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Magnetic and transport properties of $La_{0.7}Sr_{0.3}MnO_3/Pr_{0.65}Ca_{0.35}MnO_3$ multilayered films

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$Pr_{0.65}Ca_{0.35}MnO_3$ (PCMO) and $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) have completely different transport properties. For example, PCMO remains in an insulating phase for both paramagnetic and ferromagnetic states, while LSMO shows a metallic behavior in the whole temperature range. In spite of a fact thatthe Curie temperature (T_C) of LSMO exceeds room temperature, it reveals an insignificant magnetoresistance (MR) ratio due to a small value of intrinsic resistivity in the metallic phase. Recently, it was found that the substitution of small-size Pr ions with La in $Pr_{0.67}Ca_{0.33}MnO_3$ induced the metal-insulator (MI) transition at a low temperature because of melting of the charge-ordered insulating state. At the same time, doping of Sr for Ca in $Pr_{0.7}Ca_{0.3-x}Sr_xMnO_3$ result in formation of a low-temperature metallic state. Hence, it is expected that the combination of these two compounds leads to a high MR effect.

In this study, single-crystalline (SC) and polycrystalline (PC) $La_{0.7}Sr_{0.3}MnO_3$/ $Pr_{0.65}Ca_{0.35}MnO_3$ multilayered films (MLF) were prepared by the pulsed-laser deposition method. The structural, the magnetic and the transport properties of these films were investigated. It was found that the transformation from an incoherent to a coherent interface between layers results in an enhancement of the ferromagnetic coupling in the SC MLF. This process is accompanied by a modification in the temperature dependence of resistance from $R \sim T^3$ to $\sim T^{4.5}$ in the ferromagnetic metallic state, and attributed to a transition from the one-to two-magnon-electron scattering. A negative MR ratio of the SC MLF, which reaches almost 60% at room temperature in an applied magnetic field of 5 T, is due to the usual metal-insulator transition in the $La_{0.7}Sr_{0.3}MnO_3$ layers near the Curie temperature. The PC MLF demonstrates the $R \sim T^2$ dependence, which can be explained by an interference between elastic electron scattering at the grain boundaries (GBs) and electron-magnon scattering. An enhancement in the resistance at low temperatures, $R(T) \sim \exp(E_c/T)^{1/2}$, originates from a small Coulomb barrier (E_c), formed at the GBs. The MR of PC MLF turns out to be governed by the spin-polarized tunneling between grains, and can be described in the framework of double-exchange model.