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Structural and Optical Properties of Cerium Ferrite

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Abstract

$CeFe_2O_4$ ferrite powders were synthesized by sol-gel method at low temperatures. The prepared samples were characterized by X-ray diffraction, UV and FTIR, structural and optical properties of the synthesized samples were studied, from FTIR bonding and peak it confirm the material is ferrites. The lattice constants and average particle size were studied by X-ray diffraction. The synthesized powders were sintered at 700 ^oC and 800 ^oC it shows the remarkable changes in structural and optical properties of the materials. The average particle size is 28.1412 nm it is well defined Nano crystalline powder with small grain size were achieved in this study. The grain size, interplane distance, hkl planes are obtained by XRD. The optical properties with increasing the sintering temperature band gap energy increases it is in the range of semiconductor materials.

Keywords: sol-gel, FTIR, XRD and UV.

Introduction

Recent studies have shown that the physical properties of nanoparticles are enhanced significantly by various processing technique and with different composition[1-3]. This method is used to enhanced the properties of the prepared samples, such as more homogeneity and narrow particle distribution thereby influencing structural, electrical, magnetic and optical properties of cerium ferrite[4-6].

This technique is useful to develop the size and shape of the particles can be controlled[7]. In this present work we have successfully synthesized $CeFe_2O_4$ by Sol-gel auto –combustion method[8-10] and studied the effect of Ce^{3+} on the structural properties of Fe_2O_4 samples.

Materials and Methods

Experimental technique: Ce^{3+} ferrite powder was synthesized by sol-gel auto combustion technique at low temperature. Raw materials are used in the experiments are AR grade in the form of nitrates i.e. Ce $(NO_3)_2$, $Fe_2(NO_3)_2$and $C_6H_8O_7$ is used as a fuel in the ratio 1:3.

All from Merck co. of purity of 99 % using stoichiometric ratio and dissolved in distilled water. The mixture of the raw material was stirred at 80^0C on hot plate magneto-stirrer after, maintaining pH 7. It was continuously stirred to obtain uniform gel. After 4-5 hours it converts from gel to ash form, which was sintered at 700^0C and 800^0C. The FTIR characterization shows the bond formation and synthesized material is ferrite.

The structural and average particle size is studied by X-ray diffraction (XRD), it is in the crystal nature and average particle size is 28.1412 nm. Lattice constant, (hkl) planes and grain size was calculated by Bragg's law and Scherer's formulae. Optical properties studied from UV-spectroscopy to calculate the band gap energy increases with increasing temperature it is in the semiconductor range so that prepared sample confirms the nature of semiconductor material.

The chemical reaction of the synthesized sample is as follows

$$Ce(NO_3)\,6H_2O + 2Fe(NO_3)_3\,9H_2O + 3C_6H_8O_7 \xrightarrow[5\text{hrs}]{100^0\text{C}} CeFe_2O_4$$

Results and Discussion

XRD pattern is used to calculate the average size of the prepared samples is tabulated in table 1. From the figure 1 XRD of $Cefe_2O_4$ at 700^0C it shows that the crystalline phase formation of the prepared samples is not form. The Figure-2 it is clear that the phase formation of the synthesized powder is formed.

The average particle size is calculated using Scherer's formula:

$$t = \frac{0.9\,\lambda}{\beta \cos\theta}$$

Where; β = FWHM of the peak θ and it is corrected for instrumental broadening.

Optical (UV Spectroscopy) Properties: Optical properties were studied from UV-spectroscopy to calculate the band gap energy.

From Figure-3 the band gap energy of the sample is 3.351 eV and wavelength of absorb by 370 nm. From Figure-4 the band gap energy of the sample is 2.952 eV and wavelength of absorb by 420 nm.

FTIR-spectroscopy: By using FTIR spectroscopy to find bond formation.

