International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Structural, Morphological and Optical Properties of La^{3+} Doped Co-Zn Nanoferrite

V. D. Kulkarni[1], S. M. Rathod[2]

[1]Department of Physics, Hutatma Rajguru Mahavidyalaya, Rajgurunagar, Dist-Pune, Pin-410505, MS, INDIA
Research Student, Science College, SRTM University, Nanded

[2] Nanomaterials & Lasers Research Lab, Department of Physics, Abasaheb Garware College, Pune- 411 004, MS, INDIA

Abstract: ***Structural, Morphological and Optical properties of rare earth La^{3+} material doped in Cobalt-Zinc nanoferrites are studied, $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ (where x=0.025, 0.050, 0.075, 0.100, 0.125) reaction nanocrystalline ferrites were synthesized by sol-gel auto combustion method.The XRD charecterisation gives the particle size and it was calculated from XRD by Scherrer's formula. The X-ray diffraction pattern of all the samples provide the information about the particle size of synthesised samples were found to be decreases with the increase in La^{3+}concentration. The SEM and TEM of synthesised samples confirms that formation of nanopartocles.The SEM micrograph shows the uniform particle distribution.The hexagonal nature of particles observed from the TEM micrograph. .The optical properties of synthesised samples were investigated from UV visible spectra. The FTIR spectra are also studied and absorption bond is observed at 600 cm^{-1}.***

Keywords: sol-gel auto combustion method; Co-Zn ferrite; SEM; TEM; XRD, FTIR;

1. Introduction

The general formula of Spinel ferrites is MFe_2O_4 (where M = Co^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Zn^{2+}) which is a class of hybrid functional materials. These are useful for designing of electrical and magnetic devices. The physical properties such as increase in DC resistivity, low dielectric losses and magnetization characteristics are due to the substitution of tetrahedral cations in the parent crystal structure. The structural variation in the host lattice can be occurred due to proper choice and composition of trivalent cations such as Al^{3+}, Cr^{3+}, and La^{3+} to replace Fe^{3+} in the parent lattice of cobalt ferrite [1]. FARID et al studied single phase $Ni_xCo_{1-x}Nd_yFe_{2-y}O_4$ nano ferrites with cubic spinel structure through sol-gel method. They also studied the structural properties, dielectric properties and electrical properties. This paper shows that dc resistivity increases with the increase in neodymium concentration while the increase in temperature, dc resistivity decreases which gives the semiconducting materials [2]. The sol-gel method is a good combination of combustion and chemical gelation process. The advantage of sol-gel method is a good stoichiometric control and results in ultra-fine nano particles [3, 4]. Abid Hussain et al prepared $Ni_{1-x}Mn_xFe_2O_4$ nanoferrites using the sol-gel method. This paper was studied on the basis of XRD data; the phase identification and estimation of cation distribution were possible [5]. The size on nanoparticles was found to be decreases as the increase in the La content. They also showed that decrease in the saturation magnetization, retainivity and coercivity with the increase in the La content. The Lanthanum substituted nickel nanoferrite has many applications like inductor cores, transformers, recording heads, magnetic shielding, microwave devices etc. [6, 7]. The nano sized crystalline Lanthanum was synthesized and characterized by XRD, Thermo gravimetric and differential thermal analysis(TG-DTA), Nano particle size analyzer, UV-Visible absorption spectrometer, Scanning Electron Microscopy with Energy Dispersive X-ray Analysis spectrum (EDAX) and magnetic properties[8]. I. M. Abdulmajeed and L, S. Khalil was studied the synthesis of Cobalt-zinc ferrite ($Co_{1-x}Zn_xFe_2O_4$) with x= 0, 0.25, 0.5, 0.75 and 1 using sol gel auto combustion Method. The optical properties are studied and band gap energy is calculated [9]. S.M.Rathod et al studied magnetic and optical properties of Ni $_{0.5}Co_{0.5}$ Al_x $Fe_{2-x}O_4$.nanoparticles.The FTIR and UV properties are studied. The FTIR shows that the bond formation [10]. A, I. Ahmed et al studied the $Mg_{1-x}Zn_xFe_2O_4$ Nanoferrites (where x = 0.0, 0.2, 0.4, 0.6 and 0.8) using co-precipitation method. The band gap energy $Mg_{1-x}Zn_xFe_2O_4$ nanoferrite was observed between in the range 4.77 to 4.95 eV for different composition of Mg Zn [11].

