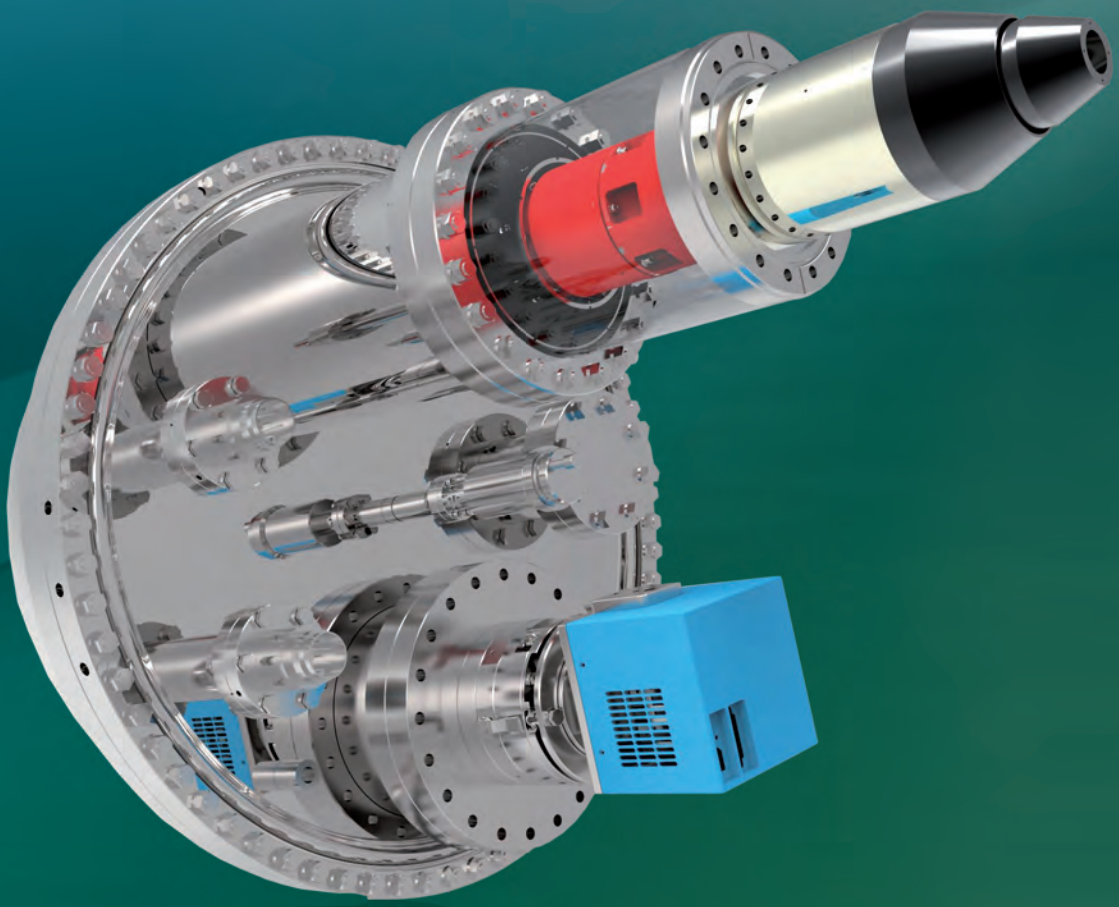
PHOIBOS 150 SAL

STATE-OF-THE-ART ELECTRON ANALYZER WITH
SCANNED ANGLE LENS FOR 2D ANGULAR MAPPING

KEY FEATURES

- In-lens Scan Unit for Polar Angle Scans
- 30° Full Acceptance Angle in Tilt and Polar Direction
- Parallel Detection of up to 1000 Tilt Angle Slices
- Energy Resolution < 2meV
- Angular Resolution < 0.1°



SPECS™

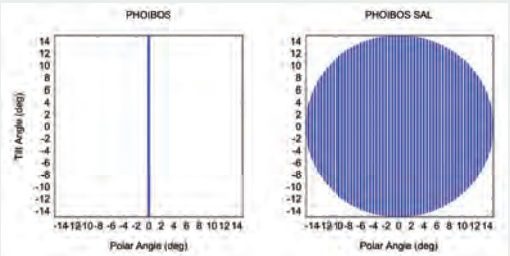
SPECS™

ELECTRON ANALYZER PHOIBOS 150 SAL

State-of-the-Art Electron Analyzer with Scanned Angle Lens (SAL) for Two-Dimensional Angular Mapping

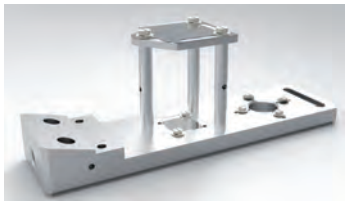
Technical Concept and Performance

Triggered by the growing demand for two-dimensional angular resolved photoemission (ARPES) studies SPECS has developed a scanned angle lens (SAL) for the state-of-the-art PHOIBOS electron analyzer series. The SAL offers 2D angular mapping with 30° full acceptance angle cone without the need for physical tilting of the sample. Despite extended functionality the new lens does not negatively affect the well-proven lens modes of the PHOIBOS. In combination with high end light sources, like small spot UV sources, Lasers or Synchrotron beamlines, the PHOIBOS 150 SAL offers excellent energy (<2meV) and angle resolution (<0.1°) in a compact design for all ARPES (with a 2D-CCD or 2D-DLD detector) or Spin/ARPES (with the patented 2D-CCD/3D Spin detector) applications.