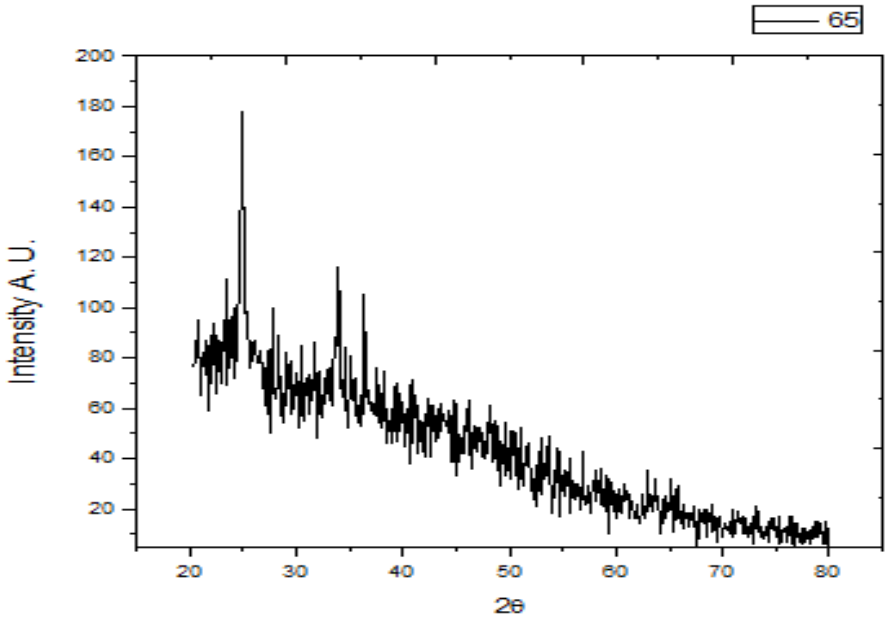

Figure-1
XRD pattern of $Cefe_2O_4$ at 700 ^{0}C

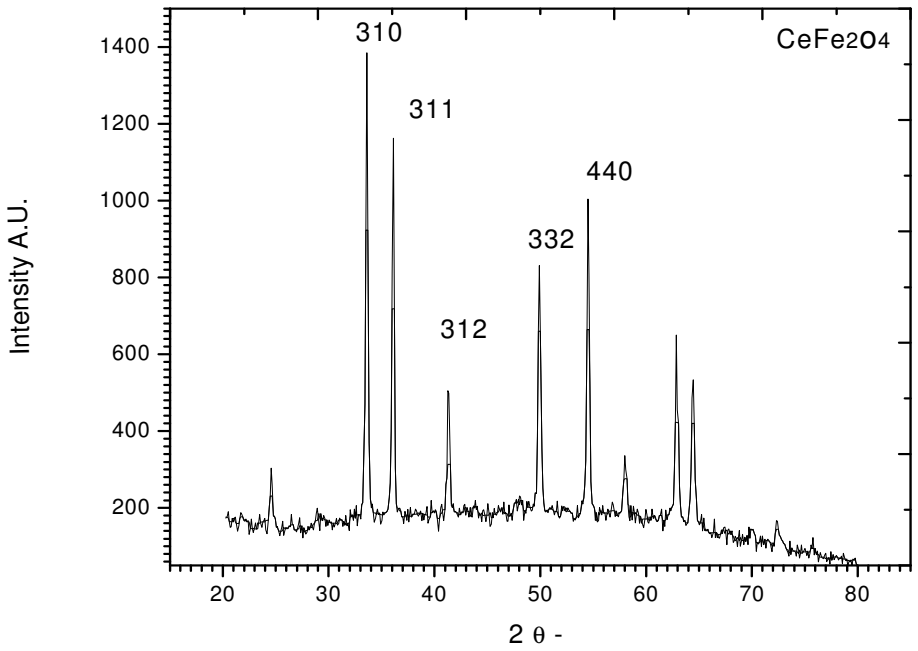

Figure-2
XRD pattern of $Cefe_2O_4$ at 800 ^{0}C

Table-1
XRD Analysis

Composition (X)	Average particle Size (nm)	Interplane distance 'd' (A)	Lattice Constant (A)
$CeFe_2O_4$	28.1412	0.2114	8.6085

