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Ptychography at finite dose in SrTiO3

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Many important materials are unstable under the electron beam and easily damaged by high-dose imaging, leading to a blurred image of a damaged sample. Ptychography is one of the most dose-efficient electron microscopy techniques currently available, providing a route to high-resolution images of undamaged samples.

The aim of this research is to develop, implement and apply new dose-efficient 4D-STEM imaging methods, based around existing algorithms for electron ptychography to improve imaging of beam-sensitive materials. Here, we lay the groundwork for an in-depth discussion of finite dose ptychography, towards the development of new low dose algorithms for ptychographic imaging to improve achievable contrast at low electron dose.

Previous studies have explored ptychographic techniques theoretically for infinite dose (Clark et al. 2023). In this study, we are investigating the thickness dependence of ptychographic imaging methods, in particular we are interested in the dependence on varied electron probe dose to see just what the dose limits are for an accurate reconstruction.

We simulate a Strontium Titanate (STO) thickness series of 1-55 unit cells (3.905 – 215 Å) along the [1 0 0] axis with a 26.6 mrad electron probe at 300 keV with a midplane focus, using µSTEM (Allen et al. 2015). We then model a dose-series across the thicknesses, by applying Poisson statistics. The resulting 4D datasets were then used to form images via a range of algorithms, including central Bright-Field (cBF), Annular Dark-Field (ADF), integrated Center of Mass (iCoM), Single Sideband (SSB), Wigner Distribution Deconvolution (WDD), and extended Ptychographic Iterative Engine (ePIE).

With these data, we then find lowest-feasible dose limits for imaging samples in realistic imaging conditions, detecting image features and atomic column positions, to provide guidelines for successful experimental data collection, advice for expected most-successful imaging approaches, and data collection parameters.

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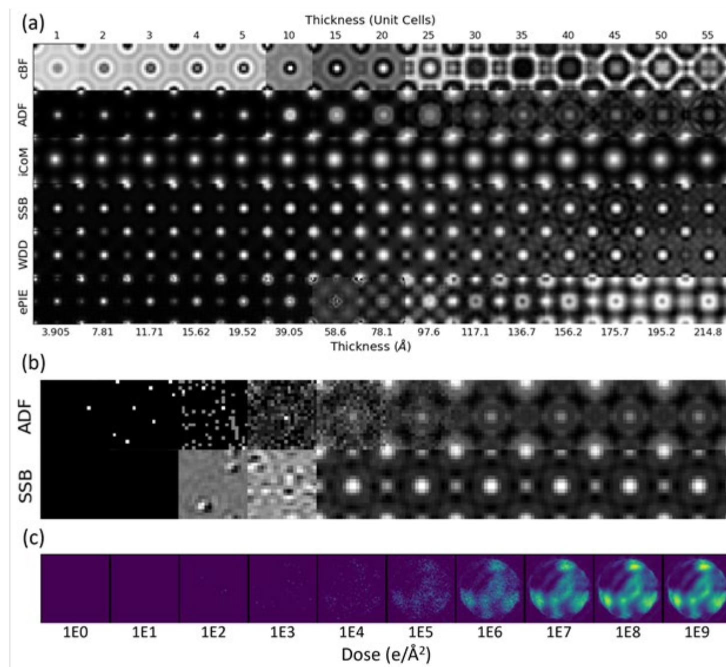
Graphic:



Keywords:

Low dose, Ptychography, 4D-STEM

Reference:

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