DE-16 Camera System

the most versatile direct detector available

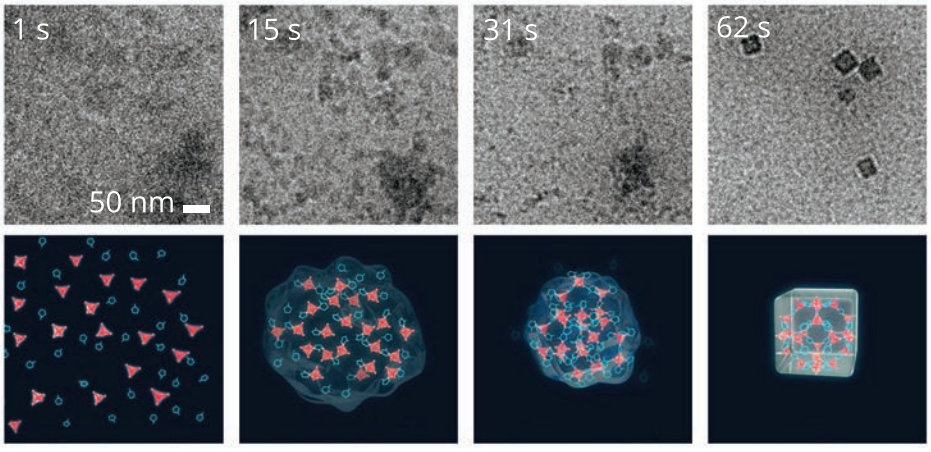
delivering | bigger | better | faster | cameras for electron microscopy

Direct Electron®
INNOVATION PROPELLING DISCOVERY

TEM Direct Detection with Stunning Sensitivity

- The most advanced direct detection sensors, delivering high speed, extraordinary resolution, and ultra-low noise.
- Superior DQE delivers higher resolution and better contrast for high-speed single frames.
- 4k × 4k (16.8 million) pixels.
- High-speed continuous streaming for *in situ* TEM, 4D STEM, and microED.
- Global shutter eliminates artifacts in high-speed applications.
- Versatility for a wide range of TEM experiments.
- Electron counting to maximize SNR for low-dose applications.
- High-dynamic range (HDR) counting for 4D STEM & EELS.
- Optional **ER sensor optimized for 30 - 300 kV**.

Metal-organic framework (MOF) formation via liquid phase *in situ* TEM using a DE-16 camera in counting mode with an ultra-low beam dose of 0.05 $e^-/A^2/s$.
Figure based on Liu, et. al 2021 (https://doi.org/10.1073/pnas.2008880118).

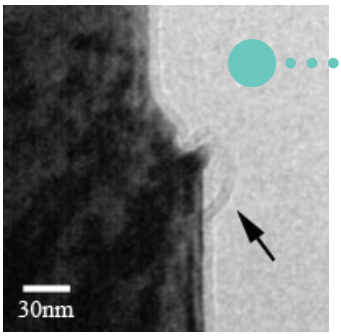


Applications

MATERIALS

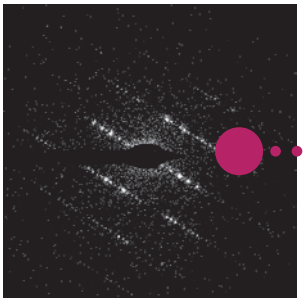
BIOLOGY

Optimized for Demanding TEM Applications



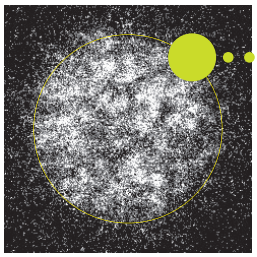
in situ TEM & Environmental TEM (ETEM)

