

Functional properties of BaTiO₃-Fe₂O₃ magnetoelectric ceramics

Larisa Mazilu^{1,2}, George Stoian^{1,2}, Petronel Postolache¹, Lavinia Curecheriu^{1*}

¹Dielectrics, Ferroelectrics & Multiferroics Group, Faculty of Physics, “Al. I. Cuza” University of Iasi, 11 Carol I Bv., 700506, Iasi, Romania

²National Institute of Research and Development for Technical Physics, Iasi 700050, Romania

***Email:** lavinia.curecheriu@uaic.ro

Abstract: These days, a lot of work has gone into designing and controlling the preparation of multifunctional materials to meet the needs of modern technologies. These materials are multi-phase systems where the functional features come from the combination of materials with diverse compositions, interphase interaction, interconnectivity, and the relative size and form of the distinct phases. One of the more interesting types of these materials in the last ten years is multiferroic magnetoelectric composites (ME). These materials have gotten a lot of attention since they can be used in memory elements, transducers, electro-optic devices, and wireless communications.

In the present paper we demonstrate that by changing ratio and sintering strategy in BaTiO₃ and Fe₂O₃ phases in composites, the formation of different magnetic phases can be promoted to induce completely different functional properties of the final ceramic composites. The functional properties of BaTiO₃-Fe₂O₃ composite ceramics with different ferroelectric/magnetic ratio and densified by Spark Plasma Sintering (SPS) are comparatively analysed and discussed in relationship with their phase composition.

Dielectric properties of the dense ceramics were determined in a wide frequency (1 Hz-1 MHz) and temperature (20-150°C) and discussed in correlation with the sample microstructures, composition and degree of phase connectivity. Thus, at lower temperatures the interfacial polarization between ferroelectric and ferromagnetic phases is predominant, while at room temperature and above it the behaviour strongly depends on the composition: below the percolation threshold the conductivity plateau was not observed even at high temperature, while above percolation the plateau was detected.

Peculiar magnetic properties, including “wasp-waisted” constricted M(H) loops were determined as result of the formation of magnetic phases with contrasting magnetic coercivities (hard/soft phases). First-order-reversal FORC method was employed to determine the Preisach-like distribution over coercivities and interaction fields and detect the new magnetic properties induced by secondary phases. This method allowed detecting magnetic components with contrasting coercivities formed at interfaces, in very small amounts below the XRD detection limits (*e.g.* the transformation of Fe₂O₃/Fe₃O₄ under reducing conditions).

Keywords: magnetoelectric materials, dielectric properties, magnetic characteristics, ferroelectric properties

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