Multiferoinės kompozitinės medžiagos fosfato matricų pagrindu

Phosphate matrix based multiferroic composite materials

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The materials, which simultaneously exhibit two or more ferroic orders are known as multiferroics. The different ferroic ordering parameters do not act independently, but coupled. The single-phase multiferroics are rare, their coupling coefficients are weak and appears at low temperatures. The two-phase composites with ferroelectric and ferri- ferromagnetic phases is a prospective alternative. The critical point in these composite materials synthesis is the reactions at the interfaces between the different phases upon sintering.

As an alternative, the matrix-based composite approach may be proposed. Aluminium phosphate ceramics are the perfect candidate for the role of the matrix: it is chemically and thermally stable, the hardening temperature is relatively low (20–300 ºC). We report on the study of the two series of the phosphate-based composite systems. The first system is the composites filled with the mixture nanosized $BaTiO_3$ and Fe_3O_4. The second system is the composites filled with $0.7Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.3PbTiO_3$ (PMN-0.3PT) and pressed under different pressures (3, 6 and 8 tonns).

Ceramic composites consist of 3 components, i.e., a binder ($Al(H_2PO_4)_3$), a filler (a mixture of Al_2O_3 and AlN for the first system, and MgO for the second), and a functional filler. The components were mixed in a mortar for 10 min and uniaxially pressed into the 10 mm tablets. After 24 h at ambient temperature, samples were thermally treated up to 300 ºC with a heating rate of 1 ºC/min.

The comparative X-ray diffraction analysis of the sample filled with $BaTiO_3$ and Fe_3O_4 (BTFO) and the phosphate matrix is presented in Fig. 1. The XRD indicates the presence of the barium titanate, magnetite and matrix peaks (Al_2O_3 and AlN). The small amount of the amorphous phase is expected as a product of the acid-base reactions, but in the studied case the halo was not detected. No additional peaks of possible side products were detected.

The electromechanical properties and hysteresis loop of the PMN-0.3PT filled samples were measured at the frequency of 10 Hz at room temperature (Fig. 2). The shapes of the displacement and P-E loops are not so sharp, compared to the pure PMN-0.3PT ceramics. This difference might relate to the impact of the matrix. It effects on the overall elastic properties of the composite and introduces additional losses to the system.

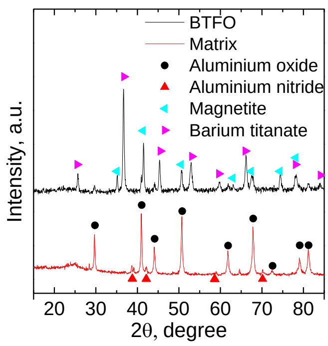

Fig 1. X-ray difraction pattern for the matrix and composite filled with $BaTiO_3$ and Fe_3O_4.

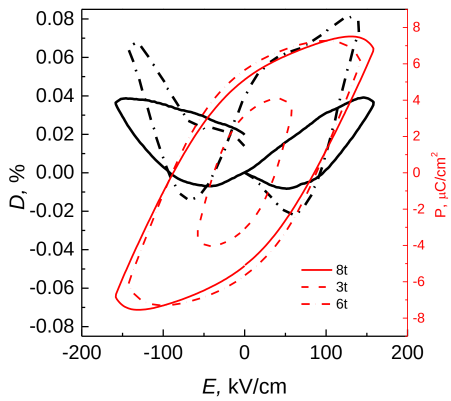

Fig 2. The strain and P-E hysteresis loops of the PMN-0.3PT filled sample.

Keywords: multiferroic composites, phosphates

Literature

[1] Grigalaitis, R. et al. Ceram. Int., 40, 6165–6170, (2014).

Acknowledgements

A.P. is supported by the European Social Fund under the No 09.3.3-LMT-K-712-19-0146 "Development of Competences of Scientists, other Researchers and Students through Practical Research Activities".