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Electrical and Magnetic properties of ZNCF

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Abstract: Cubic centred zinc nickel cerium ferrite nanoparticles $Zn_{1-x-y}Ni_yCe_xFe_20_4$ have been synthesized by a sol-gel method. The XRD patterns displayed the characteristic peaks of ZnNiCe Fe_20_4 the resulting powders also characterized by SEM, EDAX. The hysteresis property of this material was conformed through its hysteresis curves. The permeability of this material was calculated by using the magnetic saturation obtained from the hysteresis curves. The magnetic properties were determined by vibrating sample magnetometer at room temperature. The electrical measurements have been performed to determine the dielectric constant, loss tangent.
Keywords: Nano ferrite, Electrical property, Magnetic property.

Introduction

Ferrites have been in the emerging focus of recent research and development field. [1-3].As a ferrites having high dc resistivity are used in making core of the transformers and chokes and ferrites having extremely low dielectric loss are very useful for microwave communication. Nano Ferrites of $Zn_{1-x-y}Ni_yCe_xFe_20_4$ plays a vital role in the process of miniaturization and to have the importance in technology [4-6]. Zinc ferrites found a wide spread application in microwave devices because of their typical magnetic property and dielectric losses and this ferrite may have a high resistivity [7]. The magnetic and dielectric properties of cerium doped zinc ferrite as a function of temperature and frequency has been reported [8].The dielectric properties of Ni- Zn ferrite in the frequency range 10^2 to 10^5 Hz has been investigated by murthy and shobanadri [9]. A strong correlation between the mechanism and dielectric behavior of the ferrites has also been reported [10].The substitution of small amount of rare earth ions may bring about the important changes in electrical, structural and magnetic properties of this ferrite. Nickel ferrite behaves as semiconductors with low mobility of charge carriers and an exponential dependence of electrical conductivity on temperature [11].

Nano ferrite with zinc substitution synthesized using sol-gel method are studied in the present of preparing nano ferrites has many advantages such as good stoichiometric control and for the production of ultra fine particle with narrow size distribution in relatively short processing time at lower temperature [12-15]. At the same time the difference in nature of cation and its distribution in spinel as well as ionic states of metal ions in A and B sites. By using X-ray diffraction (XRD), Vibrating Sample Magnetometer (VSM), SEM, and EDAX would provide a meaning full correlation of their structure and effective changed of ions [16]. VSM studies were used to analyze the hysteresis behavior and determination of permittivity and loss tangent leads towards designing of Microstrip patch antenna.

Experimental Procedure

Ferrite powder of composition was prepared by using sol-gel method. The required amount of metal nitrates and citric acid are taken and these metal nitrates were dissolved together in said amount of de-ionized water to get a clear brown solution. Finally ammonia was added slowly to adjust the pH level at 7 to remove the acidic behavior and finally the solution was heated at 80°C to transform in to gel, this dried gel was burnt completely and form brown-black ash. The ash powder was grinded and the furnace at 1050°C for 2 hours. X-ray powder diffraction (XRD) pattern was recorded for the as prepared ferrite samples by using the (PAN analytical, X' Pert Pro) diffraction spectrometer. The recorded X-ray pattern was used to conclude the respective diffraction planes of structure and helps to determine the crystalline size of these as-prepared ferrites. Scanning electron microscope (SEM; S3000-H, Hitachi, Japan) was used to obtain the SEM microscopic of as prepared nano ferrite materials to determine the particle size. Energy dispersive analysis of X-ray (EDX) was done on Genesys 20 spectrophotometer (USA) which confirms the presence of element present in the as prepared material.The silver paste was coated on either side of the pellets for good ohmic contacts and acted as a good contacts and electrodes for measuring the electric and magnetic properties. The grain size of the nano ferrites is determined using Scherrer's formula [17],

$D=0.94\lambda/ \beta\cos\Theta$

The dielectric loss and dielectric constant were determined by N4L LCR meter (PSM 1735) at room temperature in the frequency range from 0.075 to 20 MHz [18]. A vibrating sample magnetometer (VSM; 73009, Lakeshore, USA) was used to study the hysteresis loops of the as prepared nano ferrite materials. The four-probe method (DFM-RM, SES Instruments, and India) was used to study the temperature dependence of electrical resistivity of these ferrite samples. The dielectric resistance, relative permittivity and loss tangent of the as prepared ferrites was determined by employing N4L LCR meter (PSM 1735, England).

