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High magnetostriction parameters of sintered and magnetic field annealed Ga-substituted CoFe_2O_4

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Abstract: Impact of substitution of the non-magnetic ion Ga^{3+} for Fe^{3+} on the magnetostriction parameters of CoFe_2O_4 has been investigated for samples prepared by a tartrate-gel method. All the Ga-substituted compositions in $\text{CoGa}_x\text{Fe}_{2-x}\text{O}_4$ ($0 \leq x \leq 0.3$) showed higher strain sensitivity ($d\lambda/dH$), at low magnetic fields, compared to that of the unsubstituted sample. The magnetostriction strain (λ) and $d\lambda/dH$ of the composition $\text{CoGa}_{0.1}\text{Fe}_{1.9}\text{O}_4$ could be enhanced from -228 to -296 ppm and -2.20×10^{-9} to -3.55×10^{-9} m/A, respectively, at low magnetic fields, after magnetic field annealing at 300 °C.

Keywords: Magnetic materials; cobalt ferrite, magnetostriction, substitution, magnetic field annealing.

1. Introduction

Oxide based magnetostrictive smart materials have gained much attention recently due to their potential applications, and sintered polycrystalline cobalt ferrite (CoFe_2O_4) has been studied as a suitable alternative to the currently used costly alloy-based magnetostrictive materials [1-5]. Maximum magnetostriction (λ_{max}) of sintered polycrystalline CoFe_2O_4 has been reported in the range 150–400 ppm depending on the synthesis methods and processing conditions [4-7]. Constant efforts have been made to improve or enhance the magnetostriction parameters (both λ and $d\lambda/dH$) of CoFe_2O_4 at lower magnetic fields, by changing the processing conditions as well as by metal ion substitution [8-14], to make it suitable for sensor based applications. Song et al [12] studied the magnetic and magnetostrictive properties of Ga-substituted cobalt ferrite, prepared by ceramic method, and showed that significant enhancement in the strain sensitivity, at lower doping levels ($x \leq 0.4$) can be obtained at the cost of large drop in the magnetostriction strain. The reported λ_{max} and $|d\lambda/dH|_{\text{max}}$ for the composition, $\text{CoGa}_{0.2}\text{Fe}_{1.8}\text{O}_4$, are -100 ppm and -3.2×10^{-9} m/A, respectively, against the values -212 ppm and -1.37×10^{-9} m/A for CoFe_2O_4 . In this study,

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