Poster

MerlinEM, the universal detector for 4D STEM and 3D ED

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Scanning/transmission electron microscopes (S/TEMs) are invaluable tools for the characterisation of nanosized matter, in no small part due their flexibility to be configured to perform a wide variety of experiments. The most well-known experiments are conventional high-resolution imaging modes, with a static parallel electron beam or a scanning converged electron probe. In recent years, hybrid pixel direct electron detectors (HPDEDs) have revolutionised modern electron microscopy (EM) applications, owing to their high detective quantum efficiencies (DQEs), readout speeds, dynamic ranges and radiation hardnesses.

For example, the Quantum Detectors MerlinEM was designed for 4D scanning transmission electron microscopy (4D STEM). 4D STEM is a data collection protocol in which the entire 2D diffraction pattern is collected at each probe position in a 2D scan [1]. The 4D STEM dataset is therefore richer in crystallographic information than a conventional 2D STEM image, and is ripe for processing and analysis by a host of algorithms and software. In fact, data analysis is only limited by the user's imagination: the simplest data processing strategy uses virtual detectors and apertures to remove the constraints of their physical counterparts.

Moreover, researchers have used 4D STEM to measure the electric and magnetic fields of materials [2], and to map the crystalline phase and orientations of polycrystalline domains [3], as well as the sample strain [4]. Most recently, these detectors have afforded data with sufficiently high quality to enable amplitude and phase image reconstruction from electron-beam sensitive, weak phase materials using electron ptychography algorithms [5]. The qualities of HPDEDs also make them highly suitable for 3D electron diffraction (3D ED), which is an umbrella term for a set of protocols that involves the collection of three dimensional electron diffraction data collected from several crystallographic orientations for structural elucidation [6]. 3D ED is complementary to X-ray and neutron diffraction methods, with its primary benefit being structural elucidation from nanosized volumes at accessible facilities.

Certainly, the versatility of S/TEMs necessitates a versatile detector. MerlinEM is a universal detector, capable of both 4D STEM and 3D ED data acquisition, empowering researchers to maximise the information they collect from their samples on a single S/TEM. Here, we demonstrate the MerlinEM technology, and describe how it can be incorporated into a typical microscope setup. Then, we highlight some recent work conducted by researchers across several labs, focusing on both 4D STEM and 3D ED.

[1] C. Ophus, Microscopy and Microanalysis 563-582 (2019)

[2] W. Lijun et al., Ultramicroscopy 113745 (2023)

[3] E. Thronsen et al., Ultramicroscopy 113861 (2024)

[4] P. Crout et al., arXiv:2307.01071v1 (2023)

[5] A. Strauch et al., Microscopy and Microanalysis 1078-92 (2021)

[6] M. Gemmi et al., ACS Central Science, 1315-1329 (2019)