東京大学大学院工学系研究科 総合研究機構
第19回「次世代電子顕微鏡法」講演会
2024年3月22日 15:00 – 15:45 ハイブリッド開催

Measuring local phonon dispersion by four-dimensional EELS

Peng Gao
Electron Microscopy Laboratory, and International Center for Quantum Materials, Peking University, Beijing 100871, China

Phonon, one of the most common elementary excitation/quasiparticles in crystals, plays important roles in the thermal, optical, electrical, and mechanical properties. It is therefore vital to probe the phonon structure to gain insights into control and further optimization of the material properties. Mathematically, the complete phonon structure is described by phonon dispersions (Energy-Momentum relation curve) in the three-dimensional momentum space. However, the conventional experimental methods such as inelastic neutron scattering, X-ray scattering, nano-optics, scanning tunneling spectroscopy, etc., don't have enough spatial resolution and/or high momentum resolution at the same time, making them impossible to measure the phonon dispersion for nanosized objects such as single nanostructures, crystal defects, and heterogeneous interfaces.

Recently, based on the inelastic scattering in scanning transmission electron microscope we developed the four-dimensional electron energy loss spectroscopy (4D-EELS) technique with both high momentum resolution and nanoscale spatial resolution. By scanning the electron beam in real space of sample while monitoring both the energy loss and the momentum transfer, we are able to reveal position- and momentum-dependent lattice vibrations at nanometer scale with high efficiency. The space, momentum and energy resolutions can be delicately balanced by carefully adjusting experimental parameters, and thus widely tuned to optimize the data acquirements for specific samples under study. In this talk, we show the principle of 4D-EELS and some application examples, including the phonon dispersion relation for the heterostructure interface, single nanostructure, and the edge states of 2D materials. We also attempt to correlate the measured local phonons with the local properties for these low dimensional system.

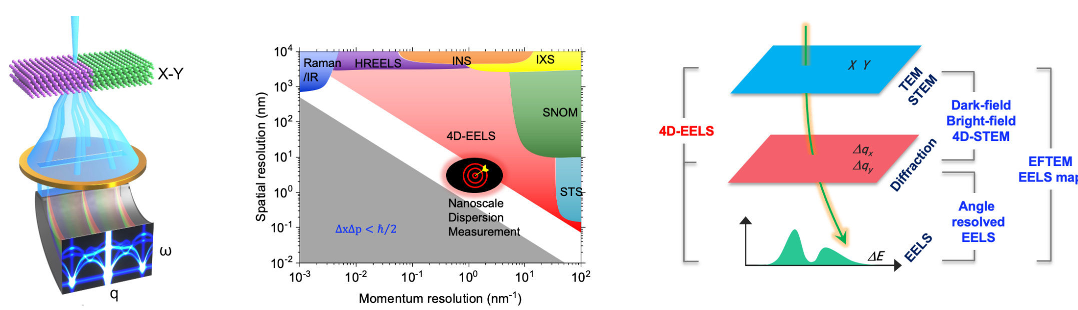

Figure. Left: Setup for 4D-EELS. Middle: The resolutions for common spectroscopies. Right: Comparison for different image/spectroscopy techniques in TEM.

東京大学
次世代電子顕微鏡法
社会連携講座

主催: 「次世代電子顕微鏡法」社会連携講講座
e-mail: ishikawa@sigma.t.u-tokyo.ac.jp