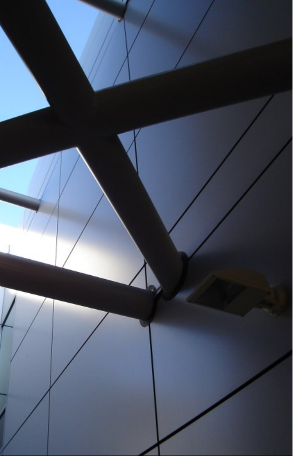

MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of
Ravindra Bhardwaj

Monday, June 29, 2020, 2PM

An Experimental Study of Spin Seebeck Effect in Ferromagnetic/Semiconductor Heterostructure Thin Films

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

Magnetothermoelectrical devices are the prominent systems to generate electrical energy from heat source having small temperature gradient. The spin-Seebeck effect mediated thermoelectric energy conversion can provide an efficient alternative to traditional thermoelectric for waste heat recovery. To achieve this goal, efficient spin to charge conversion using earth-abundant materials is essential. Also, the thermal spin current from the spin-Seebeck effect has been reported to be more energy efficient than the electrical spin injection methods. However, spin detection has been the one of the bottlenecks since metals with large spin-orbit coupling is an essential requirement. Silicon is widely used in semiconductor electronics due to its abundance and versality but having a centrosymmetric crystal structure, has insignificant intrinsic spin-orbit coupling, leading to negligible spin-charge conversion. However, in silicon, strain engineering mediated Rashba spin orbit coupling can induce interfacial spin to charge conversion arises due to an electric potential perpendicular to the interface.

The electric potential can be artificially induced, for example, using ferroelectric and piezoelectric thin films at the interface. An alternate way to induce the electric potential could be flexoelectric field. The flexoelectricity can be observed in all the material that either have or lack inversion symmetry, additionally no large gate bias is needed. Hence, the interfacial asymmetry in conjunction with strain engineering can provide an alternate pathway to achieving efficient and controllable spin-to-charge conversion for spintronics applications. In this experimental study, we report large spin to charge conversion (spin-Hall angle- 0.578) at $Ni_{80}Fe_{20}$/amorphous-Si interfaces attributed to flexoelectricity mediated Rashba spin-orbit coupling. The flexoelectricity at the interface also gave rise to interlayer spin-acoustic phonon or magnetoelastic coupling. In addition to spin-charge conversion, the strained interfaces also led to almost three-fold increase in anomalous Nernst effect. This strain engineering for spin dependent thermoelectric behavior at room temperature opens a new window to the realization of silicon spintronics and spin-caloritronics devices.