AXO

APPLIED X-RAY OPTICS

AXO DRESDEN GmbH Applied X-ray Optics Röntgenoptik und Präzisionsbeschichtung

Multilayer X-ray optics with high precision deposition

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High precision deposition

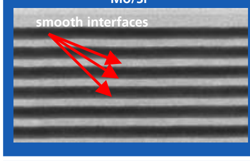
Combination of complementary high precision deposition technologies:
- Magnetron Sputtering (MSD)
- Large-Area PLD (LA-PLD)
- Dual Ion Beam Sputter Deposition *(in cooperation with IWS)*

DIBD

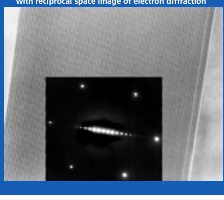
MSD

Typical multilayer systems:
MSD: W/Si, Mo/Si, Pd/B_4C, ...
DIBD: Ni/B_4C, C/C, a-C, ...
PLD: Ni/C, C/C, a-C, ...

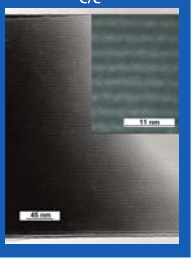
Mo/Si



Ni/C
with reciprocal space image of electron diffraction



C/C



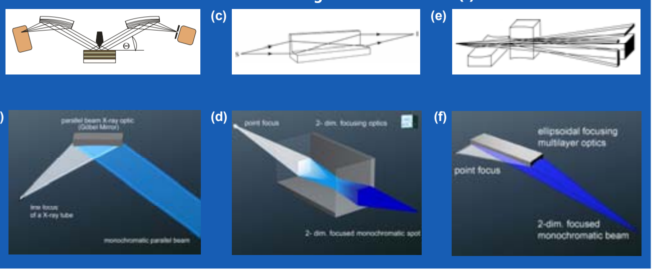
X-ray Mirror Geometries

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 Kα)

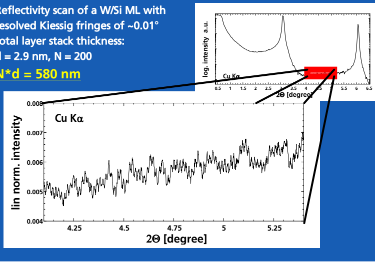
0.013° (45 arcsec) beam divergence

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 Kβ) 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 brillance of a multilayer mirror system with a high resolution comparable to channel cut systems.

Reflectivity scan of a W/Si ML with resolved Kiessig fringes of ~0.01° total layer stack thickness:
d = 2.9 nm, N = 200
N*d = 580 nm



ASTIX optics

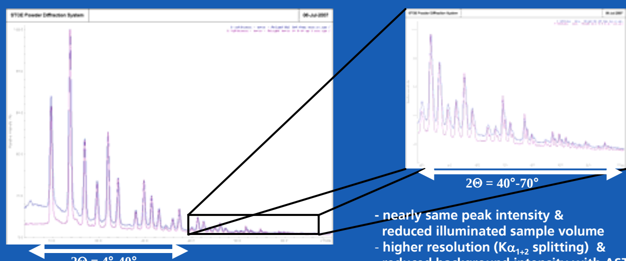
Small angle X-ray scattering: ASTIX optics – modified Montel geometry for the generation of 2-dim. high intense focused or collimated X-ray beams

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 µm to more than 300 µm 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

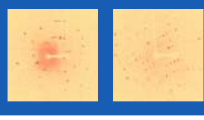
ASTIX 150 and ASTIX 100 with vacuum mirror housing

Background reduction

µ-focus MoKα 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



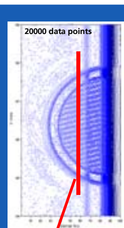
Diffraction patterns of an ylid crystal:
Improved P/B ratio due to reduced scattered background.
Arrangement 1 (left): fixed anode tube (Mo) with HOPG
Arrangement 2 (right): µ-source (Mo) with ASTIX-f

Microspots

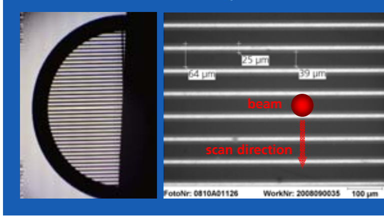
Radiation	Focal length f_2	Spot size
Cr Kα	150 mm	≈ 105 µm
Cu Kα	90 mm	< 100 µm
Ag Kα	100 mm	≈ 40 µm
Mo Kα	100 mm	< 25 µm

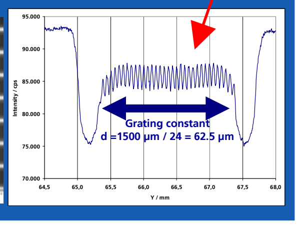
25 µm step size 2D (right) and 5 µm step size linear (below) X-ray absorption scan of a Cu SEM grating (400 lines/inch) with a 40 µm diameter Ag Kα beam. A Moiré pattern is visible in the 2D scan.

The ~60 µm grating structure can be clearly resolved.



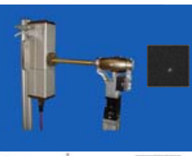
Microscope images (below) of the Cu SEM grating with an illustration of the beam spot size.

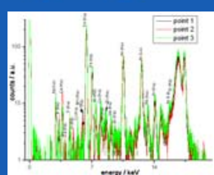




µ-XRF

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





Mo Kα µ-focus X-ray source (spot ∅ 50 µm, 30 W) and ASTIX-f100: µ-XRF spot ∅ < 30 µm at 30 W

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

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