doi:10.1017/S1431927615007527 Paper No. 0673 Microsc. Microanal. 21 (Suppl 3), 2015

Toward Deterministic Switching in Ferroelectric Systems: Insight Gained from In Situ TEM

James Hart[1], Michael Jablonski[1], Andrew Lang [1], Anoop Damadoran[2], Shi Liu [3], Miryam Arredondo[4], Lane W. Martin[2], Andrew Rappe [3], and Mitra L. Taheri[1]

[1.] Drexel University, Department of Materials Science & Engineering, Philadelphia, PA, USA
[2.] University of California-Berkeley, Department of Materials Science & Engineering, Berkeley, CA, USA
[3.] University of Pennsylvania, Department of Chemistry, Philadelphia, PA, USA
[4.] Queens University, Centre for Nanostructured Media (CNM), Belfast, United Kingdom

To gain a greater understanding of the mechanisms that control material properties, researchers often turn to in situ TEM. This technique provides insight into many processes that are otherwise unclear in static experiments. Dynamic microscopy can potentially fill in gaps in the current understanding interfacial phenomena in a wide variety of materials. In this talk, the exploration of ferroelectric domain behavior in select oxide structures is presented [1-3]. Utilization of ferroelectrics for device applications requires precise control of domain structure. To facilitate device integration, an understanding of the microstructural factors that affect ferroelectric domain switching, and in most cases, ferroelastic relaxation, must be developed. *In-situ* transmission electron microscopy is an ideal tool for studying domain dynamics due to its inherent high spatial and temporal resolution.

Specifically, we present quantitative dynamic studies of ferroelectric domain motion in two systems: a uniaxial ferroelectric, $RbKTiOPO_4$ (RKTP), and a multiferroic material, $BiFeO_3$ (BFO), which exhibits both ferroelectric and magnetic order. In situ studies were performed using a JEOL 2100 LaB_6 TEM operated at 200 keV and a Hummingbird in situ biasing holder. In RKTP, we show that by manipulating the electron beam, we can reverse the direction of domain propagation, and by using a condensed probe we can locally nucleate domains; this process is dependent on both the sample geometry and electron beam condition. In BFO, the evolution of ferroelastically switched ferroelectric domains during many switching cycles is investigated, and the role of local defects and other extrinsic factors on the reversibility of domains during cycling is discussed. The results of these time-resolved biasing experiments provide a real time view of the complex dynamics of domain switching and complement scanning probe techniques and are critical to the development of improved ferroelectric devices.

References:

[1] Winkler, C.R. *et al*, Nano Letters **14.6** (2014), p. 3617.
[2] Winkler, C.R. *et al*, Journal of Applied Physics **112** (2012), p. 052013.
[3] Winkler, C.R. *et al*, Micron **43** (2012), p. 1121.
[4] The authors acknowledge funding from the Office of Naval Research under contract number N000141410058.