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Synthesis and Ferroic Properties of Rapid Sintered and Quenched $BiFeO_3$ Magnetoelectric Ceramics

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Abstract –$BiFeO_3$ magnetoelectric powders, obtained by high-energy ball milling technique, were submitted to rapid sintering followed by quenching for high resistivity and single-phase formation improvements. The ferroic properties of processed ceramics were investigated and revealed high-resistive ferroelectrically ordered samples, with strained rhombohedral (R3c) symmetric perovskite structures.

Multiferroic are materials that exhibit simultaneously ferroelectric, ferromagnetic and ferroelasticity in the same phase (or, at least, two of them). This means that they have a spontaneous magnetization that can be reoriented by an applied magnetic field, a spontaneous polarization that can be reoriented by an applied electric field, and a spontaneous deformation that can be reoriented by an applied stress [1]. Magnetoelectric are materials that exhibit ferroelectric and ferromagnetic order in the same phase. These materials offer an opportunity for potential applications in information storage, such as spintronic devices and sensors, where both electric and magnetic order parameters can be coupled, giving an extra degree of freedom, making possible the development of multiple-state non-volatile memories [2]. Higher than these, other devices have been suggested, such as electric-field-controlled ferromagnetic resonance devices, and transducers with magnetically modulated piezoelectricity [1].

$BiFeO_3$ is one of the most investigated multiferroic magnetoelectric materials [3] because this compound exhibit simultaneously ferroelectric (T_C ~ 770 – 830 ^{o}C) and ferromagnetic order (T_N ~ 370 ^{o}C) in the same phase at room temperature. Many studies, concerning electric and magnetic properties of $BiFeO_3$, have been conducted in the last years. However, an adequate study of this intrinsic properties still being hindered because of the easy formation of secondary phases during synthesis and the low resistivity of $BiFeO_3$ samples [4,5]. The low resistivity of $BiFeO_3$ ceramics is mainly induced by the existence of Fe^{2+} and oxygen vacancies. In fact, these defects have detrimental effects on magnetic properties of $BiFeO_3$, and also make observation of intrinsic (well-saturated) electrical polarization very difficult. In this sense, rapid sintering, followed by quenching, could be an alternative in achievement of single phase and high-resistive samples [4,6].

In this work, a careful study concerning rapid sintering and quenching protocols for processing multiferroic magnetoelectric $BiFeO_3$ ceramics by using high-energy ball milled powders, was carried out. The optimization of temperature and sintering time, as well as quenching protocol, were investigated using scanning electron microscopy, which revealed highly densified samples, figure 1. The ferroic properties of sintered ceramics were carefully investigated, revealing magnetically (antiferromagnetic) and ferroelectrically ordered samples, with highly strained perovskite structure (R3c space group).

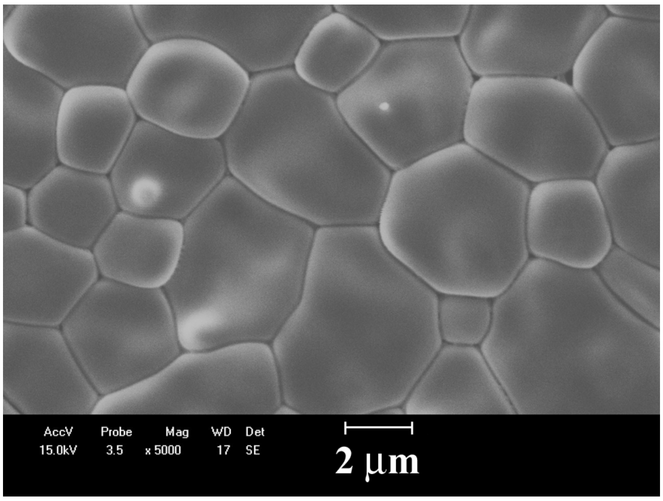

Figure 1: Scanning electron microscopy image of $BiFeO_3$ ceramic obtained by quenching (in air) of high-energy ball milled (60 min/200 rpm) powders sintered at 900 ^{o}C/5 min.

References

[1] N. A. Hill, J. Phys. Chem. B 104 (2000), p. 6694-6709;
[2] A. K. Pradhan et all, J. Appl. Phys. 97 (2005), 093903;
[3] M. Valant, A.-K. Axelsson, and N. Alford, Chem. Mater. 19 (2007), p. 5431-5436;
[4] S. T. Zhang, M. H. Lu, D. Wu, Y. F. Chen, and N. B. Ming, Appl. Phys. Lett. 87 (2005), 262907;
[5] G. L. Yuan, S. W. Or, Y. P. Wang, Z. G. Liu, and J. M. Liu, Solid State Commun. 138 (2006), p. 76-81;
[6] X. T. Zhang, L.-H. Pang, Y. Zhang, M.-H. Lu, and Y.-F. Chen, J. Appl. Phys. 100 (2006), 114108.