"Origin of strong Rashba spin orbit coupling and spin-Hall effect in Si"

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Abstract:

Silicon can be a promising material for spintronics due to long spin diffusion length at room temperature. For realization of Si spintronics, efficient generation of spin current, detection and manipulation is essential. But insignificant intrinsic spin-orbit coupling leads to insignificant spin-Hall effect (spin current generation) and inverse spin-Hall effect (spin current detection), which is a bottleneck for the realization of Si spintronics. In this work, we explore the extrinsic Rashba spin-orbit coupling in Si, which can lay the foundation of Si spintronics. Using comprehensive magneto-electro-thermal characterization, we report giant Rashba spin orbit coupling at Si interfaces. We observe strong spin-Hall magnetoresistance (SMR) in $Ni_{80}Fe_{20}$/MgO/p-Si thin films. Rashba SOC mediated spin accumulation leads to phase transition in Si. Rashba SOC is further supported by the observation of spin-Seebeck effect in $Ni_{80}Fe_{20}$/p-Si bilayer thin films. We propose that the flexoelectric effect leads to electric polarization at Si interface, which gives rise to Rashba-Dresselhaus spin orbit coupling in Si. The cubic Rashba spin-orbit coupling lifts the spin degeneracy of band structure introducing intrinsic spin-Hall effect, which is the underlying cause of SMR and spin-Seebeck effect. This behavior is supported by electric current dependent SMR behavior.

Biography:

Dr. Sandeep Kumar joined UCR as an Assistant Professor (MSE and ME) in 2012. Dr. Kumar received his B.Tech in Mechanical Engineering from Regional Engineering College, Kurukshetra (India) in 1999. He earned his MS (research) in Mechanical Engineering from the Indian Institute of Technology, Delhi (India) in 2006 and his Ph.D. in Mechanical Engineering from Pennsylvania State University in 2012. Professor Kumar has authored and co-authored 28 Journal articles and he is inventor on 6 provisional patents. His current research interests include Si spintronics, spin dependent thermoelectric energy conversion, spin mediated thermal transport behavior in nanoscale thin films.