

A study on Infrared spectroscopy of Nd³⁺ doped Cobalt Ferrite

¹Gaikwad PK, ²Shinde VS and ¹Sawant SS

¹Department of Physics, Shri Chhatrapati Shivaji College, Omerga (M.S.) India - 413606.

²Department of Chemistry, Shri Chhatrapati Shivaji College, Omerga (M.S.) India - 413606.

*Corresponding author Email: drpkgaikwad@gmail.com

Manuscript Details

Available online on <http://www.irjse.in>
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:

Gaikwad PK, Shinde VS and Sawant SS. A study on Infrared spectroscopy of Nd³⁺ doped Cobalt Ferrite, *Int. Res. Journal of Science & Engineering*, 2018; Special Issue A5: 73-76.

© The Author(s). 2018 Open Access

This article is distributed under the terms of the Creative Commons Attribution

4.0 International License

(<http://creativecommons.org/licenses/by/4.0/>),

which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

ABSTRACT

The Nd³⁺ doped Cobalt ferrite with a nominal composition of CoFe_{2-x}Nd_xO₄ (where x = 0.00 and 0.02) samples have been prepared by standard ceramic technique. The structural properties are investigated by X-ray diffraction technique and Infrared spectroscopy. The X-ray diffraction data shows single phase cubic spinel structure for both samples, whereas no extra peak of Nd³⁺ is observed when x = 0.02 sample. The effect of Nd³⁺ doped on Infrared spectroscopy properties of cobalt ferrites recorded at room temperature using Perkin Elemer spectrometer (Model 783). It shows that the two strong frequency band ν_1 and ν_2 in the wave number range 800-350 cm⁻¹ and it shows that Nd³⁺ doped cobalt ferrites are decrease than pure cobalt ferrites.

Key words: Cobalt ferrite, Rare earth, Infrared spectroscopy.

INTRODUCTION

Iron Cobalt and Nickel ferrites forms inverse spinel structure. In the inverse spinel structure, the tetrahedral (A) sites are occupied by the Fe³⁺ ions and the octahedral sites [B] are occupied by the divalent metal ions (M²⁺) and Fe³⁺, in equal proportions. The angle A-O-B is closer to 180° and the angles B-O-B and A-O-A are closer to 90°, and therefore, strong super exchange (antiferromagnetic) interaction between the A and B ions (mediated by the oxygen ion) is observed. In spinel ferrites Cobalt is a hard magnetic material possessing high magneto anisotropy, high Curie temperature, high corecivity and moderate saturation magnetization along with the chemical stability and mechanical hardness [1-4].

Several researchers have studied pure and doped cobalt ferrite with a view to understand their basic properties [5]. These studies revealed that doped of non magnetic cations in cobalt ferrite predominantly affects the magnetic as well as electrical properties compared to magnetic cations.

Rare earth (R) elements possess large magnetic moment, large magnetocrystalline anisotropy and very large magnetostriction at low temperature due to the localized nature of 4f electrons. Rare earth-ions based cubic laves phase compound (RFe_2) are known to exhibit very large magnetostriction and these compounds are employed as active elements in several magnetostrictive transducers.

Recent research shows by introducing rare earth ions into the spinel lattice, can lead to small changes in the structural, magnetization and Curie temperature of the spinel ferrite. Many researchers [6-7] have studied the role of rare earth doped in the pure $CoFe_2O_4$ matrix but to the best of our knowledge no systematic report is available in the literature showing the effect of Nd^{3+} ions in the pure $CoFe_2O_4$ matrix. In the present work we have focused to correlate the understandings Infrared spectroscopy properties of Nd^{3+} doped cobalt ferrites having molecular formula $CoFe_{2-x}Nd_xO_4$ ($x = 0.00$ and 0.02).

METHODOLOGY

Polycrystalline specimens of $CoFe_{2-x}Nd_xO_4$ ($x = 0.00$ and 0.02) were prepared by standard ceramic technique [8, 9] using analytical reagent grade oxides compounds were accurately weighed in molecular weight percentage with a single pan microbalance. The mixed powders were wet ground and pre-sintered at $950^\circ C$ for 24 hours. The sintered powder is again re-ground and pelletized. Polyvinyl alcohol was used as a binder in making circular pellets of 10mm diameter and 2-3mm thickness. The pellets were finally sintered in muffle furnace for $1180^\circ C$ for 24 hours and then slowly cooled to the room temperature.