high-speed movies with exceptional contrast



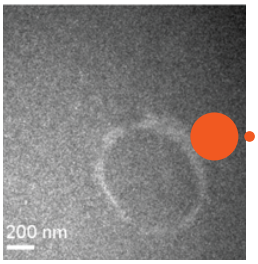
Diffraction/MicroED

high dynamic range & high speed streaming



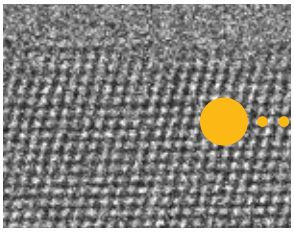
4D STEM/Ptychography

fast, large-area pixelated STEM detector



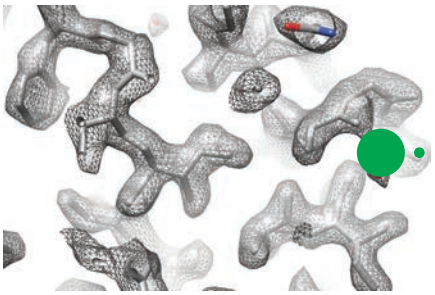
DTEM/UTEM & EFTEM

phenomenal sensitivity over long exposure times



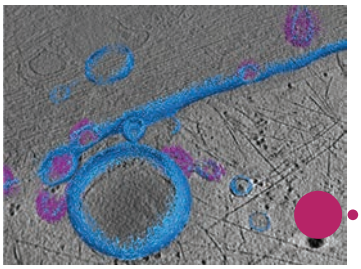
Low-Dose Imaging

exceptional SNR with electron counting



Single-Particle Cryo-EM

high-resolution 3D reconstructions



High-Resolution Tomography

conventional or continuous-rotation acquisition

The Most Advanced Direct Detection Sensor Technology

hardware binning and ROI
to increase frame rate up to 4,237 fps (236 µs / frame)

user-adjustable frame rate
in hardware to optimize SNR by reducing readout noise

hardware sync I/O
for high-speed synchronization of other hardware (e.g., scan generator) with the camera frame rate

on-chip CDS
for the lowest noise and best SNR at high-speed

global shutter mode
to eliminate high-speed artifacts that affect other CMOS cameras

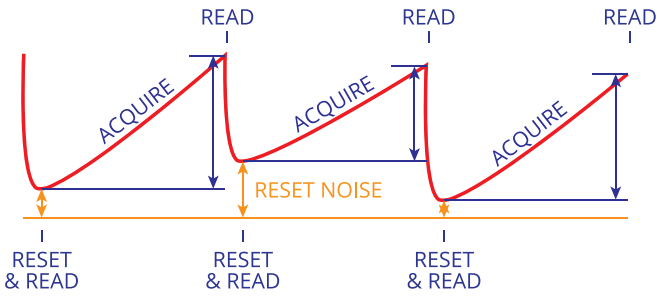
ER sensor option
for direct detection at all TEM accelerating voltages

access to all camera frames
at full-speed and full-resolution without significant delays

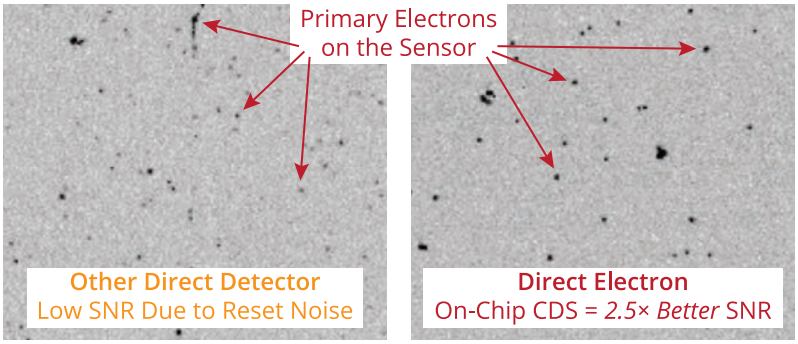
Can your direct detector do this?

compressive sensing
readout modes to further boost readout speed

Advanced Sensor Technology to Deliver the Best Sensitivity



***on-chip* correlated double sampling (CDS)** dramatically improves sensitivity by subtracting reset noise that plagues other CMOS sensors



