Ferroelectric Domain Walls – Physics and Function

Lane W. Martin

Department of Materials Science and Engineering, University of California, Berkeley, Berkeley, CA 94720, USA

Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Domain walls are a naturally occurring, essential feature of ferroic materials. The macroscopic manifest of properties in ferroic materials is as much a function of the domain structure as it is the fundamental order parameter. Said another way, the presence of domains and domain walls can, and often does, have a profound impact on the evolution of structure and properties of ferroic materials. As such, understanding how and why these features form, how they respond under applied stimuli, and how and why they can exhibit different properties from the bulk of the material surrounding them is essential to enable the control of modern materials and next-generation devices.

In this lecture we will focus on the physics and function of domains and domain walls in ferroelectric and multiferroic materials. We will begin with an exploration of the energetics of domain-wall formation and will explore their structure and coupling with the electrostatic, elastic, etc. boundary conditions of the material. From there, we will explore how to characterize domain structures and domain walls (with, for example, scanning-probe microscopy, X-ray-based techniques, transmission electron microscopy, *etc*.). In turn, we will investigate how to engineer domain structures in as-grown materials (via approaches such as thin-film epitaxy, heterostructuring, strain gradients, electrical boundary conditions, *etc*.) and how *ex post facto* processing techniques (including, for example, scanning-probe microscopy) can be used to create domain structures in an on-demand fashion. Armed with the ability to produce and characterize such domains, we will proceed to explore how domains and domain walls can give rise to marked contributions to macroscopic responses (*e.g.*, dielectric, piezoelectric, pyroelectric, *etc*.) and exotic nanoscale function (*e.g.*, domain-wall conduction, magnetism, exchange bias, *etc*.). Finally, we will touch on the future of domain walls including aspects of probing domain-wall dynamics at the ultrafast time scale, potential for roles in devices, and much more.