SINTHESIS, CRYSTAL STRUCTURE, MAGNETIC AND TRANSPORT PROPERTIES OF THE MANGANITE CRYSTALS IN THE $(La_{1-x}Eu_x)_{0.7}Pb_{0.3}MnO_3$ SERIES

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The mixed valence manganites with the perovskite are a popular subject of the investigations due to their intriguing physical properties [1]. In general, unusual magnetic and transport properties of this system result from a crossover from localized to itinerant electronic behavior of $3d$ e_g electrons in presence of localized t_{2g} electrons on the manganese ions [2]. It was found that at fixed hole concentration, which is provided by the fractional occupancy of the A site in the perovskite ABO_3 structure by the divalent $R^{'}$ ions, the transition from localized to charge delocalized state can be easily controlled by isovalent chemical substitution on the A site of the trivalent ions R with different ionic radii. At the same time, the electronic state of the rare-earth ions occupying the A-site influences on the magnetic and electronic structure of the doped manganites, too, although this influence is less understood now.

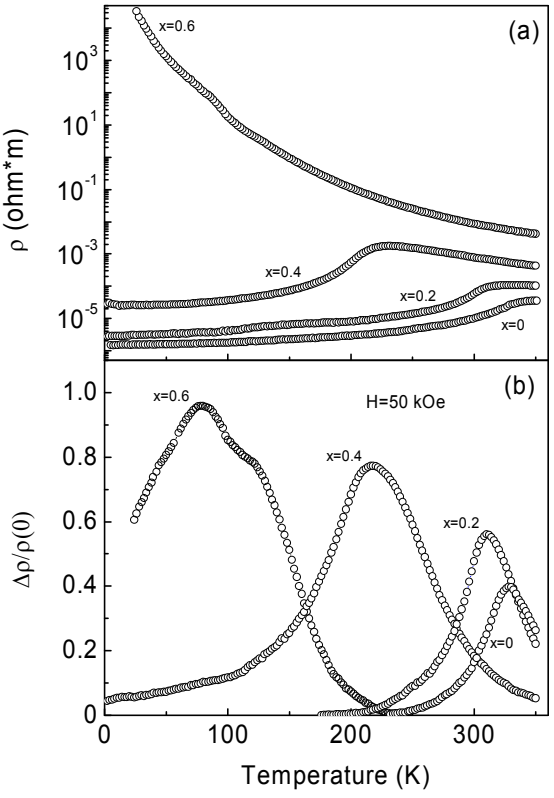

Fig. 1. (a) Temperature dependencies of the resistivity ρ and (b) magnetoresistance $\Delta\rho/\rho(0)$ for $(La_{1-y}Eu_y)_{0.7}Pb_{0.3}MnO_3$ crystals.

We studied the features of the transport, magnetic and magnetic resonance properties in the series of $(La_{1-y}Eu_y)_{0.7}Pb_{0.3}MnO_3$ crystals, resulting from the influence of the Eu ions on the A-site. The single crystals with $y = 0 - 0.6$ were synthesized by the method of spontaneous crystallization from solution in a melt. All crystals show the single phased perovskite-type structure. With doping the structure changes from the rhombohedral ($R\bar{3}c$) for $x = 0$ to the orthorhombic ($Pnma$) for $y = 0.4$, but the $y = 0.6$ sample exhibits the structure with the space group $P4/m$. The substitution of the La ions for Eu results in decreasing of the ferromagnetic (FM) phase transition temperature T_C from 360 K at $y = 0$ to 119 K at $y = 0.6$. The CMR, which takes place in the vicinity of the T_C for the $y < 0.6$ samples, increases with increase of the Eu content, Fig. 1. The $y = 0.6$ sample does not reveal the metal-insulator transition down to the lowest temperature, while the CMR effect is observed in a wide range of temperatures. The saturation magnetization M_S, which measured in the magnetic field up to 30 kOe, remains practically constant

with Eu content increasing for all compositions, except the sample with $y = 0.6$, where M_S noticeably differs from the nominal M_S, expected from formula, Fig. 2. The irreversibility between the ZFC and FC magnetization curves below T_C and possibility of the spin-glass-like state in the samples. The spin-glass behavior is more pronounced for the $y = 0.6$ sample.

The magnetic resonance measurements indicate the inhomogeneity magnetic state in the crystals of all composition in the bounded temperature interval where the CMR phenomenon is observed. With increase of the Eu content this interval considerably expands. Moreover, while for the $y = 0 - 0.4$ crystals the inhomogeneous state are constituted of the coexisting paramagnetic insulating and FM metallic phases, for the $y = 0.6$ crystal the coexistence of the two different FM phases takes place. In respect of magnetic properties, these phases are observed as a spatially separated due to the frustration of the FM double-exchange and antiferromagnetic (AFM) superexchange interactions on the phase boundaries.

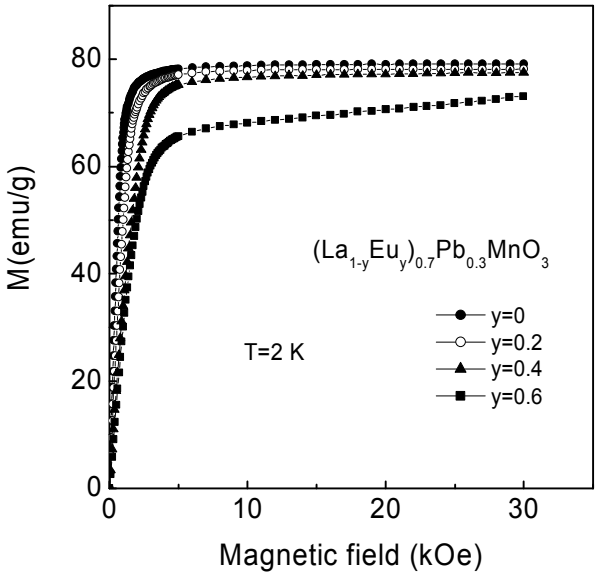

Fig. 2. Magnetic field dependencies of the magnetization for $(La_{1-y}Eu_y)_{0.7}Pb_{0.3}MnO_3$ crystals.

The experimental results are in good agreement with the progressive substitution of La^{3+} for small Eu^{3+} ions. The physical properties of the $(La_{1-y}Eu_y)_{0.7}Pb_{0.3}MnO_3$ compounds are controlled by the ionic size mismatch and the random chemical replacement at the perovskite A-site that causes the deformation MnO_6, bending the Mn-O-Mn, and, as a result, the random distribution of the competing FM and AFM exchange interactions in the system. The latter can induce the state with the magnetic phase separation [3], which is observed in our experiments.

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