



DE-16 Camera System

blistering speed & stunning sensitivity

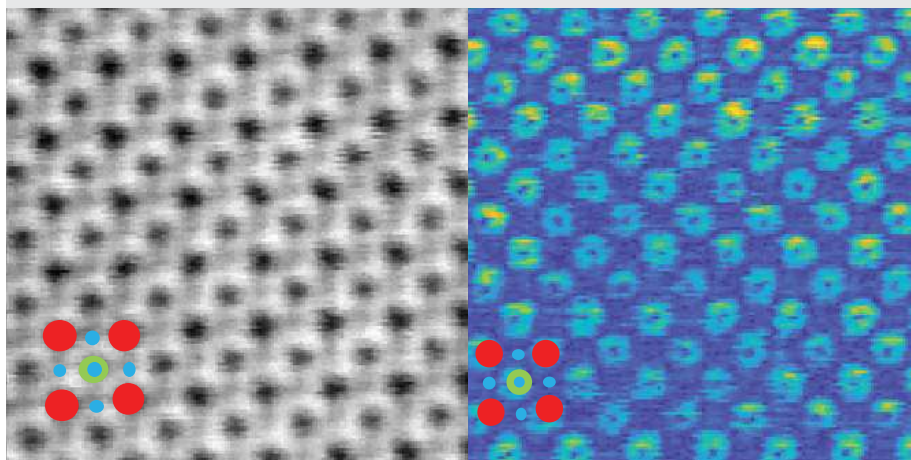
delivering | bigger | better | faster | cameras for electron microscopy

Direct Detection for Transmission Electron Microscopy

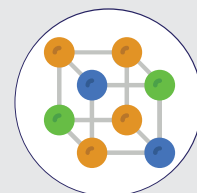
- The most advanced direct detection sensors, delivering **high speed**, **extraordinary resolution**, and **ultra-low noise**.
- **Superior DQE** delivers higher resolution and better contrast for high-speed single frames.
- **4k × 4k** (16.8 million) pixels.
- **High-speed** continuous streaming for 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.
- **Hybrid integrating/counting** for 4D-STEM.
- The **most impactful and cost-effective** upgrade to a TEM's capabilities.



Atomic-resolution 4D-STEM on strontium titanate using a DE-16, including annular bright-field (left) and center-of-mass (right) reconstructions.
Figure courtesy of Paul Voyles, (University of Wisconsin, Madison, WI, USA).



Applications



MATERIALS



BIOLOGY

Direct Electron[®]
INNOVATION PROPELLING DISCOVERY

Optimized for High-End 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

fastest speed available in a pixelated STEM detector

DTEM/UTEM and EFTEM

phenomenal sensitivity over long exposure times

Low-Dose Imaging

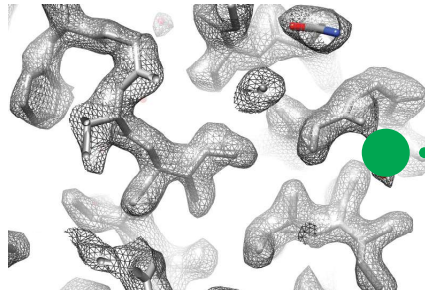
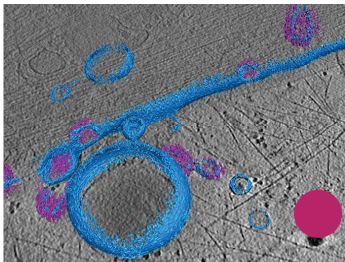
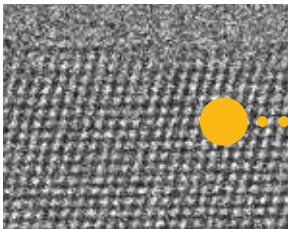
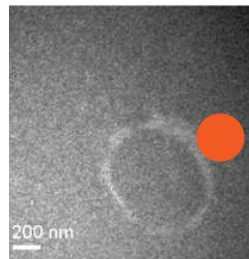
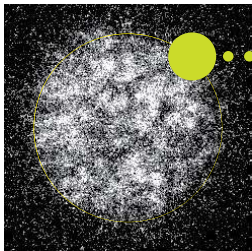
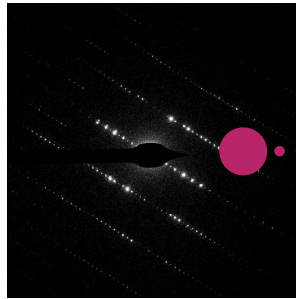
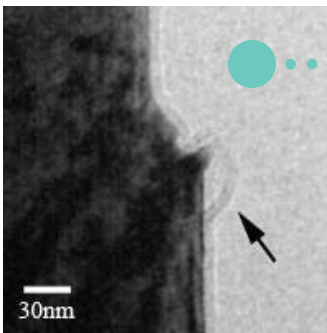
exceptional SNR with electron counting

