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Synthesis and Characterization of Europium Doped Nickel Zinc Cobalt Ferrite

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Motivation

Bangladesh is now better in software development,theoretical study and some kind of industrial works.But hardware like microprocessors, transducers,memorydevices,inductors,capacitors,transistors,etc.is not appreciated from the point of research interest.Manufacturing such devices need much more attention in the research area whereas a few researchers are active in this field.we hope that this study will bring a little contribution to the material research field.

Abstract

Ferrite sample of the composition $Ni_{0.5}Zn_{0.3}Co_{.2}Eu_xFe_{2-x}O_4$ (where,x=0.00,0.02,0.04,0.06,0.08,0.10) was synthesized using solid-state reaction method from the oxide powders of Ni, Zn, Co, Eu and Fe.The structural properties and phase identification were studied by using X-ray diffraction(XRD) and the analyses found spinel cubic structure for ferrite samples.XRD pattern of NZCEF has been introduced with $EuFeO_3$ secondary peak.The lattice parameter initially decreased then increased with Eu concentrations(maximum at x=0.08).The porosity was found decreasing from 45.43% to 39.28% as the 'x' was increased from 0.02 to 0.10.FTIR analyses confirmed the metal-oxygen bonds in ferrite structures.The average grain size measured by SEM was found slightly increasing and maximum at x=0.08.VSM was used to calculate the M-H loop at room temperature.For x=100%,the saturation magnetization was found to be maximum.The real part of relative permeability was maximum at x=0.02 and then decreased with additional content of x.The frequency dependent real part of relative permittivity(ε) was maximum for pure ferrite and decreased with europium.Resistivity(ρ) had the maximum values for x=0.10 and minimum for pure ferrites.This sample can be a good candidate for potential applications in storage device, magnetic sensors and spintronic devices.

Materials & Method

NZCEF was prepared using conventional solid state reaction method from their oxide powders. $(0.50)NiFe_2O_4$ + $(0.30)ZnFe_2O_4$ + $(0.20)CoFe_2O_4$ + $EuFe_2O_4$ + Fe_2O_4 → $Ni_{.5}Zn_{.3}Co_{.2}EuFe_2O_4$.Care was taken while preparing the sample.