Result and Discussion

XRD patterns of the synthesized materials by sol-gel route showed in fig.1.These series of XRD patterns shows that the phase formation of the prepared samples $Zn_{1-x-y}Ni_yCe_xFe_20_4$. The diffraction peaks corresponding to (440) (422) (400) (333) (311) (222) were according to the JCPDS file no 22-1086.

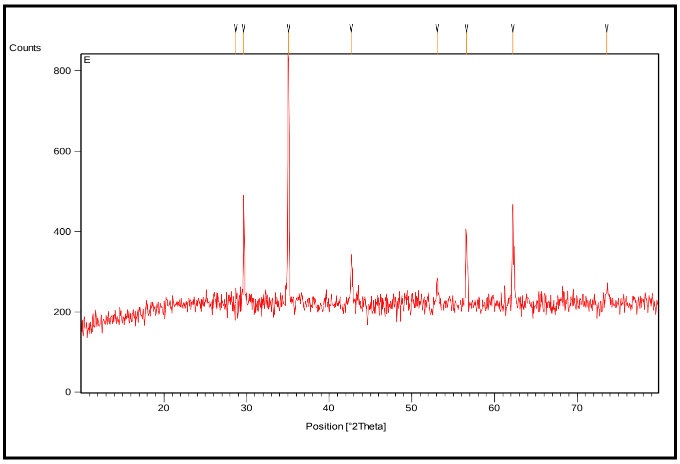


Fig 1(a) X=0.01,Y=0.003
X-ray diffraction pattern of Zn NiCeFe$_2$0$_4$ ferrites

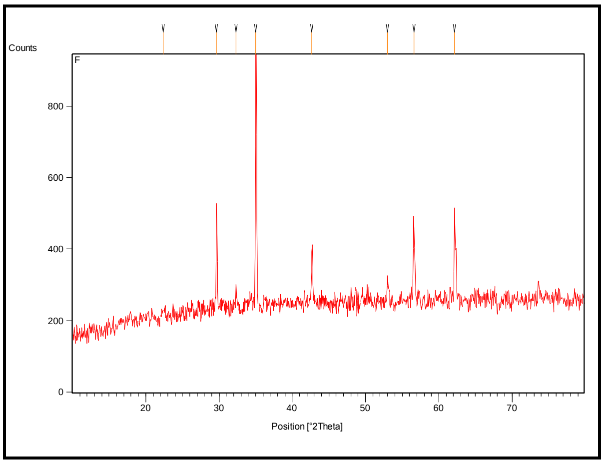


Fig 1(b) X=0.01, Y=0.003
X-ray diffraction pattern of Zn NiCeFe$_2$0$_4$ ferrites

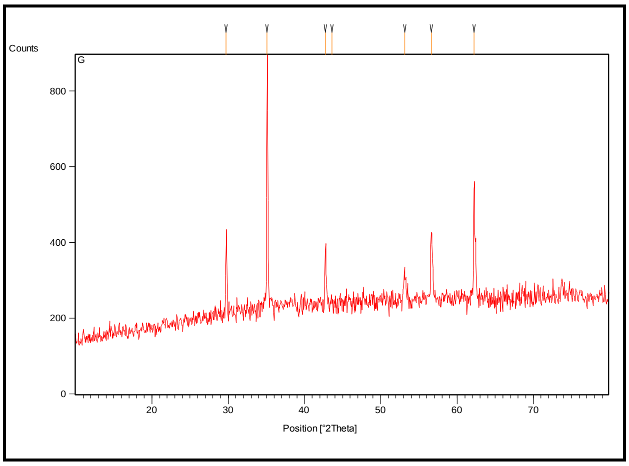


Fig 1(c) X=0.014, Y=0.003
X-ray diffraction pattern of Zn NiCe$Fe_2 0_4$ ferrites

