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Phase formation and functional properties of lead-free ceramics

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Development of lead-free piezoelectric ceramics comprises a task stimulated by both ecological problems and demands of various industries. Moreover, the compositions with high Curie temperature T_C value > 700 K are very perspective for applications at high temperatures.

The perovskite structure lead-free compounds $(K_{0.5}Na_{0.5})NbO_3$, $(Na_{0.5}Bi_{0.5})TiO_3$, $(Bi_{0.5}Mg_{0.5})TiO_3$, and $BiFeO_3$ reveal high T_C values, so they may be used as basic oxides for the development of new materials for high temperature applications [1-3].

However, preparation of dense ceramics is rather difficult due to the Bi^{3+}, K^+ and Na^+ oxides losses during sintering at high temperatures, so various additives with low melting temperatures may be useful [4, 5].

In this work, ceramic solid solutions with compositions close to the Morphotropic Phase Boundaries (MPB) in the systems $(1-y)[(1-x)(Na_{0.5}Bi_{0.5})TiO_3 - x(K_{0.5}Na_{0.5})NbO_3] - yBiFeO_3$ (system I) and $(1-y)[(1-x)BiFeO_3 - xBaTiO_3] - yBi(Mg_{0.5}Ti_{0.5})O_3$ (system II) (x, y < 0.25) were prepared by the solid-state reaction method at temperatures 800 – 1200°C. To improve sintering various additives with low melting temperatures (Bi_2O_3, KCl, V_2O_5, etc.) were used.

To control phase formation, crystal structure, microstructure, dielectric and ferroelectric properties of ceramics, the X-ray Diffraction, Scanning Electron Microscopy, Second Harmonic Generation and Dielectric Spectroscopy methods were used.

Depending on composition, type and amount of additives, and synthesis conditions, formation of solid solutions with different relative contents of rhombohedral (pseudocubic) and/or tetragonal perovskite phases was proved.

The influence of phase content, structure parameters and microstructure of ceramics in the systems I and II on Curie temperature T_C value and effects of dielectric relaxation was revealed, the possibility of the piezoelectric properties enhancement in modified ceramics discussed.

The results obtained confirmed advantages of the new functional materials development for high temperature applications using the compositions studied.

References
[1] Y. Saito, H. Takao, T. Tani, T. Nonoyama, K. Takatori, T. Homma, T. Nagaya & M. Nakamura, Lead-free piezoceramics, Nature, vol. 432, pp. 84–87 (2004).
[2] V.V. Shvartsman and D.C. Lupascu, Lead-Free Relaxor Ferroelectrics, J.Am. Ceram. Soc., vol. 95 pp. 1–26 (2012).
[3] I. Coondoo, N. Panwar and A. Kholkin, Lead-free piezoelectric Current status and perspectives, J. Adv. Dielectrics vol. 3, 1330002 (22 pages) (2013).
[4] G.M. Kaleva, A.V. Mosunov, S.Yu. Stefanovich, and E.D. Politova, Preparation and Dielectric Properties of Potassium Sodium Niobate-Based Solid Solutions, Inorganic materials, vol. 46, pp. 826–833 (2010).
[5] E.D. Politova, G.M. Kaleva, N.V. Golubko, A.V. Mosunov, V.S. Aksenov, S.Yu. Stefanovich, E.A. Fortalnova, Influence of NaCl/LiF additives on structure, microstructure and phase transitions of $(K_{0.5}Na_{0.5})NbO_3$ ceramics, Ferroelectrics (Accepted) 2015

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