Designing Next-Generation, High-Performance Materials for Advanced Devices – Functional Complex Oxides

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Complex oxide materials possess a range of interesting properties and phenomena that make them candidates for next-generation devices and applications. But before these materials can be integrated into state-of-the-art devices, it is important to understand how to control and engineer the response of these often complex materials in a deterministic manner. In this talk we will discuss the science and engineering of thin-film versions of these materials. We will explore the role of the epitaxial thin-film growth process and the use new types of lattice mismatch strain to engineer a range of systems with special attention to ferroelectric materials. In recent years, the use of epitaxial strain has enabled the production of model versions of these complicated materials and the subsequent deterministic study of field-dependent response. Here, we will investigate how new manifestations of epitaxial constraint can enhance electric field, stress, and temperature susceptibilities (*i.e.*, dielectric, piezoelectric, pyroelectric, and electrocaloric effects) in ferroelectrics. The presentation will highlight a comprehensive approach to the understanding of stimuli-dependent response of materials including aspects of design of new high-performance materials using phenomenological models, application of epitaxial thin-film strain to produce controlled domain structures and exotic new phases, identification of domain wall contributions to response, the development of novel measurement techniques, and the fabrication and testing of rudimentary devices based on these materials. In particular, we will explore three examples of how we can push the boundaries of modern thin-film strain to control materials: 1) the production and use of strain gradients in compositionally-graded materials, 2) the use of film orientation to produce exotic domain structures and responses, and 3) a new “defect strain” pathway to push the limits of strain control of materials. The discussion will range from the development of a fundamental understanding of the physics that lies at the heart of the observed effects, to an illustration of routes to manipulate and control these effects, to the demonstration of solid-state devices based on these materials.