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Topotactic Transformations in Complex Oxide Thin Films

Abstract:
Tunable transitions between crystal phases with distinct physical properties which are triggered by ion migration are potential candidates for emerging technologies such as neuromorphic computing devices. As an example, topotactic transformations involve structural changes between different phases via the loss or gain of material while retaining a crystallographic relationship. Cobaltite oxides $La_{1-x}Sr_xCoO_3$ serve as a model system for investigating such topotactic transformations due to their high surface reactivity, mobile oxygen vacancies, and the number of related crystal structures including the Grenier ($ABO_{2.7}$), brownmillerite (BM, $ABO_{2.5}$), square planar (ABO_2), and Ruddlesden-Popper phases (RP, $A_{n+1}B_nO_{3n+1}$, n=integer). In addition, $La_{0.67}Sr_{0.33}CoO_3$ (LSCO) displays magnetic heterogeneity in the form of magneto-electronic phase separation consisting of small ferromagnetic (FM)/metallic clusters within an antiferromagnetic (AFM)/insulating matrix. In this talk, I will discuss the evolution of the structural and functional properties of LSCO thin films in which their oxygen vacancy concentration was controlled through the deposition of a strong oxygen getter layer (e.g., Gd)[1] or exposure to high temperature anneals under highly reducing or hydrogen gas environments.[2] With increasing getter layer thickness, our studies showed the coexistence of perovskite and BM phases with a critical oxygen vacancy threshold above which extended BM filaments were observed. In contrast, annealing under highly reducing conditions led to the formation of the rare $La_{1.4}Sr_{0.6}Co_{1+□}O_{4-\delta}$ RP phase (where $0 < □ < 1$ and $0 < \delta < 1$) through the loss of both oxygen and cobalt ions. The formation of this RP phase was inhibited when the anneals were performed under hydrogen gas environment. In all cases, the corresponding magnetic properties were tunable between various FM and AFM phases, and the room temperature resistivity spanned eight orders of magnitude, demonstration the potential of magneto-ionics as the basis for next generation device applications.

[1] D.A. Gilbert, Y. Takamura et al., Phys. Rev. Mater., 2, 104402 (2018); G. Rippy, Y. Takamura et al., Phys. Rev. Mater., 3, 082001(R) (2019)
[2] I-Ting Chiu, Y. Takamura et al., Phys. Rev. Mater., 5, 064416 (2021); M. Feng, Y. Takamura et al., under review

Bio:
Yayoi Takamura received her B.S. from Cornell University in 1998 and her M.S. and Ph.D. degrees from Stanford University in 2000 and 2004, respectively, all in the field of Materials Science and Engineering. She was a postdoctoral researcher at UC Berkeley with Prof. Yuri Suzuki in the Dept. of Materials Science and Engineering before joining the Dept. of Materials Science and Engineering at UC Davis in July 2006. Since July 2020, she has been serving as Department Chair. Her research focuses on the growth of complex oxide thin films, heterostructures, and nanostructures and the characterization of the novel functional properties associated with their interfaces. Prof. Takamura is a recipient of the NSF CAREER Award, the DARPA Young Faculty Award, and the 2020 College of Engineering Mid-Career Research Award.