Oxides

Sample measurement

Milling for 6 hours

800°C

Presintering for 4 hours

Milling again for 2 hours

Pressing the saples

Desired shape

Sintering

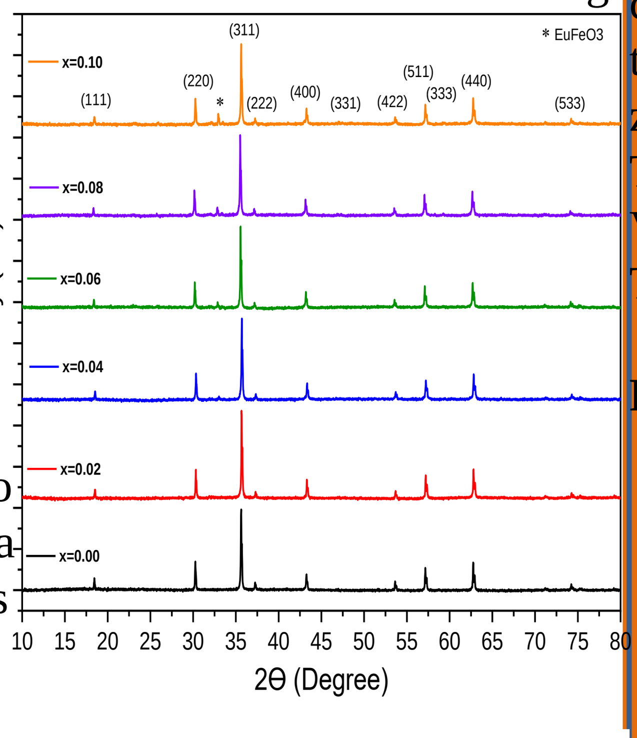
1200°C

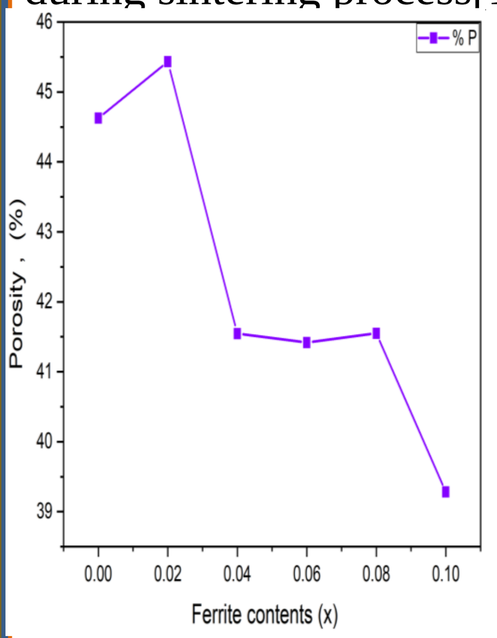
Desired shaped samples

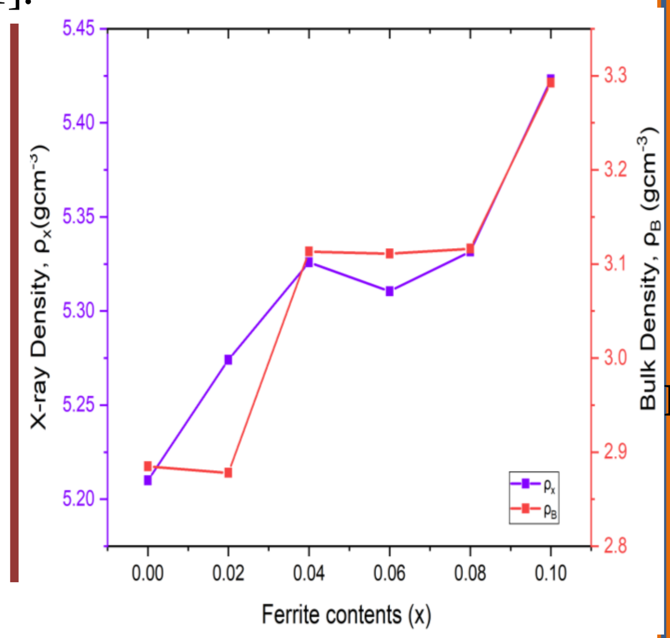
Ready for characterization

Results

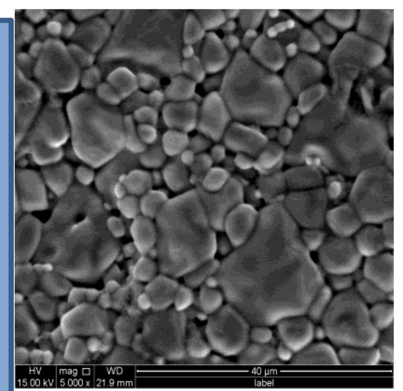
XRD Analysis: The structural properties and phase identification were studied by XRD and the miller indices of the peaks showed spinel cubic ferrite structure containing an additional peak due to $EuFeO_3$.The highest intensity peak (311) is shifted slightly towards smaller angle from x=0.02.The lattice parameter initially decresed then incresed.Porosity was found decreasing with Eu.The x-ray density was found to have higher value than bulk density which occurs as a result of porosity built during sintering process[1].



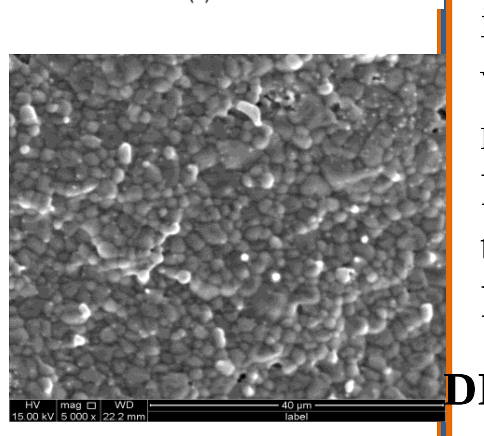




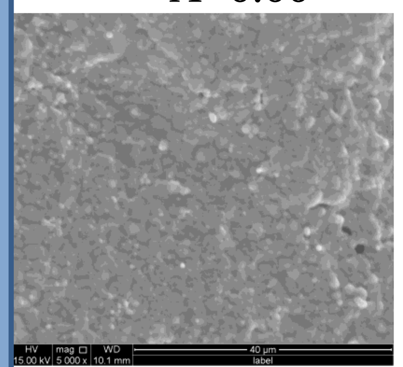
SEM Analysis: The microstructural investigation was carried out using SEM at room temperature.The averge grain size was found slightly increasing & maximum at x=0.08.The microstructural grains are randomely arranged.



