



# DE-FreeScan

flexible scan generator for STEM

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

## Customizable Scan Generator for Advanced Applications

- Completely customizable scan patterns, including snake, spiral, alternating rows, checkerboard, subsampled, etc.

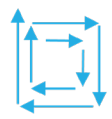
### Raster



### Serpentine

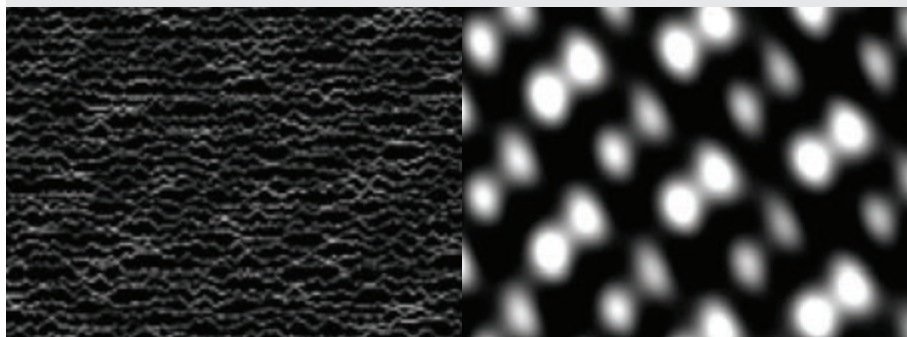


### Spiral



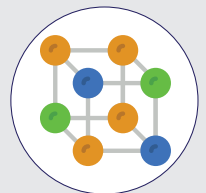
- Synchronizes with the DE-16 direct detection camera to enable 4D-STEM and ptychography.
- Enables compressive sensing STEM techniques for high-speed or low-dose STEM applications.
- Scan areas covering up to 8k × 8k pixels.
- Four analog inputs with simultaneous acquisition for conventional STEM detectors (e.g., BF, ADF, HAADF, etc.).
- Automatic averaging of multiple high-speed samples of each analog input to maximize SNR.
- Pixel dwell time from 0.33 μs to 1000 ms.
- Compatible with most STEM microscopes.

Subsampled STEM acquisition (left) and atomic-resolution reconstruction (right) of NiTiO<sub>3</sub>. Courtesy of Andrew Stevens (Duke University, Durham, NC USA) and Nigel Browning (Pacific Northwest National Laboratory, Richland, WA, USA).



**Direct Electron**<sup>®</sup>  
INNOVATION PROPELLING DISCOVERY

Applications



MATERIALS



BIOLOGY

Our custom-developed DE-FreeScan scan generator was originally developed in collaboration with academic laboratories researching compressive sensing applications for scanning transmission electron microscopy (STEM). To pursue this research, investigators required the ability to arbitrarily change the scan patterns so that various subsampling strategies could be evaluated. As a result of this collaboration, Direct Electron developed the DE-FreeScan scan generator.

In addition to subsampling and compressive sensing, the flexibility of the DE-FreeScan enables users to evaluate and use non-standard scan patterns to potentially accomplish other goals such as minimizing specimen charging or reducing image distortions.

While the DE-FreeScan works well with conventional analog STEM detectors to enable customizable STEM scan patterns, it is most powerful when paired with Direct Electron's direct detection camera systems.

DE-FreeScan is the optimal accessory for enabling 4D-STEM using Direct Electron's cameras. 4D-STEM is the acquisition of diffraction images instead of single integrated values in STEM. This enables simultaneous acquisition of a range of dark-field angles and the coherent bright-field (BF) diffraction pattern at every probe position.

By detecting the scattering angle of nearly all the primary electrons that interact with the specimen, this technique promises to provide much more information about the specimen than conventional STEM using only conventional integrating detectors. 4D-STEM enables a wide range of analysis techniques, including ptychography (for phase contrast), orientation mapping, magnetic-field mapping, and elemental discrimination.

To perform 4D-STEM experiments optimally and without significant image artifacts, the pixelated 4D-STEM detector must deliver:

- *High speed*: Thousands of diffraction patterns per second.
- *High sensitivity*: Very high single-electron signal-to-noise ratio (SNR) to capture the low-intensity dark-field signal.
- *High dynamic range*: Reliably capture both low- and high-intensity features each diffraction pattern.
- *Global shutter*: Synchronously reading and resetting all pixels in the detector so that captured diffraction patterns are NOT mixtures of multiple probe positions.

Direct Electron's DDD<sup>®</sup> Camera Systems are the only available direct detection camera satisfying all four of these requirements for optimal 4D-STEM acquisition.