Dielectric properties of Multiferroic Ceramics of the $Bi_{1-x}La_xFe_{0.50}Sc_{0.50}O_3$ Metastable Solid Solutions System

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Single-phase perovskite ceramics of the $Bi_{1-x}La_xFe_{0.50}Sc_{0.50}O_3$ system can be prepared using the conventional ceramic route, only when the lanthanum substitution rate (x) is at least 80 at.%, while application of the high-pressure synthesis is needed if $x<0.80$. The $Bi_{1-x}La_xFe_{0.50}Sc_{0.50}O_3$ ceramics ($0\leq x\leq 0.80$) were prepared at 6 GPa and 1370-1470 K from the pre-synthesized (10 min at 1140 K at ambient pressure) stoichiometric oxide mixtures. Three structural phases were found in the $Bi_{1-x}La_xFe_{0.50}Sc_{0.50}O_3$ system. The as-prepared phase at $x\leq 0.05$ is an antipolar Pnma with the $\sqrt{2}a_p\times 4a_p\times 2\sqrt{2}a_p$ superstructure. An incommensurately modulated structural phase with the Imma(00γ)s00 superspace group is observed for $0.10\leq x\leq 0.33$, while a non-polar Pnma phase ($\sqrt{2}a_p\times 2a_p\times 2\sqrt{2}a_p$) forms at $x\geq 0.34$. Below TN ~220 K, all the obtained phases exhibit the same long-range G-type antiferromagnetic order with a weak-ferromagnetic component. The very narrow compositional range of $0.33\leq x\leq 0.34$ is of a great interest since it corresponds to solid solutions with T_C close to T_N and, therefore, with the maximal lattice-magnetic coupling effect expected.

The $Bi_{1-x}La_xFe_{0.50}Sc_{0.50}O_3$ ceramics synthesized under high-pressure from the oxide mixtures were rather inhomogeneous and porous. Although quality of those ceramics was satisfactory for structural and magnetic studies, dielectric measurements were hardly possible because of high electrical conductivity. In this work, the advanced preparation methods were applied. The powders corresponding to the compositions with x=0.33 and 0.34 were prepared using a sol-gel method followed by calcination at 870 K. The calcined product was found to be a single-phase perovskite although poorly crystallized. The powders were then sonicated in ethanol media at 4 kW for 10 min. It was found that such a treatment results in further crystallization. Then the powders were compacted and subjected to a quasi-hydrostatic pressure of 8 GPa for 5 min at room temperature. Single-phase dense ceramics were obtained as a result of sintering of the compacts at 800 K for 48 h in air. We report on structure, microstructure characterization and measurements of dielectric response of these ceramics in comparison with those synthesized under high pressure.

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