



Impact of cadmium substitution on the structural, spectral, dielectric and magnetic properties of Z-type hexaferrites synthesized via sol-gel route

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ARTICLE INFO

Keywords:

Cd Z-type hexaferrite
Thermal analysis
XRD
FTIR
Dielectric properties
Magnetic properties

ABSTRACT

Cadmium substituted Z-type hexaferrites are prepared via the sol-gel route. The phase temperature of pre-sintered materials is studied from the thermal analysis. The single-phase of Z-type hexaferrite is found through X-ray diffraction investigation. The Crystallite sizes of the entire samples are evaluated within the range of 14–15 nm. The Fe–O stretching vibration band at 566 cm^{-1} is confirmed from Fourier transform infrared spectroscopy. Saturation magnetization (M_s), coercivity (H_c) and remanence (M_r) is examined by a vibrating sample magnetometer. The magnitude of M_s has been increased from 45.41 to 56.35 emu/g with an increase of Cd^{2+} concentration. The magnitude of H_c increased from 950.79 to 2186.95 Oe with an increment of Cd^{2+} concentration. Small values of squareness ratio (less than 0.5) showed the hard and single magnetic domain nature of the materials. The dielectric properties were analyzed using an impedance analyzer. Dielectric parameters show an increasing trend with the substitution of Cd^{2+} . The maximum values of quality factor up to 17,000 and 10,000 are observed for sample $\text{Ba}_{2.85}\text{Cd}_{0.15}\text{Co}_2\text{Fe}_{24}\text{O}_{41}$ at 1 GHz and 2.7 GHz, respectively. The high value of the Q-factor shows that these ferrites can be applicable for the formation of resonant circuits and multilayer chip inductors.

1. Introduction

Recently, magnetic materials such as soft and hard ferrites have received great interest because of their applications in memory, smart-phone, and high-frequency devices [1]. Among the soft (cubic) and hard (hexagonal) ferrites, Z-type hexaferrite has grabbed great interest due to high permeability, elevated ferromagnetic resonance frequency, and greater thermal stability in the GHz domain. These materials are the mainly practiced magnetic materials for high-frequency submissions, for instance, LC filters, chip inductors, microwave absorbers, and megahertz-gigahertz (MHz–GHz) transmitters [2–4]. The general chemical

formula of Z-type ($\text{Ba}_2\text{Co}_2\text{Fe}_{24}\text{O}_{41}$) ferrite is composed of the combination of Y-type ($\text{Ba}_2\text{Co}_2\text{Fe}_{12}\text{O}_{22}$) and M-type ($\text{BaFe}_{12}\text{O}_{19}$) ferrites. The crystal structure of Z-type hexaferrite is made by the stacking of R ($\text{BaFe}_9\text{O}_{11}$), S (Fe_9O_9), and T ($\text{Ba}_2\text{Fe}_9\text{O}_{14}$) blocks as models RSTSR* $S^*T^*S^*$ where asterisk designates the similar stack but revolved 180° about the c-axis. In Z-type ferrites, the cuboid site exists in the R layer, which has five oxygen ligands. It produces a uniaxial ligand field for the metal ion. Crystal magnetic anisotropy energy can be expressed by the following equation:

$$E_A = K_{d1} \sin^2\theta + K_{d2} \sin^4\theta$$

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<https://doi.org/10.1016/j.ceramint.2021.05.211>

Received 7 May 2021; Received in revised form 19 May 2021; Accepted 20 May 2021

Available online 26 May 2021

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Please cite this article as: Muhammad Adil Mahmood, *Ceramics International*, <https://doi.org/10.1016/j.ceramint.2021.05.211>