Combining thin films growth and spectroscopy for understanding the complex oxide materials

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In strongly correlated materials the intricate entanglement of different degrees of freedom gives rise to a plethora of interesting phenomena, including high-temperature metal-insulator transitions, colossal magnetoresistance, and high-temperature superconductivity. One of the grand challenges in this field is understanding precisely how strong quantum many-body interactions affect the electronic structure of these materials and ultimately lead to these exotic properties. In pursuit of this goal, researchers are increasingly turning to the design and synthesis of artificial heterostructures, which offer new ways to tune material parameters and endow these systems with novel properties. I will present our recent studies of bismuthate superconductors by combining Laser-MBE synthesis and advanced spectroscopic techniques. In the undoped insulating state, phonons dress the charges to form a lattice of frozen polarons. By introducing hole dopants, the long-range ordering of the polarons becomes disrupted, and eventually, superconductivity emerges. We have tracked both the evolution of the electronic structure and the electron-phonon coupling as a function of doping using angle-resolved photoemission and resonant inelastic X-ray scattering. The results indicate that the electron-phonon coupling strength is virtually constant as a function of doping, and remnants of the parent compound electronic phase correlation persist above the superconducting phase, leading to so-called pseudogap behavior. Furthermore, I will describe our work using interface engineering to control the electronic structure and magnetic properties of other correlated oxides such as the rare earth nickelates.