Contribution ID: **100**

Type: **Contributed talk**

High-Throughput and Efficient Hard X-ray Projection Imaging with a sub-5 nm Resolution

Tuesday 27 August 2024 18:00 (15 minutes)

The state of the art in X-ray microscopy is based on ptychography, which obtains high resolution approaching 5 nm by recording diffraction from the sample using a focused beam at photon energies of about 5 to 20 keV [1]. Robust algorithms are used to recover the diffraction phases and obtain an image of the complex-valued transmission of the sample. Achieving the high resolution requires measuring diffraction signals at high scattering angles. These diffraction intensities are weak and easily corrupted by background noise and parasitic scattering, requiring a larger dose to the sample than necessary. Significant efforts are needed to avoid this noise, making the method less practical and user-friendly. We have recently improved the fabrication of multilayer Laue lenses (MLLs) to focus hard X-rays with a high convergence angle (or numerical aperture, NA) [2,3]. In a ptychography measurement, this high convergence angle overcomes the problems of sensitivity to noise by providing a strong zero-order reference beam that coherently interferes with the weak scattering from the sample. A large field of view can be covered in a few scan steps (and detector frames) by placing the sample considerably out of the focus. This is the geometry of near-field ptychography where the detector captures a series of projection holograms. We show that near-field ptychography with MLLs is capable of achieving high resolution imaging with a high efficiency. We carried out the experiment at P11 beamline of PETRA III at DESY, Hamburg. An imaging resolution of about 4 nm was achieved at a photon energy of 17.4 keV with lenses of 0.014 NA from a hierarchical nanoporous gold structure, by ptychographically reconstructing projection holograms recorded at a magnification of more than 32,000 directly on a pixel-array detector [4]. A follow-up systematical numerical study illustrates the advantage of projection imaging modality over conventional diffraction-based method in terms of background noise tolerance.

References

1.Pfeiffer, F. X-ray ptychography. Nat. Photonics 12, 9–17 (2018).
2.Dresselhaus, J. L. et al. Precise wavefront characterization of x-ray optical elements using a laboratory source. Rev. Sci. Instrum. 93, 73704 (2022).
3. Bajt, S. et al. X-ray focusing with efficient high-NA multilayer Laue lenses. Light Sci. Appl. 7, 17162 (2018).
4. Zhang, W. et al. Hard X-ray projection imaging below 5 nm resolution. Submitted (2024).

I plan to submit also conference proceedings

Primary authors: LI, Chufeng (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); EGOROV, Dmitry (FS-CFEL-1-SC (FS-CFEL-1 Fachgruppe SC)); CHAPMAN, Henry (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); FLECKENSTEIN, Holger (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); DE GENNARO AQUINO, Ivan (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); DRESSELHAUS, Jan Lukas (FS-PS (Photon Science)); HAGEMANN, Johannes (FS-PETRA (PETRA III)); ZAKHAROVA, Margarita (FS-ML (Multilayer)); PRASCIOLU, Mauro (FS-ML (Multilayer)); IVANOV, Nikolay (FS-CFEL-1 (CFEL-Coherent X-Ray Imaging)); YEFANOV, Oleksandr (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); MIDDENDORF, Philipp (FS-CFEL-1 (Forschung mit Photonen Experimente 1)); BAJT, Sasa (FS-ML (Multilayer)); Prof. SHI, Shan (TUHH); LI, Tang (FS-PETRA (PETRA

III)); ZHANG, Wenhui (FS-CFEL-1 (Forschung mit Photonen Experimente 1))

Presenter: ZHANG, Wenhui (FS-CFEL-1 (Forschung mit Photonen Experimente 1))

Session Classification: Mikrosymposium 7/2: Imaging and Cohrerence Applications

Track Classification: 7. Imaging and coherence applications