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Features of magnetic and magneto-optical properties of lanthanum manganite microparticles

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Abstract. For $La_{1-x}Sr_xMnO_3$ powders prepared by the solid-phase reaction method using various thermal regimes and x values, the temperature dependences of magnetization, circular magnetic dichroism (MCD), and diffuse reflectance spectra were studied. The powders synthesis at temperatures of 800–900 °C for 2 h leads to the formation of a multiphase state. The higher temperatures and duration of synthesis lead to the formation of two predominant magnetic phases with the Curie temperature (T_C) of about 250 and 360 K. Correlation is established between magnetic states of the powder and the shape of the diffuse reflection spectra. The strong red shift of the MCD spectrum for the $La_{1-x}Sr_xMnO_3$ powder is revealed comparing to the MCD spectra of $La_{1-x}Sr_xMnO_3$ films available in literature.

1. Introduction

The manganite $R_{1-x}M_xMnO_3$, where R is the trivalent lanthanide and M is the divalent alkaline earth metal attracts considerable attention because of chemical stability, strong correlation between magnetism and transport properties and have potential for such applications as magnetic field sensors, giant magnetoresistive (GMR) elements in spintronic devices, and for creation of thermal stabilized coatings. In Ref. [1], strong changes were revealed of the $La_{1-x}Sr_xMnO_3$ diffusion spectrum shape in visible region in dependence on the synthesis conditions. As this material possesses ferromagnetic order, it is interesting to consider the correlations between the revealed optical peculiarities and the powder magnetic properties which are formed by the different technological regimes and x-values. The magneto-optical MCD and Kerr effect in dependence on the light wave energy and temperature were investigated here alongside with the magnetization dependences on temperature and an external magnetic field to obtain additional information about the samples magnetic phases.

2. Experiment

Two series of $La_{1-x}Sr_xMnO_3$ powders were fabricated by solid-state reaction method [1] from the mixture of La_2O_3, $MnCO_3$ and SrCO at different synthesis parameters. For the first series of samples with fixed x=0.175, the synthesis temperature changed from 900 to 1200 °C, for the second series two-stage annealing of the samples at 800 and 1200 degrees was used, while x varied from 0.15 to 0.25.

3. Results and discussions

For all samples, the effect of the synthesis thermal regimes and Sr concentration on the dependences of magnetization on temperature M(T) and external magnetic field M(H) were established, these results substantially supplemented the XRD data. In the derivative of magnetization with respect to temperature, M(T)/dT, curves (Fig.1.), the peak was observed for all samples at 42 K which was in the total agreement with XRD patterns and corresponded Mn_3O_4 phase. The synthesis temperatures exceeding 1000 °C in the one-stage regime and synthesis in two-stage regime lead to formation of two coexisting magnetic phases (1) with x close to 0.185 and Curie temperature of about 250 K and (2) with x close to 0.4 and Curie temperature of about 360 K.

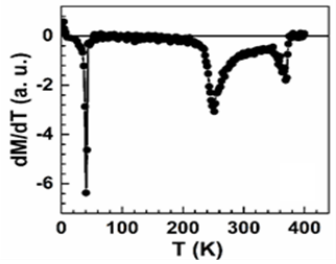

Fig. 1. *Derivative of magnetization with respect to temperature for sample x=0.175 1200 °C, 6 h.*

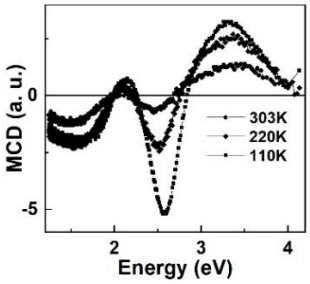

Fig. 2. *MCD spectra at different temperatures for sample x=0.175, 800 °C, 2 h +1200 °C, 2 h.*

For all samples obtained, correlation between M(T) dependences and diffuse reflection spectra was observed. Magnetic circular dichroism (MCD) was studied for the manganite powder samples for the first time. In all cases, the character of the spectral dependence of the MCD (Fig. 2) coincides in shape with the MCD literature data of a thin La0.7Sr0.3MnO3 film, but the entire spectrum is rigidly shifted to lower energies by about 0.5 eV. The most intense maxima of the MCD spectrum in the region of 2.2 and 3.3 eV are assigned to spin-allowed and spin-forbidden electronic transitions in Mn3+ and Mn4+ ions. It should be noted that the MCD data confirmed the assumption of the coexistence of several magnetic phases in the samples under study.

References

[1] M. Mikhailov, V. Vlasov, T. Utebeko et.al., Mater. Res. Bull. **89** (2017) 154.