MAS14-2014-020027

Abstract for an Invited Paper
for the MAS14 Meeting of
the American Physical Society

Multiferroic Tunnel Junctions and ferroelectric control of spins[1]

QI LI, Pennsylvania State University

Multiferroic tunnel junctions, i.e. magnetic tunnel junctions with a ferroelectric barrier, have become one of the very promising approaches for new generation of multifunctional devices and electric control of spins for spintronics. A large tunneling electroresistance (TER) is very desirable for utilizing the devices for signal processing with an on-site magnetic memory. To enhance the TER, we have designed a bilayer tunneling barrier in which one layer is ferroelectric and the other interface layer is close to ferromagnetic metal to antiferromagnetic insulator phase transition. Ferroelectric polarization reversal induces the phase transition of the interface layer due to the charge doping effect of the interface layer to screen the ferroelectric polarization. The effect of ferroelectric driven interface phase transition on the TER effect has been tested in $La_{0.7}Sr_{0.3}MnO_3/BaTiO_3/La_{0.5}Ca_{0.5}MnO_3/La_{0.7}Sr0._3MnO_3$ tunnel junctions where the $La_{0.5}Ca_{0.5}MnO_3$ is the interface phase transition layer. We have found that the TER has increased from $\sim$30% (without $La_{0.5}Ca_{0.5}MnO_3$ layer) to 10,000% (with the inserted interface layer).1 The mechanisms of such large enhancement of TER come from two sources: one is the metal to insulator transition of the La0.5Ca0.5MnO3 which effectively change the barrier width for the two polarization states and the other is the polarization driven magnetic phase transition of $La_{0.5}Ca_{0.5}MnO_3$ from ferromagnetic to antiferromagnetic state. The antiferromagnetic phase in the barrier acted as a spin valve for spin polarized tunneling current. The ferroelectric control of the interface magnetic states have been further confirmed in magnetic field dependence of the TER and magnetic second harmonic generation. Details of the experimental results and the comparison with first principles calculation will be discussed. The results have also shown that the tunneling magnetoresistance can be turned on and off with ferroelectric polarization reversal of the barrier.

[1]Work done in collaboration with Y. W. Yin, J. D. Burton, Y.-M. Kim, A. Y. Borisevich, S. J. Pennycook, S. M. Yang, T. W. Noh, A. Gruverman, X. G. Li, E. Y. Tsymbal, H. Zhai, F. Fan, X. Ma, and G. Lüpke and supported by NSF and DOE.