Condensed Matter Physics Institute Seminar

13:00 | Tuesday 10th May | P/T/111

Magnetism and Nanoscale Structural and Compositional Irregularities in MBE-grown La_2MnNiO_6 on $SrTiO_3$(001)

Prof. Scott A. Chambers

Pacific Northwest National Laboratory (PNNL), WA, USA

Double perovskites ($A_2BB'O_6$) are a fascinating class of oxides with considerable potential for applications requiring ferromagnetic and semiconducting properties. We have investigated epitaxial films of La_2MnNiO_6 grown by molecular beam epitaxy (MBE). We find that despite the fact that Mn and Ni are present as 4+ ($d^3 : t_{2g}{}^3 e_g{}^0$) and 2+ ($d^8 : t_{2g}{}^6 e_g{}^2$), respectively, as measured by *in situ* x-ray photoemission spectroscopy and *ex situ* x-ray absorption spectroscopy, and exhibit ferromagnetic signatures in *ex situ* x-ray magnetic circular dichroism, the volume-averaged moment per formula unit (f.u.) is considerably less than the expected 5 μ_B in as-grown films. Post-growth annealing in air to temperatures up to 850°C increases the moment to 4.8 μ_B per f.u. Our scanning transmission electron microscopy and energy dispersive spectroscopy results reveal that there is considerable disorder in the B-site sublattice in as-deposited films, despite excellent volume-averaged stoichiometric control as measured by Rutherford backscattering spectrometry. While air annealing results in substantial B-site ordering, the moment does not go all the way up to 5 μ_B per f.u. due to the nucleation of nanoscale NiO inclusions with needle-like shapes revealed by atom probe tomography. First-principles modeling suggests that even though the LMNO double perovskite is most stable if nucleated in high oxygen partial pressure, other solid-state reactions can occur at typical MBE pressures, leading to the localized formation of NiO along with Mn-rich LMNO. This investigation underscores the point that when attempting to synthesize complex materials such as LMNO as an epitaxial film, one must carefully consider competing kinetic and thermodynamic outcomes, and not just assume that delivering the requisite kinds and quantities of atoms to the substrate will result in the desired material.