Controlling phase separation in $La_{0.67}Ca_{0.33}MnO_3$ thin films via oxygen deficiencies

B. W. Zhi, Z. Huang, L. F. Wang, X. L. Tan, P. F. Chen, and W. B. Wu

Hefei National Laboratory for Physical Sciences at Microscale, University of Science and Technology of China, Hefei 230026, People's Republic of China

$La_{0.67}Ca_{0.33}MnO_3$, with fixed thickness as 40 nm, were grown coherently on orthorhombic NdGaO3(001) [NGO(001)] and cubic $(LaAlO_3)_{0.3}(Sr_{0.2}AlTaO_6)_{0.7}(001)$ [LSAT(001)] substrates under various deposition oxygen pressures (P_O) by pulsed-laser deposition method. The temperature dependent resistivity (ρ-T) and magnetization (M-T) were carefully examined. For all the as-grown films on LSAT(001) and NGO(001) substrates, the ρ-T curves show bulk-like ferromagnetic-metallic (FMM) ground state, of which the Curie temperature (T_C) changes with P_O. After *ex-situ* anneal in floating O_2, FMM ground state with improved T_C was found in $La_{0.67}Ca_{0.33}MnO_3$ films on LSAT(001). The double-exchange interaction enhances with decreasing oxygen deficiencies, which was widely observed in other groups. Surprisingly, ρ-T behavior of shear-strained LCMO/NGO(001) films are greatly relied on P_O. For details, the films (P_O>30 Pa) show multiple metal-insulator transitions and an "overshot" hysteresis, indicating phase separation (PS) in those samples. By contrast, only metal-like ρ-T is observed in the films under P_O<30 Pa. In addition, the evolution of structure and surface were also examined via X-ray diffraction and atomic force microscopy respectively. All these results reveal the close relationship between PS and oxygen deficiencies, which provides the potential application in such functional oxide thin films.