Reproducible Electric-Pulse Induced Resistive (EPIR) Switch Effect of Manganite Films for Non-volatile Memory Applications

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The manganite perovskite, $Pr_{1-x}Ca_xMnO_3$ (PCMO), exhibits large reproducible nonvolatile resistance changes at room temperature and without applied magnetic field when exposed to moderate DC electric fields or pulsed applied electric fields of varying polarity. Positive or negative voltage pulses can switch the resistance of thin films of the oxide between a low- (Rmin) and a high-impedance (Rmax) state in times shorter than 9ns. A resistance ratio P=(Rmax-Rmin)/Rmin of more than two orders of magnitude has been obtained for samples with an operating temperature range of 23 ^oC to 200 ^oC. The resistance change ratio P remains constant in the temperature range of 23 ^oC to 100 ^oC, but shows a decrease above 120 ^oC with major changes in P above 200^oC. An activation energy of ~110 meV has been extracted from the Arrhenius plots for both the low and high resistance states of the material. The PCMO thin film samples were grown both by RF sputtering and by pulsed laser deposition on crystalline oxide substrates and on Pt/silicon substrates. X-ray diffraction analyses indicated that epitaxial PCMO thin films were grown on YBCO/$LaAlO_3$(001) crystal substrates, and PCMO polycrystalline films were deposited on Pt/$LaAlO_3$(001) and Pt/TiN/SiO_2/Si substrates. PCMO thin films on all substrates were observed to switch although the epitaxial films showed better performance in terms of both magnitude of P and voltage applied to switch. The principles underlying the electric pulse induced resistive switch effect have been analyzed, and will be discussed.