Atomic resolution views of complex oxide materials

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The success of aberration correction in the scanning transmission electron microscope (STEM) is revolutionizing the study of materials, especially those containing light atoms such as C based materials such as graphene or transition metal oxides. These are fascinating systems that exhibit the most disparate physical behaviors such as colossal magnetoresistance, orbital and/or charge ordering, magnetoelectronic phase separation or high Tc superconductivity to just name a few. Thanks to their relatively large lattice parameters and the fact that both O and transition metals exhibit absorption edges well within the reach of modern electron energy loss spectrometer (EELS) optics, they are ideal systems for such types of electron microscopy studies. Since many of the aforementioned phenomena exhibit characteristic length scales in the nanometer regime, they are affected by reduced dimensionality (e.g., thin films or heterostructures), proximity to other materials, or depend on nanometric active regions (e.g., defects, interfaces, etc.). Understanding such phenomena must therefore rely heavily on probes capable of studying simultaneously the structure, chemistry and electronic properties with atomic resolution in real space, such as STEM-EELS. In this talk the state-of-the art of the technique will be reviewed along with a number of applications to transition metal oxide interfaces based on perovskites. Examples such as the imaging of subtle O displacements across $LaMnO_3/SrTiO_3$ (LMO/STO) interfaces will be discussed. The LMO/STO relative layer thickness ratio changes the degree of epitaxial strain within the layers and dramatically affects the physical properties of the system, which can be tuned from insulating, mild ferromagnetic, to metallic ferromagnets. While STO is a cubic perovskite, LMO is characterized by a strong Jahn-Teller distortion and orbital ordering at low temperatures. We will show how the octahedral distortions of relaxed LMO layers can be tuned through different degrees of epitaxial strain and affect the O sublattice of ultrathin STO layers. These results will be discussed and combined with density functional theory, in connection with the magnetotransport properties.

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