Direct Electron's DDD® sensors have ultra-low noise, which is clearly demonstrated by visualizing individual 300 keV electrons. TEM primary electrons clearly stand-out from the background on the Direct Electron sensor, while they are often lost in the background of other sensors. *Figure courtesy of Greg McMullan, (MRC-LMB, Cambridge, UK).*

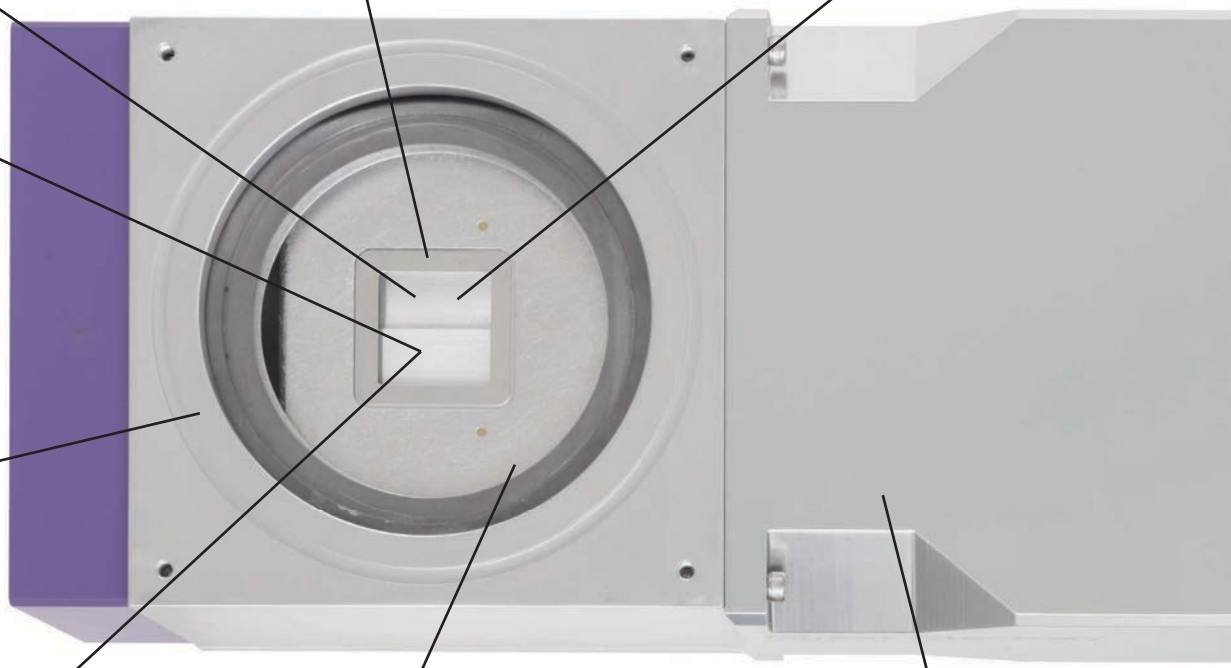
Elegantly-Designed to Maximize Scientific Productivity

photoblind option
to prevent detection of photons (especially for DTEM/UTEM applications)

integrated Faraday plate
for exposure measurement with each acquisition
(US patent #7,952,073)

sensor protection shutter
to protect the direct detection sensor from undesired exposure
(US patent #7,952,073)

high-performance 10th generation DDD® sensor
custom-designed and manufactured by Direct Electron



precision-engineered parts
that are widely compatible with TEMs from many manufacturers

field-replaceable sensor
to maximize instrument uptime over the lifetime of the camera

fully retractable
to enable use of other cameras and/or an energy filter mounted under the DE camera

