Optimizing multilayer mirrors for state-of-the-art X-ray sources

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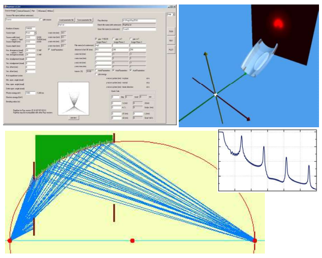
Design, fabrication & measurement

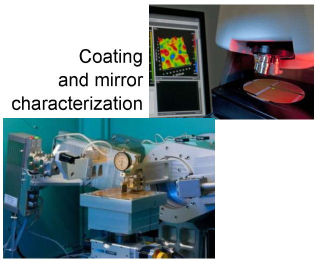
For best customer-specific solutions, the most suitable X-ray source, optics and geometry are selected, simulated and optimized. X-ray optics are entirely fabricated in-house where numerous characterization instruments are available. Each final source-optics system is tested at-wavelength (if possible in the lab) before delivery.



Multilayer simulation & mirror design

Complementary deposition methods

Flexible optics fabrication



Coating and mirror characterization

Comparison of different source types performance

Brilliance (ph / s mrad² mm² 0.1% BW) is a fixed source parameter, only flux density (ph / mm²) can be increased by optics. Depending on customers' applications the best source optics combination can be designed. Typical source performance parameters for Cu anodes (and comparable) are shown in the table. Obviously, highest power does not necessarily mean most photons on the sample, in particular for 2-dimensional focusing.

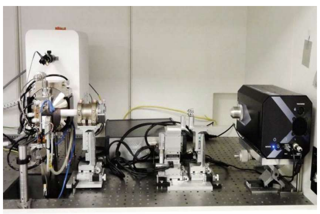
Source type	Energy [keV]	Thermal spot [µm]	Power [W]	Power density [kW/mm²]	Beam size [µm]
microfocus	8.0 (Cu Kα) or Cr, Co, Mo, Rh, Ag, W, …	50×500 50×250	50 30	2.0 2.4	50×50 50×50
metal jet	9.2 (Ga Kα) or In	20×80 10×40	250 125	156 312	20×20 10×10
rotating anode	8.0 (Cu Kα) or Mo, Ag, …	70×700	1200	24.5	70×70
fixed anode	8.0 (Cu Kα) or Co, Mo, Rh, Ag, …	12000×400	2200	0.5	12000×40

Metal Jet source – ASTIX X-ray optics system

Applications
- Powder diffraction
- SCD & protein crystallography
- SAXS
- X-ray microscopy

Parameters:
- Ga/In Metal Jet X-ray source
- spot size 5-20 µm (tunable)
- high brilliance
- high curvature accuracy (HCA) mirrors
- HR and HF optics for Ga-K & In-K radiation available

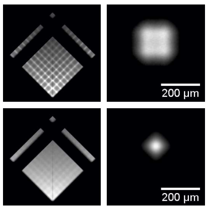
in collaboration with excillum



X-ray microscopy setup with ASTIX illumination optics and diffractive X-ray lenses (MLL) as objective

Theory and simulations

When high resolution optics for hard X-rays are required, various parameters can be optimized yielding different benefits and problems.
Especially for short wavelength sources, longer mirrors are advantageous as they provide larger collection angles and thus higher integrated intensity. On the other hand, using standard fabrication techniques (SCA) the focal spot on the sample position becomes larger and achieving the required performance gets more challenging. Here, high curvature accuracy (HCA) substrates can help with their inherently low slope errors.



Example (raytracing simulation) of improvement from conventional SCA (upper row) to HCA with significantly reduced slope errors (other parameters identical). Strong oscillations in the beam profile in the near-field (left column) are result of assumed sinusoidal slope errors of different amplitudes. In the focal plane (right column) these oscillations are not visible, but the focal spot size decreases significantly for the HCA mirror.

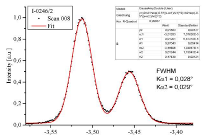
X-ray source-optics combinations

Primux 50 Micro focus X-ray source
- stand-alone and with tailored 1D or 2D multilayer X-ray mirrors
- spot Ø: 50 µm
- 50 W
- Cu, Mo, Ag, W and others
- water cooling

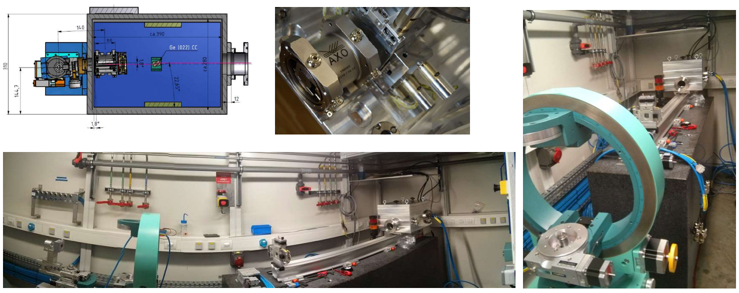
Primux 3000 Long fine focus X-ray source
- exchangable multilayer mirrors
- applied in XRDynamic500
- 12 mm × 0.04 mm line focus
- e.g. 2.2 kW (44 kV, 50 mA, Cu)
- water cooling

Laboratory „beamline" at BM28 (XMaS)

Lab „beamline" at BM28 (XMaS) beamline at ESRF, Grenoble, France, for single crystal XRD
- Cu microfocus source (50 µm, 50 W)
- 2D collimating ASTIX-c optics for Cu Kα radiation plus optional double-bounce Ge (022) channel-cut crystal (CC) for Cu $K\alpha_1$ radiation
- divergence ≈ 0.03°
- divergence with CC around 3× to 10× smaller



rocking scan on Si behind ASTIX-c optics showing Cu $K\alpha_1$ and $K\alpha_2$ peaks



References

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