

A new electron-counting detector for electron diffraction

Clemens Schulze-Briese¹, Sacha DeCarlo¹

¹DECTRIS Ltd., Baden-daettwil, Switzerland

E-mail: clemens.schulzebriese@dectris.com

We propose a new generation of direct electron detectors that enable time-resolved TEM and electron diffraction without the need of a beam stop at energies up to 300kV.

Direct electron detectors played a key role in the resolution revolution that occurred in the Life Sciences in the past three years. Electron microscopy became a mainstream structural biology technique to understand structure and dynamics of macromolecular assemblies. However, in material sciences, TEM resolution is usually not the bottleneck, and while speed and sensitivity of the detector are surely appreciated, there is currently a need for direct detection devices that can provide a very high count rate and high dynamic range, even with an intense electron beam.

Hybrid Photon Counting (HPC) detectors were initially developed for high energy physics applications. The detector unit is composed of sensor and readout pixels individually connected by indium bumps that transfer the signal charge for counting. The sensor can be made of CdTe, a HiZ material more suitable for high electron energies (300 kV). The readout electronics, are designed to ensure noise-free single electron counting, even at kHz frame rates. The unique properties of HPC detectors in electron detection will be illustrated with EIGER tests results at energies between 40 and 200 kV.

In the life sciences, microcrystal electron diffraction (MicroED) is a new technique based on collecting electron diffraction patterns from a crystal placed inside a transmission electron cryo-microscope. It has already produced outstanding results [1]. In MicroED the crystals are small, usually of the size that cannot be exploited for X-ray diffraction studies using laboratory or synchrotron sources. The standard 'low-dose' electron beam in one of these microscopes would normally damage the crystal after a single diffraction pattern has been collected [2]. However, it is possible to obtain diffraction patterns without severely damaging the crystal if the electron dose is dramatically reduced by a factor of a thousand or more. The accurate recording of these weak diffraction patterns is possible only with a noise-free detector with improved sensitivity. With less beam damage, it is thus possible to collect hundreds of diffraction patterns from the same, very small three-dimensional crystal, and to determine the structure of the protein.

HPC detectors offer a tuneable energy threshold that allows for the suppression of X-ray background, which results in improved spot detection for MicroED at electron dose rates that would go undetected with a traditional CCD.

We will demonstrate the potential of HPC detectors in MicroED by discussing examples of protein nanocrystal data collected on EIGER and other HPC detectors [3].

[1] Palatinus L. et al. (2017). *Science*, 355, 166-169

[2] Shi D. et al. (2013). *eLife*, 2, e01345.

[3] Nederlof I. et al. (2013). *Acta Cryst*, D69, 1223-1230.

Keywords: [direct electron detection](#), [electron diffraction](#), [hybrid detector](#)