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Developing a Cryo-milling System for Material Engineering of BiFeO3-based Nanostructured Ceramics

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Multiferroic magnetoelectric materials have attracted much attention because they can exhibit simultaneous effects of ferroelectricity and ferromagnetism in the same phase, and a linear coupling between magnetization and polarization order parameters. This coupling between ferroelectric and ferromagnetic orders creates new degrees of freedom that enable the development of new devices. Among this class of materials is Bismuth Ferrite (BiFeO3– BFO), one of the most studied multiferroic materials, mainly due to its reported magnetoelectric properties at room temperature. BFO has a rhomboedrally distorted perovskite structure (ABO3), with R3c space group, exhibiting ferroelectric and antiferromagnetic ordering at room temperature with high Currie (~1103 K) and Neel (~ 643 K) temperatures. The BFO magnetic ordering is characterized by a canted spin structure that gives rise to a spiral modulation with a periodicity of 62 nm, leading to null macroscopic magnetization. In this sense, size dependent properties of BFO have attracted attention and many protocols for the synthesis of nanoparticles and nanostructured ceramics have been trying. In this context, we developed a home-built sample environment for sample cooling down to liquid nitrogen temperature and temperature monitoring system which when allied to a high-energy planetary ball-mill can produce nanostructured nanoparticles. In this work, we applied the cryo-mill protocol to obtain single-phased nanostructured BFO nanoparticles with enhanced ferroic properties. The cryo-milling protocol showed to be a powerful protocol to control crystallite size and internal strain level and, consequently, change the magnetic behavior with an expressive increase of magnetization.