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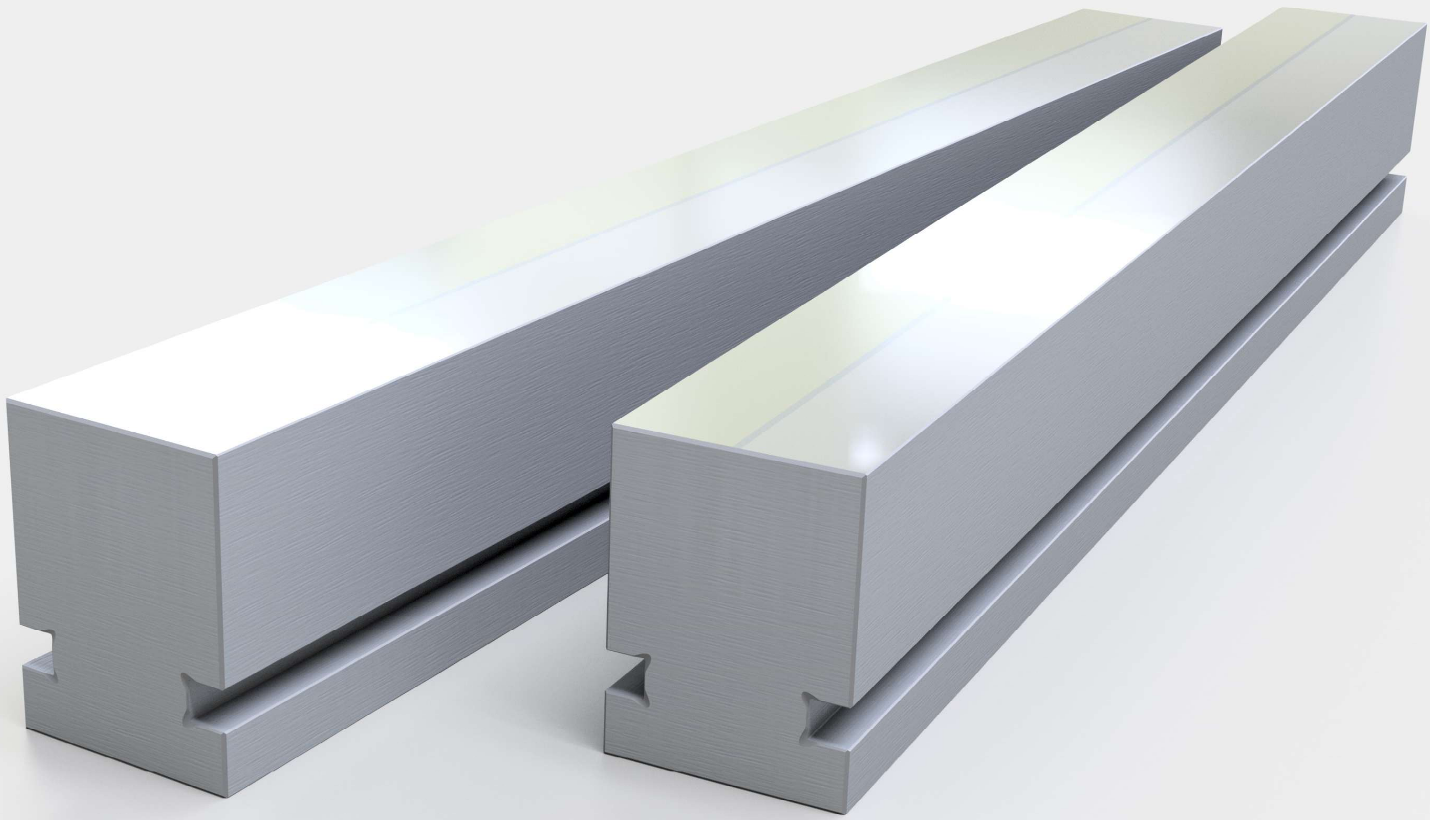
Multilayer Synchrotron Mirrors



Multilayer Synchrotron Mirrors

Monochromator and Kirkpatrick-Baez (KB) mirrors for synchrotron and similar applications can be fabricated customer-specific for energy ranges from XUV till the hard X-ray region with the bandwidth tunable from high resolution to broadband. Monochromators on plane substrates are applied widely as double multilayer monochromators (DMMs) to select individual photon energies from a broad source spectrum. 2- or 3-stripe versions can cover even larger energy ranges. An extremely high lateral homogeneity over the entire substrate length and width can be achieved. Curved synchrotron mirrors (e.g. KB mirrors, toroids, cylinders or paraboloids) on the other hand can provide beams with tailored focusing properties.

