ROZPRAWA DOKTORSKA

Synteza i własności mikro- i nano- struktur magnetoelektrycznego multiferroika $BiFeO_3$

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1 Abstract

The present dissertation is devoted to the synthesis and studies of structural, magnetic and dielectric properties of a unique compound, which is bismuth ferrite $BiFeO_3$ (BFO). Bismuth ferrite is one of the few single-phase substances that exhibit magnetoelectric multiferroic properties at room temperature. Multiferroics are also considered as so-called "smart materials", namely materials with properties that can be significantly changed in a controlled way by external stimuli [1]. They are essential in modern technology since they can work as high-sensitivity sensors and simultaneously perform functions of gathering and processing information. Particularly noteworthy in the family of smart materials are magnetoelectric multiferroics in which the magnetization M can be adjusted by means of an external electric field E and the dielectric polarization P through the magnetic field H. This type of multiferroics are used in microelectronics, advanced information technology and nanodevices.

Nowadays, nanotechnology is one of the most developing areas of solid state physics. Physical and chemical properties of nanomaterials strongly depend on their size and morphology. As a result, scientists have focused their efforts on the development of simple and effective methods to fabricate nanomaterials with a controlled size and morphology, thereby tailoring their properties.

The studies presented in the following dissertation refer to polycrystalline micro- and nano- materials obtained by microwave-hydrothermal synthesis. Use of this method in inorganic materials synthesis is at the beginning and it is currently under development. In this thesis, however, was shown that the control of synthesis parameters influences the morphology and size of obtained samples.

To achieve the objectives of this dissertation a numbers of methods were used, such as: X-ray diffraction, scanning electron microscopy, magnetometry and impedance spectroscopy. X-ray diffraction was used for identifying the purity and crystallinity of obtained compound. It also allowed to determine the lattice parameters and the average size of crystallites. Scanning electron microscopy methods were used to determine the morphology, elemental composition and the local crystal structure of obtained materials. Magnetometric studies allowed to determine the nature and type of magnetic interactions in BFO samples. Impedance spectroscopy studies was used to investigate the dielectric response of BFO and to determine the relaxation processes taking place in samples.

By means of precise control of shape and size of BFO structures (cubes, spheres, flakes and “nanoflowers”) it was possible to enhance magnetic properties of samples like remanence and magnetization that are crucial parameters specifying magnetoelectric coupling. Furthermore size control of BFO structures allowed to modify two from three main relaxation processes determining dielectric properties of BFO (relaxation at the grain boundaries and interaction of oxygen defects with ferroelectric domain walls).