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Author(s)	Nguyen, Thi Hoa Hong
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Description	今井捷三，材料科学研究科，博士

Abstract

Effects of Ba doping on physical properties of La-Ca-Mn-O thin films

Nguyen Thi Hoa Hong

Hole doped manganites, $RE_{1-x}AE_xMnO_3$ (where RE is a trivalent rare-earth element and AE is a divalent alkaline earth element), present an exotic magnetoresistance (MR) effect, whereby magnetic fields induce large changes in their resistivity. That effect has been called Colossal Magnetoresistance (CMR) and basically explained by Double Exchange (DE) theory. Recently, experimental results have revealed that the doped manganites show many interesting phenomena besides the large MR effect such as the insulator-to-metal (IM) transition induced by external and internal factors, phase separation, antiferromagnetic metallic phase and so on. Those phenomena are rather complex and DE theory seems to be insufficient to explain them.

The transport and magnetic properties of $La_{1-x}(Ba,Ca)_xMnO_3$ (LBCMO) thin films fabricated by the Pulsed Laser Deposition (PLD) technique were investigated in order to elucidate the effects of the partial substitution of small atom Ca by Ba which is much bigger.

It is found that the doping enables the IM transition in antiferromagnetic insulating (AFI) compositions which are near to the boundaries between ferromagnetic metallic (FMM) and AFI phases and enhances the paramagnetism (PR)-ferromagnetic (FM) transition temperature as well as the IM transition temperature in FM compositions (in some cases, T_C and T_{IM} are very high, about room temperature, therefore, those materials seem to be useful for applications).

Ba doping causes completely different effects in the heavily doped region (x $\geq$ 0.5) and the slightly doped region ($x < 0.5$). In the heavily doped region, Ba substitution causes an anomalous response of the system to the magnetic field. As for $x = 0.55$ and 0.6, when the magnetic field increases, T_{IM} shifts to a lower temperature and a positive MR was observed (or in some other cases, simply the materials become less metallic). This cannot be explained by DE theory. Besides, our magnetization data with very monotonous temperature dependence implies the two possibilities of PS. If we adopt the assumption of DE theory that FM is responsible for the metallic phase, there must be the coexistence and the competition of AFI and FMM domains with small volume. To explain the anomalous field dependence of the resistivity, another possibility for metallic phase at a low temperature region is antiferromagnetic metallic (AFM) state coexisting with the canted antiferromagnetic insulating (CAFI). As for x= 0.65 and 0.8, the transport data shows that there is a metallic phase at low temperatures. From the small magnitude of magnetization, the assumption of the coexistence of AFI and FMM domains with small volume arises again.

As for the slightly doped region (ferromagnetic host), that effect is not observed. There is no anomalous field dependence caused by Ba doping. The significant change is the expansion of FM phase. Both T_C and T_{IM} are enhanced about 40 K. As the results, we obtained samples which transit to FMM at about room temperature and at low field which may be useful for application purposes.

The transport and magnetic properties of La-Ba-Ca-Mn-O thin films show that Ba doping plays a certain role in changing properties of the parent La-Ca-Mn-O system. Besides enabling the induced IM transition, Ba doping makes the FMM phase expanded and Curie temperature enhanced remarkably in the slightly doped region, while it causes many interesting phenomena in the heavily doped region such as the anomalous field dependence, PS as well as the AFM phase.

Furthermore, the comparison between films and bulks that we made was also estimated as important data.

In conclusion, we might say that we have been obtained some important results on perovskite manganese oxide thin films in order to contribute to the knowings about physical properties of this interesting but complicated system.