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Characterization of a Multilayer Laue Lens as Condenser for Projection Tomography to Enable the XtremeCT Requirements at the DanMAX Beamline of MAX IV

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The tomographic station of the DanMAX beamline at MAX IV Laboratory entered user operation in Spring 2024. The scope of the beamline is predominantly diffraction and imaging for material science. With the XtremeCT project we aim to enable DanMAX to perform, in an optimized and disruptive manner, 3D measurements of all microstructural features within large sections of brains and bones, to visualize the full hierarchical organization and connectivity in multiscale samples, with the aim of understanding their structural function and possible connection to diseases. The goal is to achieve a voxel-to-image ratio of 104 - 105, resulting in significantly higher information density compared to current methods. To expand the field-of-view and for zooming into the cells using projection nano-tomography, a focusing X-ray optics with sub 100 nm spot size and high numerical aperture is required.

The focusing element must work across a large energy bandwidth and preserve the coherence, both essential to generate low dose 3D phase contrast tomography with a ratio between field-of-view and resolution of 10,000:1 or better, e.g. for visualizing all cells within tissues. We report here on the outcome of a pilot study using a Mo/C/Si/C Multilayer Laue Lens (MLL) from AXO DRESDEN and Fraunhofer IWS. MLLs offer a high diffraction efficiency for hard X-rays and a large energy bandwidth. Thus, even a MLL that is optimized for 20 keV can be well used in the entire photon energy range of the DanMAX beamline (15 keV –35 keV) without sacrificing the diffraction efficiency more than a factor of 2. The MLL ensures that the incident beam diameter (~1.3 mm) is expanded by a factor of 10 to encompass the entire Field-of-View of the detector (12.0 mm).

We plan to present detailed characterization of the MLL at the DanMAX beamline, with specific emphasis of full-field tomography at the micron and sub-100 nm scale respectively. Assessment of beam quality after beam expansion has been performed as well as a comparison of the image quality and phase retrieval performance when using the MLL in projection geometry and as an objective lens.

I plan to submit also conference proceedings

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