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Enhancement of Tunneling Electroresistance in tunnel junctions using bilyer barriers with ferroelectric driven phase transition

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Ferroelectric and Multiferroic tunnel junctions (magnetic tunnel junction with a ferroelectric barrier) have become one of the very promising approaches to new generation of multifunctional devices. A large tunneling electroresistance (TER) (the resistance on-off ratio) is very desirable for utilizing the device as a resistance switch or for signal processing. We have designed a bilayer tunneling barrier in which one layer is ferroelectric and the other layer is close to metal-insulator as well as ferromagnetic to antiferromagnetic phase transition with a goal to significantly change the barrier parameters and the interface state with the ferroelectric polarization reversal. The phase transition can occur when the ferroelectric polarization is reversed. In $La_{0.7}Sr_{0.3}MnO_3/BaTiO_3/La_{0.5}Ca_{0.5}MnO_3/La_{0.7}Sr_{0.3}MnO_3$ tunnel junctions[1] where the $La_{0.5}Ca_{0.5}MnO_3$ is the phase transition layer, this has resulted an increase of TER from 30% (without the $La_{0.5}Ca_{0.5}MnO_3$) to 10,000% (with the inserted layer). The mechanisms of such large increase of TER come from two sources: one is the metal to insulator transition of the $La_{0.5}Ca_{0.5}MnO_3$ which effectively change the barrier width for the two polarization states and hence the tunneling current; and the other is the polarization driven magnetic reconstruction 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 to significantly reduce the tunneling current. The details of the sample structures, electrical characterization, and the magneto transport studies will be presented and the results will also be compared with the first principles calculation.

[1]Y. W. Yin, et al, *Nature Materials* 12, 397 (2013).