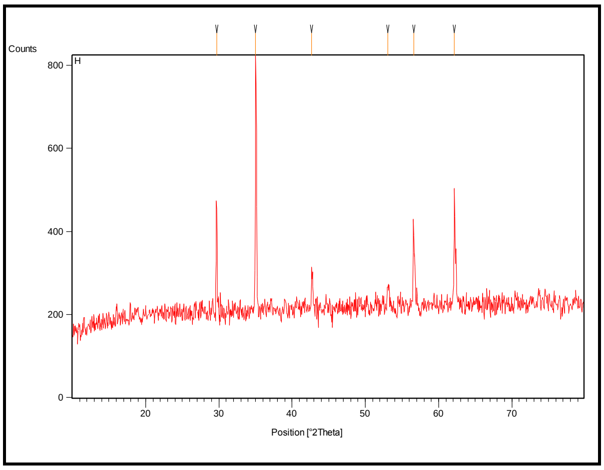


Fig 1(d) X=0.016, Y=0.003
X-ray diffraction pattern of Zn NiCe$Fe_2 0_4$ ferrites

The lattice constant of spinel structure was calculated for prominent peak (311) using Bragg's equation,

$a = d_{hkl}[h^2+k^2+l^2]^{1/2}$

Where h,k,l are the indices of mentioned planes. Lattice constants of all Ni Ferrite samples are listed in below table 1.

Table1: Lattice constants of all Ni Ferrite samples

S.No	Sample		Lattice constant (Å)
	X	Y	
1	0.01	0.003	7.791131
2	0.12	0.003	8.459332
3	0.14	0.003	8.447344
4	0.16	0.003	8.456669

It is seen that the lattice constant and to have the value in the range of 8.447 and 8.459 Å. Below figure shows the microstructure of sintered specimen. This specimen shows the presence of a monophasic homogenous microstructure. Ce doped specimen shows a biphonic microstructure. The earth ions occupy the A-site of ferrite ions. This is due to the fact that tetrahedral sites are small to be occupied by the large rare earth ions which have large ionic radius [19, 20].The probability of occupancy of the octahedral (B site) by the rare earth ions will increase with decrease in the R ionic radius.

