Experiment Brief

eaSI 4D STEM

Title

K3 IS camera for electron ptychography: Mapping oxygen in $SrTiO_3$.

Gatan instrument used

K3® IS camera enables direct detection electron counting, fast continuous data collection, and low-dose imaging. The **STEMx®** system leverages **eaSI™** technology to synchronize the STEM probe with the K3 IS fast frame rate to acquire high-quality 4D STEM datasets at high speed.

Background

One of the most promising applications of 4D STEM is electron ptychography. Electron ptychography is a dose-efficient method that enables high-resolution spatial imaging (beyond the traditional numerical-aperture-limited resolution) and detection of light and heavy atoms with high signal-to-noise ratio and contrast linearity (as opposed to conventional annular dark field imaging). Hybrid-pixel detectors have been most commonly used in recently published electron ptychography results, mainly because of their large pixel size, high-dynamic range, and fast frame rate. Here, we show that the K3 IS camera, a monolithic active pixel detector, can similarly be used for high-quality electron ptychography studies.

Materials and methods

$SrTiO_3$ (containing elements with largely different Z) was used as a model sample to examine the robustness of the K3 IS camera and the adaptive-propagator ptychography (APP) method [1]. In a typical 4D STEM data collection session, STEM was set up to achieve ~27 $e^-/A^2/s$ dose (spot size = 10 C, convergence semi-angle = 24 mrad, defocus = -20 nm on a JEOL Grand ARM) and a 100 x 100 x 512 x 512 pixel 4D STEM dataset, with a step size of 0.3 Å was acquired. APP method was then used to reconstruct the atomic resolution phase image of the specimen, revealing the position of O atoms, which were not visible in the in-focus acquired HAADF reference image (Figure 1).

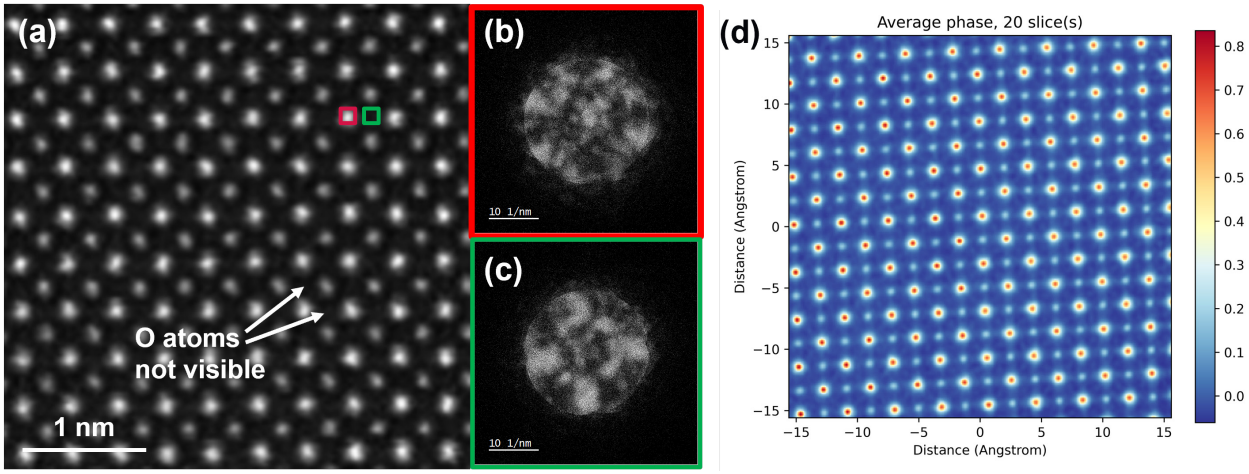

Figure 1. $SrTiO_3$ aligned along the [001] zone axis. (a) STEM-HAADF image, arrows show the position of O atoms not visible. Diffraction patterns from red and green squares in (a) are shown in (b) and (c), respectively. (d) Ptychographic phase image of $SrTiO_3$ along [001], small white dots reveal the position of O atoms.

Summary

Similar to hybrid pixel detectors (such as the Stela* camera), monolithic active pixel detectors (such as K3 IS) are capable of collecting high-quality electron-counted 4D STEM datasets for ptychographic research. In this experiment brief we successfully used the K3 IS camera and an APP method to map the position of O atoms in $SrTiO_3$. Such an experiment can also be applied for structure characterization and defect analysis in other materials.

Reference

[1] Sha, H., et al "Deep sub-angstrom resolution imaging by electron ptychography with misorientation correction." Science Advances 8.19 (2022): eabn2275.

Credit(s)

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*Stela camera utilizes DECTRIS hybrid-pixel technology

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