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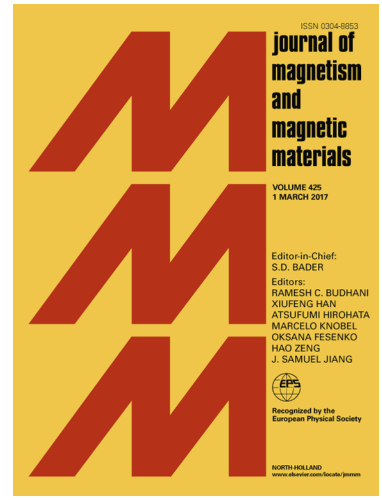

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Magnetostriction Studies in Nano-Crystalline Zinc Ferrite Thin Films by Strain Modulated Ferromagnetic Resonance

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Abstract

The magnetoelastic properties of nano-crystalline zinc ferrite ($ZnFe_2O_4$) thin films prepared by Pulse laser deposition on amorphous fused quartz substrates have been investigated by means of the strain-modulated ferromagnetic resonance, as a function of the substrate temperature during the deposition, and as a function of the annealing temperature. Magnetoelastic constants reveal the same trends as the magnetization, showing correlation between these two parameters. The results are similar to that obtained earlier for the $Y_3Fe_5O_{12}$ ferrite.

1. Introduction

Magnetostriction is an important property of magnetic materials and arises out of the interaction of the crystal field with the energy levels of the magnetic ions, which possess a spin orbit coupling. It has a similar origin as that of the magnetic anisotropy. This property is important both from the fundamental and application points of view. There is a plethora of studies of this property in ferrites and garnets. However, S state ions such as Fe^{3+} are also known to contribute to the magnetic anisotropy and to magnetostriction as is well established to day.

It is well established that bulk zinc ferrite ($ZnFe_2O_4$) is paramagnetic at room temperature and becomes antiferromagnetic at low temperatures [1]. The main reason for this is that the superexchange interaction between the Fe^{3+} ions on the B sites is too weak and all the A sites are occupied by the nonmagnetic Zn^{2+} ions resulting in an absence of otherwise stronger A-B superexchange interaction. However, in the nano-crystalline films a sizeable quantity of Zn^{2+} ions enter B sites thereby yielding place to Fe^{3+} ions on the A site. Thus normal superexchange interactions appear and the substance becomes ferrimagnetic, with a relatively high Curie temperature. It is also known that the magnetic properties of nano-crystalline Zn ferrite films are quite sensitive to the condition of preparation of the material [2-11].

Investigating the magnetic property such as magnetostriction in this material is of great academic interest because this is a novel material exhibiting magnetic properties unlike the bulk counterpart. Also the magnetostriction arises entirely from the magnetic S state Fe^{3+} ions. This situation is similar to say in $Y_3Fe_5O_{12}$ (YIG). The nano-crystalline material could present local deformations, lowering the symmetry of the crystal fields as compared to YIG. This could lead to a different behaviour of the S state Fe^{3+} ion in the nano-crystalline Zn ferrite films.

Determination of this property is a bit delicate because one measures changes in length on the order of one part in a million. When it comes to thin films it is out of question to use classical techniques. One of the methods of measurement in thin films is to observe the changes in the resonance field under the application of a stress. The dynamic version of this method was known as the strain modulated ferromagnetic resonance (SMFMR) [12 and refs therein]. We have developed and perfected this technique and investigated several kinds of thin films with very valuable results. In the present paper, we have used this technique to determine magnetoelastic constants of zinc ferrite nano-crystalline films, as a function of the substrate temperature during the deposition, and as a function of the annealing temperature, as a continuation of previous investigations of magnetic properties of these films [2,3]. The purpose of present studies is to find out correlation between the magnetic, structural and magnetoelastic properties of the investigated samples, which may put some new light on the mechanisms of the observed phenomena.

2. Experiments

$ZnFe_2O_4$ thin films with a thickness of ~ 500 nm were deposited using pulsed laser deposition (PLD) unit. Films were grown on amorphous fused quartz substrates using a polycrystalline $ZnFe_2O_4$ target of 25 mm diameter. The target to substrate distance was fixed at 45 mm. The chamber was evacuated to a base pressure of 5.4×10^{-4} Pa prior to the deposition. The films were deposited at different substrate

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