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# PECULIARITIES OF MAGNETIC PROPERTIES OF THE $Bi_xLa_{1-x}MnO_3$ ($0.2 \le x \le 0.6$) SYSTEM: CONNECTION WITH THE CONDITIONS OF THE SYNTHESIS UNDER PRESSURE

Solid solutions based on $BiMnO_3$ and $LaMnO_3$ are examples of the systems with a strong relationship of the magnetic and electrical properties. Both manganites have a perovskite structure: $BiMnO_3$ is a multiferroic with the temperature of ferromagnetic ordering $T_C$ = 100 K, the temperature of ferroelectric ordering ~ 750–780 K and monoclinic structure, and $LaMnO_3$ is an antiferromagnetic ($T_N$ = 140 K) with orthorhombic structure.

The synthesis of polycrystalline compounds of the $Bi_xLa_{1-x}MnO_3$ system ($x$ = 0.2, 0.4 and 0.6) with the dispersion of powder grains up to ~ 90 nm was performed by co-precipitation of the hydroxides. The powders of the compounds with the concentration $x$ = = 0.2, 0.4, 0.6 (sample I) have been pressed at 0.2 GPa and calcinated at 800°C (20 h). The powders of the same compounds (samples II) have been compacted at 1000°C and $P$ = 4 GPa (60 s). X-ray diffraction studies showed that all compounds had distorted perovskite structure. The crystal structure of the solid solutions with $x$ = 0.2 and 0.4 is identified as the $Pm3m$ pseudocubic space group, and $x$ = 0.6 is associated with the $C2$ monoclinic one (like $BiMnO_3$).

The results of magnetic (measurements of specific magnetization and magnetic susceptibility) and resonance (electron spin resonance (ESR)) tests have demonstrated the absence of magnetically ordered phase in samples I. With increasing temperature, the intensity of the ESR resonance absorption is reduced, which is typical for paramagnetics. The value of the resonant field (≈ 3400 Oe) does not change with increasing concentration $x$ and is not practically dependent on the temperature. The width and the position of the resonance line is the same for the perpendicular and parallel orientations of the magnetic field. The value of the paramagnetic Curie temperature was estimated on the basis of the temperature dependences of inverse intensity of ESR. The value of the specific magnetization of the $Bi_{0.4}La_{0.6}MnO_3$ compact (II) ($T_C$ = 105 K) is about 100 times more than the value of specific magnetization of the rest of compounds. The presence of ferromagnetic clusters in the $T_C < T < T^*$ temperature range is assumed.

**Keywords:** nanopowders, multiferroics, bismuth-lanthanum manganites, monoclinic structure, pseudocubic structure, magnetic properties, electron spin resonance

**Fig. 1.** X-ray diffractograms of $Bi_xLa_{1-x}MnO_3$ (I) with $x$ = 0.2 (*а*), 0.4 (*б*) and 0.6 (*в*) in Cu $K_\alpha$ radiation at room temperature

**Fig. 2.** ESR spectra of $Bi_{0.2}La_{0.8}MnO_3$ (I) for the parallel orientation of the field in a wide temperature range $T$, K: *1* – 111.2, *2* – 129.3, *3* – 148.5, *4* – 169.0, *5* – 190.9, *6* – 211.8, *7* – 231.5, *8* – 249.1, *9* – 268.4, *10* – 288.7

**Fig. 3.** Typical ESR spectra of $Bi_{0.6}La_{0.4}MnO_3$ (I) for the parallel orientation of magnetic field at $T$ = 100 K (*а*), 190 K (*б*), 272 K (*в*). In the insert: the lines of resonance absorp-

tion at the temperature of 100 K at the perpendicular orientation of magnetic field (····) and the parallel one (—)

**Fig. 4.** Temperature dependence of the resonance field for the $Bi_xLa_{1-x}MnO_3$ (I) samples: □ – $x$ = 0.2, ○ – 0.4, Δ – 0.6

**Fig. 5.** Temperature dependence of the inverse intensity of ESR for the $Bi_{0.6}La_{0.4}MnO_3$ (I) sample. The insert illustrates bismuth concentration dependence of the paramagnetic Curie temperature

**Fig. 6.** Temperature dependences of σ and $\chi^{-1}$ of the compacts II of the samples of $Bi_xLa_{1-x}MnO_3$: *а* – $x$ = 0.2, *б* – 0.4, *в* – 0.6, *г* – 0.8, *д* – 1.0

**Fig. 7.** Temperature dependences of σ (*а*) and $\chi^{-1}$ (*б*) of the $Bi_{0.4}La_{0.6}MnO_3$ (II) sample