Element, valence and orbital depth profiling with resonant x-ray reflectometry

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Spurred by advances in atomic-precision film growth, oxide heterostructures have become a very active field of study in recent years. The interfaces in such heterostructures exhibit a wide range of emergent phenomena, such as interface charge transfer, two dimensional electron liquids, superconductivity, and ferromagnetism between non-magnetic materials [1]. Such phenomena result from the interface-induced tuning of the various spin, charge, orbital, and lattice degrees of freedom, and show great promise for electronics applications. However, while the emergent properties are readily apparent, obtaining electronic structure information specific to the nanometer-scale buried interface region—in order to understand and further tune the these properties—is an understandably difficult task.

In this talk I will present our studies of the interfacial and depth dependent electronic structure of heterostructures using resonant x-ray reflectometry (RXR), a new experimental technique which combines the powerful electronic structure probing capability of x-ray absorption spectroscopy with the interface and depth sensitivity provided by quantitative reflectometry. By tuning our x-ray experiment to various different reflection geometries and resonance energies, we can obtain information on the depth-dependent, element-specific electronic structure directly at and near buried interfaces. For the paradigmatic $LaAlO_3/SrTiO_3$ heterostructure which exhibits orbital and electronic reconstructions [2,3], we extract atomic layer-resolved, reconstructed Ti orbital energies within a few unit cells of the interface, and determine the depth profile of the charge in the interfacial 2D electron liquid. These results provide important insight into physics behind the intriguing emergent phenomena, and show RXR to be an ideal tool for studying oxide interfaces.

References.

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