SCEaMS: Tuesday, February 20, 2007

Probing Nanoscale Charge Ordering and Interfacial Electronic Structure in Strongly Correlated Oxides Using Electron Microscopy

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Probing nano-scale electronic structure is a major challenge in condense matter research. Techniques, such as X-ray and neutron diffraction, are used for studying bulk crystals and scanning probe microscopy (SPM) are used for surfaces. Studying nanoscale phenomena observed in many strongly correlated oxides, however, requires a significant improvement in the sensitivity of these probes or penetration in case of SPM. Progress in synthesis techniques, such atomic layer epitaxy, also makes it possible to fabricated meta-structures with built-in nanoscale interfaces to create new properties. Understanding the physics of these materials requires a probe, or probes, that can provide structural, chemical and electronic structure information.

High energy electrons can be focused by magnetic lenses to form angstrom-sized probes. Electrons also penetrate and electron interactions with matter can be analyzed using electron energy loss spectroscopy to reveal the electronic structure of the material. By detecting scattering of electrons, electrons can also form atomic resolution images. All of these makes the electron beam a very useful probe for studying nanoscale structure and interfaces. Here I will report on the recent progress in electron microscopy, especially the aberration corrected scanning transmission electron microscope, which is being installed at MRL and discuss their applications in condense matter research. Two examples will be used to highlight the electron microscopy methods, the information that can be obtained and the potential with the new microscope. One is charge ordering manganites. The other is the investigation of interfacial electronic structures in oxide superlattices synthesized by Eckstein's group.