Single-Particle Cryo-EM

high-resolution 3D reconstructions

High-Resolution Tomography

conventional or continuous-tilt acquisition



The Most Advanced Direct Detection Sensor Technology

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

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

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

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

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

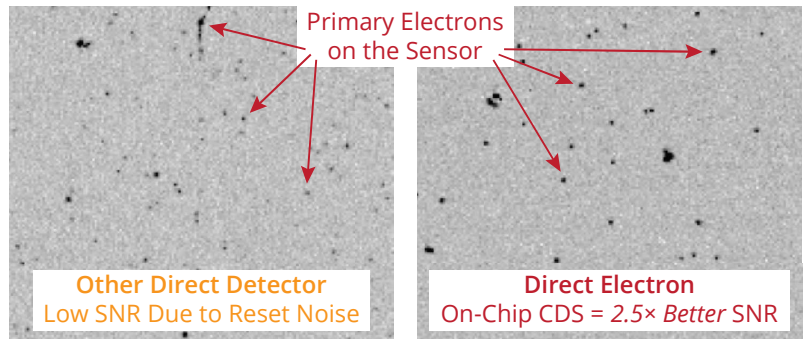
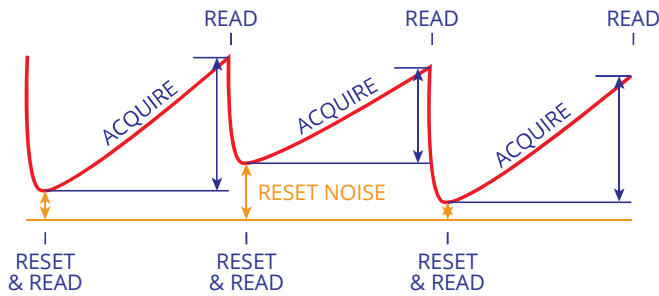
hardware sync I/O
for high-speed synchronization of
other hardware (e.g., scan generator)
with the camera frame rate

adjustable sensor gain
to optimize performance
for dim or bright conditions

compressive sensing
readout modes to further
boost readout speed

*Can your
direct detector
do this?*

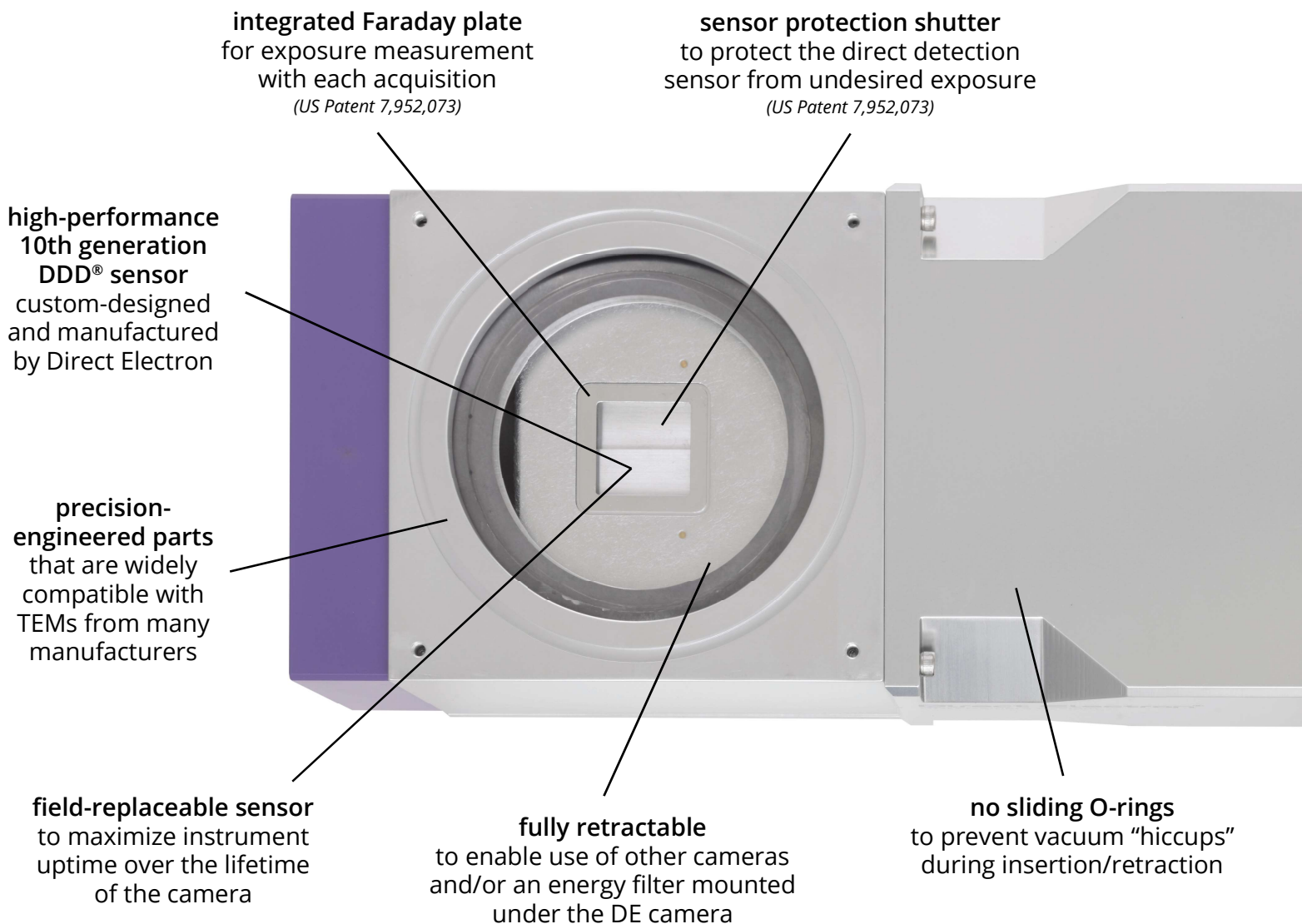
Advanced Sensor Technology to Deliver the Best Sensitivity



