doi:10.1017/S1431927610060873
Microsc. Microanal. 16 (Suppl 2), 2010

Performance of the DDD as a Direct Electron Detector for Low Dose Electron Microscopy

L. Jin,* and R. Bilhorn,*

* Direct Electron, LP, 13240 Evening Creek Drive S., Suite 311, San Diego, CA 92128

In recent years, low dose electron microscopy techniques, including single particle CryoEM and Cryo-Electron Tomography [1,2], have become powerful tools for studying macromolecular assemblies. These techniques require extremely low total electron dose, which proves to be a challenging imaging condition for CCD based camera systems that rely on phosphor scintillators coated on fused fiber optic bundles that are bonded to the CCD.

A new type of detector, that is capable of direct electron detection, holds great promise for dramatically improving the image quality for low dose EM images [3-6]. In this report, we introduce the principles of the Direct Detection Device (DDD®), describe the performance of the 12 megapixel DDD camera (DE-12), and compare the results with film as well as with scintillator-based CCD systems.

FIG. 1 shows Detective Quantum Efficiency (DQE) curves for the DE-12 camera system measured at 300 and 400 keV. DQE is an objective method for comparing performance of different camera systems. In this case a precision edge is used to create a shadow image from which the measured Edge Spread Function (ESF) is used to calculate the Modulation Transfer Function (MTF). The DQE at zero spatial frequency was calculated using the noise binning method and the microscope beam intensity was measured using a Faraday plate with applied backscattering correction. The details of the calculation can be found in references [7,8]. DQE values 3 to 4 times higher than those for CCD based systems at frequencies at and beyond the half-Nyquist frequency are the basis for the tremendous performance advantage of the DDD®.

FIG. 2 shows three images of a grid with GroEL and TMV in ice taken with the DE-12 camera using the automated Multi-Scale Imaging (MSI) feature in the Leginon software package [9]. The data was acquired on a FEI Tecnai Spirit 120kV microscope at the National Resource for Automated Molecular Microscopy at the Scripps Research Institute. The high resolution image taken at 21000x magnification (2.3 Angstrom/pixel) was cropped to show the TMV. Total electron dose in the final image is ~11 e^-/Angstrom^2. As these images demonstrate, the high SNR of the DE-12 camera provides excellent contrast from inherently low-contrast specimens while the high sensitivity and large array size allow coverage of large specimen areas at low dose.

References

[1] J. Frank, *Annu. Rev. Biophys. Biomol. Struct.* 31 (2002) 303-319.
[2] S. Subramaniam and J.L.S. Milne, *Annu. Rev. Biophys. Biomol. Struct.* 33 (2004) 141-155.
[3] A.C. Milazzo, *et al.*, *Ultramicroscopy* 104 (2005) 152-159.
[4] L. Jin, *et al.*, *Journal of structural biology* 161 (2008) 352-358.
[5] G. McMullan and A.R. Faruqi, *Nucl. Instrum. Meth. A* 591 (2008) 129-133.

[6] G. Deptuch, *et al.*, *Ultramicroscopy* 107 (2007) 674-684.
[7] R.R. Meyer and A.I. Kirkland, *Microsc. Res. Tech.* 49 (2000) 269.
[8] G. McMullan, *et al.*, *Ultramicroscopy* 109 (2009) 1126-1143.
[9] C. Suloway, *et al.*, *Journal of structural biology* 151 (2005) 41-60.

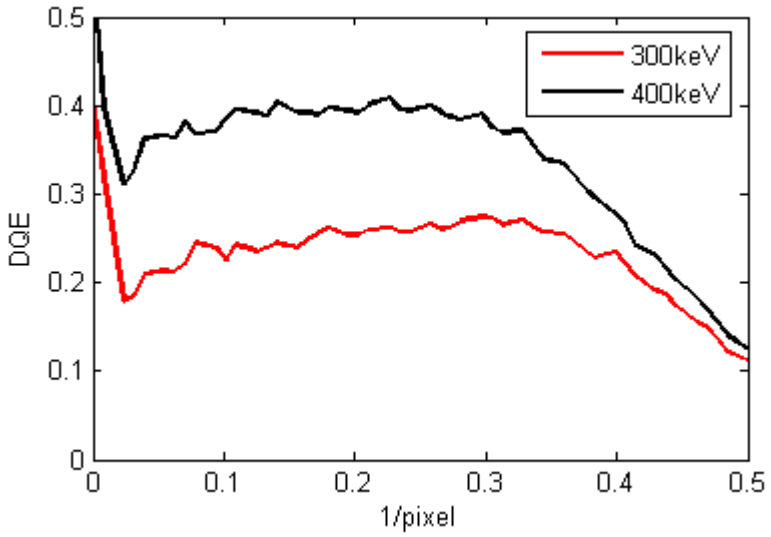

FIG. 1. DQE for the DE-12 DDD® camera system at electron acceleration energies of 300kV and 400kV. JEOL 4000EX, National Center for Microscopy and Imaging Research at the University of California, San Diego (UCSD).

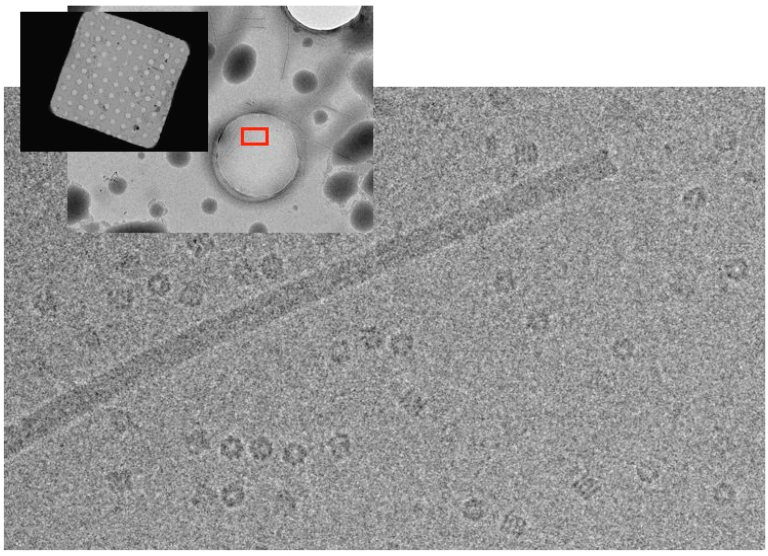

FIG. 2. Automated Multi-Scale Imaging of GroEL and TMV acquired at 120kV using Leginon. Images were recorded at 290x, 2700x, and 21000x magnifications on a FEI Tecnai Spirit at the National Resource for Automated Molecular Microscopy at the Scripps Research Institute.

https://doi.org/10.1017/S1431927610060873 Published online by Cambridge University Press