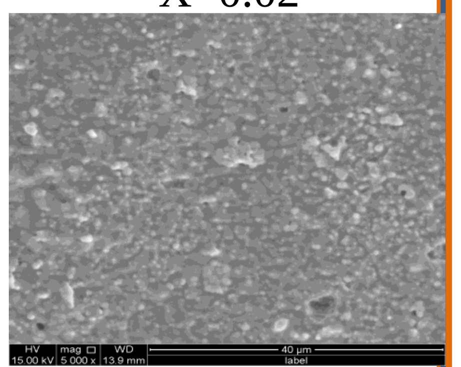
X=0.00



X=0.02

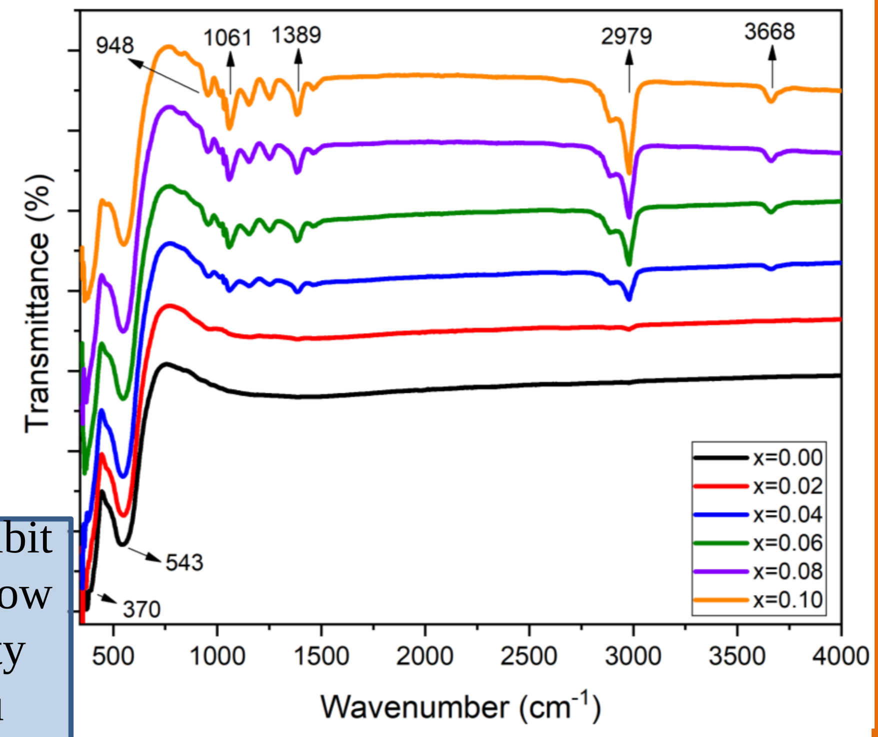


X=0.06

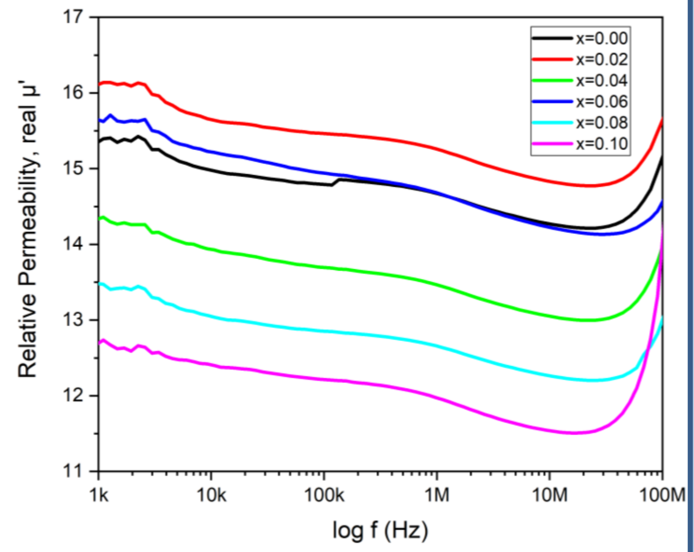


X=0.10

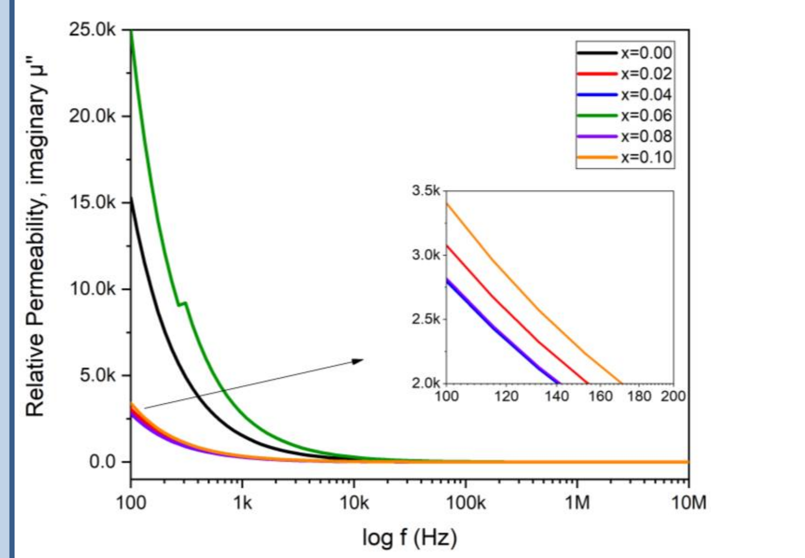
FTIR Analysis : FTIR analyses confirmed the metal-oxyzen bonds in ferrite structures.The lower frequency absorption band in the range 350-490 cm^{-1} represents the octahedral group whereas range 500-600 cm^{-1} represents tetrahedral group [2].In pure NZCEF,there appeared two strong peaks around 370 cm^{-1} and 543 cm^{-1} indicating metal-oxygen bond at octahedral site (e.g Ni-O)and tetralhedral site(e.g. Fe-O). The low intensity peak around 1400 cm^{-1} is