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HZB BESSY II Light Source

AT-WAVELENGTH METROLOGY FACILITY FOR EUV, XUV AND TENDER X-RAY ENERGY RANGE OPTICS

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INTRODUCTION

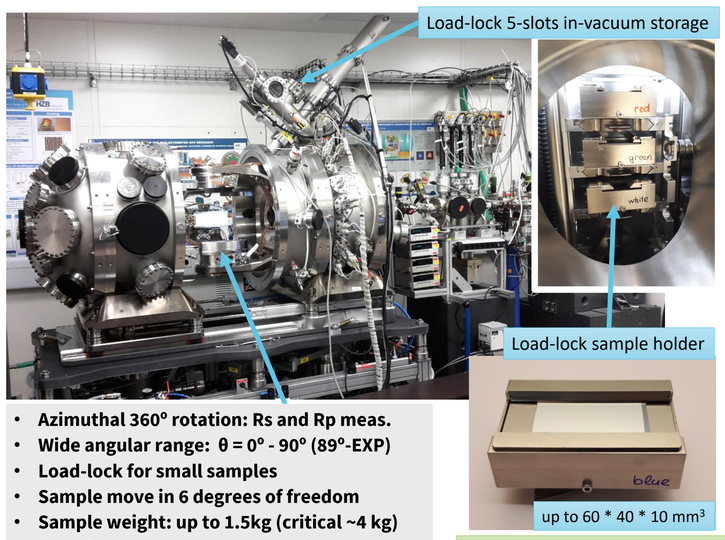
The At-Wavelength Metrology facility for sophisticated XUV optics such as diffraction gratings is operating since many years at the BESSY-II storage ring. As the main instrument a versatile 11-axis UHV-reflectometer is permanently connected to dedicated Optics beamline is available with 100% beam access to the beam [1,2]. The setup covers energy ranges of the EUV and XUV. High spectral purity of the incident beam is achieved by a set of 12 absorption filters and a High-Order Suppressor System consisting of 4 mirrors which can be inserted into the incident beam under variable angles of incidence without changing of the original beam path.

It was experimentally tested that this system gives a nearly high-order free beam between 13.5 eV and 1800 eV. A flexible sample support system based on an UHV-tripod gives 6 degrees of freedom for a precise alignment and mapping of tested optical elements. A load-lock system with in-vacuum storage for five samples size of 60 x 40 x 10 mm^3 provides quick sample change.

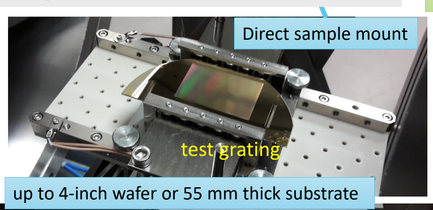
In additional to that a small Reflectometer as a portable end station is used to get access to UV-EUV or X-ray energy ranges. We had tested possibility to operate in lower energy range starting from 4 eV up to 30 eV by coupling with U125-2_NIM beamline [3] which is equipped with normal incidence monochromator. As well an accurate measurements on multilayer coated gratings [4] and different optical coatings were carried out with small Reflectometer attached to KMC-1 beamline working with double crystal monochromator in energy range 2000 eV - 10000 eV.

EXPERIMENT

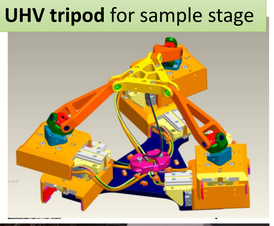
11-axis UHV-reflectometer

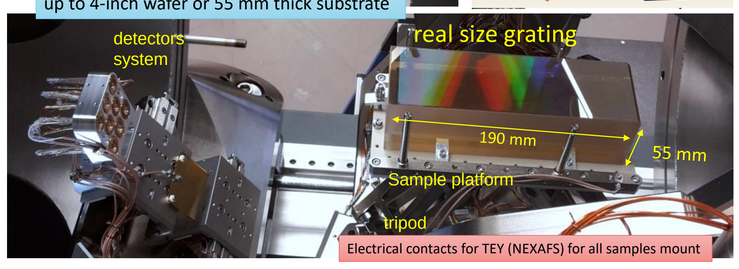


- **Azimuthal 360° rotation: Rs and Rp meas.**
- **Wide angular range: θ = 0° - 90° (89°-EXP)**
- **Load-lock for small samples**
- **Sample move in 6 degrees of freedom**
- **Sample weight: up to 1.5kg (critical ~4 kg)**
- **Sample size: <300 x 60 x 55 mm^3**



