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Dielectric and Magneto-dielectric properties of $GdFeO_3$ modified $PbTiO_3$ nanofibrous mats obtained through electrospinning technique

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ABSTRACT

This study intends to create and analyze electrospun nanofibrous mats of $GdFeO_3$ doped $PbTiO_3$ i.e $Pb_{0.8}Gd_{0.2}Ti_{0.8}Fe_{0.2}O_3$ (GF-PT) using sol gel method. The polyvinylpyrrolidone PVP/GF-PT material was attempted to generate a highly viscous sol that is used to transform into nanofibers utilizing various parameters. The crystallographic parameters were estimated using X-ray diffraction (XRD) patterns, which supported single phase tetragonal structure. Also, Scherer equation was used to calculate the typical nanocrystallite size of the manufactured nanofibrous mats, and the result was 15.92 nm. The morphological investigations showed that a variety of factors, such as applied voltage, flow rate, and needle-collector distance, had a significant impact on the average diameter of nanofibrous mats. The nanofibers displayed ferromagnetic behavior and exhibited residual magnetism of approximately 0.0257 emu/g. The created nanofibers exhibit significant magneto-electric (ME) coupling characteristics having the highest magneto-dielectric response (MDR) at 1.2 T of about −38.62 % and the calculated magneto- dielectric coefficient value is −275.05 emu^2/g^2.

1. Introduction

In the sphere of scientific research, nanotechnology has emerged attention as one of the most significant and well-liked areas. It is a procedure that involves working with materials at incredibly small scales, often between 50 and 500 nm. There are numerous uses of one-dimensional (1D) metal oxide nano-structures in a variety of domains, including engineering, material sciences, chemistry, biology, and physics, among others. The innate characteristics of the materials have an impact on the applications for nanofibers. [1-3]. The use of nanofibers in clothing insulation, personal fitness care, and other new qualities resulting from size compact creation has enhanced their appeal in a variety of electrical gadgets and biomedical materials [4-6]. The synthesis of ferroelectric nanomaterial with various forms has drawn a lot of attention recently because of their potential value in enabling the shrinking of devices to produce ferroelectric random access memories (FE-RAMs). They can be more effectively leveraged in numerous opto-electronic and nanoscale regimes of various devices due to their improved optical and mechanical capabilities [7,8]. To form the binary or complex nanostructures, hydrothermal, evaporation, electro-deposition method and electrospinning sol gel method approach have all gained a lot of popularity to synthesis 1-D nanostructures and nanowires. However, electrospinning is the remarkable and incredibly useful technique has been used in numerous investigations on polymeric and ceramic nanofibers reported in recent years [9,10]. It functions on basis of applying a range of voltage between the needle and collector, which causes the solution to stretch and volatilize to produce nanofibers with diameters ranging from a few nanometers to several micrometers. The process consists of following steps: (i) preparation of precursor solution (ii) addition of polymer into the solution (iii) solution injected into a syringe and exposed to high voltage (iv) formation of Taylor cone (v) the collection of acquired non-woven Nano fibrous mats [11,12]. With the help of this technology, effective nanofibers with a range of nano-dimensions, a higher surface to volume ratio, and a superior aspect ratio could also be formed, leading to the development of diverse ceramic nanofibers. The formation of fibers is affected by a number of variables, including those related to the polymeric solution and processing parameters such as applied voltage, flow rate, needle-collector

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