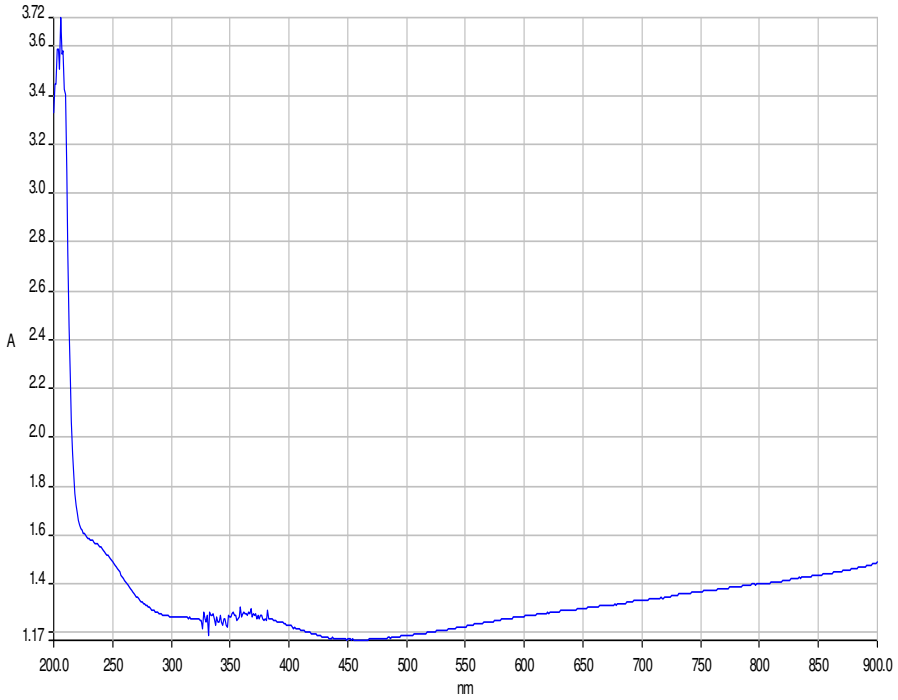

Figure-3
Shows the UV of $Cefe_2O_4$ at 700 ^{0}C

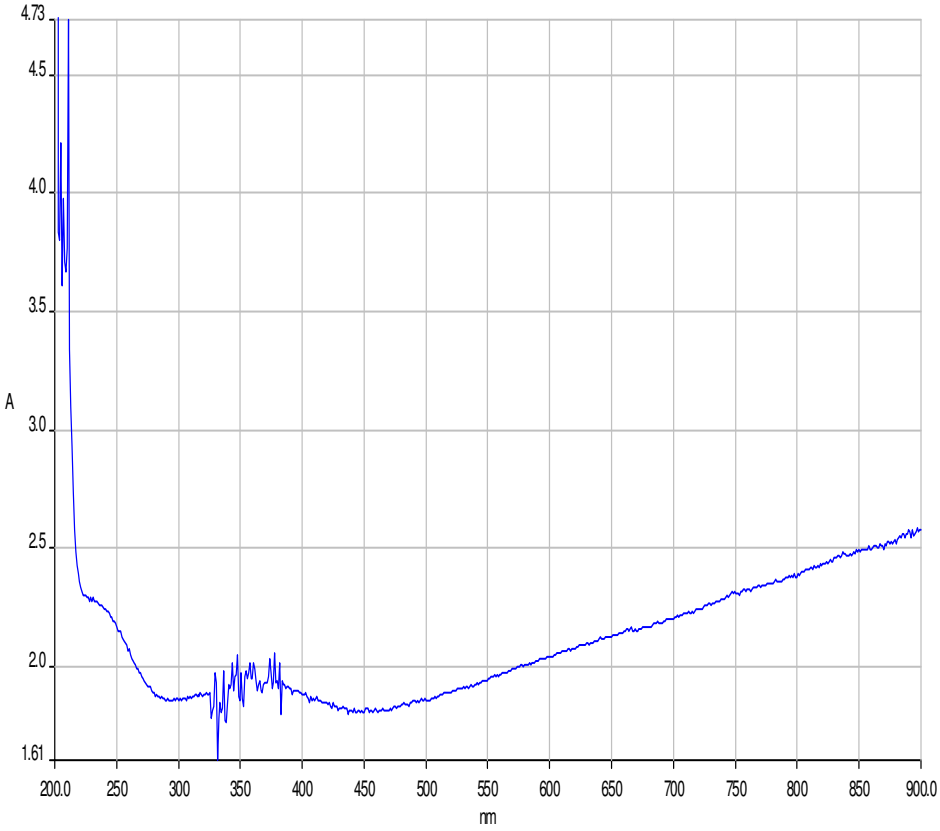

Figure-4
Shows the UV of $Cefe_2O_4$ at 800 ^{0}C

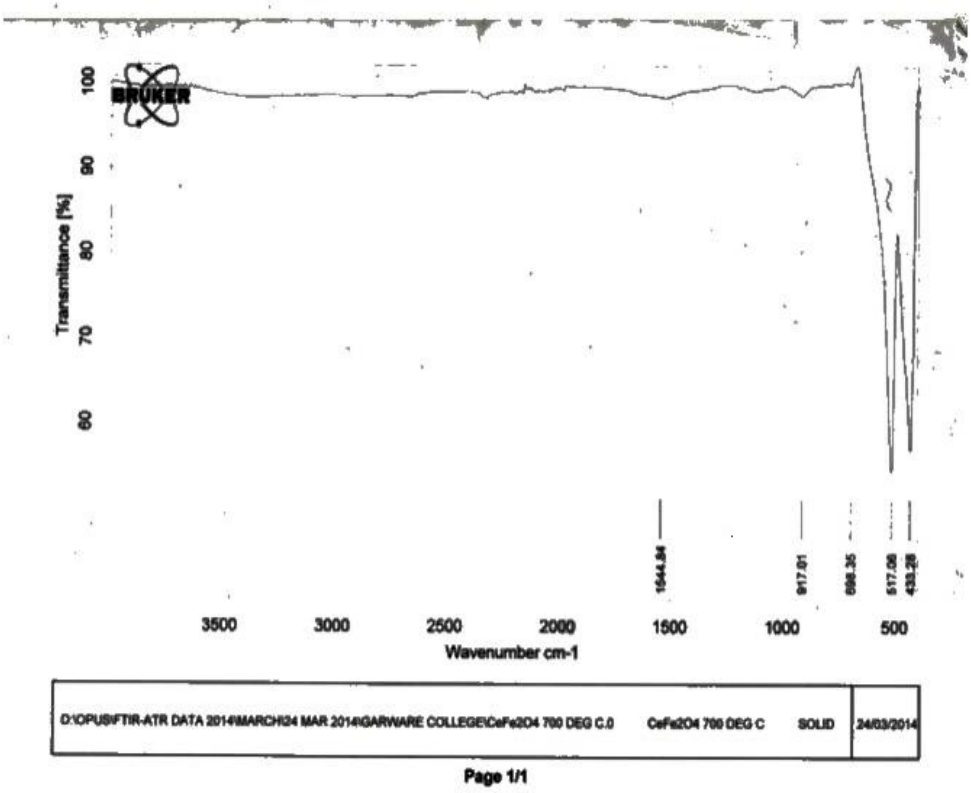

Figure-5
FTIR of $Cefe_2O_4$ at 700 ^{0}C

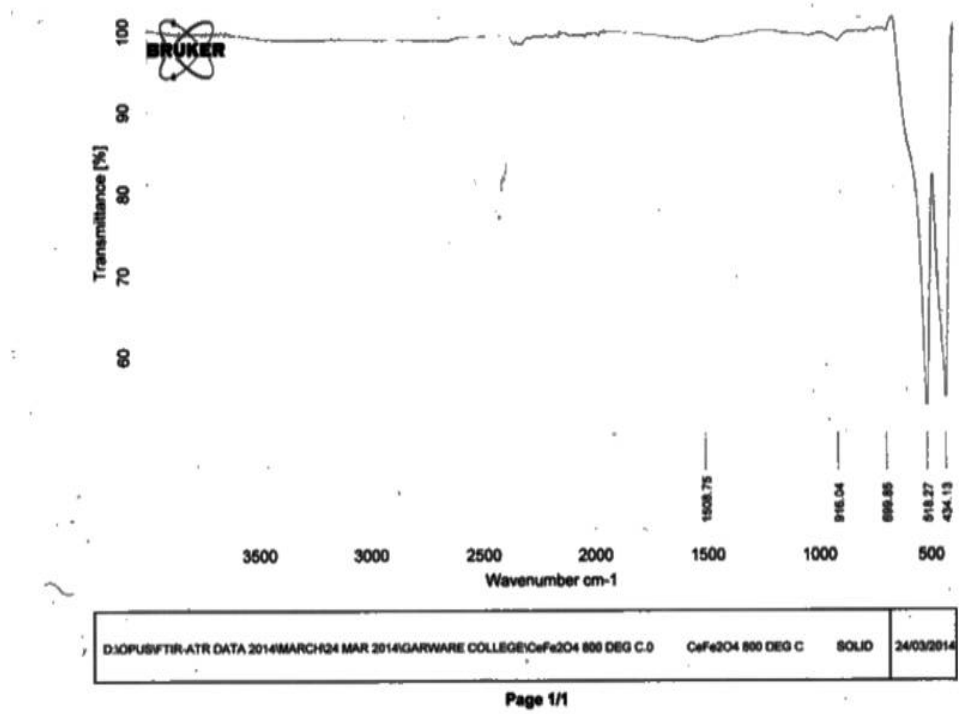

Figure-6
FTIR of $Cefe_2O_4$ at 800 ^{0}C

Conclusion

$Cefe_2O_4$ ferrite was synthesized using sol-gel method successes fully and it obtains in nanopowder form. The synthesized powder was characterized by FTIR, XRD, and UV-Spectroscopy. From the FTIR graph it is clear that the peak at 700 ^{0}C at 433.28-517.06cm $^{-1}$ and at 800^{0}C at 434.13-518.27 cm $^{-1}$ it shows that the prepared sample is ferrite. The average crystalline size of the prepared $CeFe_2O_4$ from XRD graph was calculated using Scherrer's formula is 28.1412 nm. From UV-Spectroscopy band-gap energy was calculated it is in the range of semiconductor material Band gap of given sample is 2.952 eV and wavelength absorb by 420 nm. At 700 ^{0}c and Band gap of prepared sample is 3.351eV and wavelength absorb by 370 nm at 800 ^{0} C.

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