attributed to stretching Vibration of O-H group.However,with increasing ferrite contents,the Two major peaks slightly chaged towards higher frequency range.



PERMEABILITY:

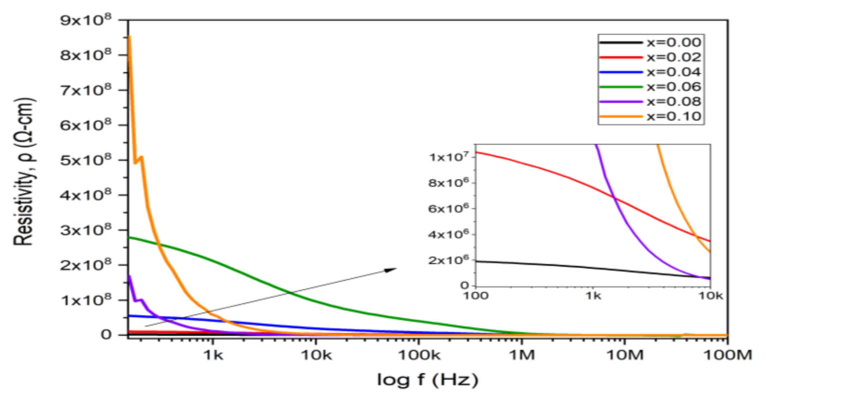


It is noticed that samples exhibit high permeability at low frequency.The initial permeability decreased with the increasing Eu content.The reversible motion of domain walls mainly affects the initial permeability [3].At high frequency, the imaginary part of permeability was attained almost constant values and the reason is saturation of polarization values. Non-uniform variation of values Is due to the variation of porosity of the samples.



