THE HYDROTHERMAL SYNTHESIS OF PROMISING MULTIFERROIC PIEZOCERAMICS

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Abstract

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Motivation

Lead-free piezoceramics aiming at replacing the market-dominant lead-based ones have been extensively searched for more than a decade worldwide [1]. From the beginning, the goal was obviously to develop lead-free piezoceramics whose properties are no less than those of the market-dominating lead zirconate titanate (PZT). With the functionality of interconverting mechanical and electrical energy, piezoelectric materials have the versatility to address a wide range of applications, including actuators, sensors, and transducer devices [2]. Multiferroics have been known to have ferromagnetic and ferroelectric properties at the same time, with interesting physical properties as well as the possibility of the practical applications for new memory devices. Multiferroic piezoceramics maintain considerable piezoelectricity, whilst presenting challenges in terms of processing of single-phase material. The synthesis of high-purity of $BiFeO_3$ (BFO) ceramic using solid-state reaction is known to be very difficult due to inevitable formation of the secondary phases, mostly mullite-type $Bi_2Fe_4O_9$ and sillenite-type $Bi_{25}FeO_{39}$ [3]**.**

Methodology of Research

In this study, we report the synthesis and characterization of $BiFeO_3$ by hydrothermal methods using $Bi(NO_3)_3\ 5H_2O$ and $Fe(NO_3)_3\ 9H_2O$ as precursors with a solution of 1M NaOH as mineralizer at a 200℃ temperature for 12 hours. In typical synthesis process, the precursors were mixed in 15 ml of water. a temperature of 200℃, 12 hours.

Results and Comparison with State-of-the-art

The structure of $BiFeO_3$ was determined by powder X-ray diffraction (XRD) PW 3040/60 X'Pert PRO using Cu-Kα radiation with (λ=1.5418Å), in the range 2θ = 10-80°, at room temperature (Fig. 1b). A Scanning Electron Microscope InspectS (SEM) was used to observe the morphology of synthesized nanocrystals (Fig. 1a). The diffuse reflectance spectra (DSR) was obtained using a Lambda 950 UV-Vis-NIR Spectrophotometer with 150 mm integrating sphere in the wavelength range of 300–800 nm.

Conclusions

In summary, $BiFeO_3$ particles were obtained by hydrothermal synthesis at 200℃ for 12 hours with 1M NaOH. The preliminary studies on the structure of the obtained powder, present a rhombohedral unit cell and space group R3c but that changes at temperatures above 200℃, when a phase-change occurs.

In our upcoming work, the dielectric properties of this polymorph $BiFeO_3$ and its applications in the medical sensors will be studied.

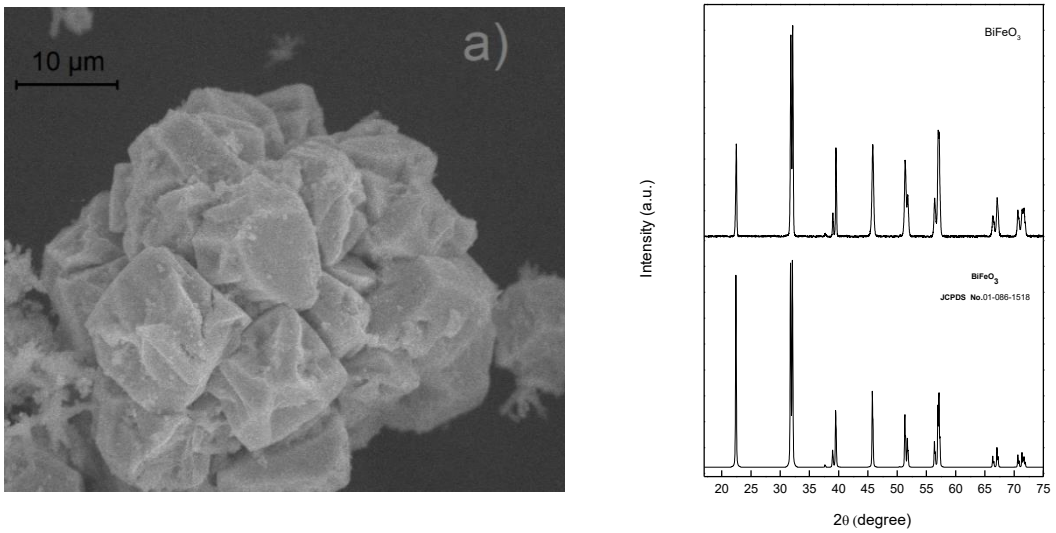

Figure 1. a) SEM image and b) X-ray diffraction patterns of $BiFeO_3$ obtained frrom hydrothermal methods using $Bi(NO_3)_3$ $5H_2O$ and $Fe(NO_3)_3$ $9H_2O$ as precursors with a solution of 1M NaOH as mineralizer at a 200℃ temperature for 12 hours.

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