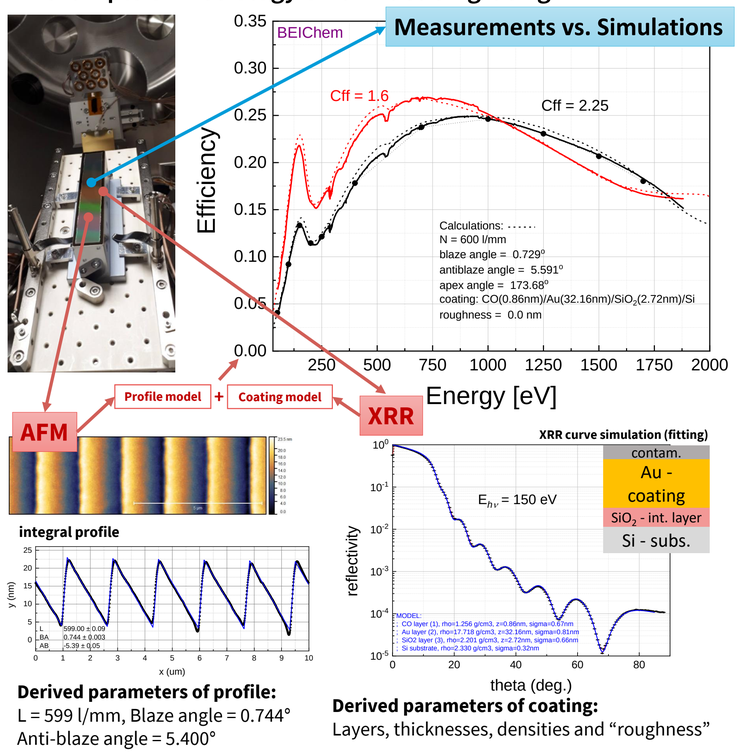
UHV tripod for sample stage





SOME RESULTS

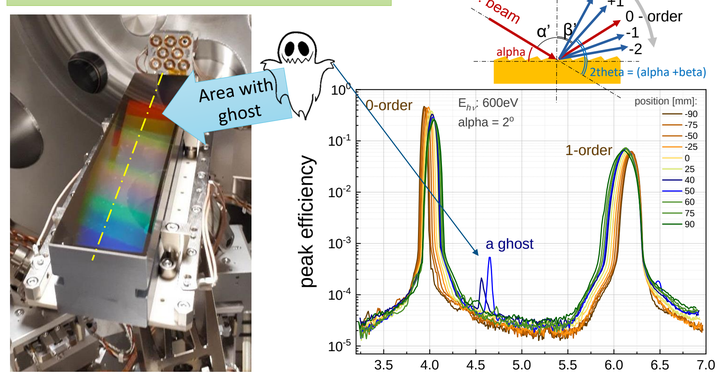
An example of metrology on diffraction grating



Derived parameters of profile:
L = 599 l/mm, Blaze angle = 0.744°
Anti-blaze angle = 5.400°

Derived parameters of coating:
Layers, thicknesses, densities and “roughness”

Additional resonances - Ghosts !

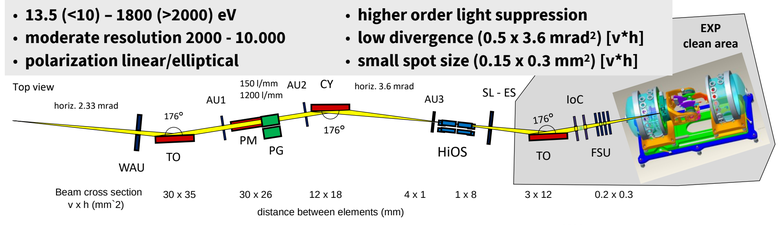


at-WL METROLOGY FACILITY

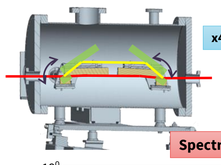
Optics beamline (PM1) - beamline for XUV metrology

Collimated PGM

- **13.5 (<10) – 1800 (>2000) eV**
- **moderate resolution 2000 - 10.000**
- **polarization linear/elliptical**
- **higher order light suppression**
- **low divergence (0.5 x 3.6 mrad²) [v*h]**
- **small spot size (0.15 x 0.3 mm²) [v*h]**



