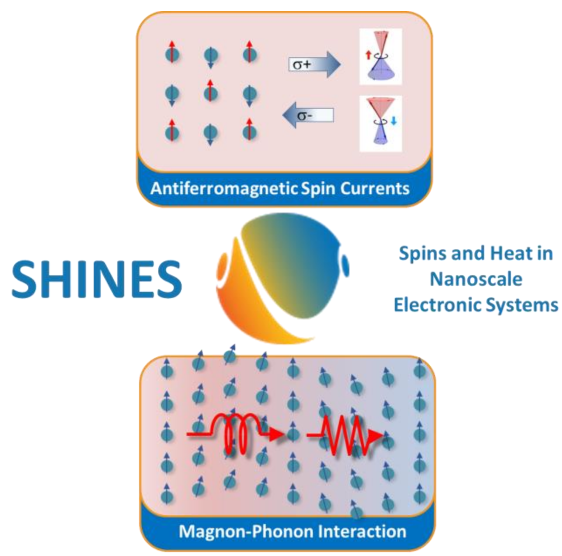
Spins and Heat in Nanoscale Electronic Systems (SHINES)
EFRC Director: Jing Shi
Lead Institution: University of California, Riverside
Class: 2014– 2020

Mission Statement: *To control interactions involving spins and lattice to achieve high energy efficiency in nanoscale electronic devices.*

Based on the progress made in the last four years, the renewed EFRC will focus on the understanding and control of fundamental interactions involving spins and lattice in magnetic thin films and heterostructures with the goal of increasing energy efficiency in nanoscale electronic and spintronic devices. Microscopic interactions such as spin-spin exchange interaction, spin-orbit coupling, and magnon-phonon interaction strongly affect or determine macroscopic properties of magnetic materials and spintronic devices such as magnetic anisotropy, spin-charge conversion efficiency, energy dissipation, etc. A research frontier in spintronics is discovering how to control these important interactions on the atomic scale by designing and synthesizing novel thin film materials and heterostructures. A great deal of progress has been made in SHINES since 2014 in advancing the spintronics frontier. For example, SHINES research has demonstrated that strong exchange interaction at the interface of magnetic and non-magnetic materials (e.g., magnetic insulators and topological insulators) can be created and manipulated through proximity coupling arising from electron wavefunction overlap between the two materials. The artificially created exchange interaction can then have profound consequences in the physical behaviors of the materials such as formation of chiral edge states, emergence of Majorana fermions, strong modification of spin relaxation and damping, etc. In the following two years, SHINES will continue exploring new materials (e.g., antiferromagnetic/topological insulator heterostructures) and new phenomena (e.g., exchange modulated ultrafast spin dynamics) that will lead to new functionalities and high energy efficiency in nanoscale electronic and spintronic devices.



The two-year objectives include discovering or demonstrating new spintronic phenomena in ferromagnetic and antiferromagnetic heterostructures, developing an in-depth understanding of these phenomena, controlling microscopic interactions via material growth and application of external stimuli such as electric and magnetic fields and therefore the resulting magnetic properties such as magnetic anisotropy, magnetic transition temperature, and damping. A special emphasis will be placed on the antiferromagnetic spintronics, an emerging research area that several SHINES investigators pioneered. The experimental techniques to be employed for this team research include molecular beam epitaxy and pulsed laser deposition for high-quality thin film and heterostructure growth, structural characterization using X-ray diffraction and neutron scattering, magnetic domain imaging, non-local transport, THz spectroscopy, magnetic resonance, spin pumping, spin Seebeck effect measurements, Raman and Brillouin light scattering, etc. The experimental investigations will be complemented with theoretical and computational work within SHINES through close collaboration.

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