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Resistive Random Access Memory Effects in Oxide based planar and MIM structures: Properties and Mechanisms

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Electric Pulse Induced Resistive (EPIR) switching phenomena observed in some oxide compounds has opened up new horizons for potentially most viable alternative to non-volatile memory devices viz. the resistive random access memory (RRAM)[1]. The memory behavior of oxides, based on current-induced bistable resistance effects or voltage-controlled negative resistance phenomena, as observed in compounds such as Nb_2O_5, TiO_2, Ta_2O_5, NiO etc. has been studied in all oxide thin-film heterostructures involving ferroelectrics and simple metal–insulator–metal (MIM) structures[2]. More recently, the observation of room-temperature resistive switching driven by electric fields in various perovskite oxides such as Cr doped $SrTiO_3$ and manganite $Pr_{0.7}Ca_{0.3}MnO_3$ (PCMO) has triggered a lot of interests due to the their potential use for nonvolatile RRAM nano device applications. The latter showed memory retention times exceeding 18 months. Several models based on either the bulk or the interfaces effect, such as the Schottky-like barrier model, the filamentary model, the trap controlled space charge limited current model, and the model involving the dislocations and/or electromigration of oxygen atoms etc., have been proposed; although the exact origin of universal resistance switching behavior in these oxides still remain an open question. In addition, several obstacles, such as the compatibility to modern semiconductor processes, the uniformity of memory behavior, and the retention property of RRAM devices need to be overcome before potential device applications can be considered.

We have systematically undertaken a research to investigate the possible mechanism to explain the resistance switching phenomena induced by electric fields in several binary oxides such as NiO, SnO_2, TiO_2, In_2O_3 as well as PCMO. Both planar structures forming the same pair of metal electrodes and MIM sandwich structures with different pair of top and bottom electrodes were grown by simple chemical solution deposition and pulsed laser ablation. In the present talk, I will present some of our recent results on binary and ternary oxide based RRAM device cells. Possible conduction mechanism in the vicinity of the metal/oxide interface will be reviewed. Our recent findings on the defect states induced resistance switching in binary oxides[3] will also be presented.

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