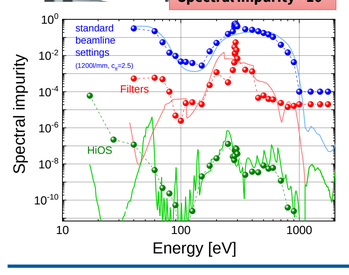
HiOS – higher orders suppression



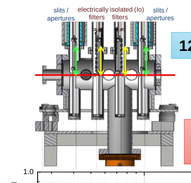
x4 times reflection

Coatings: AlF_3, C, Si

Spectral impurity <10^6



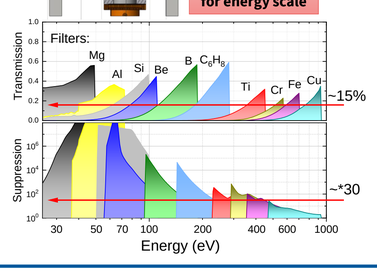
FSU – filter slit unit



12 abs. filters

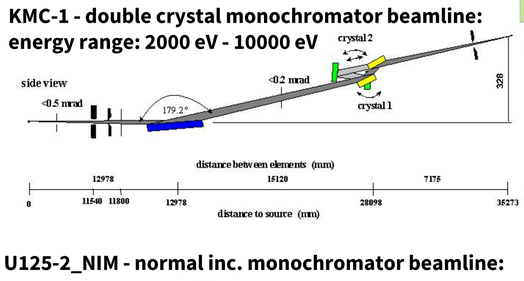
2x set pinholes and apertures

>50 ref. points for energy scale

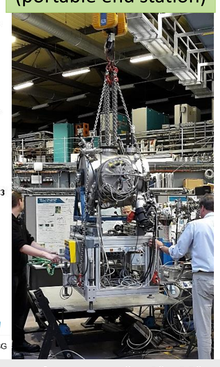


EUV + Tender X-ray range

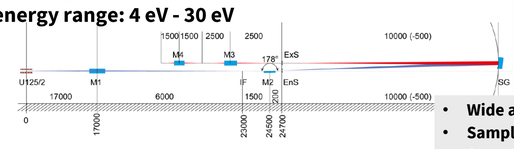
KMC-1 - double crystal monochromator beamline: energy range: 2000 eV - 10000 eV



small Reflectometer (portable end station)

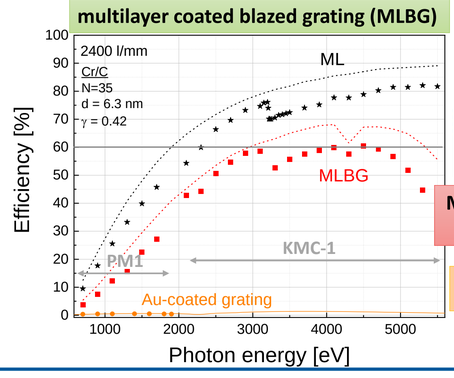


U125-2_NIM - normal inc. monochromator beamline: energy range: 4 eV - 30 eV



- **Wide angular range: θ = 0° - 88°**
- **Sample scan in lateral direction**
- **Sample size: <150 x 40 x 35 mm^3**
- **On-board set of absorption filters**
- **Adjustable front aperture**

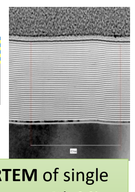
multilayer coated blazed grating (MLBG)



ML: Cr/C (35), d=6.3 nm,
blazed GR: N = 2400 l/mm

MLBG efficiency up to 60%

single layer coated GR efficiency <<5%

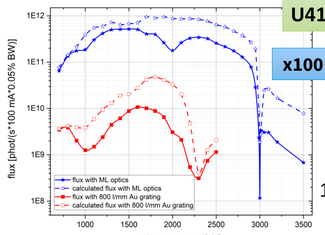


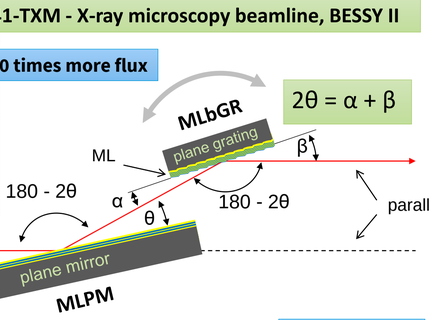
HRTEM of single groove with ML coating

Multilayer coated based monochromator

U41-TXM - X-ray microscopy beamline, BESSY II

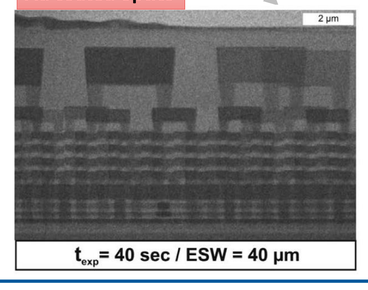
x100 times more flux



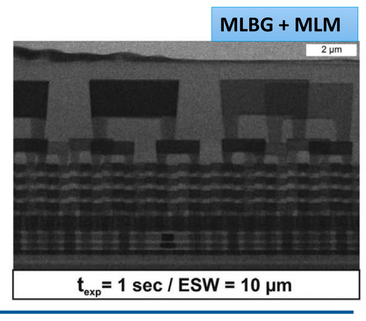


TXM images

Au coated optics



MLBG + MLM



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[5] Franz Schäfers, “The crystal monochromator beamline KMC-1 at BESSY II.” Journal of large-scale research facilities, 2, A96 (2016)
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