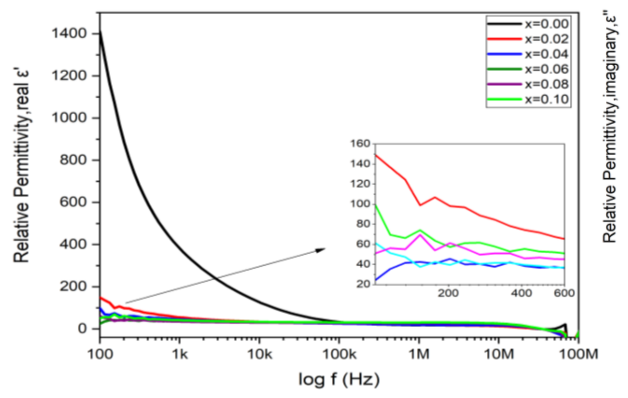
RESISTIVITY:

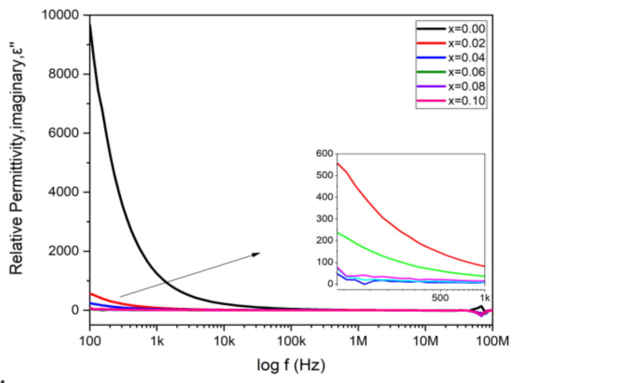
The AC resistivity of the samples was found to decrease with the increase of frequency as shown in figure.The increased frequency may enhance the hopping of charge carriers resulting in an increase in the conduction process that decresed the resistivity.The resistivity was found increasing with Eu concentrations.Addition of Eu reduced
Fe concentrations at B-site which reduced electron hoping rate and the resistivity improved [4].The resistivity had the maximum values For x=0.10 and had the minimum value for pure ferrite



DIELECTRIC MEASUREMENT:

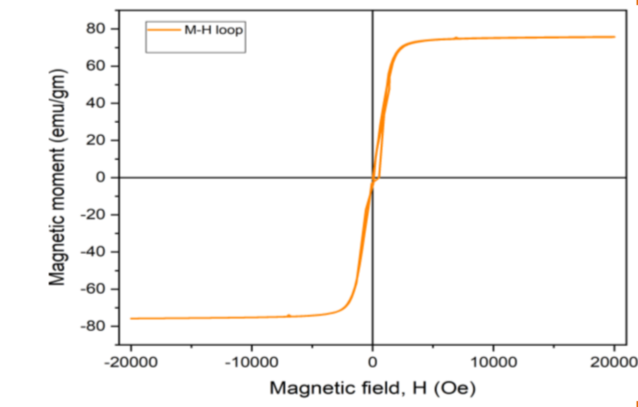
It is clearly seen that the dielectric constant decreased with increasing frequency rapidly at lower frequency but slowly at higher frequencies.After that it shows a stable structure which is the usual dielectric nature of spinel ferrite[5].The dielectric constant reduced with increasing Eu content and minimum for x=0.10.





MAGNETIZATION:

Fig. shows the magnetization curve measued at room temperature with a VSM as function of field to reach saturation values.The saturation magnetization value of the sample,taken as the magnetization which was decreased with Eu firstly and then increased.The initial decrease of magnetization with the increased EU content was due to the decrease of resultant sublattice magnetic moment.This can be explained on the basis of Neel's two sublattice models [6].VSM was used to calculate the M-H loop at room temperature.



Future Scopes

- Storage device
- Magnetic sensors
- Sprintonic sensors

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Conclusion

- The synthesized samples are single phase spinel cubic structure as confirmed by X-ray diffraction.
- The lattice parameter initially decreases then increases with Eu concentrations.
- The porosity is found decreasing with increasing Eu concentrations.
- The X-ray density is larger than bulk density because of the porosity produced during sintering process.
- Resistivity shows increasing trend with the increasing concentraton of Eu.
- The frequency dependent dielectric decreases with the increase of Eu.
- Progressive decrease of magnetization with increasing Eu content is observed.

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