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Strain-induced oxygen defect formation and interfacial magnetic phase separation in $SrTiO_3(001)/La_{1-x}Sr_xCoO_3$[1]

CHRIS LEIGHTON, University of Minnesota

The remarkable functionality and epitaxial compatibility of complex oxides provides many opportunities for new physics and applications in oxide heterostructures. Perovskite manganites and cobaltites provide excellent examples, being of interest for solid oxide fuel cells, catalysis, ferroelectric RAM, gas sensing, resistive switching memory, and oxide spintronics. However, the same delicate balance between phases that provides this diverse functionality also leads to a serious problem - the difficulty of maintaining desired properties close to the interface with other oxides. Although this problem is widespread, manifests itself in several ways, and could present a significant roadblock to the development of heterostructured devices for oxide electronics, there is no consensus as to its origin, or even whether it is driven by electronic or chemical effects. In this work, using $SrTiO_3(001)/La_{1-x}Sr_xCoO_3$ as a model system, we have combined epitaxial growth via high pressure oxygen sputtering with high resolution x-ray diffraction, atomic resolution electron microscopy and spectroscopy, and detailed magnetic, transport, and neutron scattering measurements to determine the fundamental origin of the deterioration in interfacial transport and magnetism. The effect is found to be due to nanoscopic magnetic phase separation in the near-interface region driven by a significant depletion in interfacial hole doping due to accumulation of O vacancies. This occurs due to a novel mechanism for accommodation of lattice mismatch with the substrate based on formation and long-range ordering of O vacancies, thus providing a fundamental link between strain state and O vacancy density. Further impacts of the O vacancy ordering and interfacial magnetic phase separation, such as formation of a spin-state superlattice and an extraordinary coercivity enhancement, will also be discussed. Work in collaboration with M. Sharma, M. Torija, J. Schmitt, C. He, S. El-Khatib, J. Gazquez, M. Varela, M. Laver and J. Borchers.

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