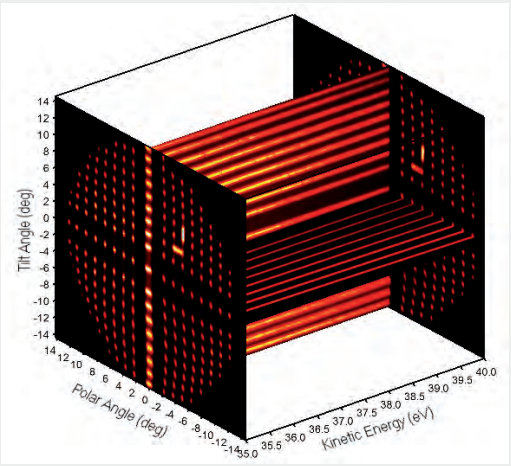
Using an analyzer with a standard lens the polar angle is restricted by the entrance slit (left figure). A scanned angle lens gives access to the full acceptance angle cone (right figure).

The performance of the new lens has been tested using a special device: a Ag sample mounted 30 mm below a precisely hole-patterned Mo foil. Excited by a SPECS EQ 22/35 electron source electrons from the Ag sample can only be transmitted into the analyzer lens through the holes. Thus a well-defined angle distribution of the electrons is produced allowing to probe the angle resolution in dependence of the electron energy.



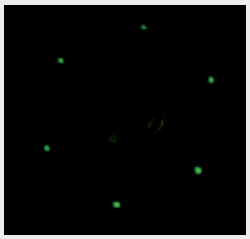
Test device with Ag sample and hole-patterned Mo foil.

The complete map has been acquired for kinetic energies ranging from 35 eV to 40 eV and for 250 sequential polar angels between -14.5° and 14.5° by using the deflection unit of the lens system. The tilt direction was resolved by the direct angular mapping in the angle resolving direction. The scanned angle lens mode is fully supported by SpecsLab Prodigy.



Demonstration of the PHOIBOS 150 SAL 2D angular resolution in dependence of the electron kinetic energy.

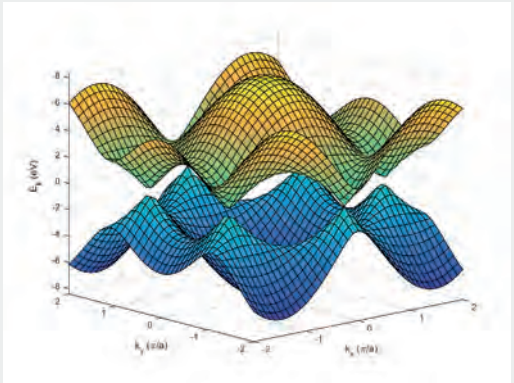
Application: Band Structure of Graphite



LEED pattern of the graphite sample at E = 71 eV indicating a highly ordered graphite surface.

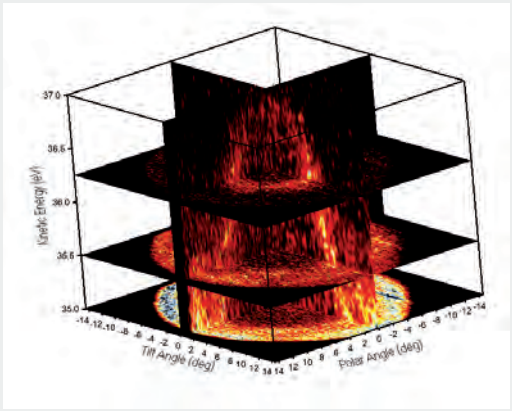
A natural graphite single crystal (graphitecrystals.com) was cleaved in air with an adhesive tape just prior to insertion into the analysis chamber. After flashing a few times to 1000 °C the crystal surface was well-prepared showing an ordered surface structure in LEED.
Since natural graphite consists of layered graphene, its properties were known since P. R. Wallace (Phys. Rev. 71 (1947) 622) calculated the electronic structure of the hexagonal graphene lattice using the tight-binding model. The resulting band diagram is shown below.

$$E = \pm\gamma_0\sqrt{1 + 4\cos^2\frac{k_y a}{2} + 4\cos\frac{k_y a}{2}\cdot\cos\frac{k_x\sqrt{3}a}{2}}$$



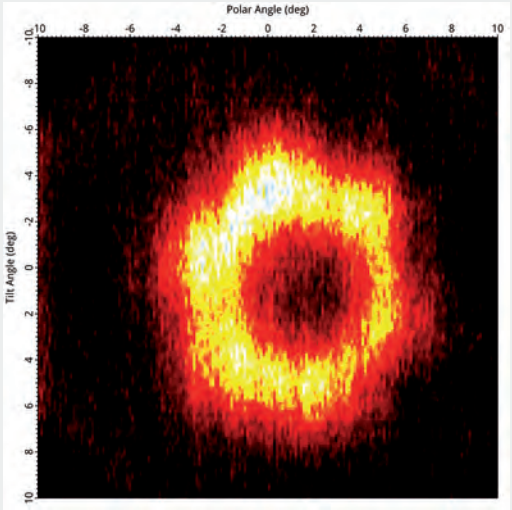
Simple formula for the energy describing the bands. The resulting band diagram is shown in the figure.

The band structure of crystalline graphite was measured at room temperature around the Γ-point. The analyzer entrance slit size was 0.2 mm width and the pass energy 20 eV. The Scanned Wide Angle Mode (SWAM) allows to measure an angular range of up to ±15° simultaneously. The polar angle was scanned from -14.5° to 14.5°. The experiments were performed using a SPECS UVS 10/35 source, with an energy width of about 2 meV and a spot size of about 0.6 mm in dia-meter. The photon energy for all measurements were 40.81 eV (He II).



3D intensity plot of the photoemission spectra at the Γ-point in the (k_x,k_y,E) space.

A 2D constant energy slice of graphite clearly reveals the sixfold geometry of the electronic states.



Constant-energy slice of graphite.

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