Multilayer Synchrotron Mirrors

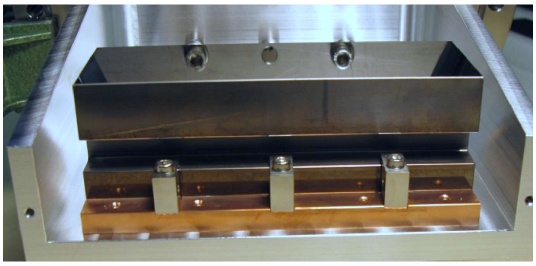
Technology

Typical synchrotron monochromators consist of periodic multilayer stacks on superpolished flat substrates. The reflected wavelength can be adjusted by selecting the corresponding Bragg angle for a given multilayer period thickness. Multilayers can be made as high resolution, high flux or broadband versions as well as optimized for polarization experiments near the Brewster angle for low energy X-rays.

References:

Optics upgrade of XPBF

For the upgrade of the X-ray pencil beam facility (XPBF) of PTB at BESSY II to XPBF 2.0, different toroidal, multilayer coated synchrotron mirrors were manufactured. The toroidal mirrors were milled and polished from monocrystalline silicon and coated with multilayers for best reflectance around 1.0 and 1.6 keV. The monochromatized and focussed beam of this new optics system was used to characterize a Wolter telescope of the ESA mission ATHENA+ (Advanced Telescope for High ENergy Astrophysics).

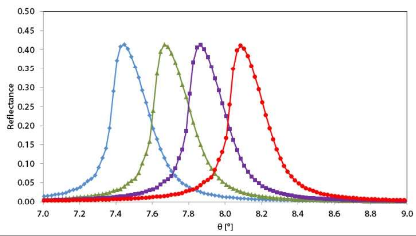


Toroidal multilayer mirror for soft X-rays at beamline XPBF 2.0 in the PTB laboratory at BESSY II.

Cooperation with M. Krumrey, PTB, Berlin, Germany.

Low energy optics for special sources

Multilayers can be individually designed and optimized for virtually any photon energy available at synchrotron facilities as well as less common or special energy regions. An example is the Berlin Laboratory for innovative X-ray technologies (BLiX) which uses, among other sources, a laser-produced plasma source to generate X-rays in the range of 100 eV to 1300 eV. Here, tailored multilayer optics can significantly improve lateral resolution, overall performance and detection limits. These advantages are particularly relevant for applicatons in μ-XRF, XAFS, XANES, and GEXRF.

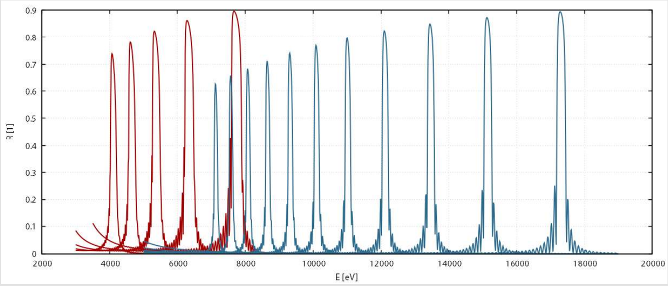


Reflectance at different positions (25 mm steps) of a multilayer mirror at the target photon energy 1078 eV. (Curves shifted in angular direction for clarity.)

Measurements by J. Baumann/A. Jonas, TU Berlin, Germany.

Multi-stripe monochromators

Multi-stripe monochromators equipped with two or three stripes enable easy switching between different multilayer types by simple stage movement. This allows users to select between optics optimized for distinct energy ranges — for example, one stripe can be tailored for lower photon energies, while another is suited for higher energies. A further option is to combine a high-resolution multilayer with narrow energy bandwidth and a high-flux multilayer with broader peaks, offering enhanced flexibility for various experimental requirements.



Calculated reflectance versus photon energy for an exemplary two-stripe multilayer system. A 5.5 nm Ni/C multilayer covers the energies below 8 keV while a 3.0 nm Mo/Si multilayer allows access to photon erniergies up to 18 keV. Peak positions move on the E axis when varying the Bragg angle from 0.7° to 1.7°.

3-stripe multilayer monochromator for applications at synchrotron beamlines between 5 keV and 80 keV.

Cooperation with G. Falkenberg, DESY, Hamburg, Germany.

2-stripe multilayer monochromator with harmonic suppression working between 6 and 15 keV.

Cooperation with S. Fiedler, EMBL/DESY, Hamburg, Germany.

Synchrotron optics features	
Spectral range	below 50 eV to above 100 keV
Coating material	optimized for flux or resolution
Period thickness	constant (high lateral homogeneity) lateral gradient (adjust to divergence) depth gradient (broadband mirrors)
Typical size	up to 8" diameter or 50 cm length (depending on system parameters)
Optical surface	flat 1D curved (e.g. plane-parabolic or -elliptic) 2D curved (e.g. toroidal, spherical, etc.)
Energy resolution	ΔE/E ~0.25% to ~2% (periodic) ΔE/E up to 25% (aperiodic)
Lateral homogeneity	Δd/d typically < 0.2%

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