Defect Engineered Electrical and Ionic Conductivity of Lanthanide Cobaltite Double Perovskite Thin Films

Double perovskite oxides have long attracted attention due to their interesting physical properties including a metal-insulator transition, giant magnetoresistance, spin blockade, etc., stemming from their strongly correlated charge, spin, orbitals, and lattice. In particular, recent research has focused on the double perovskite cobaltites of the form LnBaCo$_2$O$_5$+$\delta$ (Ln = La, Pr, Eu, etc.), due to their excellent mixed ionic and electronic conductivity (MIEC) behavior making them suitable candidates for many next generation energy device applications. While the low temperature behavior has been well studied in both bulk and thin film LnBCO materials, the high temperature behavior is not well understood especially in thin films. By combining non-ambient X-ray diffraction (XRD) with electrical transport property measurements I have conducted an investigation into the high temperature behavior of LaBCO and PrBCO thin films. These materials were chosen specifically due to the A-site order/disorder structure that can be present in LaBCO, whereas the PrBCO film is more prone to having ordered oxygen vacancies giving an A-site ordered structure. The ordered oxygen vacancy structure is advantageous for various device applications due to the ultra-fast oxygen exchange/diffusion as well as its ability to quickly incorporate hydrogen into the lattice. These unique properties make it possible to fabricate symmetric fuel cells with LBCO materials acting as both anode and cathode as well as chemical membranes. Through this study we have established that a structural transition occurs in the high temperature regime indicative of oxygen vacancy ordering, this ordering also having a large effect on the films electrical transport properties.

Another double perovskite system, BaYMn$_2$O$_5$+$\delta$, has garnered attention recently for its remarkable oxygen intake and release ability making it a prime candidate for oxygen storage and separation, CO$_2$ sequestration, and other interesting energy applications. To systematically investigate the physical properties of this material, highly epitaxial thin films have become the best system due to the difficulty of growing bulk single crystals. Thin films were grown by pulsed laser deposition (PLD) and characterized by XRD and film resistance measurements. Films of good crystallinity were produced and show interesting oxygen intake and release behavior similar to that of bulk materials. Highly epitaxial films of this material may pave the way for new chemical sensors and electronic device development.