Magnetoresistance of the Ferromagnetic Combined System

Seung-Iel Park and Chul Sung Kim *

Department of Physics, Kookmin University, Seoul 136-702, Korea

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For the ferromagnetic combined samples, results of x-ray diffraction patterns showed no evidence of reaction between the La$_{0.67}$Ca$_{0.33}$MnO$_3$, La$_{0.67}$Sr$_{0.33}$MnO$_3$ and CoFe$_2$O$_4$. For the amount of CoFe$_2$O$_4$ increased, the Curie temperature of combined samples showed no appreciable change, whereas a metal-semiconductor transition temperature rapidly decreased. For the La$_{0.67}$Sr$_{0.33}$MnO$_3$ and 20 wt % CoFe$_2$O$_4$ combined sample, the metal-semiconductor transition temperature was decreased to 160 K compared with the La$_{0.67}$Sr$_{0.33}$MnO$_3$ with 192 K.

Key words: Mössbauer spectroscopy, Magnetoresistance, Combined sample, Grain boundary

1. Introduction

The magnetotransport properties of the perovskite La$_{0.67}$A$_{0.33}$MnO$_{3+\delta}$ (A=Ca, Sr etc.) system have received attention recently after the discovery of the colossal magnetoresistance (CMR) effect in the ferromagnetic phase of the system [1, 2]. A prominent feature of these materials is a metal-insulator transition near the ferromagnetic transition temperature [3]. Recent extensive studies have revealed that the doped manganites showed a variety of phenomena besides the large MR effect, such as magnetostructural phase transition [4], magnetovolume effect [5], change-ordering transition [6], magnetic-field-induced insulator to metal transition [7, 8] and grain boundary effect [9, 10]. The grain boundaries and interfaces can be an important factor of low field magnetoresistance in polycrystalline samples [11, 12].

In the present work, we have studied the magnetoresistance properties in combined materials by introducing insulating magnetic CoFe$_2$O$_4$ powders into polycrystalline La$_{0.67}$Ca$_{0.33}$MnO$_3$ and La$_{0.67}$Sr$_{0.33}$MnO$_3$. An amount of CoFe$_2$O$_4$ powder for the combined materials has a weight percentage (wt %) 10, 15 and 20.

2. Experiment

The La$_{0.67}$Ca$_{0.33}$MnO$_3$(LCMO), La$_{0.67}$Sr$_{0.33}$MnO$_3$(LSMO), and CoFe$_2$O$_4$(CF) combined samples were prepared by a sol-gel process by two steps. At first, the La$_{0.67}$Ca$_{0.33}$MnO$_3$, La$_{0.67}$Sr$_{0.33}$MnO$_3$, and CoFe$_2$O$_4$ powders were prepared by a sol-gel process [13]. Second, the LCMO, LSMO, and CF powders were mixed and 1000 °C for 30 min to obtain the La$_{0.67}$Ca$_{0.33}$MnO$_3$ and CoFe$_2$O$_4$, and La$_{0.67}$Sr$_{0.33}$MnO$_3$ and CoFe$_2$O$_4$ combined samples. In the first step, stoichiometric amounts of La(NO$_3$)$_3$·6H$_2$O, Ca(NO$_3$)$_2$·H$_2$O or Sr(CH$_3$CO$_2$)$_2$ and Mn(CH$_3$CO$_2$)$_2$·4H$_2$O were dissolved into 2-methoxyethanol. The stock solutions were refluxed for 24 hours at 80 °C, than distilled H$_2$O was added for hydrolysis. Dried sol-gel was prepared through vacuum distillation of the solution and was dried in a hot oven at about 100 °C. The La$_{0.67}$Ca$_{0.33}$MnO$_3$ and La$_{0.67}$Sr$_{0.33}$MnO$_3$ powders can be obtained after a heat treatment at 1300 °C in O$_2$ for 12 h. The CoFe$_2$O$_4$ powder were also prepared by a similar citrate-gel route and obtained by annealing at 1000 °C for 12 h.

The x-ray diffraction patterns of the samples were obtained with Cu K$_{α}$ radiation. Mössbauer spectra were measured with a $^{57}$Co(Rh) source moving at room temperature while absorbers were kept fixed at room temperature. The temperature dependence of magnetization and magnetoresistance were measured as a function of external field at temperature ranging from 77 to 320 K.

3. Results and Discussion

The x-ray diffraction patterns of LCMO, LSMO, CF and the combined materials with 20 wt % CF at room temperature are shown in Fig. 1. The x-ray spectra of LCMO, LSMO and CF indicate that the perovskite and