invited talk
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Investigation of Complex Oxides in the Scanning Transmission Electron Microscope

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INVESTIGATION OF COMPLEX OXIDES IN THE SCANNING TRANSMISION ELECTRON MICROSCOPE

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Most of the physical properties of materials are determined by small size active regions such as defects or grain boundaries. Hence, the understanding of the relations between their nature, electronic properties and macroscopic behavior requires the use of probes with ultimate atomic resolution. Aberration correction in the Scanning Transmission Electron Microcope (STEM) is pushing the achievable spatial resolution for imaging and spectroscopy into the sub-angstrom regime [1,2], allowing the properties of defects and interfaces to be probed with unprecedented detail. The combination of atomic-resolution Z-contrast scanning transmission electron microscopy and electron energy loss spectroscopy (EELS) provides a powerful method to link the atomic and electronic structure of solids to their macroscopic properties, enabling the local investigation of the relationship between electronic structure and epitaxial strain, structural disorder, and dimensionality.

This work presents several examples of such atomically resolved studies in complex oxide interfaces and grain boundaries. Some of them will include colossal magnetoresistant (CMR) oxide thin films and high-T_c superconductor based superlattices. Grain boundaries in CMR materials, like the one shown in figure 1, are of tremendous interest due to their low-field magnetoresistant properties. High spatial resolution EELS could be the key to correlate such behavior with the local chemistry and/or the electronic structure around the dislocation cores. Another example we will discuss is related to the study of single atom impurities in $CaTiO_3/La_{1-x}Ca_xTiO_3$ superlattices with low La doping, in which single La atoms have been identified through intensity traces as shown in figure 2. Our attempts to obtain single atom EELS data on these impurities will also be described.

[1] B. Rafferty, S.J. Pennycook. Ultramicoscopy **78** 141 (1999)
[2] G. Duscher, R. Buczko, S.J. Pennycook, S.T. Pantelides. Ultramicroscopy **86** 355 (2001).
[3] This research was supported by Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-96OR22725. Financial support from CAM 07N/0008/2001 and Fundación Ramón Areces is acknowledged as well.

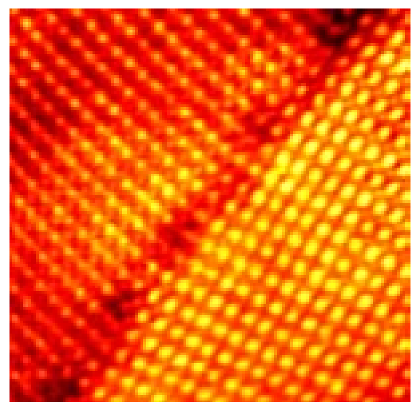

Figure 1: Z-contrast image of a 12º grain boundary in a $La_{0.67}Ca_{0.33}MnO_3$ film

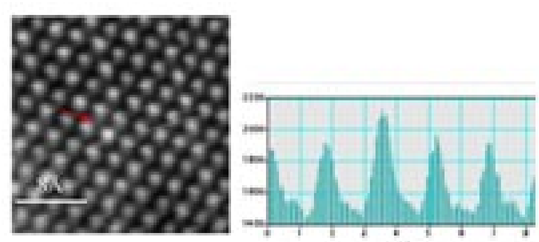

Figure 2: Z- contrast image of a $La_{0.025}Ca_{0.9975}TiO_3$ layer in a $CaTiO_3/La_{1-x}Ca_xTiO_3$ superlattice, showing an isolated La ion. Left: Intensity trace along the white dotted line.