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3D electron imaging with scanning confocal electron microscopy

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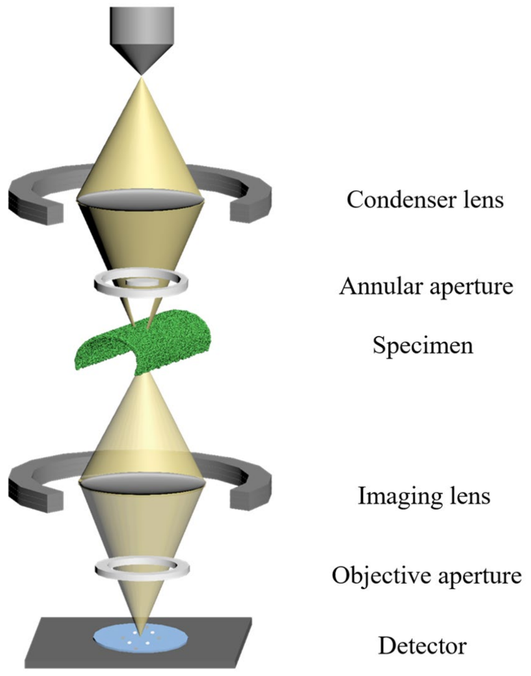
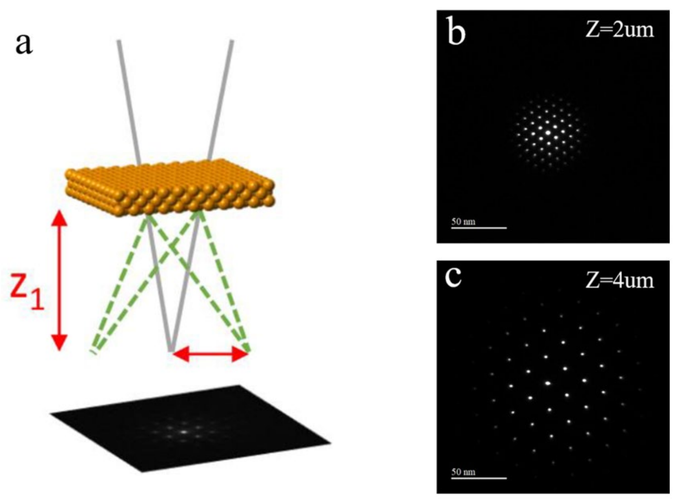
Scanning confocal electron microscopy

Aberration corrected scanning transmission electron microscopy (STEM) enables us to observe the structure of condensed matter at atomic scale. But the depth resolution of STEM is much worse than the lateral resolution. The semi-convergent angle of the probe forming lens in STEM is less than 30 mrad (@ 300 keV), and the collection angle of the HAADF detector is extended to several hundred milliradian in reciprocal space. The scattered electrons from different height of the sample are all collected by the HAADF STEM detector at the far field plane. The depth resolution of STEM is then limited to only a few hundred nanometers. In this work, we developed a novel Bessel confocal imaging technique to dramatically improve the depth resolution of STEM.



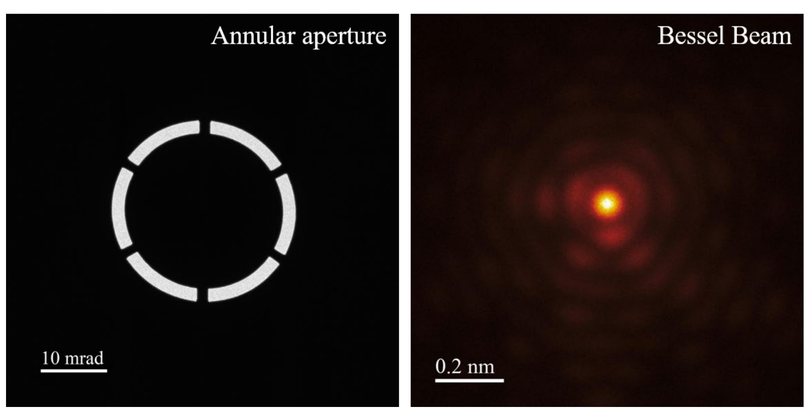
hybrid-space electron diffraction

The depth information of the sample is extracted from a hybrid-space electron diffraction at the confocal plane. The momentum changed electrons carry the height information in imaging plane. We use Bessel beam illumination to create a hollow structure in momentum space to exclude the transmitted beam which is not sensitive to the sample z-height.



