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Magneto-Structural behavior of Gd doped nanocrystalline CO-Zn ferrites govered by domain wall movement and spin rotations	Anil B. Mugutkar, Shyam K. Gore", Rajaram S. Mane, Khalid M. Batoo, Syed F. Adil', Santosh S. Jadhav	Physics	Ceramics International	2018-2019	0272-8842 UGC CARE	https://www.sciencedirect.com/journal/ceramics-international	https://doi.org/10.1016/j.ceramint.2018.08.255	Yes

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Magneto-structural behaviour of Gd doped nanocrystalline Co-Zn ferrites governed by domain wall movement and spin rotations

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ABSTRACT

The rare earth gadolinium (Gd^{3+}) ions doped nanocrystalline cobalt-zinc ferrites chemically formulated as $Co_{0.7}Zn_{0.3}Gd_xFe_{2-x}O_4$ (x = 0–0.1) were synthetically prepared by sol-gel self-ignition process. The characterization the ferrite samples was performed by powder x-ray diffraction method. The analysis of x-ray diffractograms (XRD) reveals formation of cubic spinel phase without presence of any ambiguity peak. The calculated particle size of the samples varies between 18 nm and 28 nm showing decreasing trend with Gd^{3+} doping. The distribution of cations analysed from XRD data propose occupancy of tetrahedral (A)-site by Zn^{2+} and Fe^{3+} while octahedral [B]-site by Fe^{3+}, Gd^{3+} and Co^{2+} ions. The morphology of the ferrites was studied from the SEM images. The nanocrystalline particles arranged in layers with presence of porous structure can be observed in the SEM images. The particles of spherical shape with mean diameter of 27 nm were observed in the TEM image. The confirmation of peaks revealed by XRD data was performed by SAED image of the ferrite. The fringe width of the lattice fringe in HRTEM confirms formation of pure spinel phase in the Gd^{3+} doped Co-Zn ferrite. The VSM data analysed for measurement of magnetic parameters viz. coercivity, retentivity and saturation magnetization. The compositional variation of magnetization with Gd^{3+} doping reveals spin canting due to non-collinearity of spins of (A) and [B]-site. The Y-K angles calculated from cation distribution data were increased with Gd^{3+} doping due to spin canting. The variation of coercivity with Gd^{3+} doping was in accordance with the variation of anisotropy constant. The frequency variation of real part (μ') and imaginary part (μ") of μ* (complex permeability) were studied as a function of Gd^{3+} composition and frequency. The permeability was influenced by magnetic and structural parameters. The domain wall movement and spin rotations were responsible for magnetism in the ferrites.

1. Introduction

The nanocrystalline spinel ferrites (NSF) is a category of technologically important minerals with variety of applications including high density storage media, microwave absorbing materials, hypothermia for cancer treatment, magnetic drug delivery, gas sensing elements and electrochemical supercapacitive material [1–6]. The properties of the NSF particles are sensitive to synthesis method [7,8]. The sol-gel route for synthesis is the most versatile method to synthesize reproducible nano particles of spinel ferrites [9]. The salient features of sol gel route are; reaction at low temperature, synthesis of chemically stable materials with controlled morphology and porous structures by modification of synthesis conditions [10]. The type and molar composition of the dopant is another important criterion that has impact on properties of NSF particles. The verity of cations (Zn^{2+}, Cd^{2+}, Cr^{2+}, In^{3+}, Ti^{4+}) were doped in spinel ferrites to modify their physical properties [11–13].

The rare earth (RE) doping in spinel ferrites is responsible for remarkable modifications in crystallographic, magnetic and electric behaviour of the ferrites [14–17]. Group III lanthanides La, Sm, Gd, Ce, Pr, Dy are of particular interest as the substituent / dopant in ferrites. The magnetism in RE metals originates from electrons in 4f shell which

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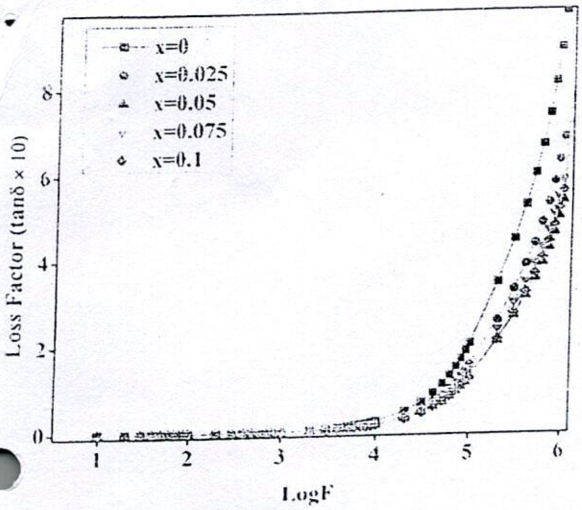

Fig. 11. Magnetic loss factor (tanδ) of CZG ferrites.

χ_{dwm} and χ_{sr} decreases, result in decrease in values of μ'. For x = 0.05, he particle size was at its lowest leading to reduced contribution of χ_{dwm} to μ'. Thus, for compositions x = 0.05, χ_{sr} contribution to μ' is nore and thus spin rotation is the manifestation of governing permeability. Owing the contribution of χ_{dwm} and χ_{sr} in variation of μ', we can conclude that the permeability is governed by domain wall motion nd spin rotation; for x > 0.05, spin rotation is predominant.

The magnetic loss factor (tanδ) as a function of frequency is depicted in Fig. 11. The factor is almost constant up to 10 kHz, increases lightly at 100 kHz and shows rapid increase for high frequencies in ange 1–10 MHz. The lattice imperfections are responsible for the lagging of domain walls behind the magnetic field during magnetization. his lagging gives rise to magnetic loss. The loss decreases with Gd omposition increase in CZG ferrites. The continuous increase in loss ctor infers the possibility of resonance at some higher frequency [70].

C[illegible]usions

The nanocrystalline gadolinium substituted Co-Zn (CZG) ferrites ere successfully prepared by sol gel self-ignition route of synthesis. e peak indexing of x ray diffractograms reveal the presence of spinel ase in the ferrite crystal. The absence of ambiguity peak in the x ray fractograms indicates the formation of mono-phase spinel ferrites. e calculated size of the particles according to Debye-Scherer's forla varies from 88 nm to 18 nm; the decrease in size of the ferrite ticles with Gd^{3+} substitution was observed. The decrease in density increase in porosity reveals the formation of porous ferrite mates with rare earth Gd substitution. The increase in values of lattice ameter with substitution of larger radii ions of Gd^{3+} replacing ller Fe^{3+} ions was concluded. The variations of bond lengths, tetra octa edges and hopping lengths attributed to lattice parameter ations. The SEM images show spherical particles arranged in layers micrometer sized pores. The nanocrystillinity of the ferrites was irmed from TEM analysis which confirms the production of sphe- particles with mean diameter of 27 nm. The SAED and HRTEM ysis concludes the production of phase (spinel) purity of the fer- The distribution of cations obtained from XRD analysis proposes Co and Gd occupies octahedral [B]-site, Zn occupies tetrahedral ite and specific fraction of Fe occupies (A) and [B]-sites. VSM 'sis shows that saturation magnetization is decreased due to etic frustration induced in Co-Zn by Gd^{3+} substitution. The im- of magneto-crystalline anisotropy was observed on the coercivity ries. The complex permeability analysis reveals the domain wall ment and spin rotation as the phenomena governing the process of

parameters indicate the possible application of the ferrites in [illegible] recording and storage devices.

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