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Computed X-ray microtomography

Wednesday 28 August 2024 15:30 (30 minutes)

Ptychography is a coherent lensless imaging technique that incorporates scanning of the sample. As such, it relies heavily on computations and has benefitted from advances in algorithms since its original conception in 1969 [1] and its more modern iterative implementation from 2004 [2]. Leveraging the coherence of X-ray sources, it does away with imaging lenses and their limitations in resolution and efficiency, that are inherent to their challenging manufacturing. It has been shown to work with perfect as well as aberrated, or partially coherent, illuminations, as well as being able to correct for multiple scattering effects, and even figure out and correct for inaccurate positioning of the sample due to scanning-stage errors.

It may seem that for ptychography all that matters is the reconstruction algorithms and all instrumental errors and other imperfections can be accounted for in post-processing. This is to some extent true due to the richness of information in a ptychogram. However, these postprocessing corrections come at the cost of signal-to-noise ratio, or in other words, of photon statistics. Joint improvements both in algorithms and instrumentation can yield significantly more efficient imaging.

Years of research into optimizing ptychographic tomography [3, 4] have led to important advances in instrumentation that enable high throughput and resolution. These include using optical interferometry for accurate sample positioning, design X-ray illuminations with engineered wavefront aberrations, and implementing hybrid scanning approaches of optics and sample. In this presentation I will showcase some important advances in instrumentation as well as algorithms that have allowed a sustained improvement in imaging throughput at the cSAXS beamline of about 3 times per year over 10 years.

References

[1] W. Hoppe, "Beugung im inhomogenen Primarstrahlwellenfeld. I. Prinzip einer Phasenmessung von Elektronenbeungungsinterferenzen," Acta Crystallographica Section A 25, 495-501 (1969). https://doi.org/doi:10.1107/S0567739469001045

[2] H. M. L. Faulkner and J. M. Rodenburg, "Movable aperture lensless transmission microscopy: A novel phase retrieval algorithm," Physical Review Letters 93, 023903 (2004). https://doi.org/10.1103/PhysRevLett.93.023903

[3] M. Holler, M. Guizar-Sicairos, E. H. R. Tsai, R. Dinapoli, E. Müller, O. Bunk, J. Raabe, and G. Aeppli, "High-resolution non-destructive three-dimensional imaging of integrated circuits," Nature 543, 402-406 (2017). https://doi.org/10.1038/nature216

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I plan to submit also conference proceedings

No

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