Condenser for lab-based full-field X-ray microscopy with multilayer Laue lenses

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Multilayer Laue lenses – MLLs

- Concept: linear zone plate to realize enhanced efficiency and resolution for hard X-ray imaging [1]
- Crossed MLLs for point focusing and full-field imaging

- Fabrication of partial MLLs
  - magnetron sputtering: thin film deposition
  - shaping: precision sawing and focused ion beam milling
  - glue bonding: crossed MLL
  - focal length adjustment by exploiting radial thickness variations

- Properties
  - focal length: 8.0 mm (Cu-Kα)
  - zones: 50…2500 = 79…11 nm
  - WSi_2/Si multilayer, height: 48 µm

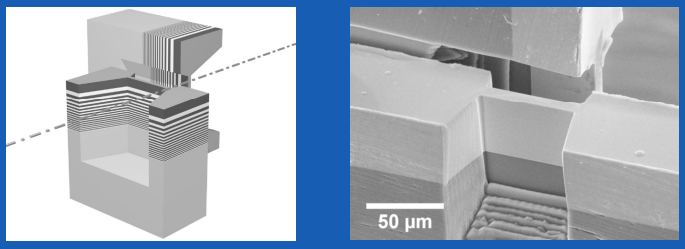
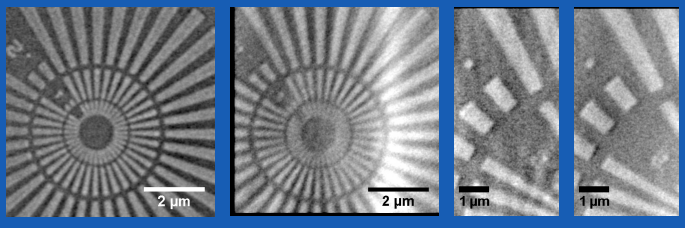


Fig 1: Illustration and SEM image of crossed partial multilayer Laue lenses

Full-field X-ray microscopy

- Full-field imaging demonstrated in a laboratory X-ray microscope Zeiss Xradia NanoXCT-100 using the hollow cone illumination of a capillary condenser and one-sided imaging [2]

- Current issues
  - ghost image formation due to Cu-Kβ radiation
  - reduced intensity due to hollow cone illumination
  - size of the illumination exceeds the field of view



a) FZP, reference *b) MLL + Ni* *c) MLL* *d) MLL + Ni*

Fig 2: Recent results compared to imaging with a Fresnel zone plate (FZP). A Nickel filter is mandatory to suppress Cu-Kβ ghost images. [2]

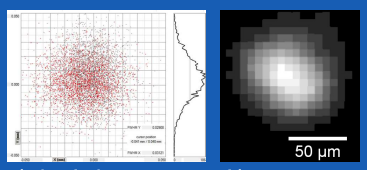
References

[1] J. Maser, G. B. Stephenson, S. Vogt, W. Yun, A. Macrander, H. C. Kang, C. Liu, R. Conley: Multilayer Laue lenses as high-resolution x-ray optics. Proc. SPIE vol. 5539, p. 185, 2004.
[2] S. Niese, P. Krüger, A. Kubec, S. Braun, J. Patommel, C. G. Schroer, A. Leson, E. Zschech: Full-field X-ray microscopy with crossed partial multilayer Laue Lenses. Optics Express, 2014. Accepted.

Illumination with AXO ASTIX-f optics

- Two-dimensional focusing X-ray mirror in a modified Montel geometry
  - solid illumination
  - efficient suppression of Cu-Kβ radiation and bremsstrahlung
  - matching of numerical apertures using a slit system
  - spot simulation considering slope errors

- Properties of the fabricated mirror
  - f_1 = 325 mm, f_2 = 125 mm
  - designed for Cu-Kα radiation
  - secondary focus FWHM = 28 µm



a) simulation *b) measurement*

Fig 3: Spot characterization

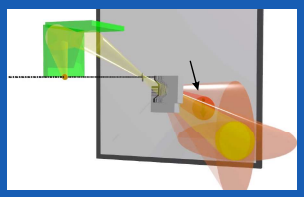


Fig. 4: Optical path illustration

Experimental set-up

- Demonstrator setup with combined optics for basic evaluation
  - Cu microfocus X-ray tube
  - ASTIX-f mirror & slit system
  - 6-axis sample stage
  - Multilayer Laue lens
  - X-ray detector, 6.45 µm pixel size

- In progress
  - proof-of-principle demonstration for X-ray microscopy and tomography
  - study of the influence of the illumination

- Outlook — hard X-ray microscopy with …
  - enhanced efficiency
  - from sub-100 nm to sub-10 nm resolution
  - photon energies E > 10 keV

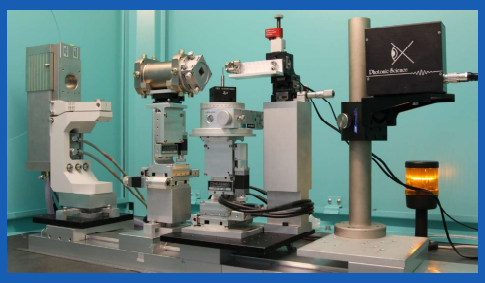


Fig 4: Demonstrator setup – µFocus Cu X-ray source, ASTIX-f mirror, object, MLL, X-ray detector

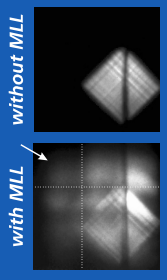


Fig. 5: Preliminary results

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