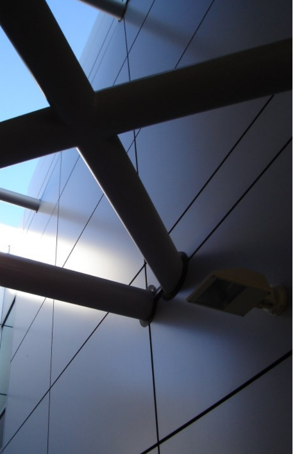

MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Anand Katailiha

Thursday, June 18, 2020, 3PM

Magneto-Thermal Transport in Metal and Semiconductor Thin Film

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, June 2020
Dr. Sandeep Kumar, Chairperson

Spin polarization, when induced in a non-ferromagnetic material, can change the underlying material behavior especially if the spin diffusion length is of the same order as the sample dimension, for example thickness. We demonstrate thermal hysteretic behavior induced by spin polarization in Ni80Fe20 (10 nm)/Au (100 nm) bilayer freestanding sample. The thermal hysteresis behavior is uncovered using magneto thermal characterization based on self-heating 3w (three omega) method. The third harmonic voltage shows diverging behavior and thermal hysteresis during cooling and heating of the sample under an applied magnetic field, which is attributed to the spin accumulation. We demonstrate that the spin accumulation and thermal hysteresis in Au occurs due to ferromagnetic proximity polarization from Ni80Fe20 layer. The observed hysteresis behavior is also attributed to freestanding thin film structure and absence of substrate effects leading to longer spin diffusion length. These results in Au thin films may provide scientific direction to study spin dependent behavior in widely studied diamagnetic and paramagnetic materials. In addition, layered thin films such structures of normal metals/ferromagnetic metals can be used to achieve magnetocaloric effect for magnetic refrigeration without using complex and rare earth magnetic materials.

Silicon is a prominent material for electronics but not a preferred one for spintronics due to its inefficiency in producing large enough spin current. The culprit is a weak spin orbit coupling in Si. We present an experimental proof of crystallographic direction dependent spin polarization and thermal spin current generation using spin-phonon interactions in silicon thin films in spite of it having insignificant intrinsic spin-orbit coupling. We find that the strain gradient acts as an external switch that breaks the symmetry of spin relaxation behavior and modify the spin-phonon interactions. The spin-phonon interactions lead to a phonon-driven redistribution of spin potential and spin current. The phonon-driven spin current gives rise to a phononic spin-Nernst effect due to interlayer coupling with Ni80Fe20 thin film. The coefficient of spin-Nernst magneto-thermopower of the Si (45.4 μV/K) is estimated to be an order of magnitude larger than heavy metals such as tungsten (W). The primary heat carrier in Si are phonons and resulting spin-Nernst effect is expected to arise due to spin dependent electron-phonon scattering, which is also supported by spin-Hall magnetoresistance and Hall resistance measurement. Observation of phononic spin-Nernst effect puts a spotlight back on Si for spintronics and spin caloritronics applications.