At-Wavelength Metrology Facility for UV- and XUV Reflection and Diffraction Optics

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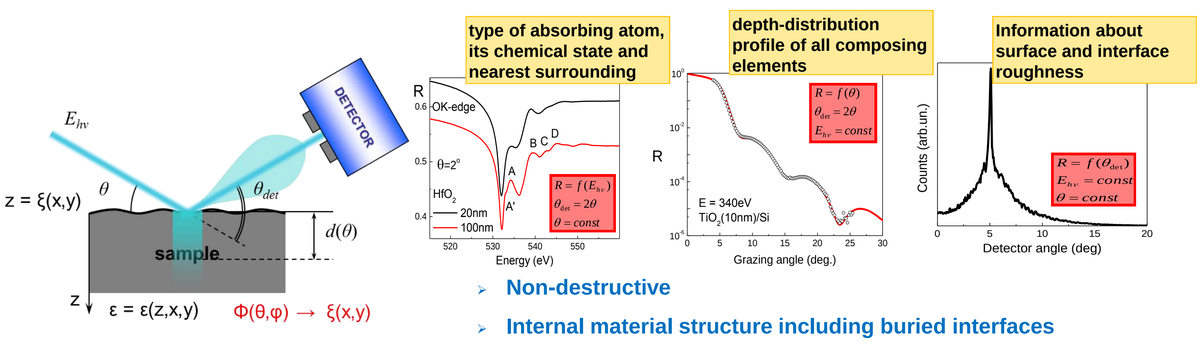
Institute for Nanometre Optics and Technology / BESSY II

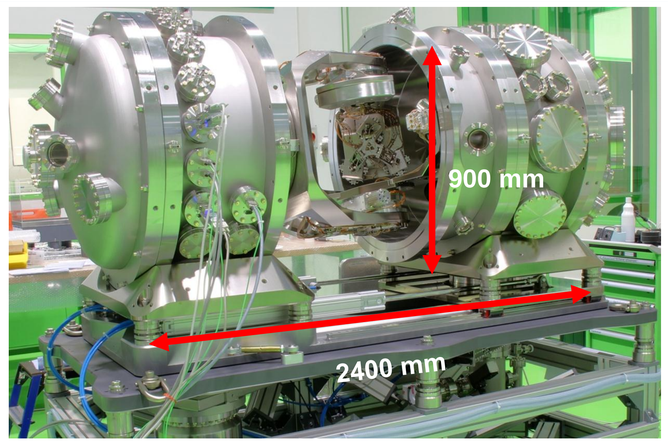
Research with Reflectometry

Reflectometry - a powerful technique

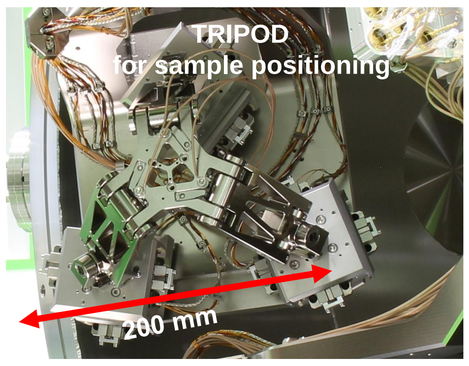


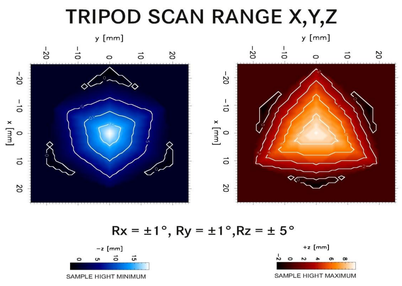
- Non-destructive
- Internal material structure including buried interfaces
- Interface quality (compound and roughness)
- At-wavelength metrology (quality control)
- Optical constants

11 axes UHV-Reflectometer



- Clean room surrounding
- UHV-tube volume 2 m^3
- Chamber weight 2.1 tons
- 2000 l/s Turbomolecular pump
- LN_2 cold trap, Ti-Suppl. Pump
- Base pressure <5x10^{-9} mbar
- Pneumatic drive for chamber opening
- Renishaw encoders at all axes
- Measurements of R_s and R_p
- Samples electrically isolated
- Sample weight: 4 kg
- Sample size: 300 x 60 x 60 mm^3





Axis	Hardware	Range	Pos. accuracy
Azimuth angle β	HUBER 430	-180° - 180°	3.6“
Sample angle θ	HUBER 411	-90° - 270°	3.6“
Detector angle 2θ	HUBER 411	-180° - 180°	3.6“
Detector off-plane (2 axes)	Ceramic motors	-25 mm – 25 mm (-4° - 4°)	50 nm
Sample Adjustment Tx, Ty, Tz	Ceramic motors	-20 mm – 20 mm (not simul.)	500 nm
Sample Adjustment Rx, Ry, Rz	Ceramic motors	-10° - 10° (not simul.)	1“

