

“Spintronics Preeminent Team Faculty Seminar”

November 21, 2016 @ 9:00am

MSEE, ROOM 239

Weigang Wang

Assistant Professor, Department of Physics
University of Arizona

Title: Putting a spin on next generation transistors

Bio: Dr. Wang is an Assistant Professor in the Department of Physics at the University of Arizona. He received his Ph.D. degree from the University of Delaware in 2008. He was a Postdoctoral Fellow at the Johns Hopkins University from 2008 to 2012. Subsequently he joined the University of Arizona in 2012 and established the Nanomagnetism and Spintronics Lab. He is the receipt of an NSF CAREER award to study ultra-low energy switching in spintronic structures. His work has focused on the transport of charge and spin at nanoscales. He has systematically investigated the ballistic transport of spin-polarized electrons over insulating barriers, and the dynamic evolution of symmetry-conserved tunneling magnetoresistance in the solid-state epitaxy process. His lab is currently working on voltage-controlled spintronics aiming to greatly reduce the switching energy. He has demonstrated a record low switching current density at 10^4A/cm^2 in CoFeB/MgO perpendicular magnetic tunnel junctions (pMTJ), and his group has achieved a record high tunneling magnetoresistance (>200%) in pMTJs that can be controlled by voltage. less than 10 fJ has been realized in these pMTJs.

Abstract: Electron undoubtedly is one of the most important elementary particles that are intimately related to human activities. From radio, TV to smart phone, electronics has revolutionized our lives. Surprisingly, in most electronics to date we have only utilized the charge carried by electrons, while ignoring the other inherent property, the spin. In spintronics we explicitly make use of the spin degree of freedom of electrons to achieve new functionalities. A unique advantage of spintronics is its nonvolatility, which is particularly critical for future digital devices utilizing transistors smaller than 10nm. However, the Achilles heel for spintronics is the lowest switching energy through the well-known spin transfer torque effect (100 fJ) is still three orders of magnitude higher than that of CMOS transistors (0.1 fJ), which severely limits the present applications of spintronic devices. After an introduction on fundamental spintronic effects based magnetic fields and electric currents. I will focus my talk on the exploration of new phenomena that can be controlled by electric fields, driven by the premise that voltage-controlled switching could be far more efficient therefore could eventually lead to ultra-low energy spintronics. I will describe our approaches to increase the magnetoresistance and thermal stability in perpendicular magnetic tunnel junctions (pMTJs) by employing new materials and new structures. Through the voltage controlled magnetic anisotropy (VCMA) effect where the energy barrier can be altered by redistribution of electron density amount different d orbitals of transitional ferromagnets, a 100-fold reduction in switching current density has been realized in pMTJs. Then I will present the voltage controlled magnetism (VCM) effect where both magnetic anisotropy field and saturation magnetization of Pt/Co/Gd₂O₃ trilayers can be manipulated by controlling the oxidation state of Co through external electric fields, reaching an unprecedentedly large control of 11.3 pJ/Vm and giant modulation (up to 10 times) of spin Hall switching current density. Finally I will describe our recent effort to reduce the switching energy of fully perpendicular MTJ nanopillars. Through the effective in-plane magnetic field generated by a sub-ns voltage pulse, switching energy less than 10 fJ has been realized in these pMTJs.