Direct observation of electrons focusing with atom lens

Guangyi Huang¹, Wenhao He¹, Xian Li¹, Changlin Zheng¹

¹State Key Laboratory of Surface Physics and department of physics, Fudan University, Shanghai 200438, China

gyhuang19@fudan.edu.cn

Keywords: Atom, Lens, Confocal, STEM

Scanning transmission electron microscopes (STEM) provides the excellent capability for probing the atomic configurations and electronic structures of crystals with sub-angstrom resolution. To achieve such extreme resolution, an aberration corrector must be applied to correct the geometric aberrations of the probe forming lens up to fifth order. Further improvement of the spatial resolution in STEM is extremely difficult due to the technical challenges in building the new correctors beyond the fifth order correction. In 1990s, John Cowley first realized that a single or a column of heavy atoms could act as strong atomic lens to focus the electrons in near field using the intrinsic atomic coulomb potential. [1-3]. The atoms act as strong spherical electrostatic lens but with extremely short focal lengths. In this work, we report the first experimental evidence to observe such near-field focusing effect for high energy electrons with these atomic focusers.

The experiments were performed on a double aberration correction S/TEM system (Thermo Fisher Themis Z installed with a CEOS SCORR probe corrector and a CETCOR image corrector). The microscope was operated at confocal mode with both probe and imaging lens system were carefully tuned. By focusing the probe onto a single atom or a column of atoms, a reduction of the size of probe were directly observed comparing to the original probe transmitting through vacuum. This opens a new path for breaking the diffraction limitation of electron imaging with near-field optics.