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Research articles

Interface assisted strain-induced magnetoelectric coupling in core-shell nanostructures of $CoFe_2O_4$ @ZnO

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ABSTRACT

Artificially engineered magnetoelectric materials, whose electrical properties can be manipulated by an external magnetic field and vice versa are a new class of materials and find extensive applications in the field of emerging technologies like sensors, electrically controlled spintronic, and microelectronics and memory storage devices. Composites, having ferromagnetic and ferroelectric components are commonly employed where coupling between magnetic and electric fields is relatively weak. It is known that the interface between the components plays a very crucial role for achieving a stronger magnetoelectric (ME) coupling in artificially engineered magnetoelectric materials if the composites are synthesized with a ferro/ferri magnetic core and a ferro/piezoelectric shell. Such core-shell architecture ensures strong interaction and enables better connectivity. In realizing this goal, we report a simple technique to fabricate a core-shell nanostructure consisting of a ferrimagnetic core of $CoFe_2O_4$ and a piezoelectric shell of ZnO. The core size is varied and the elastic strain mediated magnetoelectric coupling mechanism through the interface of the core-shell nanostructure is examined.

1. Introduction

Artificially engineered magnetoelectric (ME) materials are increasingly being investigated as their magnetic/electric polarization can be altered by an external electric field or vice versa. A subset of these classes of materials is magnetoelectric multiferroic where electric and magnetic orders coexist and are coupled [3,8,21,24,32,33,38]. They find extensive applications in areas such as sensors, electrically controlled spintronics, signal processing devices, memory storage, nanoelectronics and microelectronics [2,12,13,16,25,41]. The necessity of having d^0-ness and d-ness metal ions simultaneously in a single phasic material forbids the natural occurrence of a room temperature multiferroic material. The weak magnetoelectric properties displayed by single-phasic materials necessitate the search for alternatives and composites are found a better choice. Composite materials are engineered materials with extrinsic ME coupling that originates from the direct interaction between magnetic and electric order parameters or interfacial strain [5,14]. For this, the physical mixing of a magnetic and electric components in the required ratio is employed to fabricate such composites. However, complete coupling cannot be achieved in these composites. Hence it is required that particles or grains of individual components interact either covalently or by van der Waals forces so that there exists a possibility for coupling. With the advent of nanotechnology and low-temperature synthesis techniques, nanostructured core-shell structures serve this purpose of coupling. The particle/grain size plays a vital role in determining the overall magnetoelectric characteristic of such nanostructures. The interactions of the composite at the shared interface between magnetostrictive and piezoelectric materials help to tune the entire composite properties [9].

A well-harmonized interface between the magnetic and electric phase of the composite is an exciting subject for the study of magnetoelectric coupling [44]. A better connectivity and excellent interface can be achieved in composites in which the magnetic phase is covered by the piezoelectric phase, but not without limitations. The three common schemes of connectivity in composites are 0–3, 1–3, 2–2 in which the mostly used scheme is 0–3 particulate composites. The 0 represents the dimension of magnetostrictive phase and 3 represents the dimension of piezoelectric phase. Particulate composites make a

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