Probing electronic, magnetic and structural heterogeneity in nanoscale material systems with advanced synchrotron-based x-ray techniques

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In this talk, I will present the results of several recent studies, in which we used a combination of advanced synchrotron-based x-ray spectroscopic, scattering and imaging techniques to investigate the coupling between the electronic, magnetic and structural properties of materials and material systems which exhibit natural, as well as engineered, nanoscale structural distortions. As the first example, I will discuss our recent combined polarization-dependent photoemission microscopy and nano-diffraction investigation of the nanoscale magneto-elastic structure of the Fe-Ga magnetic alloy, which was recently reported to exhibit nonconventional magnetostrictive properties. Our data suggest a strong coupling between the structural distortions and nanoscale magnetic modulations throughout the crystal, forming a magneto-structural basis for the nonconventional magnetostrictive behavior in this material. As a second example, I will discuss our recent study, in which we used a combination of soft x-ray standing-wave photoemission spectroscopy, hard x-ray photoemission spectroscopy, and scanning transmission electron microscopy to probe the depth-dependent and single-unit-cell resolved electronic structure of isovalent manganite superlattices, wherein the electronic and magnetic properties are intentionally modulated with depth via engineered oxygen-octahedral rotations and A-site displacements. Our results suggest a new way of tailoring and spatially-confining electronic and ferroic behavior in complex-oxide heterostructures and creating novel ordered surface-reconstruction effects.