X-Ray diffraction patterns were taken at room temperature to confirm the crystal structure of the prepared samples. The XRD patterns were recorded in the 2θ range from 20° to 80° using $Cu-K\alpha$ radiation ($\lambda = 1.5406 \text{ \AA}$) with scanning rate 1° per/m.

Infrared spectra of both the samples of the present series were recorded at room temperature in the range $350 \text{ cm}^{-1} - 800 \text{ cm}^{-1}$ on a Perkin Elmer spectrometer (Model 783). To study the I.R. spectra of both the samples, about one gram of fine powder of each sample was mixed with KBr in the ratio 1:250 by weight to ensure uniform distribution in the KBr pellet. The mixed powder was then pressed in a cylindrical die to obtain clean disc of approximately 1 mm thickness. The IR spectra were used to locate the band position. The IR spectra were used to determine bond length R_A and R_B , in a cubic crystal for tetrahedral (A) and octahedral [B] site using formula given by Gorter [10].

RESULTS AND DISCUSSIONS

Structural Analysis:

X-ray Diffraction:

Room temperature X-ray powder diffraction patterns (XRD) for series having molecular formula $CoFe_{2-x}Nd_xO_4$ (where $x = 0.00$ and 0.02) were prepared by standard ceramic technique shown in Fig 1. The Bragg reflections (hkl) belonging to the plane (220), (311), (222), (400), (422), (511), (440) and (533) confirms the formation of single phase cubic spinel structures. No extra peak of Nd^{3+} doped cobalt ferrite materials is observed. Similar reports of XRD pattern are available for different rare earth substituted in spinel ferrites in the literature [11, 12].

Infrared spectroscopy:

IR spectra of both the samples of $CoFe_{2-x}Nd_xO_4$ whereas $x = 0.00$ and $x = 0.02$. According to Waldron [10] ferrite materials shows presence of two absorption bands near 400 cm^{-1} and 600 cm^{-1} . The high frequency band (ν_1) is attributes to the A-site and the low-frequency band (ν_2) assigned to the B-site. The two bands occur at different positions which may be due to the difference in

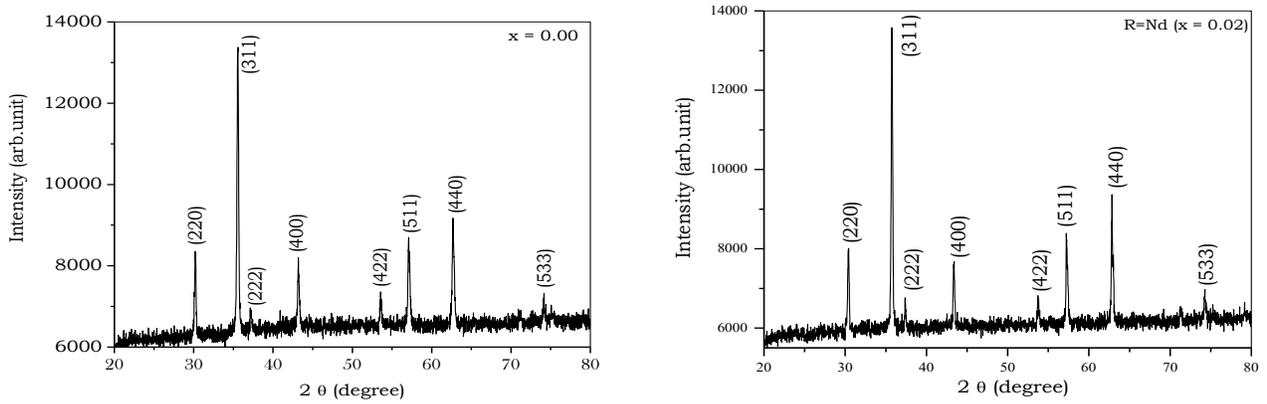


Fig 1: XRD patterns of CoFe_{2-x}Nd_xO₄. (x = 0.00 and 0.02)

Table 1: Vibrational band frequency (ν_1, ν_2) and Force constant (K_t, K_o) of CoFe_{2-x}Nd_xO₄ system (where as x= 0.00 and x = 0.02).