Therefore, the ferrite nanoparticles have a wide range of applications. This paper studied the rare earth La^{3+} material substituted in Cobalt-Zinc nanocrystalline ferrites were synthesized by sol-gel auto combustion method and characterized by various characterizations.

2. Material and Method

The high purity AR grade ferric nitrate ($Fe(NO_3)_3.9H_2O$), Zinc nitrate ($ZnNO_3{\cdot}6H_2O$), Cobalt nitrate ($CoNO_3{\cdot}6H_2O$), Citric acid ($C_6H_8O_7$), Ammonium hydroxide solution (NH_4OH) were used for the preparation of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ (Where x=0.025, 0.050 ,0.075, 0.100, 0.125) nanoparticles by sol-gel auto combustion method. The Citric acid was used as a fuel. All nitrates and citric acid are using stoichiometric ratio proportion to obtain the final product. All chemicals are dissolved in distilled water and were stirred till to obtain the homogeneous solution.By adding drop by drop ammonium hydroxide to maintain pH=7 during the stirring process.This solution was stirred continuously with 100 $^{\circ}$C for 3 to 4 hours to obtain sol. After half an hour ,this sol becomes a viscous gel. Finally we get fine powder of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ ferrite nanoparticles after auto combustion. The powder was sintered at 600 $^{\circ}$C for 4 hours.

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

3. Results and Discussion

3.1 Structural properties using XRD

The X-ray diffraction patterns (XRD) of the prepared ($Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$) (where x = 0.025, 0.050, 0.075, 0.100 and 0.125) nanocrystals were studied using a X-ray diffractometer with CuKα radiation of wavelength 1.5405 AU. The X-ray diffraction pattern of the synthesized cobalt zinc lanthanum ferrite nanocrystals as shown in Fig.1 and shows the formation of spinal cubic structure. The particle size was determined using Scherrer's formula,

$$t=(0.9*\lambda)/(\beta*\cos\theta)$$

Where, λ = wavelength of X-ray used,
θ = peak position and
β = FWHM of the peak θ and it is corrected for instrumental broadening.
The average sizes of nanoparticles are decreases as the concentration of La increases which is shown in Table 1.

Table 1: Value of Structural properties of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ by XRD

Composition (X)	Average Particle Size (nm)
0.025	23.5752
0.050	23.1061
0.075	22.2584
0.100	21.0672
0.125	18.7011

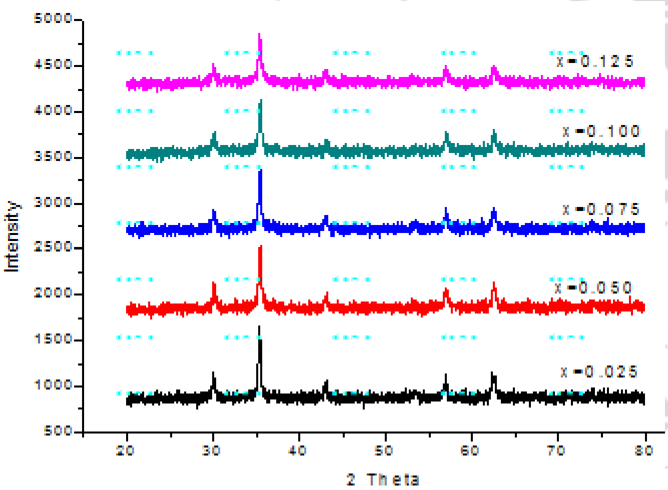

Figure 1: Structural properties of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ by XRD

3.2 Morphological Properties

a) **SEM:** The SEM images of Cobalt-Zinc nanocrystalline ferrites by Sol-gel auto combustion method as shown in Fig.2. The SEM image of the prepared ($Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$) (where x= 0.125) samples are composed of nanocrystals and shows the distribution of nanoparticles.

