NAPLES, ITALY 23-27 JUNE
DSL2025 NAPLES
21st International Conference on Diffusion in Solids and Liquids

ABSTRACT

Magnetic phase transitions in multiferroic perovskite solid solutions based on $BiFeO_3$

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Lead-free materials with piezo properties comparable to those observed in lead zirconate-titanate at the morphotropic phase boundary are of current application interest. Most of the reported single-phase perovskite $BiFe_{1-y}B^{3+}_yO_3$ compositions with $y>0.1$ can be prepared only using the high-pressure synthesis technique and demonstrate a series of structural transitions with increasing y. The annealing of the as-prepared metastable perovskites may result in irreversible transformations into new perovskite phases with unique combinations of ferroic orders [1]. Particularly, in the $0.1\leq y<0.3$ range of the $BiFe_{1-y}Sc_yO_3$ solid solution system, the anomalies associated with possible transitions between three different antiferromagnetic (AFM) structures (collinear, canted, and cycloidal spin arrangements) were observed below Néel temperature (T_N) [2]. Therefore, the Fe-rich compositional range of the $BiFe_{1-y}[Zn_{0.5}Ti_{0.5}]_yO_3$ with $y=0.05$-0.25 was studied. The $T_N(y)$ evolution was compared with that reported for compositions of the $BiFe_{1-y}B^{3+}_yO_3$ family with B^{3+}= Co, Mn, Cr, and Sc. It showed the same general trend, independent of both the type (magnetic or non-magnetic) and the size of substituting ion. The study of the temperature-dependent magnetic moment revealed similarities to $BiFe_{1-y}Sc_yO_3$, but possible transformation between different AFM structures was observed only for $y\geq0.2$. In addition, the short- and long-range structural distortions due to substitution or mechanical strain in $BiFeO_3$ may induce uncompensated induced ferromagnetic moment because of the suppression of cycloidal order or appearance of spin-canting. The evidence of the spin-canting is pronounced in all $BiFe_{1-y}[Zn_{0.5}Ti_{0.5}]_yO_3$ samples by a jump in magnetization close to a zero magnetic field, and the magnetization loops have a much higher coercive field in comparison to those observed in $BiFe_{1-y}Sc_yO_3$, up to 4.63 kOe found in the annealed $BiFe_{0.85}[Zn_{0.5}Ti_{0.5}]_{0.15}O_3$ at 300 K.

This work was supported by APVV-22-0172, APVV-23-0006, and APVV-SK-BY-RD-19-0008 / T20SLKG-001.

[1] D.D. Khalyavin, et al., ChemComm. 55, 4683 (2019).
[2] E.L. Fertman, et al., Crystals 10, 950 (2020).