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Enhanced Magnetization in Pre-Nanocrystalline $BiFeO_3$ Prepared by Mechanosynthesis

K. L. Da Silva,[*,1,2] D. Menzel,[3] A. Feldhoff,[4] A. Paesano Jr.,[2] V. Šepelák,[5] F. J. Litterst,[3] K.-D. Becker*[2]

[1] Braunschweig University of Technology, Institute of Physical and Theoretical Chemistry, Hans-Sommer-Str. 10, 38106 Braunschweig, Germany
[2] State University of Maringá, Department of Physics, Av. Colombo, 5790, 87020-900 Maringá Brazil
[3] Braunschweig University of Technology, Institute of Condensed Matter Physics, Mendelssohnstr. 2-3, 38106 Braunschweig, Germany
[4] Leibniz University Hannover, Institute of Physical Chemistry and Electrochemistry, Callinstr. 3a, 30167 Hannover, Germany
[5] Karlsruhe Institute of Technology, Institute of Nanotechnology, Hermann-von-Helmholtz-Platz 1, 76347 Eggenstein-Leopoldshafen, Germany

E-Mail: lucenildodasilva@yahoo.com.br

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Multiferroics are promising materials for the design and synthesis of multifunctional materials. They are noteworthy for their unique and strong coupling of electric, magnetic, and structural order parameters, giving rise to simultaneous ferroelectricity, ferromagnetism, and ferroelasticity [1]. $BiFeO_3$ (BFO) is one of the most studied multiferroics, exhibiting antiferromagnetic and ferroelectric properties at room temperature [2]. In spite of intense study, a fundamental understanding of structure-property correlations in $BiFeO_3$ is still lacking. Specifically, the fundamental dependence of its magnetic behavior on the particle size is an issue of interest.

In the present work, a one–step synthesis of BFO prepared via mechanochemical processing of the α-Fe_2O_3/Bi_2O_3 mixture at room temperature is reported. The mechanically induced phase evolution of the mixture is followed by XRD (Fig. 1) and ^{57}Fe Mössbauer spectroscopy (Fig. 2). It was revealed that the mechanosynthesis of BFO phase is completed after 12 h. Compared to the traditional synthesis (ceramic) route to BFO, the mechanochemical process used here represents a one-step, high-yield, low-temperature and low-cost procedure for the synthesis of BFO.

High-resolution TEM studies revealed the nanocrystalline nature of the mechanosynthesized ferrite. The rhombohedral structure of the as-prepared BFO with space group R3c was refined using Rietveld method. Mössbauer spectroscopy revealed the superparamagnetic state of the nanocrystalline ferrite at room temperature.

Quantitative information on the short-range structure, provided by the nuclear spectroscopic technique, is complemented by the investigation of the magnetic behavior (SQUID measurements) of mechanochemically prepared BFO on a macroscopic scale. The saturation magnetization of the mechanosynthesized BFO is compared with that of the bulk material prepared by the conventional synthesis method. An attempt is made to find correlations between the structural disorder and magnetic behavior of mechanosynthesized BFO.

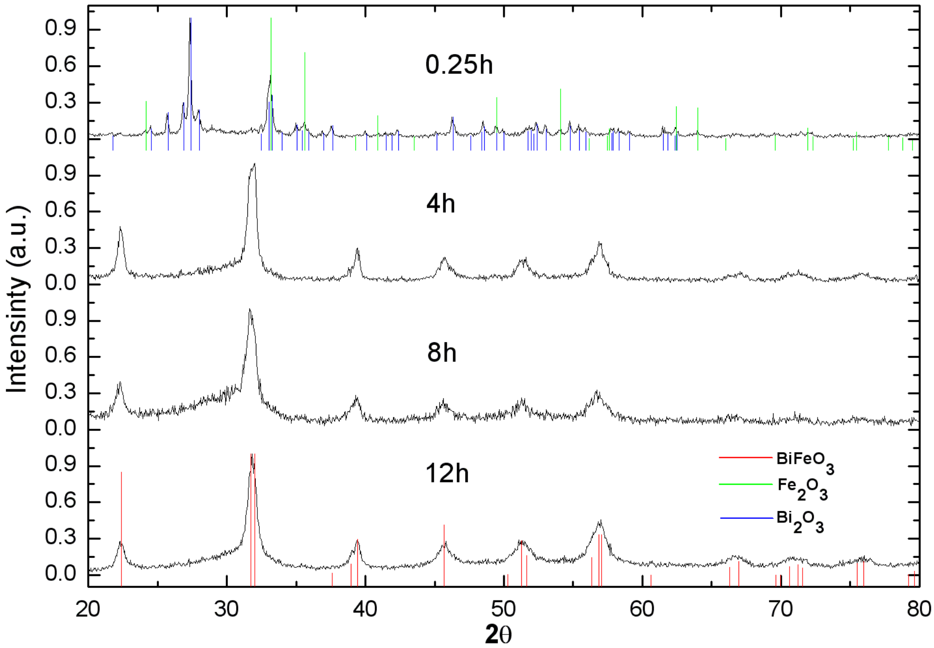

Fig. 1 X-ray diffraction of Fe_2O_3/Bi_2O_3 milled for: 0.25 h, 4 h, 8 h and 12 h.

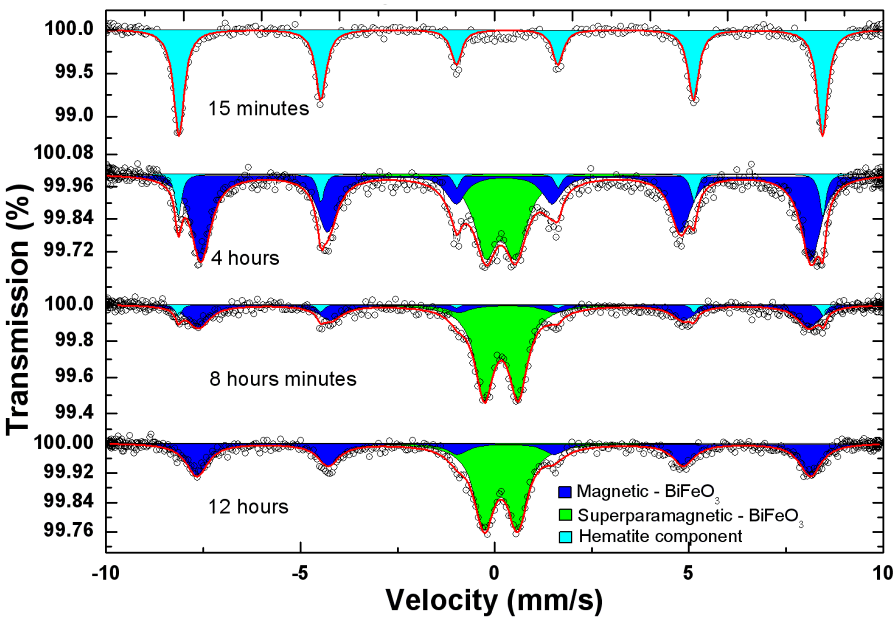

Fig. 2 Mössbauer spectra of $BiFeO_3$ prepared by ball milling of the Bi_2O_3/Fe_2O_3 mixture for: 15 min, 4 h, 8 h and 12 h.

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