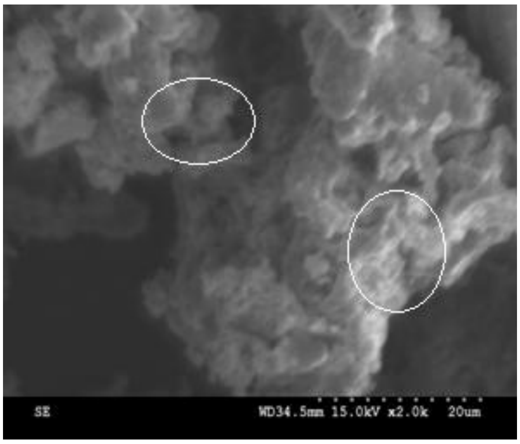


Fig 2(a) X=0.01, Y=0.003 SEM of Zn NiCe$Fe_2 0_4$ ferrites

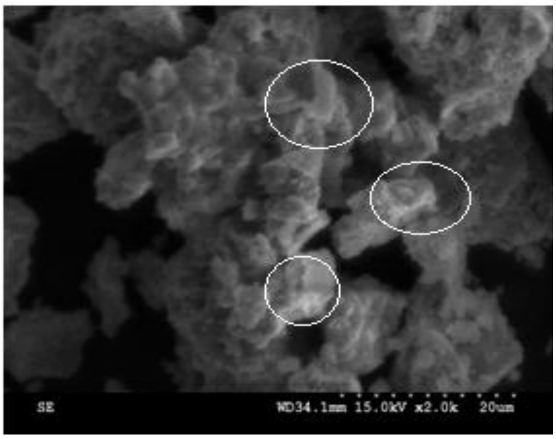


Fig 2(b) X=0.012, Y=0.003 SEM of Zn NiCe$Fe_2 0_4$ ferrites

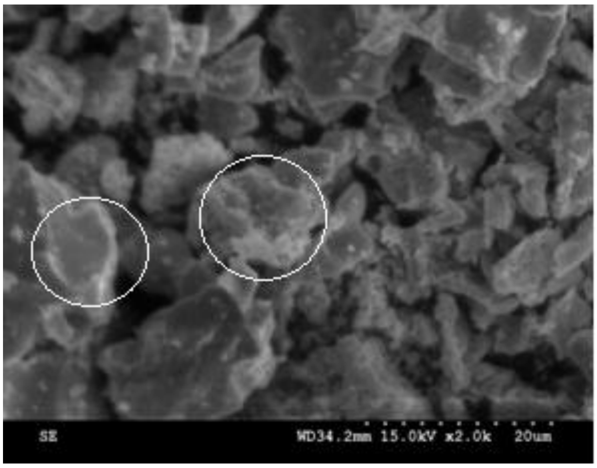


Fig 2(c) X=0.014, Y=0.003 SEM of Zn NiCeFe$_2$0$_4$ ferrites

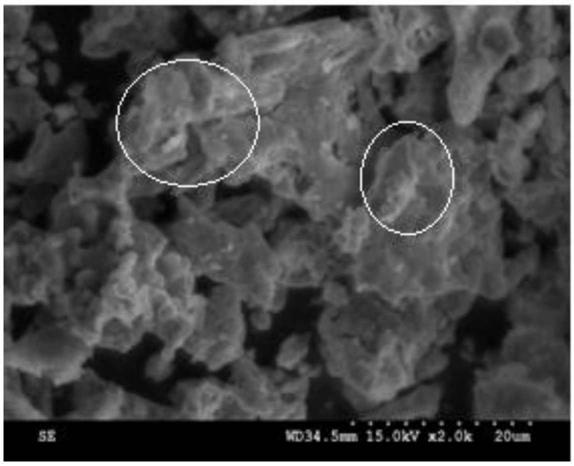


Fig 2(d) X=0.016, Y=0.003 SEM of Zn NiCeFe$_2$0$_4$ ferrites

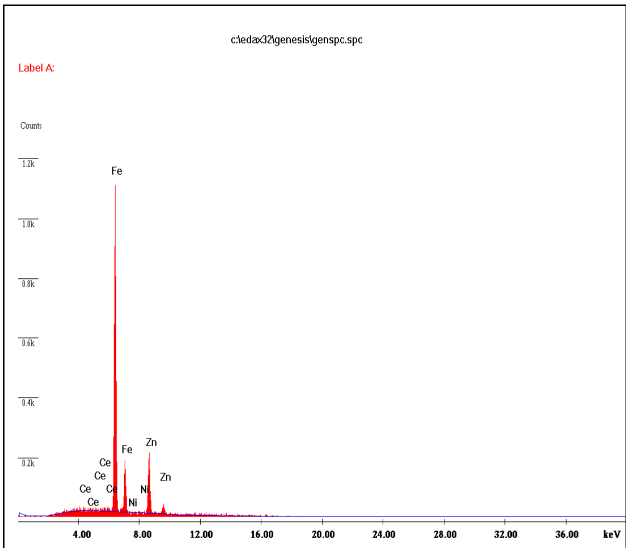


Fig 3(a) X=0.014, Y=0.003 EDAX of Zn NiCeFe$_2$0$_4$ ferrites

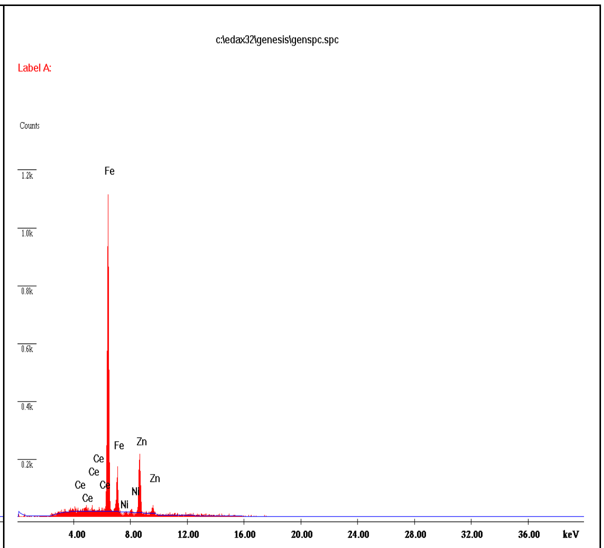


Fig 3(b) X=0.016, Y=0.003 EDAX of Zn NiCeFe$_2$0$_4$ ferrites

