$La_{1-y}Sr_yMnO_3$ / $Ba_{1-x}Sr_xTiO_3$ Junction Band Structure Tuning Through Combinatorial Interface Chemical Modulation

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Metal / ferroelectric (FE) / Metal junctions, used in nonvolatile memory, energy harvesting and actuation devices, suffer from two interface controlled limiting factors : presence of dead layer for very thin FE films, due to depolarizing field, and high leakage current due to insufficient Schottky barrier height. Band engineering at the interfaces is one solution to circumvent these issues as it was extensively shown in semiconductors. We propose to extend this approach to oxide epitaxial heterostructures using a combinatorial modulation of the interface composition. Chemical modulation of the dielectric and the electrode over a few monolayers allows for the tuning of electronic affinity and band gap of the dielectric and of work function and carrier doping of the electrode. These parameters control the band structure of the heterojunction through the alignment of the Fermi levels. The resulting band bending at the interfaces leads to a built-in voltage suitable for polarization stabilization [1]. The leakage current is controlled by the Schottky barrier (SB) height and width. The SB height depends on the electrode work function and the dielectric electronic affinity [2,3]. The SB width can be modulated by the FE polarization direction through induced metallicity in the FE layer in the vicinity of the interface [4].

We chose the archetypal $Ba_{1-x}Sr_xTiO_3$ as the dielectric material, $La_{1-y}Sr_yMnO_3$ (LSMO) as the electrode material and $SrTiO_3$ as the substrate to obtain an epitaxial growth of the heterostructure by Combinatorial Pulsed Laser Deposition (CPLD). We report here on the sample $La_{0.7}Sr_{0.3}MnO_3$ (22nm)/ $La_{1-y}Sr_yMnO_3$ (1.2nm) /$SrTiO_3$ (0.4-6nm) ($0<y<1$ and $x=1$) in order to set aside polarization effects and focus on the effects of carrier concentration and work function modulations. The LSMO carrier doping level was varied continuously across one sample direction over 10mm, while a unique LSMO composition is kept in the thickness (1.2nm). A shadow mask was used to keep access to LSMO electrode and to vary the $SrTiO_3$ thickness (see figure 1). Local electric (IVs) and electrostatic (Kelvin Probe Microscopy KPM) characterizations were carried out using a UHV AFM without air exposure of the sample. IVs showed strong dependence on the interface carrier concentration with 4 orders of magnitude in the 6V current leakage (Figure 1b). Furthermore, the onset voltage exhibit a discontinuity correlated to the onset of the KPM potential (Figure 1c). These results clearly show the chemical tuning efficiency of the band structure. X-ray Photoelectron Spectroscopy characterizations are underway to shed light on the local band structures [5, 6] and will be discussed versus composition.

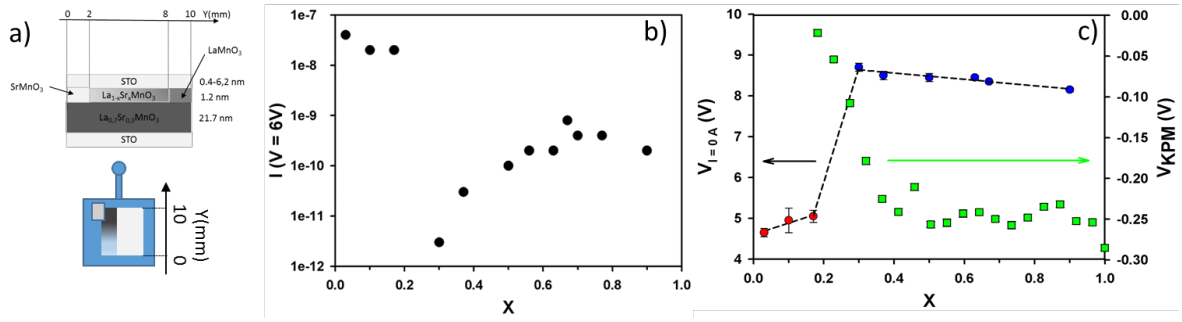

Figure 1: a) Schematic of the sample b) Current leakage versus doping level x and c) Onset voltage and KPM potential

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