

Multilayer X-ray optics with high precision deposition

M. Krämer*, R. Dietsch*, Th. Holz*, D. Weißbach*, St. Braun**

* AXO DRESDEN GmbH, Siegfried-Rädel-Str. 31, 01809 Heidenau, Germany; contact@axo-dresden.de

** Fraunhofer IWS, Winterbergstr. 28, 01277 Dresden, Germany

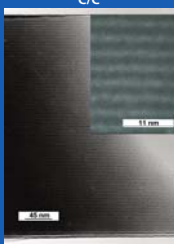
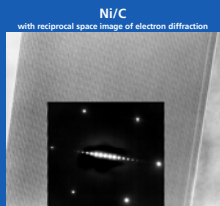
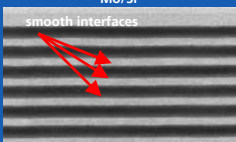
High precision deposition

Combination of complementary high precision deposition technologies:

- Magnetron Sputtering (MSD)
- Large-Area PLD (LA-PLD)
- Dual Ion Beam Sputter Deposition (in cooperation with IWS)



Typical multilayer systems:
MSD: W/Si, Mo/Si, Pd/B₂C, ...
DIBD: Ni/B₂C, C/C, a-C, ...
PLD: Ni/C, C/C, a-C, ...



X-ray Mirror Geometries

1D

Parallel beam optics:

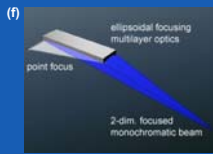
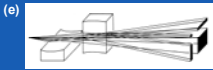
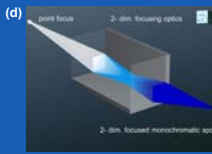
- Twin mirror arrangement (a)
- Goebel Mirror (b)



2D

Side-by-side optical systems:

- Montel (c)
- ASTIX (d)
- Kirkpatrick-Baez arrangement (e)
- Single bounce mirrors (f)



Parallel beam for X-ray reflectometry

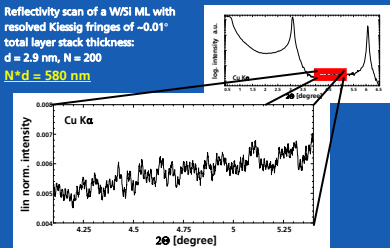


α -TWINS – High resolution mirror setup for reflectometry (XRR)

$I_0 > 10^8$ cps (Cu $K\alpha$)
0.013° (45 arcsec) beam divergence
600 nm resolution without channel cut

The optimized combination of low divergence multilayer optics and reflectometry X-ray tube yields to a divergence of less than 50 arcsec (compared to 110 arcsec in standard TMA) in the parallel beam. So it is possible to measure total thin film thicknesses up to 600 nm without channel cut monochromators in the beam path. An improved P/B ratio is achieved due to suppression of other characteristic emission lines (Cu $K\beta$) and sample fluorescence radiation. So a dynamic range of more than 7 orders of magnitude can be covered.

α -Twins combine the high intensity and brilliance of a multilayer mirror system with a high resolution comparable to channel cut systems.



ASTIX optics

Small angle X-ray scattering: ASTIX optics – modified Montel geometry for the generation of 2-dim. high intense focused or collimated X-ray beams

Features of ASTIX-f optics:

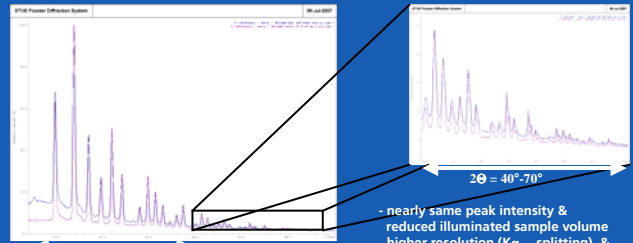
- symmetric spots in focal plane even for highly asymmetric source dimensions
- better lateral & temporal homogeneity of beam profile in the focal plane
- wide variety in spot dimension from $<30 \mu\text{m}$ to more than $300 \mu\text{m}$ with fixed anode tubes depending on multilayer system, deposition and geometry parameters
- imaging properties are more independent of source dimension in beam path direction (take-off angle effects)
- typical length up to 150 mm
- improved P/B ratio due to low background

ASTIX 150 and ASTIX 100 with vacuum mirror housing

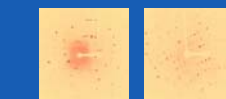


Background reduction

μ -focus Mo $K\alpha$ source coupled with ASTIX-f (red curve) vs. X-ray tube + HOPG + capillary (blue)



- nearly same peak intensity & reduced illuminated sample volume
- higher resolution ($K\alpha_{1,2}$ splitting) & reduced background intensity with ASTIX-f
→ 2 times higher flux density
→ half of the total flux in the focal spot

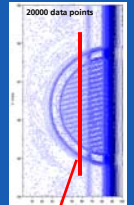


Diffraction patterns of an ylid crystal: Improved P/B ratio due to reduced scattered background. Arrangement 1 (left): fixed anode tube (Mo) with HOPG. Arrangement 2 (right): μ -source (Mo) with ASTIX-f

Microspots

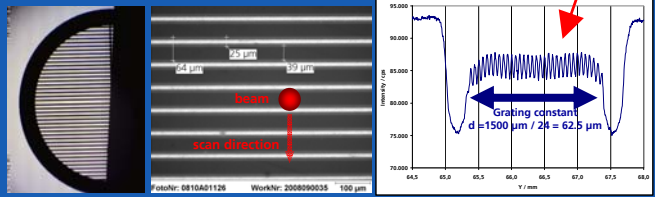
Radiation	Focal length f_z	Spot size
Cr $K\alpha$	150 mm	$\approx 105 \mu\text{m}$
Cu $K\alpha$	90 mm	$< 100 \mu\text{m}$
Ag $K\alpha$	100 mm	$\approx 80 \mu\text{m}$
Mo $K\alpha$	100 mm	$< 25 \mu\text{m}$

25 μm step size 2D (right) and 5 μm step size linear (below) X-ray absorption scan of a Cu SEM grating (400 lines/inch) with a 40 μm diameter Ag $K\alpha$ beam. A Moiré pattern is visible in the 2D scan.



The $\sim 60 \mu\text{m}$ grating structure can be clearly resolved.

Microscope images (below) of the Cu SEM grating with an illustration of the beam spot size.



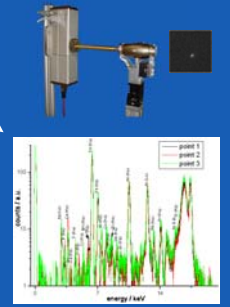
μ-XRF

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

Mo $K\alpha$ μ -focus X-ray source (spot $\varnothing 50 \mu\text{m}$, 30 W) and ASTIX-f100: μ -XRF spot $\varnothing < 30 \mu\text{m}$ at 30 W

Application:

- Scanning μ -XRF by monochromatic excitation
- Combination of scanning μ -XRD and μ -XRF



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