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).*

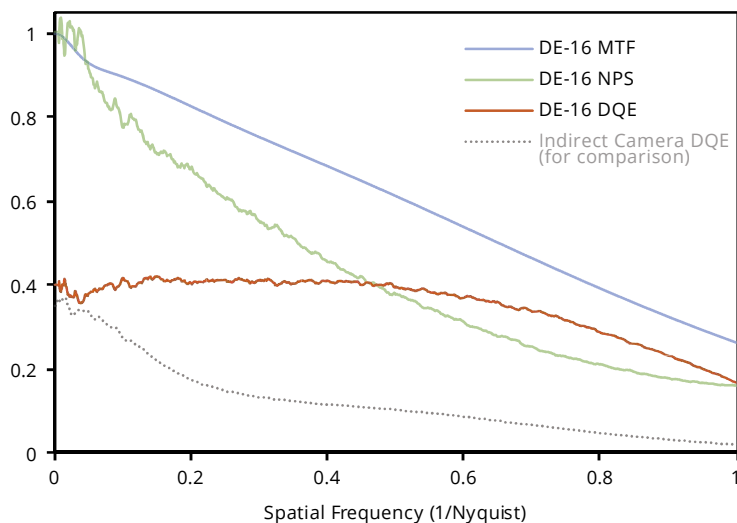
Elegantly-Designed to Maximize Scientific Productivity



TEM electron energy	sensitive to 80 keV – 1.25 MeV optimized for 200 & 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	>3T pixel design with on-chip correlated double sampling (CDS) backthinned radiation hardened rolling or global shutter
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
acquisition modes	integrating mode counting mode (with optional counting system)
exposure rate	large dynamic range with consistent performance (e.g., >1,000 e ⁻ /pixel/s)
mounting position	fully retractable mounted on-axis TEM bottom port or in JEOL film drawer
exposure measurement	integrated Faraday plate for exposure measurement with each acquisition
sensor protection	integrated sensor protection shutter TEM blanking/shuttering failsafe software
computer system	high-performance computer Windows 10 NVidia GPU(s) up to 58 TB storage
image format	non-proprietary to ensure broad compatibility TIFF, MRC, AVI, MP4, etc.
acquisition software	image acquisition: DE-IM (full-featured, modern GUI) ImageJ / μManager streaming acquisition: DE-StreamPix (realtime, continuous display and recording)
automation	compatibility: SerialEM Leginon EMTTools (TVIPS) JADAS (JEOL) others customization: software development kit (SDK) for integration with custom software

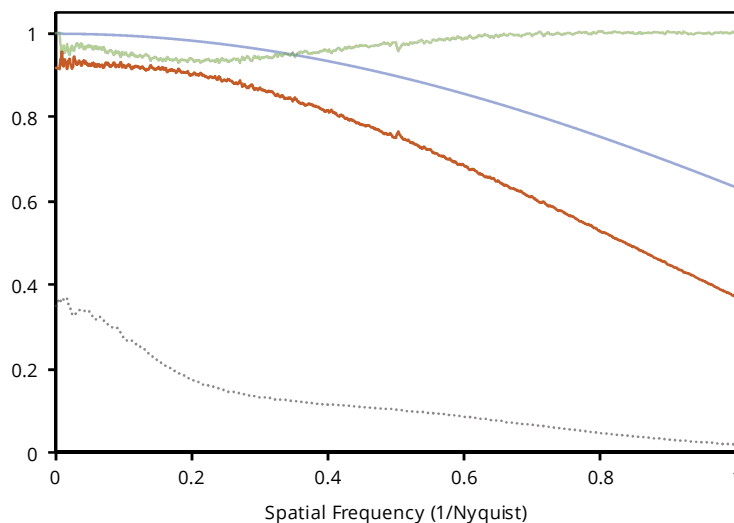
Integrating (Linear) Mode

best for in situ TEM, 4D-STEM, diffraction, & high-dose imaging



Electron Counting Mode

best for low-dose imaging, holography, & DTEM/UTEM



DQE curves are shown for 300 kV electrons | Counting Mode DQE is with 2×-binning and assuming a flat NPS | 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).