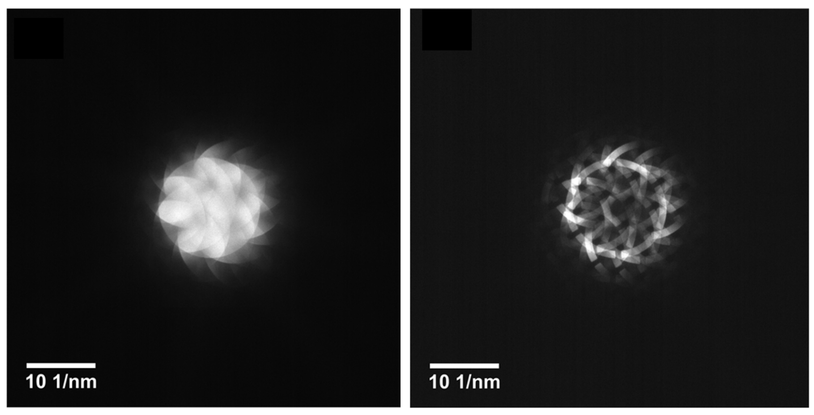
Generation of electron Bessel beam

Electron Bessel beam is generated with a ring aperture located at the condensed aperture plane. According to the Fourier transform theory, the ring structure in reciprocal space forms a Bessel function beam in real space.

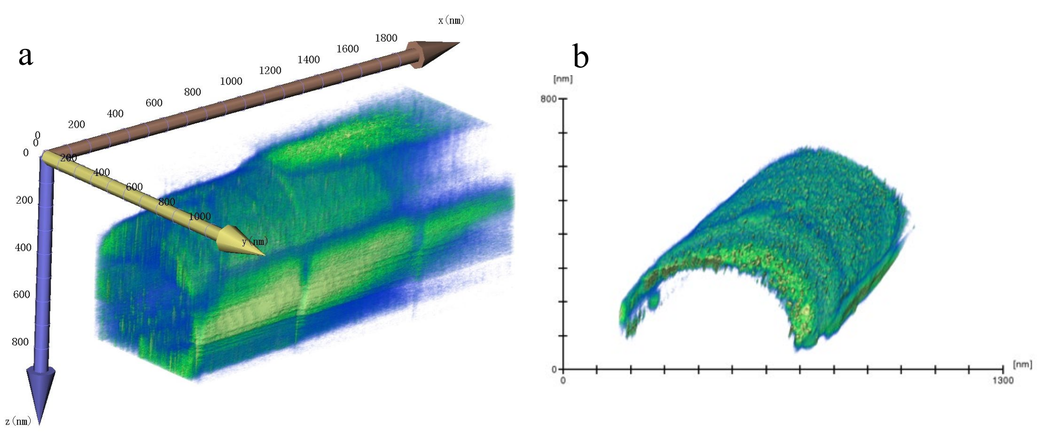


Select the momentum changed electrons

Different from coherent convergent beam electron diffraction patterns, the CBED pattern at the back focal plane of images lens system contains a multiple ring structures and the transmitted beam could be easily excluded using a circle objective lens aperture.



Imaging 3D object with SCEM



Two nanotubes coated with small crystalline nanoparticles are used as test samples. The volume render 3D image show the high spatial resolution in both the x-y direction and the z direction.

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