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David Adler Lectureship Award Talk: Multifunctional Complex Oxide Heterostructures

RAMAMOORTHY RAMESH, University of California, Berkeley

Complex perovskite oxides exhibit a rich spectrum of functional responses, including magnetism, ferroelectricity, highly correlated electron behavior, superconductivity, etc. There exists a small set of materials which exhibit multiple order parameters; these are known as multiferroics. Using our work in the field of ferroelectrics and magnetoresistice oxides (CMR) as the background, we are now exploring such materials, as epitaxial thin films as well as nanocomposites. Specifically, we are studying the role of thin film growth, heteroepitaxy and processing on the magnitude of the coupling between the order parameters. In single phase multiferroic perovskites, such as BiFeO3, we have found enhancements in magnetism and ferroelectricity compared to bulk. Detailed measurements indicate the possibility that the enhancement in magnetism is due to a mixed Fe+2/Fe+3 state in the films. A very exciting new development has been the discovery of the formation of spontaneously assembled nanostructures consisting of a ferromagnetic phase embedded in a ferroelectric matrix that exhibit very strong coupling between the two order parameters. This involves 3-dimensional heteroepitaxy between the substrate, the matrix perovskite phase and spinel phase that is embedded as single crystalline pillars in this matrix. This epitaxial coupling is critical and is responsible for the significantly higher magnetoelectric coupling and magnetic anisotropy in such vertical heterostructures compared to a conventional heterostructure. This work is supported by the UMD-MRSEC and by the ONR under a MURI program.