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Transport and Magnetic Properties in $La_{0.67}Ca_{0.33}MnO_3$ Thick Films

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ABSTRACT: We present transport and magnetic measurements in thick films of the perovskite $La_{0.67}Ca_{0.33}MnO_3$ on alumina substrates, made by a conventional paint-on method. In our case the temperature dependence of resistance is characterized by the existence of a broad peak (at 180 K) far below the Curie temperature (240K). The samples show a strong ferromagnetism, while the magnetoresistance coefficient exhibits a general diminishing monotonic behavior with the temperature. We discuss these results, considering the magnetic disorder related with possible local variation of the Mn^{4+}content and its relation with the transport properties.

INTRODUCTION

The perovskite-like $LaMnO_3$ exhibits both strong ferromagnetism (FM) and metallic conductivity, when La^{3+} ions are partially replaced by A^{2+} valence ions (A=Ca, Ba, Sr, Pb and Cd.) [1]. It is reported that this substitution creates a Mn^{3+}- Mn^{4+} mixed valence state, creating mobile charge carriers which couple with the Mn spins [2]. On the other hand in these materials the resistivity (ρ) changes by orders of magnitude when a magnetic field (H) is applied i.e. the magnetoresistance (MR) is colossal (CMR) [3]. The large MR of these compounds is also connected to the strong dependence of ρ on the spin structure and the spin order. The double exchange model (DE) gives an illustrative picture of the correlation of the magnetic order with the electric transport [4]. As is known, the antiferromagnetic phase (AFM) [5] is governed by superexchange (SE) via the oxygen p-shell and possesses a semiconductor behavior with relatively high values of the resistivity and without MR phenomena. That depends on the concentration (x) of the divalent metal (A); in general, for a given range of concentration x (0.21-0.3), ρ exhibits a sharp peak at a temperature T_p near to the Curie temperature (T_c) [6]. The MR has a peak near T_c [3,6]. Although this interpretation is comprehensive for the magnetic transition associated with the insulator to metal transition, there remain many discrepancies between the theoretical predictions and the experimental results for the MR phenomena [7]. In our case, in particular, $La_{0.66}Ca_{0.33}MnO_3$, as it is reported in other works which have used the same composition [8], both "critical" temperatures (T_c and T_p) are somewhat separated; the resistivity shows a broad transition far below T_c and in general the MR decays monotonically, with a little peak near T_c. On the other hand, our samples exhibits a strong ferromagnetism (M=200 emu/g at the saturation field of 5 kOe), which suggests a well defined ferromagnetic phase in apparent contradiction with the transport measurements. In this work, we propose some hypotheses to explain this apparent contradictory behavior.

We have prepared thick films on alumina substrate by a simple paint-on method. The thick film technology could represent the basis for a broad range of applications, where lower cost should be advantageous [9].