Chemically sensitive ptychographic imaging of nanoscale 3D objects

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The X-ray/EUV coherent diffraction imaging (CDI) opens wide perspectives for relatively easy characterization of nano-structures. The huge benefit of CDI-based techniques over conventional microscopy is that CDI generally does not rely on complex high-quality X-ray/EUV optics. However, in order to obtain a reconstructed image of the object, generally, large amount of diffraction data is required. Ptychography is a form of CDI technique where the sample is scanned with a focused light beam to reach the necessary amount of over-sampled data. The technique allows reconstruction of both amplitude and phase distributions in the sample plane, much like holography, via customized iterative phase retrieval algorithms. Utilizing information on both absorption and phase shift in every pixel of the sample's image enables chemical resolution.

So far, X-ray/EUV ptychography was used for imaging of actinic samples. Here we present results on the first-time soft X-ray chemically sensitive ptychographic imaging of a non-planar nanoscale 3D object, i.e. specimens for atom probe tomography (APT) with resolution down to 11 nm at 800 eV using the MAXYMUS scanning X-ray microscope at the electron storage ring BESSY II at Helmholtz-Zentrum Berlin. We show that this approach can be used for quantitative analysis of chemical composition, shape determination and resolving of embedded structures. We were able to image buried interfaces with below 30 nm resolution. Additionally, we demonstrate feasibility of this technique for future in-situ imaging and characterization of APT specimens with table-top 13.5 nm high harmonic generation (HHG) sources and hyper-NA detection with 10 nm target resolution. Ultimately, this could enable a substantial improvement in the spatial resolution and accuracy of Atom Probe data reconstructions [1].

[1] J. Op De Beeck *et al.*, 2022, Microscopy and Microanalysis **28(4)**, 1141–1149.