Magnetic Properties

Field Vs Momentum

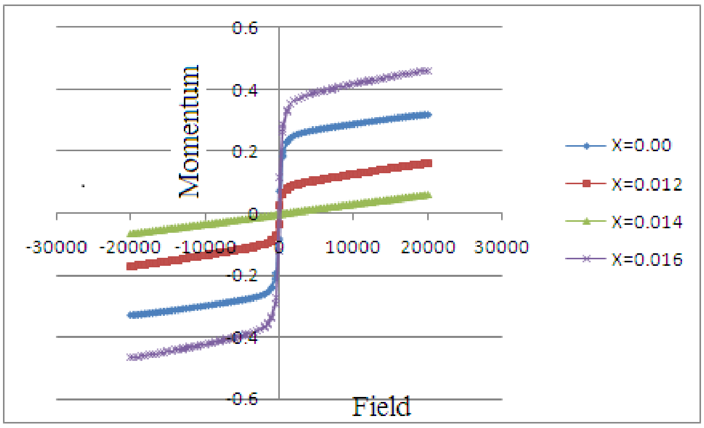
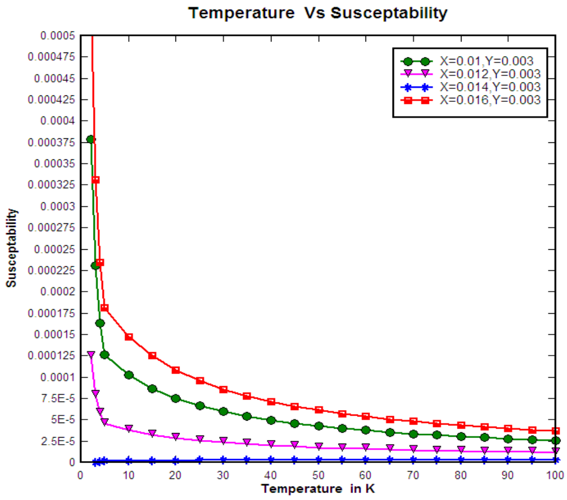


Fig 4 Magnetic hysteresis curve for Zn NiCeFe$_2$0$_4$ ferrites

The hysteresis loop shows the magnetization as the measuring field of the magnetometer is cycled through positive and negative fields of magnetic field for the synthesized $ZnNiCeFe_2O_4$ .The above figure 4 shows the increase in saturation magnetization with respect to magnetic field. The magnetic properties tested by VSM at room temperature for different produced ferrite powders.



