Scope of Research

Crystallographic and electronic structures of materials and their transformations are studied through direct imaging of atoms or molecules by high-resolution electron spectromicroscopy which realizes energy-filtered imaging and electron energy-loss spectroscopy as well as high resolution imaging. By combining this with scanning probe microscopy, the following subjects are urging: direct structure analysis, electron crystallographic analysis, epitaxial growth of molecules, structure formation in solutions, and fabrication of low-dimensional functional assemblies.

Selected Publications


KEYWORDS
Surface Plasmon
EELS
Dispersion Curve
STEM
Transition-Metal Oxide
Dispersion Relations for Coupled Surface Plasmon-polariton Modes Excited in Multilayer Structures

The coupled surface plasmon-polariton (SPP) modes excited in an Al/SiO$_2$/Al multilayer structure were analyzed using angle-resolved electron energy-loss spectroscopy (AREELS) with a relativistic electron probe. Three dispersion curves for coupled antisymmetric short range (AC-SR), symmetric short range (SC-SR) and antisymmetric long range (AC-LR) modes were observed, but the symmetric long range (SC-LR) mode could not be detected because of its low excitation probability. The obtained dispersion curves agreed well with the calculated curves when an aluminum oxide layer was present on the surfaces, which indicates that the dispersion relations are very sensitive to multilayer surface conditions. In the multilayer structures, the dispersion relation for the coupled SPP modes was found to be sensitive to the thickness of each film, which could be interpreted qualitatively by the electron energy-loss probability calculated for thin aluminum (Al) films and narrow Al gaps using Kröger’s formula. It was demonstrated that significant differences in the excitation probability for SPPs could be observed depending on the coupling modes.

Control of Structural Distortions in Transition-metal Oxide Films through Oxygen Displacement at the Heterointerface

Structural distortions in the oxygen octahedral network in transition-metal oxides play crucial roles in yielding a broad spectrum of functional properties, and precise control of such distortions is a key for developing future oxide-based electronics. Here, it is shown that the displacement of apical oxygen atom shared between the octahedra at the heterointerface is a determining parameter for these distortions and consequently for control of structural and electronic phases of a strained oxide film. The present analysis by complementary annular dark- (HAADF) and bright-field (ABF) imaging in aberration-corrected scanning transmission electron microscopy (STEM) reveals that structural phase differences in strained monoclinic and tetragonal SrRuO$_3$ (SRO) films grown on GdScO$_3$ (GSO) substrates result from relaxation of the octahedral tilt, associated with changes in the in-plane displacement of the apical oxygen atom at the heterointerface. It is further demonstrated that octahedral distortions and magnetotransport properties of the SrRuO$_3$ films can be controlled by interface engineering of the oxygen displacement. This provides a further degree of freedom for manipulating structural and electronic properties in strained films, allowing the design of novel oxide-based heterostructures.