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Study of Dielectric and Electric properties of La^{3+} Doped Ni-Zn Nanoferrite

Kulkarni VD[1] and Rathod SM[2]

[1]Department of Physics, Hutatma Rajguru Mahavidyalaya, Rajgurunagar, Pune, 410505, MS, India
*Research Student, Science College, SRTM University, Nanded
[2]Nanomaterials & Lasers Research Lab, Abasaheb Garware College, Pune, 411004, MS, India
E-mail: kulkarni_vd55@yahoo.co.in | smragc@rediffmail.com

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ABSTRACT

The rare earth La^{3+} material substituted in Nickel-Zinc nano ferrite was synthesized by sol-gel auto combustion method. The dielectric and electric properties of the $Ni_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$nanoferrite where (x=0.025, 0.050, 0.075, 0.100, 0.125) were studied. The dielectric constant and dielectric loss was observed with the variation in frequencies. The a. c. resistivity was observed with the increase in Lanthanum concentration. The dc resistivity of $Ni_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$ nanoferrite with increase in frequency was investigated at constant temperature 200^0C using Two Probe method. The dc conductivity of $Ni_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$ nanoferrite was observed with increase in Lanthanum concentration.

Keywords: - Sol-gel method, Ni-Zn nano ferrite, dielectric constant, dielectric loss, dc resistivity, a. c. resistivity.

INTRODUCTION

The Al^{3+} and Cr^{3+} doped Co-Ni spinel ferrites was successfully synthesized by the sol gel auto combustion method. The dielectric parameters decrease due to the doping of the nickel, aluminum and chromium ions in the cobalt ferrites. Such ferrite has the applications in the high frequency and electromagnetic wave absorbing devices due to the high dc resistivity [1]. The sol gel auto combustion method has the excellent mixture of the combustion and chemical gelation route. The sol gel auto

combustion method has the good stoichiometric ratio and gives the ultrafine nanoparticles. The Lanthanum substituted in Nickel ferrite [2]. The cadmium substituted nickel- cobalt nanoferrite was synthesized by standard double sintering ceramic method. The resistivity was decreases with increase in cadmium content. The dielectric constant decreases as frequency increases. The AC conductivity increases as increase in frequency [3]. The Ni-Zn ferrite was prepared using the solid state reaction method. As temperature increases then the DC resistivity also decreases and DC resistivity was obtained by Two Probe Method [4]. The Zinc doped cobalt ferrite was successfully prepared by the solution combustion method. The electric and dielectric properties of Zinc doped cobalt ferrite were studied and it was found that dielectric constant and dielectric loss decreases as frequency increases [5]. The Cu^{+2}doped Ni-Zn ferrite was synthesized by auto combustion method. It was reported that that dielectric constant and dielectric loss are depends on the frequency. The dielectric constant increases as copper content increases [6]. The $Ni_{1-x}Cd_xFe_2O_4$ ferrite was obtained by the sol gel auto combustion method. It was noted that dc resistivity is the temperature dependent. The dc resistivity decreases as temperature increases and hence Ni-Cd ferrite shows that the semiconducting behavior [7]. The $Cu_{1+x}Ti_xFe_{2-2x}O_4$ (x= 0.0, 0.05, 0.1, 0.15, 0.2 and 0.3) was synthesized by ceramic method. It was noted that dielectric constant and dielectric loss decreases as frequency increases and concluded that normal behavior of the dielectric [8]. The Ni–Cu–Zn ferrites were prepared by the oxalate based precursor method. The dielectric constant and dielectric loss decreases as increase in frequency [9].

The ferrites have large number of applications in various fields. Therefore, rare earth La^{3+} material doped in Nickel- Zinc ferrite was prepared by sol-gel auto combustion method. The dielectric and electric properties was studied.

