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IT-15-P-2231 Multilayer Laue Lenses as High Resolution hard X-ray Optics

Kubec A.[1, 2], Niese S.[1], Melzer K.[1, 2], Braun S.[2], Patommel J.[1], Leson A.[2], Zschech E.[3]

[1]Technische Universität Dresden, Dresden, Germany, [2]Fraunhofer IWS Dresden, Dresden, Germany, [3]Fraunhofer IKTS-MD, Dresden, Germany

Email of the presenting author: adam.kubec@tu-dresden.de

X-ray Microscopy provides a high resolution sample analysis method while demands on sample preparation are typically less restrictive than for transmission electron microscopy. Resolutions are still limited by the available optics but improvements in this field can easily be implemented in existing setups and will thus directly influence and improve measurements. Multilayer Laue lenses (MLL) are promising x-ray optics to achieve high efficiency focusing with small spot sizes down to sub-10 nm with current and down to sub-1 nm with improved geometries.

We have deposited multilayer stacks with layer thicknesses according to the zone plate law and a total deposition thickness of more than 50 micrometer. Deposition processes using magnetron sputtering took up to 83 hours and the stacks containing up to 6500 individual layers with thicknesses down to 5 nm have been obtained.

These parameters require long term system process stability on the one hand and a high precision in zone deposition on the other hand. The actual one dimensionally focusing lens is subsequently fabricated with mechanical preparation and focused ion beam milling. Two of these lenses have to be placed perpendicularly in a distance of about 30 micrometers from each other to obtain point focusing [Fig. 1]. Two of these lenses were crossed perpendicularly at a distance of 30 µm to obtain a point focus [Fig.1].

We have successfully demonstrated several focusing and imaging experiments using crossed MLLs. In synchrotron beam times at ID13, ESRF in Grenoble, France and P06, PETRA III in Hamburg, Germany spot sizes down to 39x49 nm^2 at 20 keV x-ray energy have been shown using the coherent diffraction imaging method of Ptychography [Fig. 2 and 3]. Furthermore we have demonstrated measurements with a wedged MLL realizing the improved geometry. Global diffraction efficiency was enhanced by more than 50% on average over the entire aperture of the lens. In addition, full field imaging was shown for the first time using multilayer Laue lenses at a laboratory microscope with a rotating copper anode.

References:

[1] A. Kubec, S. Braun, S. Niese, P. Krüger, J. Patommel, M. Hecker, A. Leson and C. Schroer: Ptychography with Multilayer Laue Lenses and their Initial Characterization with a Laboratory Based X-ray Microscope, to be published

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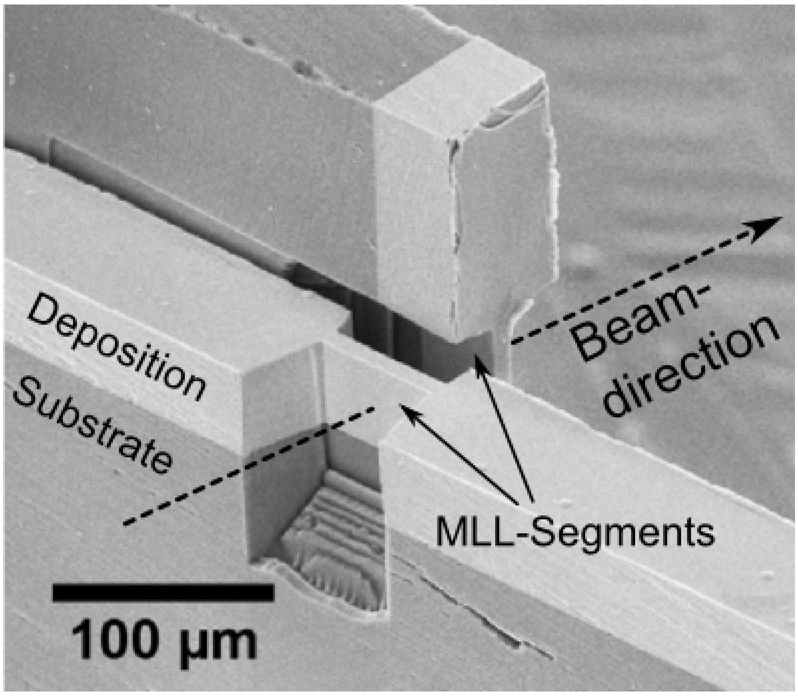

Fig. 1: A pair of crossed multilayer Laue lenses with the designated beam direction.

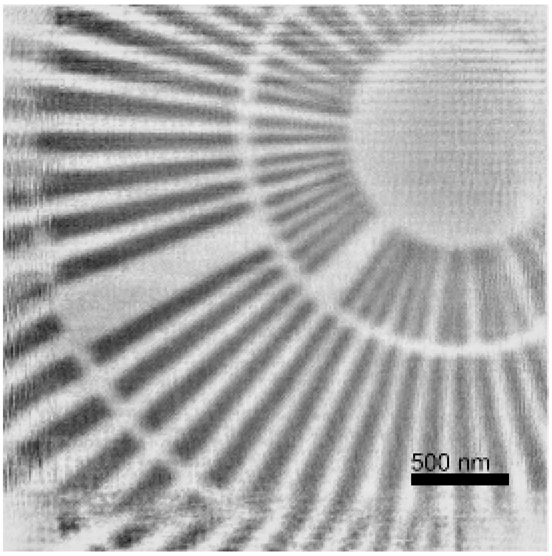

Fig. 2: A phase reconstruction of the test sample used for the ptychography measurements. [1]

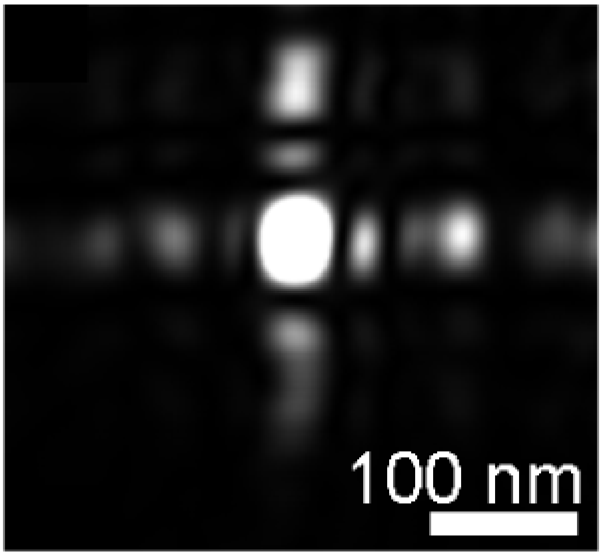

Fig. 3: Amplitude reconstruction of the focal plane. [1]