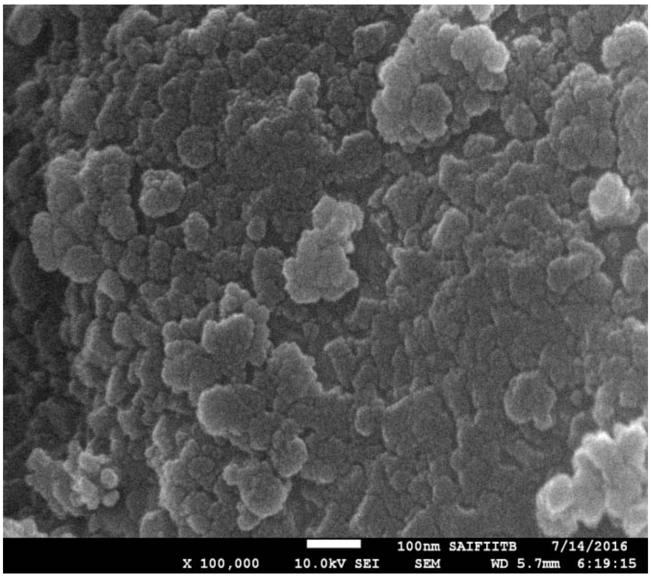

Figure 2: SEM of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$(x=0.125)

b) TEM: The TEM images of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$(x=0.100) nanoferrites by Sol-gel auto combustion method as shown in Fig.3.The nanoparticles are clearly observed in the hexagonal shape.The size of nanoparticles confirms that from 16.95 nm to 20.34 nm.

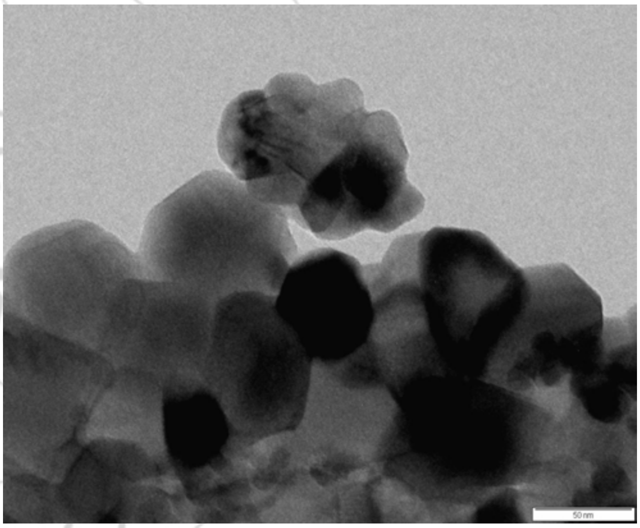

Figure 3: TEM of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$(x=0.100)

3.2 Optical properties

a) **FTIR:** The FTIR Spectra of the prepared ($Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$) (x = 0.025) are shown in Fig.4.The intense absorpion bond is observed at 600 cm^{-1} which shows the characteristic bond of spinel structure.

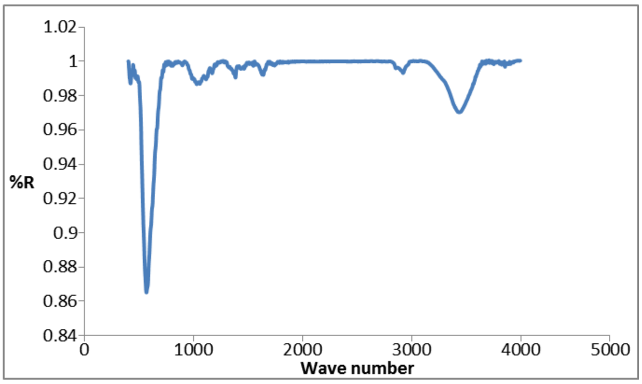

Figure 4: FTIR of $Co_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$(x=0.025)

b) **UV-Visible:-** The UV-Visible spectrum of the prepared ($Co_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$) are shown in Fig.5. UV-Visible spectrum analysis was observed in the wavelength range 200 nm to 800 nm. The absorption peaks are observed at 323nm,324nm,326 nm and wavelength peaks are shifted.The UV visible indicates that sintering temperature and composition of the sample has the best influence on the optical property.

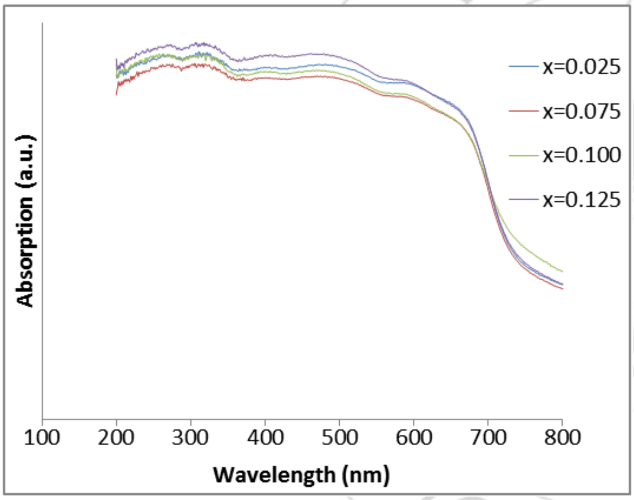

Figure 5: UV-Visible of $Co_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$

