1. INTRODUCTION

Cooperative systems of magnetic tunnel junctions (MTJs) based on manganites are of interest due to their ability to enhance magnetoresistance (MR) [1]. Among these systems are the La_{0.7}Sr_{0.3}MnO_{3}/Sb_{2}O_{3} (LSMO) ceramics and the related composites in which insulators filling the intergrain space are used as the second phase [1–6].

Tunnel junctions in the ceramics are located between adjacent ferromagnetic (FM) crystallites having metallic conductivity and separated by thin disordered surface layers with lower conductivity [1, 7, 8]; in the composites, dielectric interlayers play the role of barrier layers. In contrast to single-crystal LSMO, both in the ceramics and in the composites, the low-field magnetoresistance increases at room temperature [2, 5], which is interesting for practical applications. This effect is due to the fact that MTJs actually are filters for spin-polarized electrons, whose current across a sample depends on mutual orientation of the magnetizations of adjacent crystallites and is, consequently, controlled by external magnetic field. It has maximum at parallel magnetization orientation of adjacent magnetic crystallites, and resistance of the sample is minimum, which results in negative magnetoresistance effect.

Moreover, the current of spin-polarized electrons depends on quality of MTJs, which is determined by degree of spin polarization of electrons, its constancy during carrier transport through MTJs, and their scattering by defects in crystallites and barrier layers. LSMO is the most suitable material for the production of magnetoresistance-effective composites, because it provides almost the complete spin polarization of electrons [1], while other factors which affect the MTJ quality, such as sizes of crystallites, material and thickness of barrier layers, and their structural imperfection, can be related to technological parameters, more or less able to be controlled. It should be noted that material of barrier layers has effect on values of the magnetoresistance and its sign [1, 6].

This paper presents the results of the investigation of the magnetoresistance of LSMO-based composites prepared by the original method of synthesis, in which the glass-forming additive Sb_{2}O_{3} is used as the second phase.

2. SAMPLE PREPARATION AND EXPERIMENTAL TECHNIQUE

A glass-forming additive, antimony oxide Sb_{2}O_{3} (5–25%), with the melting point of 570°C, was added to a stoichiometric mixture of La_{2}O_{3}, SrCO_{3}, and Mn_{2}O_{3} for the synthesis of the La_{0.7}Sr_{0.3}MnO_{3} composite. After grinding and homogenization the pressed tablets 8 mm in diameter and 2 mm in thickness were held for synthesis at temperatures from 800 to 1150°C for 4 h and then cooled slowly. The La_{0.7}Sr_{0.3}MnO_{3} structure formation proceeded in the presence of the glass-forming additive. A series of samples with different concentrations of Sb_{2}O_{3} were prepared. The samples were characterized using a Shimadzu XRD-7000 S automated diffractometer (CuK radiation) and a Zeiss Supra 25 scanning electron microscope. The X-ray diffraction patterns were processed by Rietveld method using the Fullprof 2013 software. Electrodes
were applied on developed surfaces of the samples by firing silver paste at 500°C. The resistance of the samples was measured by two-electrode scheme using a direct current (dc) voltmeter–ammeter in magnetic fields of 0–20 kOe at room temperature. The magnetoresistance was calculated by the formula

\[ \text{MR} = \left( \frac{R(H) - R(0)}{R(0)} \right) \times 100\% \]

where \( R(0) \) is the resistance of the sample without field and \( R(H) \) is the resistance in a magnetic field.

3. RESULTS AND DISCUSSION

The technology we used makes it possible to produce samples of the composite in “one step,” because the stage of LSMO synthesis in the presence of the \( \text{Sb}_2\text{O}_3 \) glass-forming additive was combined with the sintering of the ceramics. It was found that dense ceramic samples suitable for the studies are formed at the temperature of synthesis no lower than 900°C. The temperature regime was chosen according to the results of the magnetoresistance studies of the samples containing different concentrations of the dielectric dopant. Figure 1 shows the dependence of the magnetoresistance on the temperature of synthesis, from which it follows that the optimum temperature should be considered 1100°C. At this temperature, the best effect is obtained in the composite samples containing 10 wt % of the glass-forming additive.

Resistance of the samples produced at 1100°C depends considerably on percentage of this additive, as is shown in Fig. 2. It can be assumed that the composite with the optimum magnetoresistance is near the threshold of conduction through crystallites [1, 2].

The X-ray structural study of the samples of this composite revealed the formation of the LSMO perovskite phase with space group \( \text{R}3\text{c} \) (no. 167) and the unit cell parameters \( a = 5.4855 \) Å, \( c = 13.3495 \) Å. The X-ray diffraction pattern of the sample is shown in Fig. 3.

Micrograph of the cleaved plane of the sample is shown in Fig. 4. Image of crystallites of the FM phase can be distinguished in this micrograph as dark areas surrounded by light thin layers of the glass-forming phase. These phases of the composite, probably, are not mutually soluble. The crystallite sizes lie in the range from 0.2 to 3 \( \mu \)m, and thickness of the insulating layer does not exceed 0.15 \( \mu \)m. The FM crystallites...