MATERIALS AND METHODS:

All chemicals such as Ferric nitrate ($Fe(NO_3)_3.9H_2O$), Nickel nitrate ($Ni(NO_3)_2 \cdot 6H_2O$), Zinc nitrate ($Zn(NO3)_2 \cdot 6H_2O$), Citric acid ($C_6H_8O_7$), Ammonium hydroxide (NH_4OH) was used in high purity AR grade. The stoichiometric ratio proportion of all nitrates and citric acid was used. All nitrates were added in distilled water and stirred till to obtain the homogeneous solution. To maintain pH= 7, the ammonium hydroxide solution was added drop by drop during the stirring process. The Citric acid was used as a Fuel. This solution was stirred constantly for 3 to 4 hours to obtain sol at temperature 100˚C. When a viscous brown gel was formed, then the auto-combustion takes place. The fine powder of $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ nanoferrite was obtained. The $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ nanoferrite powder was sintered at 600 ˚C for 4 hours. The $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ (Where x=0.025, 0.050, 0.075, 0.1, 0.125) nanoparticles were synthesized by sol-gel auto combustion synthesis Method.

RESULT AND DISCUSSION:

Dielectric Properties:

The dielectric constant **(ε)** was calculated using the formula

$$\varepsilon = \frac{C^* t}{Eo * S}$$

Where

C=capacitance in farad,
t =thickness in meters,
C=cross sectional area of pellet and
εo = permittivity of free space.

The dielectric constants (ε) of the $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ where (x=0.025, 0.050, 0.075, 0.100, 0.125) nanoferrite was observed from 100Hz to 5 MHz and it is shown in Fig.1. It was found that the dielectric constant decreases as increase in the frequency, this shows that normal behavior of magnetic material. The dielectric loss (Tan δ) of the $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ where (x=0.025, 0.050, 0.075, 0.100, 0.125) nanoferrite was observed from 100Hz to 5 MHz and it is shown in Fig.2.The peaks was observed initially at lower frequencies. It was noted that the dielectric loss decreases with increase in frequencies at higher frequencies. Hence it gives the abnormal behavior of the dielectric loss at certain frequencies. The AC resistivity versus concentration of the Lanthanum graph is shown in Fig.3.

The AC resistivity is maximum at x=0.075. The AC resistivity is varying with the increase in Lanthanum concentration.

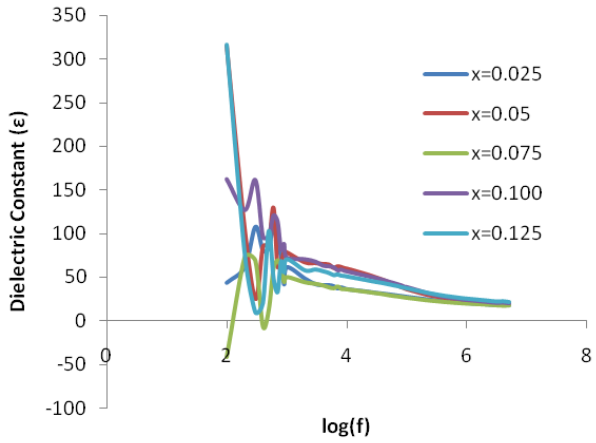

Fig.1: Graph of Dielectric Constant (ε) with log(f)

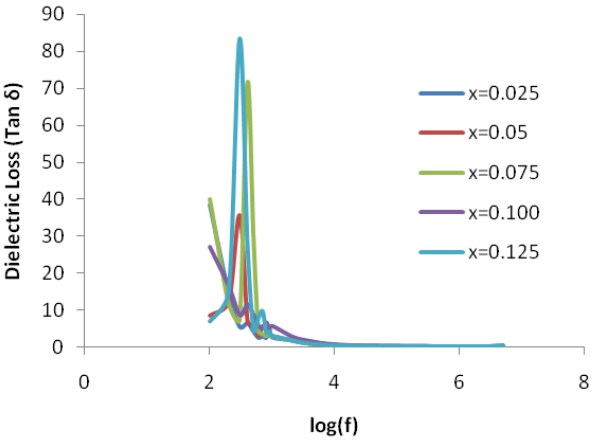

Fig.2: Graph of Dielectric Loss (Tan δ) with log(f)