no sliding O-rings
to prevent vacuum "hiccups" during insertion/retraction

DE-16 Camera System

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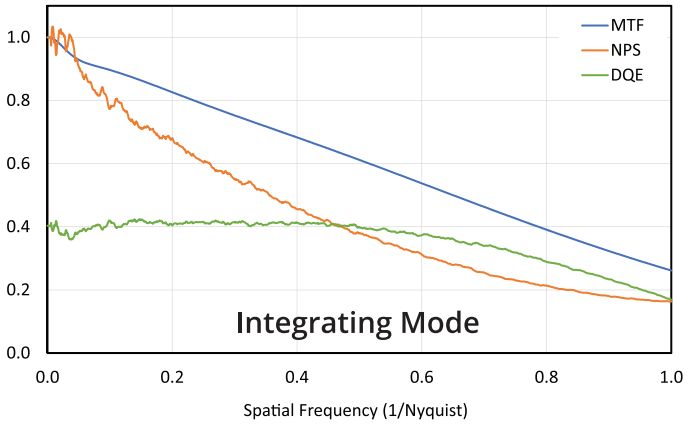
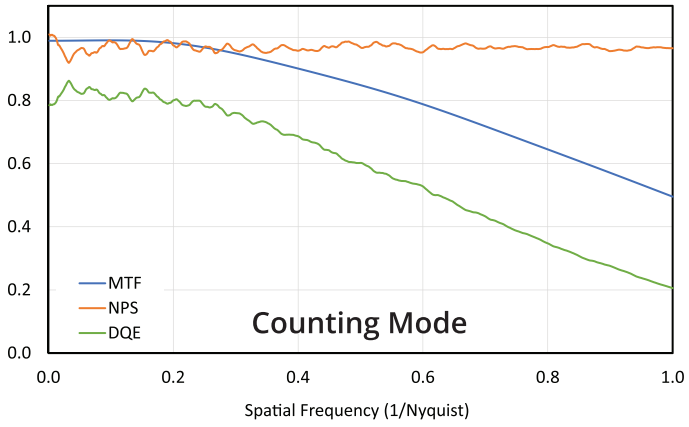
TEM electron energy	standard sensor optimized for 200 - 300 keV | ER sensor optimized for 30 - 300 keV
pixel array specification	4096 × 4096 (16.8 million pixels) | 6.5 µm pixel pitch
single electron SNR	~50:1 (300 kV)
sensor design	custom-designed DDD® sensor on-chip correlated double sampling (CDS) | backthinned | radiation hardened
acquisition frame rate	92 fps max, unbinned full-frame | 281 fps max, binned-2× full-frame, low-noise subarray readout up to 4,237 fps (2048 × 128) | user-selectable hardware frame rate
readout modes	rolling with on-chip CDS | global with optional off-chip CDS
acquisition modes	integrating mode | electron counting mode HDR counting mode (US patent #11,252,339)
exposure rate	large dynamic range with consistent performance (e.g., >10,000 e^-/pixel/s)
TEM compatibility	all major TEM manufacturers & models | DE-FreeScan requires STEM capability
mounting position	fully retractable | compatible with a wide-range of configurations typically in TEM bottom port, pre- or post-energy filter, or in JEOL film drawer
sensor protection	sensor protection shutter | TEM blanking/shuttering | failsafe software
computer system	high-performance computer | Windows 10 | Nvidia GPU(s) | up to 55 TB storage
image format	non-proprietary | HDF5, MRC, TIFF, or TIFF LZW compatible with ImageJ, LiberTEM, Hyperspy, Py4DSTEM, etc.
automation software	SerialEM | open API for custom integrations (with Python, C, C++, C#, etc.)
integrations	CEFID post-column energy filter (CEOS) | precession diffraction (Nanomegas)
scan control	DE-FreeScan scan controller (also includes 4 analog detector inputs) hardware synchronization signal (BNC) | selectable as either input or output





DQE curves are shown for 300 kV electrons | Specifications and performance are subject to change.
Example images of various camera applications were collected by researchers using one of Direct Electron's cameras (not necessarily the DE-16).

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