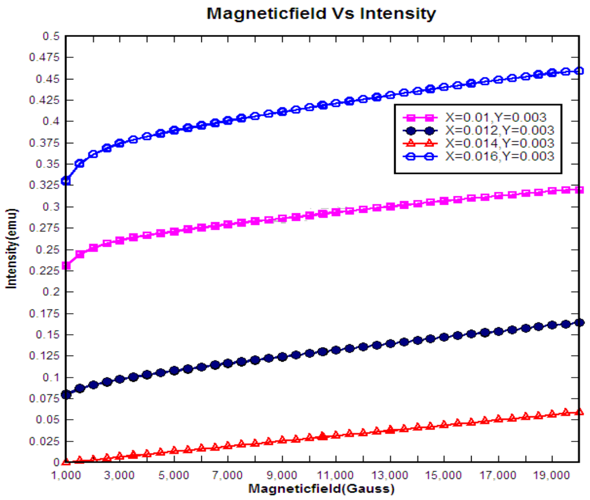


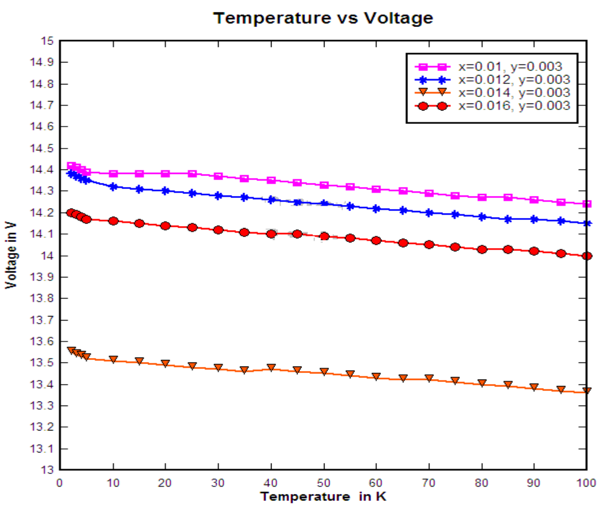
Fig 5 Variation of Susceptibility of Zn NiCe Fe_20_4 ferrites with applied temperature

Fig 6 Saturation magnetization for Zn $NiCeFe_20_4$ ferrites

The above figure 5 shows that the increasing cerium content induced a polar to non polar phase transition. Within the polar region a rhombohedral and two orthorhombic modifications of $Zn_{1-x-y}Ni_yCe_xFe_20_4$ were found. It was shown that cerium substitution resulted in the appearance of spontaneous enhanced modification upon the composition driven transition from to a rhombohedral to orthorhombic phase. From figure 6 it is observed values of magnetization and magnetic moment do not show agreement with the magnetic moment contribution of respective ions substituted in Zn ferrite i.e., Ce^{2+} and Ni^{2+} and figure 6 shows the variation in saturation magnetization (Ms) for the different x values of $Zn_{1-x-y}Ni_yCe_xFe_20_4$ ferrite, the saturation magnetization (Ms) value increases with increase in the value of x. The increasing cerium and nickel content induced a transition. The observed values of magnetic field and intensity

Electrical property

The voltage and temperature study of our material (Zn $NiCeFe_20_4$) was carried out for a temperature 100K. It was seen as figure 7, that the voltage was decreasing with the increase in temperature. This conduction is nano structured Zn Ferrite doped with Ni and Ce showed the polaron conduction. It is reach that the voltage/resistance decreases with the increase in temperature which confirmed the n type behaviour of the material between the temperatures of 100K. The d.c. resistivity decreases as a function of temperature, indicating semi conducting nature of the ferrites and the positive value of See beck coefficient establishes n-type conduction behaviour for all the ferrite samples.



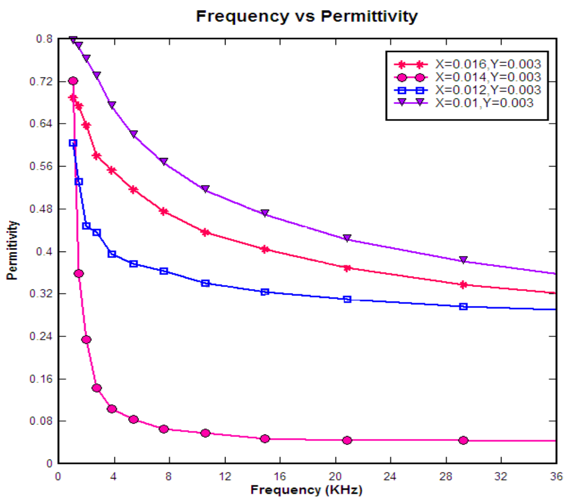
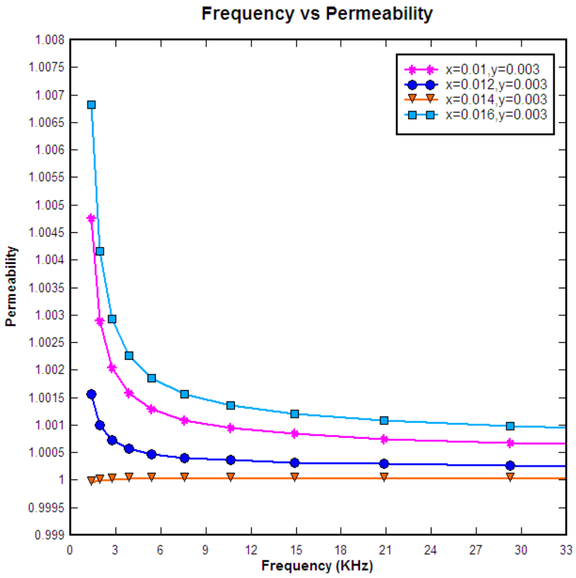