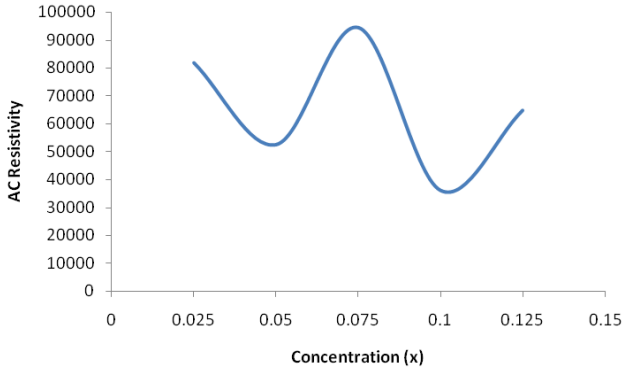

Fig.3: Graph of Concentration (x) with AC Resistivity

Electric Properties:

The dc resistivity (ρ) of the $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$(where x = 0.025, 0.050, 0.075, 0.100 and 0.125) nanoferrite was obtained by Two Probe method. The dc resistivity was calculated by the formula

$$\text{DC Resistivity } (\rho) = \frac{AP * R}{L}$$

Where,

Ap= Surface area of the pellet,

R= Resistance of the sample,

L= Length of the pellet

It was found that the DC resistivity of the $Ni_{0.5}Zn_{0.5}La_xFe_{2-x}O_4$ nanoferrite at 200^{0}C increases as Voltage increases and shown in Fig.4. The electric properties of the nanoferrite were decided by the cation distribution. The DC conductivity increases up to x=0.05 and decreases after x=0.05 at 200^{0}C, which is shown in Fig.5.

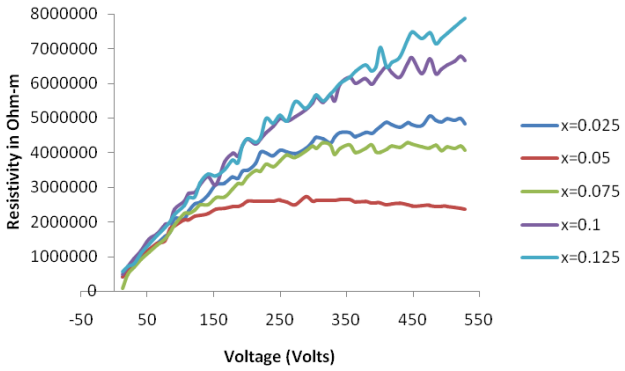

Fig.4: Graph of dc Resistivity with Voltage at 200^{0}C

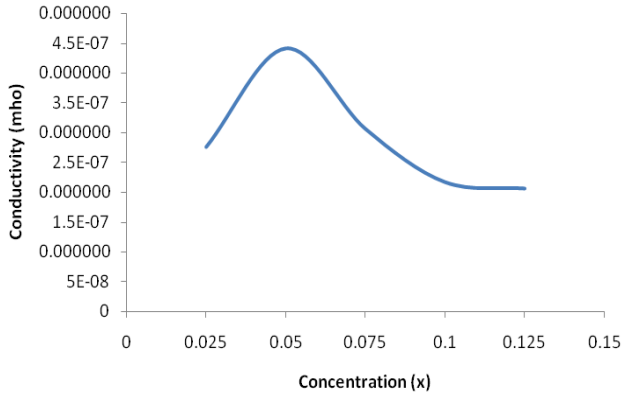

Fig.5: Graph of dc conductivity with concentration (x) at 200^{0}C

CONCLUSION

The $Ni_{0.5}Zn_{0.5}$ $La_xFe_{2-x}O_4$nanoferrite where (x=0.025, 0.050, 0.075, 0.100, 0.125) were synthesized successfully by the sol gel auto combustion method. The dielectric constant of all samples decreases as increase in the frequency; this indicates the normal behavior of magnetic material. The dielectric loss of all samples decreases with increase in frequencies after some initial peaks. It shows that the abnormal behavior of the dielectric loss at specific frequencies. The AC resistivity is fluctuating with the increase in Lanthanum concentration. The DC resistivity of all nanoferrite samples at 200^0C increases with increase in Voltage. The DC conductivity decreases after x=0.05 at 200 ^{0} C.

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