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Characterization of a High Frame Rate Direct Electron Camera and Its Applications in CryoEM

The paper presents characterization of the EMPIX (Electron Microscopy PIXel) [1] camera and its applications in cryoEM, including STEM, diffraction and ptychography. The camera consists of a hybrid silicon pixel detector, TEC and water cooling and the high bandwidth DAQ (data acquisition system) up to 82.5 Gbps. The detector consists of 128 x 128 array and the pixel size is 150 um x 150 um. Each pixel works at integration mode and the dynamic range of 24 bit is implemented by combining the counts of charge injection and digitized residual charge with Wilkinson-type ADCs. Thanks to the on-chip digitization and high readout bandwidth, the frame rate of up to 100 kfps can be achieved for full size.
The camera was installed in a field emission 200 kV S/TEM (FEI Tecnai F20) and was carefully calibrated before characterization. The coefficients for one count of injected charge and the ADC bin was estimated by linear interpolation with flat field irradiation data. Single electron response was measured with low beam current. The signal to noise ratio is only 7 @ 200 kV, which is much lower than expectation and is due to some circuit design problem. But the peak of the single electron can be clearly separated from the noise floor. The MTF was measured using the edge of the beam stop and then the DQE was estimated as shown in Figure 1. The DQE(0) is measured to be 0.92, which is comparable to other hybrid pixel detectors.
The beam scanning signal generator has been also developed and the beam positions was integrated into the imaging data for each frame. Various STEM images can ben synthesized in real time, e.g., HAADF, BF and iCOM. Figure 2 shows some example images of negatively stained proteasome sample using 512 x 512 scan. Figure 3 shows a reconstructed 4D STEM image of the proteasome sample. More imaging applications in cryoEM are undergoing and the detailed results will be present at the workshop in July.

Reference:
[1] T. Wei et al Design and evaluation of EMPIX2, a 100 kfps, high dynamic range pixel detector readout ASIC for electron microscopy, 2023 JINST 18 C12007

Figures are shown in attached pdf.

Workshop topics

Detector systems

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