

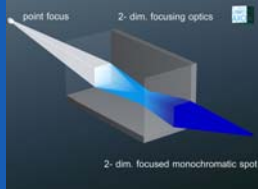
X-Ray analytical application of multilayer X-ray optics

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ASTIX-f – Optics for micro focusing



Beam path and monochromatization of a focusing ASTIX-f system

Advantages of the ASTIX-solution

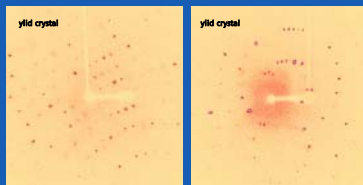
Symmetric spot geometry in the focal plane even for highly asymmetric source dimensions

Improved lateral and temporal homogeneity

Wide variety in spot dimension of less than 30µm to more than 300µm on fixed anode and micro focus X-ray tubes depending on multilayer system, deposition and geometry parameters

Typical mirror length up to 150 mm

Improved P/B ratio due to reduced scattered background



arrangement 1: µ-source (Mo) coupled with ASTIX-f*

arrangement 2: Fixed anode tube (Mo) coupled with HOPG*

Resolution A	measured offset	best offset	average intensity	P/B ratio	Rate
180-1.186	600	550	1.5	60.26	0.014
180-1.194	600	600	6.0	58.05	0.015
180-1.194	600	100	8.2	58.08	0.020
180-1.194	600	200	8.1	58.04	0.021
180-1.194	600	300	7.2	58.01	0.020
180-1.194	600	400	6.4	58.02	0.020
180-1.194	600	500	5.5	58.05	0.021
180-1.194	600	600	5.1	58.05	0.021
180-1.194	270	270	2.3	58.08	0.021
180-1.194	170	170	1.6	58.01	0.020
180-1.194	600	600	1.4	58.05	0.019

Table: Results of data collection (YLiF crystal); completeness > 99 %
* data of yLiF single crystal diffraction by courtesy of Oxford Diffraction



ASTIX 150 and ASTIX 100 with vacuum mirror housing AMH100 and AMH150

∅ > 300µm ∅ < 100µm



Symmetric shape of secondary focal spots with ∅ < 100µm up to ∅ > 300µm measured at fixed anode tubes (Cu) coupled with ASTIX-f (marcam images)

Modular X-ray system (micro source + ASTIX-f optics) applicable both for standard XRD (powder diffraction / SCD) and micro diffraction



FWHM < 150 µm

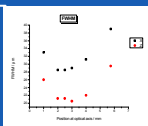
Geometry 100/300:
∅ = 150 µm
∅ = 7.5 × 10⁸ cps

Mo Kα Microfocus X-ray source (spot ∅ 50 µm @ 30 W) and ASTIX-f100



Geometry 300/100:
∅ = 28 µm × 21 µm
∅ = 2.5 × 10⁹ cps

FWHM < 30 µm

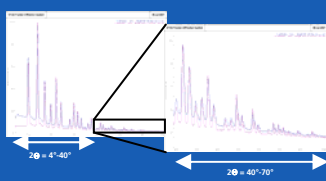


µ-focus MoKα source coupled with ASTIX-f (a) vs. X-ray tube + HOPG + capillary (b)



STOE powder diffraction system
LaB₆ powder sample / capillary ∅ 250 µm
time: 3 min / image plate detector

experimental setup:
(a) spot size: 150 µm
cone angle: 3 mrad
(b) spot size: 300 µm
cone angle: 7 mrad

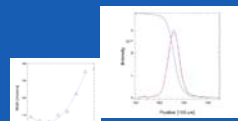


Results with ASTIX-f:
• highly symmetric spot at sample position
• low background intensity
• twice the flux density in a 150 µm spot
• nearly the same peak intensity with reduced illuminated sample volume
• higher resolution (K_α splitting)
• increased P/B ratio with ASTIX-f solution
• higher efficiency due to precise application

Combination of sealed X-ray source with ASTIX-c (L=60) for Cr Kα



Cr Kα sealed tube X-ray source (spot 1.2x0.4 / 1.2kV) and ASTIX-c 60 ∅ / 150



Geometry ∅150:
Beam profile: ∅ = 100µm (FWHM)
1 × 1 × 10⁹ cps (Cr Kα)
Long distance focussing
Measurement up to 2θ > 160°

Ag Kα parallel beam optics for X-Ray diffraction

Goal

- covering a large q-range up to 20 Å⁻¹ in the reciprocal space (0.1° < 2θ < 160°)
- high penetration depth also in metal samples
- reduced influence of sample fluorescence, displacement errors and sample transparency in parallel beam geometry with secondary monochromator

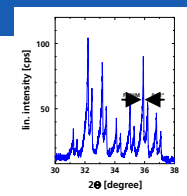
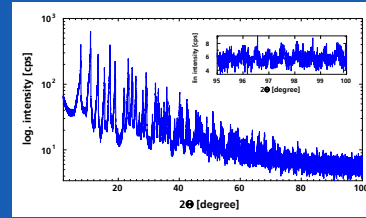


experimental setup: Diffractometer XRD 3003 (Gö-1) for samples up to 200 mm × 200 mm or 8" ∅ and for measurements up to 2θ = 160°

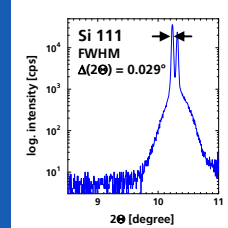


Parallel beam profiles without (a) and with sample (b) in the beam path (LaB₆ capillary ∅ 500 µm)

XRD measurements of LaB₆ powder sample (50kV / 25mA)



XRD measurement of single crystal Si111 reflection



Results:

- intensity > 10⁸ cps
- I(Ag Kα) : I(Ag Kβ) > 10.000
- beam divergence Δθ ≈ 0.015° (< 60 arcsec)
- improved P/B ratio due to suppression of other characteristic emission lines (Ag Kβ)
- low background intensity level (< 5 cps)
- reflexions up to 2θ = 100° detected at LaB₆

Multilayer Monochromators for Synchrotron Applications



Application : from EUV to hard X-rays (< 50 eV – 100 keV)
Material systems : optimized on wavelength and bandwidth on customers' request
Dimensions : up to 8" diameter or up to 500 mm in length
Thickness homogeneity: Δd < 0.002 nm for d = 1 nm (Δd/d < 0.2%)
Resolution: 0.25% < ΔE/E < 10%

Stability of Ni/C multilayer



water cooled Ni/C (IW5): d = 3.38 nm
100 layers
Γ = 0.45
ΔE/E = 2 × 10⁻²
deposited on Si-mirrors (Zeiss)
size 120 × 30 × 10 mm³
energy range: 3-8 keV and 10-100 keV



Results:
Ni/C multilayer used as DMM (HASYLAB at DESY)
Physical life: 1.5 a / effective 4 months
Energy range: 12 keV, 18 keV, 40-60 keV / water cooling
Vacuum: base pressure 1 × 10⁻⁴ mbar
Results of Cu Kα reflectometry: No remarkable decrease of reflected peak intensities at both multilayers
WH1: increase of mean period thickness about 0.15 nm
Higher heat load at mirror WH1 up to a temperature of approx. 200°C



WH 1: close to source
WH 2