Abstract: In the recent years, there has been a renewed interest in exploiting magnetic and correlated materials in thin films and nano-devices. For instance, materials showing metal-insulator transition have become potential candidates for novel electronics and photonics devices. In the field of spintronics, the discovery of Giant Magnetoresistance (GMR) effect has revolutionized the hard disk drives and very recently, spin transfer torque has emerged as a new potential for spin-based memory devices. More generally, there is an increasing interest in understanding and controlling the interplay of charge, magnetic and lattice, in complex materials. I will describe recent experimental studies using emerging synchrotron techniques that can probe these materials with both high spatial and temporal resolution. The first study explores the metal insulator transition (Verwey transition) in magnetite triggered by optical excitation. Magnetite (Fe₃O₄) is the first oxide where a relationship between electrical conductivity and fluctuating/localized charges was observed. The Verwey transition is also accompanied by a structural change from monoclinic to cubic symmetry. Despite decades of research and indications that charge and orbital ordering play an important role, the mechanism behind the Verwey transition is yet unclear. I will present measurements showing real time response of insulating magnetite to optical excitation using ultrafast soft X-ray scattering as well as optical pump probe experiments, showing phase separation into metallic and insulating regions on a timescale of 1.5 picosecond, providing new insight to the Verwey transition. The second part of my talk probes spin transport across ferromagnet/copper interface. It has been predicted that near such an interface copper develops a small non-equilibrium magnetization due to spin accumulation. However, directly observing these spin currents is extremely challenging due to magnetic moment injected into copper being very small, less than 1/10000 of a regular ferromagnet. I have developed an extremely sensitive spectro-microscopy detection method based on element-specific x-ray magnetic circular dichroism to probe spin transport in Co/Cu devices. The sensitivity of this new ‘lock-in’ technique has allowed us to detect the extremely small transient Cu magnetization with sub 100 nm spatial resolution.

Biography: Roopali Kukreja received her PHD in materials science at Stanford University in 2014. She received the Melvin P. Klein Scientific Development Award in 2015 for her studies of the effects of X-rays on nanoscale magnetic and electrical properties of materials. Kukreja has also worked at the Department of Energy’s SLAC National Accelerator Laboratory. She is now a postdoctoral researcher at the University of California, San Diego, where she continues to work with X-rays and the magnetic properties of materials in addition to fabricating exotic materials for these experiments.