First Results from the X-Ray Microscopy Beamline U41-PGM1-XM at BESSY II.

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The newly designed beamline U41-PGM1-XM at BESSY II for the Helmholtz-Zentrum Berlin (HZB) transmission soft X-ray microscope (TXM) was successfully set up and went in operation in 2017 [1]. During the commissioning of the beamline we determined the spectral resolution, horizontal focus value at the exit slit and the flux for different undulator harmonics. The experimental results meet the values from raytracing calculations. For the horizontal focus at the exit slit position we calculated a FWHM value of 108 µm at 510 eV which is in good agreement with the experimental value of 107 µm. The flux for photon energies higher than 550 eV is now much higher compared to the previous U41-SGM-XM beamline [2] (Fig. 1).

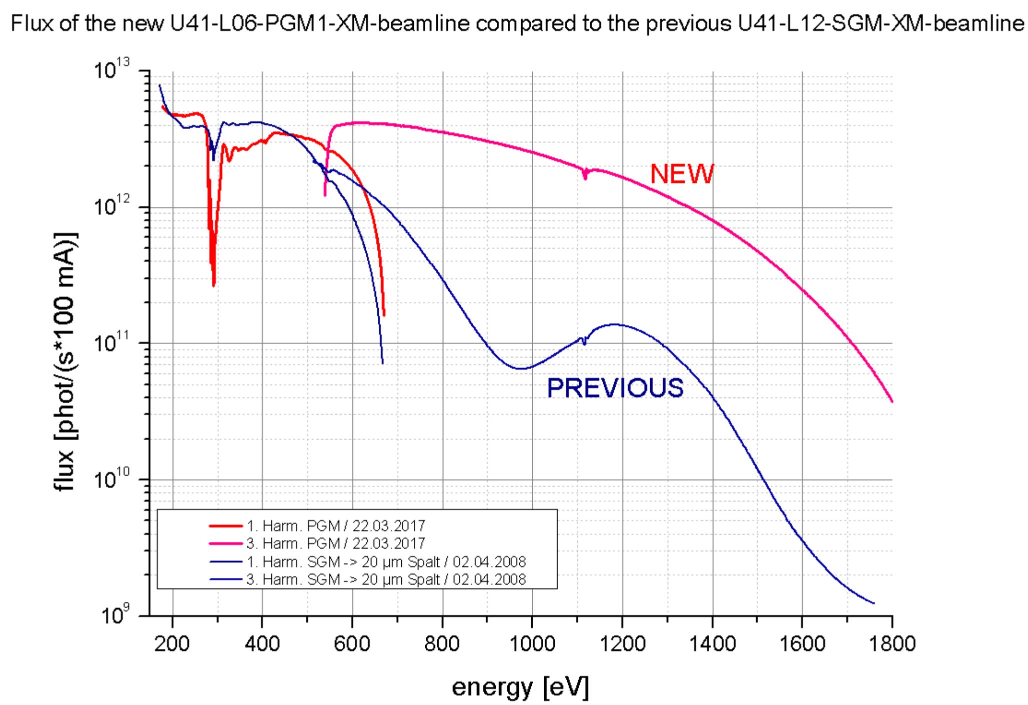

Figure. 1. The measured flux downstream of the exit slit with 20 µm opening is shown in comparison to the previous U41-FSGM beamline at location L12. Note the gain especially for the photon energy range larger than 550 eV. At both beamlines we have used the same GaAsP-photodiode at the same distance to the exit slit and Keithley device for the measurements.

With the 800 l/mm Au-grating with a blaze angle of 0.93° we reached a spectral resolution of about 7600 resp. 10600 at 400 eV with c_{ff} (constant magnification for fixed focus) = 2.25 resp. c_{ff} = 10 which is sufficient for the standard nano-tomography applications [2] and NEXAFS-TXM studies [3].

The high performance of the new beamline is also demonstrated by the high quality of the X-ray microscopic images. A comparison of images taken from the same Siemens star test pattern with a zone plate having 25 nm outermost zone width shows clearly artifact free imaging at the new beamline (Fig. 2). Note the improved homogeneity of the illumination. Additionally, a multilayer test pattern lamella demonstrates the high spatial resolution of about 10 nm (Fig. 3). Third order imaging at higher photon energies, e.g. at 1400 eV, can be performed with shorter exposure times compared to the previous beamline (Fig. 3).

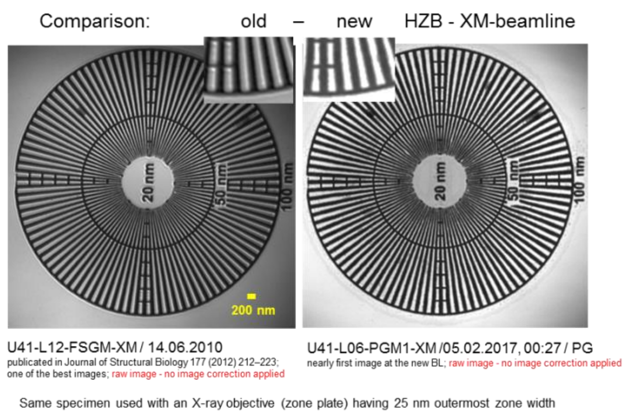

Figure. 2. The beamline optics were designed to illuminate the capillary symmetrically, therefore no imaging artifacts by asymmetrical illumination as we have it before are occurring.

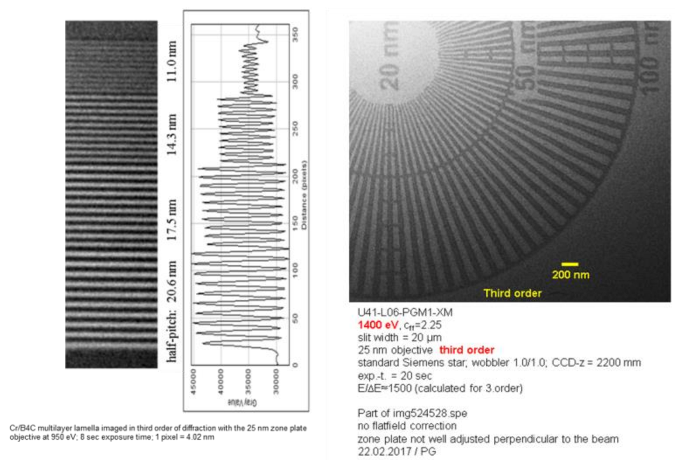

Figure. 3. With test specimens we could demonstrate again a high spatial resolution of about 10 nm and that we can do imaging at higher photon energies with shorter exposure times.

During first friendly user experiments imaging at 1800 eV could be demonstrated. This is very helpful for studies of e.g. thicker (up to 2 µm) lamellas of materials sciences projects like semiconductor devices. Several NEXAFS-TXM investigations could be carried out underlining the high quality of the beamline [4].

The X-ray microscope using up-to-date EPICS- and QT-based control software is in normal user operation since the second beamtime period of 2017. Now, a special cryo-holder for round standard EM grids can be used for nano-tomography together with a new zone plate objective with 25 nm outermost zone width for tilt-ranges up to ±60°.

References:

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[3] P. Guttmann *et al*, Nature Photonics 6 (2012), 25-29
[4] C. Bittencourt *et al*, this conference