東京大学大学院工学系研究科　総合研究機構

結晶界面工学研究室

Crystal Interface Laboratory, The University of Tokyo

Crystal Interface Lab. Seminar Series

“Multipole phase tomography: a possible route towards 3D nanoscale field mapping with coherent electrons”

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Tomography aims at the reconstruction of a 3D signal from a limited set of 2D projections: the archetypal inverse problem that electron microscopists face daily. Obstacles along the way are both technical and fundamental. Technical: the limited tilt range, the varying thickness and diffraction conditions, etc.; fundamental: a unique solution for the reconstruction is never guaranteed. Several approaches exist to achieve 3D reconstructions, but most of them are algorithmic: back projections, Fourier-slice theorem, Radon transform etc. They are all essentially brute-force based, and recently have been considerably improved by artificial intelligence. In other branches of sciences, however, there are examples of highly sophisticated 3D reconstructions that are not relying exclusively on brute force. A case in point: the gravity and magnetic models of the earth in geophysics, assembled by combining the measurements of high-order multipoles carried out by remote satellites. Inspired by these ideas, I will describe the perspective of using phase sensitive electron microscopy to measure the multipoles of a charge or spin distribution at the nanoscale. With such information available, we can attempt a 3D reconstruction of the electric or magnetic field generated by the target nano-object. As a validating example, I will discuss how off-axis electron holography can be used to quantify the magnetic moment vector and volume of individual nanoparticle clusters named “nanoflowers”. This information, although not yet fully 3D, reveals that despite their complex structural arrangement, nanoflowers tend to sustain a single-domain state with a magnetization close to that of bulk. In contrast to the expectation of structural complexity leading to spin disorder, the results suggest that nanoflowers have a distinct ferromagnetic character with a significant magnetization at remanence.

Main meeting room at Institute of Engineering Innovation

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