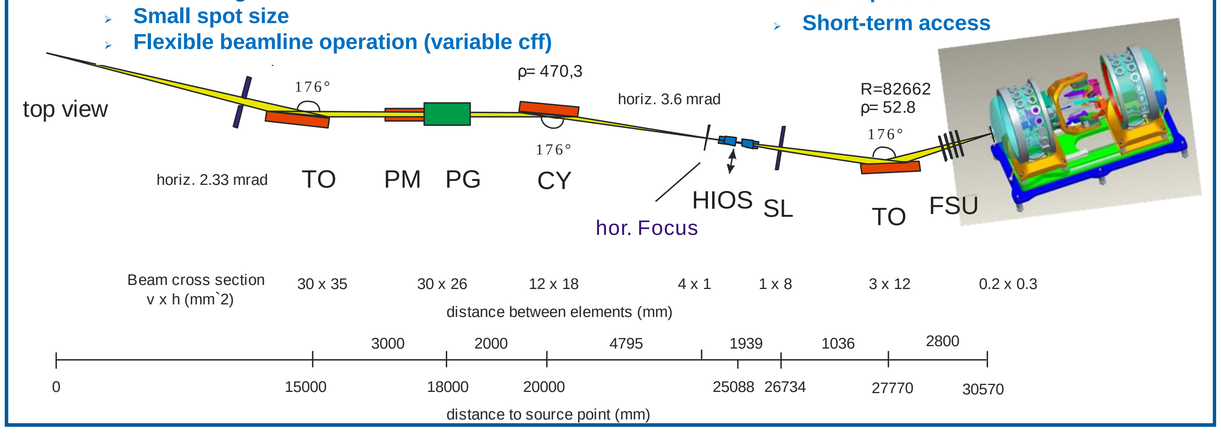
Optics Beamline

Collimated c-PGM

- 10 - 2000 eV
- Moderate resolution 5.000 (@400 eV)
- Polarization linear / elliptical
- Higher order suppression
- Low divergence
- Small spot size
- Flexible beamline operation (variable cff)

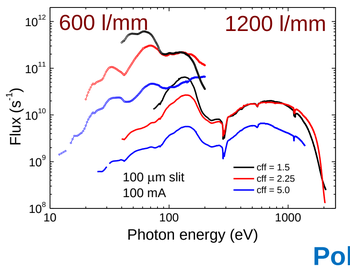
Reflectometry

- At-wavelength metrology
- Quality control
- In-house R&D
- User operation
- Short-term access