CoFe _{2-x} Nd _x O ₄	ν_1 (cm ⁻¹)	ν_2 (cm ⁻¹)	$K_t \times 10^5$ (dyne /cm)	$K_o \times 10^5$ (dyne /cm)
X=0.00	630.86	440.89	1.694	1.185
X=0.02	593.92	407.42	1.501	1.027

$$K_o = 10.62 \left(\frac{M_B}{2} \right) \times \nu_2^2 \times 10^{-3} \quad \dots 1$$

$$K_t = 7.62 M_A \times \nu_1^2 \times 10^{-3} \quad \dots 2$$

interatomic distances. Since there is no obvious difference in the crystal structure, the change of wavenumber may be related to the cation substitution in A-site [13]. The values of absorption bands ν_1 and ν_2 for both the samples are given in Table 1. The force constant K_o and K_t were calculated [14- 16].

Using equations 1 and 2 the values of force constant K_t and K_o were calculated [14-16] and given in Table 1. It is observed from Table 1 that, the values of force constant are decreases with Nd³⁺ doped cobalt ferrites [17-20]. The slight shift in the position and intensities of ν_1 and ν_2 doped Nd³⁺ content is due to the change in Fe³⁺-O²⁻ distance of the tetrahedral sub-lattice of the ferrites.

CONCLUSION

A series of CoFe_{2-x}Nd_xO₄ ferrites (where x=0.00 and x=0.02) were prepared by standard ceramic technique. The X-ray diffraction data shows single phase cubic spinel structure for both samples, whereas no extra peak of Nd³⁺ is observed when x =0.02 sample. Infrared spectroscopy shows that vibrational band frequency and Force constant decreases with Nd³⁺ doped cobalt ferrites.

REFERENCES

- Shobana MK, Hoon Kwon, Heeman Choe. J. Magn. Mater, 324, 2012, 2245-2248.
- Liping Guo, Xiangqian Shen, Xianfeng Meng, Yuhua Feng. J. Alloys Compd, 490, 2010, 301-306.
- Hemeda OM, Said MZ, Barakat MM. J. Magn. Mater, 224, 2001, 132.
- Gabal MA, Al Angari. Mater. Chem. Phys., 115, 2009, 578.
- Ying Zhang and Dijiang Wen, Mater. Sci. Eng. B., 172, 2010, 331.

6. Muthuselvan IP and Bhowmik RN. J. Magn. Magn. Mater., 322, 2010, 767.
7. Jianhong Peng, Mirabbos Hojamberdiv, Yunhua Xu, Baowei Cao, Juan Wang and Hong Wu, J. Magn. Magn. Mater., 323, 2011, 133.
8. Patil DR, Chougule BK. Mater. Chem. Phys. 117, 2009, 35.
9. Ahmed MA, EL-Khawtani AA. J. Magn. Magn. Mater, 321,2009,1959.
10. Gortor EW. Philips Res. Rep. 9, 1954, 295.
11. Jie S, Lixi W, Naicen X, Qitu Z. J Rare earth,28, 2010, 451.
12. Jiang J, Yang Y, Li L. Physica B., 399, 2007, 105.
13. Ying Zhang, Dijiang Wen, Materials Chemistry and Physics, 131,2012, 575-580.
14. Hamada IM. J. Magn. Magn. Mater.,271,2004, 318.
15. Srivasatav CM and Srinivasan, TT. J. Appl. Phys., 53. 1982, 8184.
16. UI-Islam M, Abbas T and Rana MU. Int. J. Mod. Phys.,B 20, 2008, 725.
17. Ravinder D, Ravi Kumar B. Mater. Letter., 57, 2003, 4471-4473.
18. Reddy PV, Reddy MB, Mulay VN, Reddy KB, Ramana YV. J. Mater. Sci. Lett., 7,1988, 1243.
19. Ravinder D. J. Appl. Phys., 75, 1994, 6121.
20. Ravinder D, Alivelu Manga T. Mater. Lett., 41, 1999, 254.

© 2018 | Published by IRJSE

Submit your manuscript to a IRJSE journal and benefit from:

- ✓ Convenient online submission
- ✓ Rigorous peer review
- ✓ Immediate publication on acceptance
- ✓ Open access: articles freely available online
- ✓ High visibility within the field

Email your next manuscript to IRJSE
: editorirjse@gmail.com
