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Magnetoelectric coupling in strained strontium titanate and Metglas based magnetoelectric trilayer

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ABSTRACT

Direct magneto electric coupling is observed with a magnetoelectric coupling coefficient (MECC) of 806 mV cm^{-1} Oe^{-1} at 750 Hz in strontium titanate (STO) - Metglas - strontium titanate (STO-Metglas-STO) trilayer thin films with a total thickness of 600 nm. The piezoelectricity in the strained STO layer, which is otherwise a paraelectric material, enabled the sandwiched magneto electric structure to exhibit a fair sub resonant magneto electric coupling. Theoretical models proposed by Bichurin et al. and Hasanyan et al. are employed to calculate the values of MECC at sub resonant condition for the system, which is noted as 853 mV cm^{-1} Oe^{-1}. The frequency dependence of MECC coefficient is also calculated and the resonance frequency is estimated as 706 Hz.

1. Introduction

Multiferroics are multifunctional materials with the coexistence of two or more ferroic orders. Ferroic orders can be ferroelectric, ferro/antiferromagnetic, ferroelastic and ferrotorroidic. In magnetoelectric multiferroics, both magnetic and ferroelectric states exist together and they are coupled to each other. Generally, it can be classified into single phase and composite magnetoelectric multiferroics. Single phase magnetoelectric materials have displayed many interesting physical phenomena like magnetism driven ferroelectricity [1], observation of skyrmions [2], magnetization switching using electric field at room temperature, [3] etc. But for device fabrication, magnetoelectric composite materials are preferred due to their superior magnetoelectric coupling compared to their single phase counterparts [4]. The magnetoelectric characteristics of magnetoelectric composites are product tensor property. Because of the strong mechanical coupling between ferromagnetic and ferroelectric layers, strain induced via magnetostriction in the ferromagnetic layer changes piezoelectric properties of the ferroelectric/piezoelectric layer [5]. It is important to study different magnetoelectric systems to understand the coupling mechanisms better.

Piezoelectrics are materials that can convert mechanical energy into electrical energy and vice versa. These materials are actively being researched since it finds applications in the field of energy harvesting, microsensors, actuators, robotics, etc [6]. Realization of a piezoelectric FET based on single ZnO nanowire has opened up a new arena of research [7]. Such coupling of material properties to strain can give an additional control over the electronic transport. The piezoelectric material used in this study is STO. It is one of the widely investigated materials due to the rich diversity of physical phenomena displayed by it like incipient ferroelectricity [8], enhancement of dielectric constant at cryogenic temperature [9], low temperature phase transition [10], superconductivity [11], etc.

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