4. Conclusions

We have successfully synthesized Nanoparticles of $Co_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$. The XRD pattern of $Co_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ (where x=0.025, 0.050, 0.075, 0.100, 0.125) shows that size of nanoparticles decreases with the increase in La^{3+} content. The SEM and TEM confirm the formation of nanoparticles and TEM shows the nanoparticles observed in hexagonal shape. The FTIR shows that intense absorption bond is observed at 600 cm^{-1} which gives the characteristic bond of spinel structure. The UV-visible graph shows that analysis of UV-Visible spectrum was analysed in the wavelength range 200 nm to 800 nm and absorption peaks are observed at 323nm,324nm,326 nm.

References

[1] E. Pervaiz and I.H. Gul, "Low temperature synthesis and enhanced electrical properties by substitution of Al^{3+} and Cr^{3+} in Co–Ni nanoferrites", Journal of Magnetism and Magnetic Materials, 343, 2013, 194-202.

[2] M.T. Farid, I. Ahmad, S. Aman, M. Kanwal, G. Murtaza, I. Ali, I. Ahmad, and M. Ishfaq, "Structural, Electrical and Dielectric Behavior of $Ni_xCo_{1-x}Nd_yFe_{2-y}O_4$ nano-ferrites synthesized by sol-gel method", Digest Journal of Nanomaterials and Biostructures,10(1) , 2015, 265- 275.

[3] M. Mozaffari, J. Amighian, and E. Darsheshdar, "Magnetic and structural studies of nickel-substituted cobalt ferrite nanoparticles, synthesized by the sol-gel method", Journal of Magnetism and Magnetic Materials, 350, 2014, 19-22.

[4] A.A. Sattar, H.M. El-sayed, K.M. El-shokrofy, and M.M. El-tabey, "Improvement of the magnetic properties of Mn-Ni-Zn Ferrite by the non-magnetic Al^{3+} Ion substitution", Journal of Applied Sciences, 5, 2005, 162-168.

[5] A. Hussain, T. Abbas, and S.B. Niazi, "Preparation of $Ni_{1-x}Mn_xFe_2O_4$ ferrites by sol-gel method and study of their cation distribution", Ceramics International, 39, 2013, 1221-1225.

[6] R.U. Mullai, P. Priyadharsini Pradeep, and G. Chandrasekaran, "Synthesis and Characterization of Lanthanum Doped Mg-Zn Ferrite Nanoparticles Prepared by SOL-GEL Method", International Journal of Recent Trends in Science and Technology, 5(2), 2012, 78-85.

[7] M. Maria Lumina Sonia, S.Blessi ,and S. Pauline, "Role of Lanthanum Substitution on the Structural and Magnetic Properties of Nanocrystalline Nickel Ferrites", International Journal of Advance Research In Science And Engineering, 3(7), 2014, 360-367.

[8] G. Venkaiah, K. Venkateswara Rao, V. Sesha Sai Kumar, and C.H. Shilpa Chakra, "Solution Combustion Synthesis and Characterization of Nano crystalline Lanthanum Ferrite using Glycine as a fuel", International Journal of Materials, Methods and Technologies, 1(1), 2013, 01-07, ISSN: 2327- 0322 (Online).

[9] I. M. Abdulmajeed and L. S. Khalil "Structural and Optical Properties of $Co_{1-x}Zn_xFe_2O_4$ Synthesis by Sol-Gel Auto Combustion Method", International Journal of Current Engineering and Technology, 6(3),2016,976-981.

[10] S. M. Rathod , V. G. Deonikar , R. R. Shah , P. P. Mirage, " Synthesis, Magnetic and optical properties of $Ni_{0.5}Co_{0.5}$ Al Nanoferrite by autocombution Technique", International Journal of Engineering Research & Technology,3(5),2014,1486-1489.

[11] A. I. Ahmed, M. A. Siddig, A, A. Mirghni, M. I. Omer, A. A. Elbadawi , "Structural and Optical Properties of $Mg_{1-x}Zn_xFe_2O_4$ Nano-Ferrites Synthesized Using Co-Precipitation Method", Advances in Nanoparticles, 4,2015, 45-52.