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Structural, Ferroelectric, and Magnetic Properties of Pure and Doped $BiFeO_3$

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His expertise is in the fields of Electroceramics (Varistors, Ferroelectrics, Magnetic Materials, Multiferroics), Grain Boundary Phenomena, Materials for Energy Applications (Materials for SOFC, Photovoltaics, Thermoelectrics), Nanomaterial Design and Synthesis, Sintering and Ceramics Processing, Electrochemistry; Solid State Reactions, Thin Films Deposition.

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Bismuth ferrite is a unique multiferroic material because it exhibits both electric and magnetic ordering at room temperature. It has a rombohedrally distorted perovskite structure (space group R3c). Below its Curie temperature (T_C= 826–845 ° C) it shows spontaneous polarization along one of the eight pseudo-cubic [1 1 1] axes. Furthermore, $BiFeO_3$ has two magnetic ordering, both antiferromagmetic, G-type of antiferromagnetism and cycloidal (spiral) spin structure with a long modulation period λ = 620–640 Å. Néel temperature is T_N= 370 ° C. Magnetoelectric coupling occurs due to weak ferromagnetism and/or spatial distribution of magnetic moments.

However, high leakage current, low remnant magnetic polarization, a high electric coercive field, and challenges in achieving a pure phase remain significant drawbacks that hinder the practical use of $BiFeO_3$ in electronics. Great effort has been made to obtain dense single-phase $BiFeO_3$, but so far it has been proven to be quite a difficult task. The preparation of pure $BiFeO_3$ powders and ceramics is still a challenging issue because of a narrow temperature range of phase stabilization. Furthermore, $BiFeO_3$ is metastable in the air and above 675 ° C decomposes gradually into Bi_2O_3, $Bi_2Fe_4O_9$ and $Bi_{25}FeO_{39}$, whereas the density of ceramics sintered below 675 ° C is very low.

In this work we applied hydro-evaporation and hydrothermal method of synthesis of $BiFeO_3$ which did not require calcination at high temperatures. In this way we obtained powders with even 99.9 % of purity under optimal conditions. Powders were further sintered and their microstructural, structural, ferroelectric and magnetic properties were investigated.

The other approach to improve ferroelectric and magnetic properties was doping with aliovalent Nb and rare-earth elements such as Gd, La and Eu. Detailed characterization of doped samples prepared by hydro-evaporation method showed that combination of optimal synthesis method and certain dopants can significantly improve microstructure, reduce leakage current and improve ferroelectric and magnetic properties of $BiFeO_3$ ceramics.