Fig 7 Behaviour of Temperature and Voltage for

Fig 8 Dielectric constant for Zn $NiCeFe_20_4$ ferrites

Zn NiCeFe_2O_4 ferrites



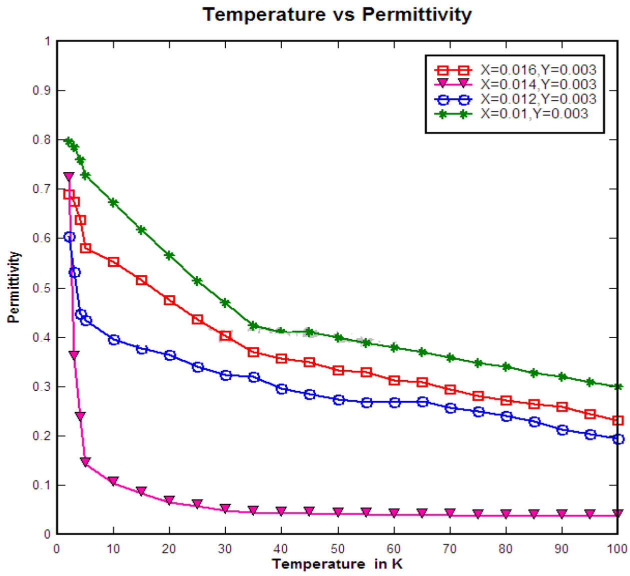


Fig 9 Frequency dependency of permeability for Zn

Fig 10 Behaviour of Temperature and Permittivity NiCeFe_2O_4 ferrites

The variation of dielectric constant with frequency as shown in above figure 8, it can be seen that the dielectric constant decreases with increase in frequency and reaching constant value at higher frequencies as observed in the case of Zn NiCeFe_2O_4 ferrites is a normal dielectric behavior of spinel ferrites [21]. Similar dielectric behavior was also observed by several authors in the case of NiZn [22], LiCd [23], LiTiZn [24] and MnZn [25]. The plot shows that while the dielectric constant remains constant at certain frequency. The electron exchange between the ions gives local displacement of electrons in the direction of the applied electric field which determine the polarization.

The above figure 9 shows the frequency dependency of the permeability in of Zn NiCeFe_2O_4 ferrites with different Ce content. The permeability is stable in frequency range up to 100 KHz.

From the figure 10 shows the variation in initial permittivity as a function of temperature for Zn NiCeFe_2O_4 ferrites. It is evident from the figure that initial permittivity remains constant over a wide range of temperatures for all samples. It can also be noticed from figure 10 that the microwave sintered ferrites show good thermal stability. This indicates that the shape of the permittivity-temperature curves depends on the preparation conditions. It can be also noted from fig 10 the permittivity decreases and maintain constant at certain temperature.

Conclusion

Nano crystalline powder of $ZnNi_yCe_xFe_{2-x-y}O_4$ was successfully synthesized by sol-gel route method. Nano sized formation was confirmed by XRD and SEM micrograph. The ferrite powder was sintered at >950˚c resulting in to a highly dense ceramic material. The purity of the as prepared doped Zinc ferrite samples was confirmed by EDAX. The saturation magnetization of this powder was determined using a Vibrating Sample magnetometer. Semiconducting behavior of the material was confirmed by using four probe instruments. Permittivity and tanδ was determined by using LCR meter.

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