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Combining Mott insulators and ferroelectrics

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We investigated the properties of high quality heterostructures consisting of a Mott insulator, (Ca,Ce)MnO_3 (CCMO) and a ferroelectric, $BiFeO_3$ in the supertetragonal phase (T-BFO) materials. In particular, we studied the electrical response induced by ferroelectric switching in both planar and vertical devices. In the planar geometry, we used thick T-BFO films to explore the possibility to electrically tune the properties of the CCMO compound in a ferroelectric field-effect device with a CCMO channel and a T-BFO gate. Upon polarization reversal of the T-BFO ferroelectric gate, the CMO channel exhibits a nonvolatile resistance switching by a factor of 4 around room temperature, and up to a factor of 10 at 200 K [1]. We also studied Ferroelectric tunnel junctions (FTJs) composed of an ultrathin ferroelectric tunnel barrier of T-BFO sandwiched between a CCMO electrode and a Co/Pt counter-electrode. In these junctions, the tunneling current significantly depends on the orientation of the ferroelectric polarization, resulting in large electroresistance enabling a simple nondestructive readout of the ferroelectric state [2]. FTJs based on ultrathin T-BFO films show fast, stable multistate switching with very high resistance ratios of up to four orders of magnitude [3]. Combined piezoresponse force microscopy (PFM) and electrical measurements give a clear correlation between ferroelectric domain configurations and multiple resistance states They also provide insights into the switching dynamics in response to trains of nanosecond pulses. Additionnaly, we demonstrated the very good endurance and retention characteristics of these FTJs [4].

[1] H Yamada et al., Scientific Reports 3, 2834 (214)
[2] V. Garcia et al, Nature 460, 81 (2009)
[3] H Yamada et al., ACS Nano 7, 53855390 (2013)
[4] S. Boyn et al., Appl. Phys Lett. 104, 052909 (2014)