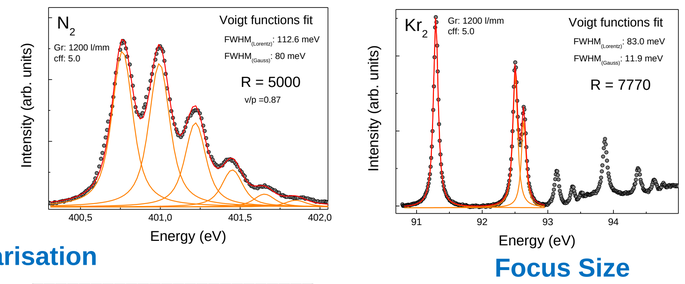


Performance

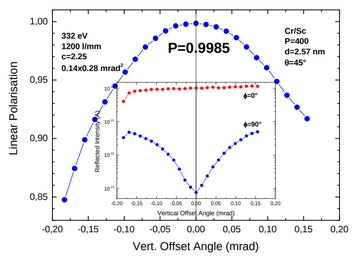
Photon flux

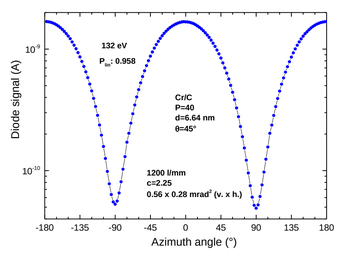


Resolving Power

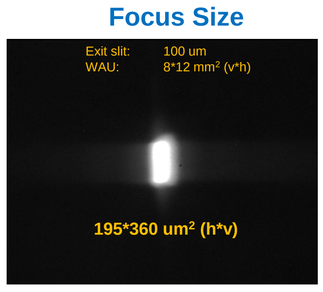


Polarisation



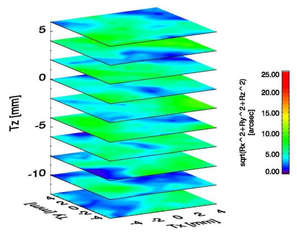


Focus Size

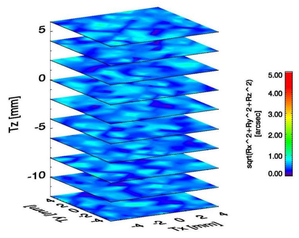


Performance

Positioning accuracy of the Tripod

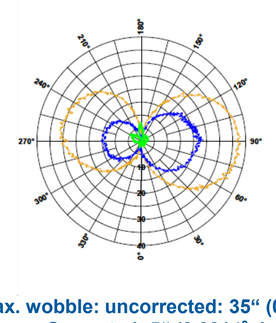


Cross-talk of translation to rotation



Elimination of cross-talk by a correction matrix
Accuracy: <1“

Autocollimation of ϕ-stage



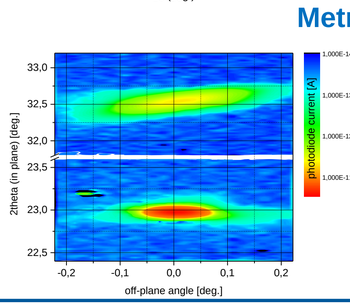
Max. wobble: uncorrected: 35“ (0.01°)
Corrected: 5“ (0.0014°)

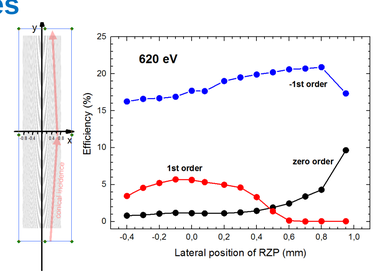
Alignment of Axes			
Axis 1	Axis 2	Tilt (°)	Distance (mm)
θ	2θ	179.979°	0.014
θ	β	90.025°	0.049
2θ	β	89.994°	0.057

Sample pointing stability: 50 µm / 0.025°

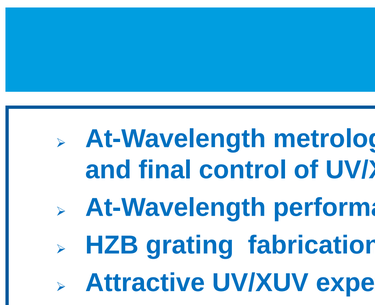
At-Wavelength Metrology

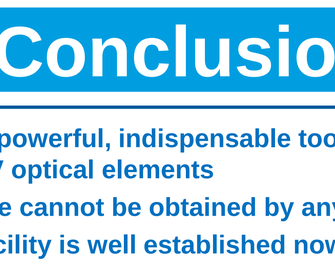
Metrology on Multilayers

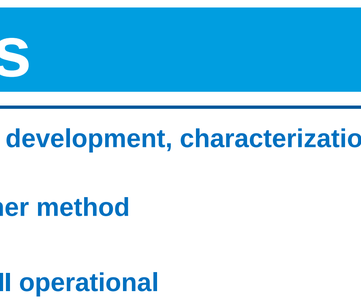




Metrology on blazed gratings







Metrology on blazed multilayer gratings

Metrology on Reflection Zone Plates

Conclusions

- At-Wavelength metrology: powerful, indispensable tool for development, characterization and final control of UV/XUV optical elements
- At-Wavelength performance cannot be obtained by any other method
- HZB grating fabrication facility is well established now
- Attractive UV/XUV experimental beamline setup at BESSY-II operational
- Metrology on large-scale samples with versatile 11-axes UHV-reflectometer operational
- Ellipsometry, polarimetry possible with elliptically polarised bending magnet radiation
- Open for user operation
- Short-term access at 24 h / 7d operation possible

[1] A.A. Sokolov et al. *An XUV Optics Beamline at BESSY II*, Proc. of SPIE 9206, Advances in Metrology for X-Ray and EUV Optics V, 92060J-1-13 (2014)
[2] F. Eggenstein et al. *A reflectometer for at-wavelength characterization of XUV-reflection gratings,* Proc. of SPIE 9206, 920607-1-12 (2014)
[3] F. Eggenstein et al. *A reflectometer for at-wavelength characterization of gratings*, Nucl. Instrum. Meth. A710, 166–171 (2013)
[4] B. Loechel et al. *Installation of a technological center for highly efficient optical gratings at Helmholtz-Zentrum Berlin (HZB)*, J. Phys.: Conf. Ser. 425, 212012 (2013)
[5] F. Schäfers, *RAY - the BESSY raytrace program*, (In: Springer Series in Modern Optical Sciences: Modern Developments in X-Ray and Neutron Optics) Vol. 137, 9-41 (2008)
[6] F. Schäfers, R. Cimino, *Soft X-ray reflectivity: from quasi-perfect mirrors to accelerator walls*, Proc. Ecloud'12, CERN-2013-002, p 105-15 (2013)

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