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The Performance of Detectors for Diffraction-Based Studies in (S)TEM.

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Recent advances in electron microscopy have been propelled by the development of new pixelated electron detectors technologies. In comparison to conventional scintillator-coupled detectors (Fig. 1a), these detectors do not depend on conversion to light in a phosphor, followed by the detection of the photons. More specifically, one of the key advantages of some of these detectors is that they count individual electron events and consequently have no readout or amplifier noise in the counts (Fig. 1b). Consequently, the detective quantum efficiency (DQE) increases, and it is mainly limited by the spreading of the primary beam electrons in the sensor. While direct detectors with monolithic active pixel sensors have been successfully employed in imaging mode, and directly impact cryoEM development [1], they have limited applications on studies that require a combination of electron counting with high frame-rates, linear response to high electron flux and radiation hardness. On the other hand, hybrid pixelated detectors (Fig. 2c) can maintain a linear response even when subjected to high electron flux ($>10^3$) making them suitable for diffraction-based experiments. Examples include the utilization of these detectors in micro-electron diffraction (microED) in structural biology and 4D scanning transmission electron microscopy (4D-STEM) in soft and hard materials. In addition, they are promising for use in electron energy-loss spectroscopy [2].

Here we focus on comparing these three different electron detection technologies that are widely utilized in the electron microscopy community. A scintillator detector with CMOS sensor (Gatan® OneView), a direct electron detector (Gatan® K3-IS) and a hybrid-pixelated direct detector (Gatan® Stela) were used to acquire diffraction data using a JEOL Grand ARM300 operated at 80kV. The experimental parameters were kept the same for all the detectors utilized, as they are all mounted in the same microscope

In 4DSTEM experiments, hybrid-pixelated detectors have advantage over other detectors as techniques such as strain mapping and differential phase contrast (DPC) depend on precise measurement of the deflection of convergent beam electron diffraction (CBED) discs in the reciprocal space. These precise measurements can be achieved, for example, by template-matching which would greatly benefit from a better detector point spread function. We will discuss the performance of these detectors operating at different voltages ranging from 40kV to 300kV as well as the performance for *in-situ* studies that depends on different frame-rates [3].

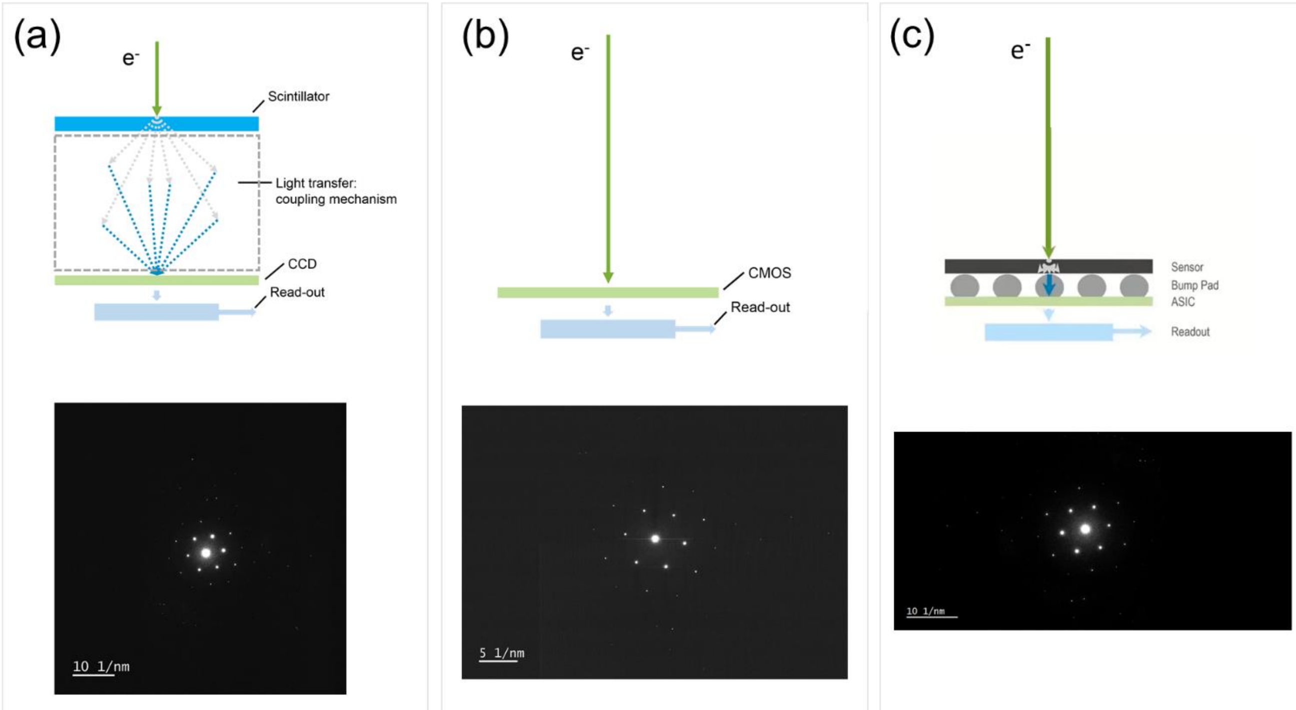

Figure 1. Schematics showing the construction of (a) a scintillator detector with CMOS sensor, (b) a direct electron detector and, (c) a hybrid-pixelated direct detector. The row below presents an example of a selected area diffraction (SAED) pattern acquired from a MoS_2 test sample along [001] projection with each one of these detectors using same total exposure time (5s).

References:

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