Magnetoelektrinė sąveika fosfatais surištuose $BaTiO_3 - x CoFe_2O_4$ multiferoiniuose komopozituose.

Magnetoelectric coupling in phosphate-bonded bulk $BaTiO_3 - x CoFe_2O_4$ multiferroic composites.

A. Plyushch[1], D. Lewin[2], R. Grigalaitis[1], V.V. Shvartsman[2], J. Macutkevič[1],
P. Kuzhir[3], D.C. Lupascu[2] and J. Banys[1]
[1]Faculty of Physics, Vilnius University, Sauletekio Al. 9, Vilnius, LT-10222, Lithuania,
[2]Institute for Materials Science and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Universitatsstraße 15, 45141 Essen,
[3]University of Eastern Finland, Yliopistokatu 7,Joensuu, FI-80101, Finland

artyom.plyushch@ff.vu.lt

Magnetoelectric composite multiferroics are materials that can be polarized through the application of an external magnetic field or magnetized with an external electric field. Magnetoelectric materials are promissing for a wide range of practical applications in multifunctional devices such as AC and DC magnetic field sensors, current sensors, energy harvesters, transducers, memories and spintronic logics, and microwave interference shielding materials. In contrast to single-phase multiferroics, like $BiFeO_3$, composite muliferroics demonstrate an enhanced working temperature range and higher coupling coefficients. The coupling in two-phase composites usually occurs through the mechanical strain mediation at the interfaces. Therefore, the mechanical contact of the different phases is a factor the extreme importance in material design.

The critical step in the synthesis of the magnetoelectric materials is the sintering of the ferroelectric and ferromagnetic (FE and FM) components into one material since their chemical and structural properties are very different. Due to interdiffusions and high-temperature reactions, the purity of the FE and FM phases drastically decreases [1,2]. This reduces possible combinations of FE and FM powders that can be sintered together, down to very few acctualy feasible, like $BaTiO_3$ - $CoFe_2O_4$ or $BaTiO_3$ - $NiFe_2O_4$. But even working with these material pairs, researchers encounter many difficulties.

The report delivers a novel approach to the synthesis of composite magnetoelectrics. Phosphate binding of powders was utilised instead of the sintering. Such a method allows avoiding the unexpected reactions at interfaces, diffusion. At the same time, the absence of the sintering step means that grains of both phases remain of the same size. That allows to develop of composites with extremely high interface surface area. Bulk $BaTiO_3$-$xCoFe_2O_4$, x=0.1–0.6 magnetoelectric composites were prepared using the phosphate bonded ceramics approach. XRD analysis proved the purity of both phases. The dielectric properties are governed by a series of composition-dependent Maxwell-Wagner relaxations and conductivity at lower frequencies and a phase transition-related anomaly at higher frequencies. A dielectric constant as high as 616 – 9387i is observed at 500 K for x=0.6. The measured direct magnetoelectric coupling coefficient of 1.1 mV Oe^{-1} cm^{-1} is higher than that of the conventionally sintered ceramics and compatible with that of core-shell structures.

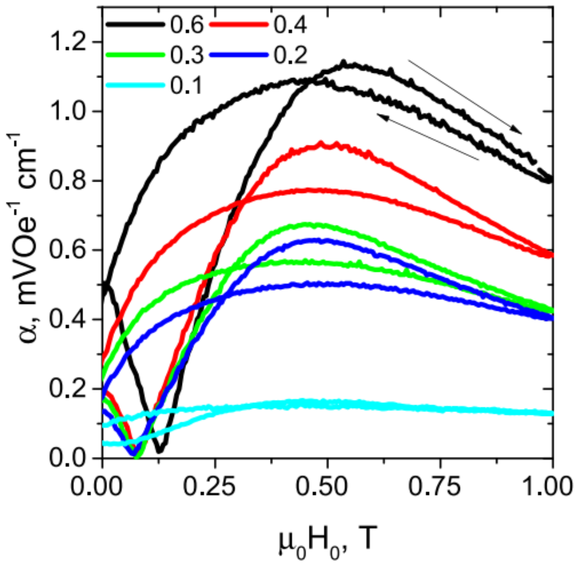

Figure 1: Amplitude of the magneto-electric coupling coefficient for the samples with different x.

Keywords: phosphate-bonded ceramics, barium titanate, cobalt ferrite, multiferroics, magnetoelectrics, mangetoelectric coupling.

Literature

[1] C. Gumiel, M.S. Bernardo, P.G. Villanueva, T. Jardiel, J. De Frutos, A.C. Caballero, M. Peiteado, J. Mater. Sci. **52**(7), 4042–4051, (2017).
[2] M. Murakami, K.-S. Chang, M. Aronova, C.-L. Lin, M.H. Yu, J.H. Simpers, M. Wuttig, I. Takeuchi, C. Gao, B. Hu, et al., Appl. Phys. Lett. **87** (11), (2005).