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Structure, Morphology & Infrared Spectroscopic Characterization of $Ga_{(2x+2)}$ N $Fe_{2\,(49-X)}$ O_3 Ferrite Synthesized Using Sol Gel Technique

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Abstract: *This paper presents experimental analysis and results of GaN (being a III-V semiconductor) doped with Ferrite elements synthesized using Sol-Gel technique which are carried out at National Chemical Laboratory, Pune Maharashtra. The GaN is employed as dopant for x=1 and x=5, in the formula* $Ga_{(2x)}$ *N* $Fe_{2(49-x)}$ O_3 *. A non-spinel ferrite system (* Fe_2 O_3*) is chosen for our study. The XRD (Structural), SEM (Morphological) & FTIR spectroscopic studies were carried out to confirm the size, type of bonding and study the surface between the compounds and present results are in good agreement with the literature.*

Keywords: *III-V Semiconductors; Ga N; Synthesis of doped ferrites; Sol-Gel technique; XRD; SEM; FTIR.*

I. Introduction

The Nanoscience and Nanotechnology deals with the materials which are at Nanoscale (1nm = 10^{-9} nm). This technology primarily deals with the synthesis, characterization, exploration, and exploitation of nanostructured materials. Nanostructures constitute a bridge between molecules and infinite bulk systems. Individual nanostructures include clusters, quantum dots, Nanocrystals, Nanowires and Nanotubes, while collections of nanostructures involve arrays, assemblies, and super lattices of the individual nanostructures [1,2]. The physical and chemical properties of nanomaterials can differ significantly from those of the atomic-molecular or the bulk materials of the same composition. The uniqueness of the structural characteristics, energetics, response, dynamics, and chemistry of nanostructures constitutes the basis of Nanoscience. Suitable control of the properties and response of nanostructures can lead to new devices and technologies. Semiconductors are the key components of devices used every day, including computers, Light emitting diodes, sensors etc. These are a unique class of materials in that they can assume characteristic properties of both metals and insulators, depending on conditions that determine the electronic nature of the valence and conduction bands. Studies these days are being focussed on reducing the size of semiconductors to Nano Scale, wherein they become a novel type of materials that possess characteristics between the classic bulk and molecular descriptions and exhibit the properties of Quantum confinement [3]. Interest derives from the many attractive attributes in charge transport, light emission, mechanics and thermal diffusion that emerge at nanometer dimensions, due explicitly to size scaling effects[4]. Band gap energies of Nanoscopic semiconductors are strongly dependent on size, such that as the radius of the nano crystal decreases, the band gap increases. This is very exciting feature of semiconductor nanoparticles, as it allows one to tune the emission wavelength of the nanoparticle by adjusting its size within the quantum confined region. As the semiconductor particles exhibit size-dependant properties like scaling of the energy gap and corresponding change in the optical, electrical properties, they are considered as the front runners in the technologically important materials [5]. In the last few years the necessity of realizing electronic devices for high temperature, high power, and high frequency and, more recently, resistance to high energy radiation beams has increased [6].

1.1 Importance of Doped GaN as III-V semiconducting material in LED technology

The 2014 Nobel Prize winners Isamu Akasaki, Hiroshi Amano and Shuji Nakamura used GaN as the base for the Material development of the LEDs that produce blue radiation. J. I. Pankove and co-workers even after Considerable effort, could not manage to make a marketable GaN LED, primarily due to the difficulty of making strong p-type GaN[7,8].Shuji Nakamura successfully fabricated double- heterostructure In GaN/GaN blue LED chips for the first time in 1993. He later in 1994 succeeded in producing l-cd-brightness high-power blue In GaN/Al GaN LEDs suitable for commercial applications [9-14]. However, the introduction of ferrite into the GaN lattice is expected to produce several useful and versatile Developments, and this forms the basis of the authors work. This communication reports specific results, and in the Communications to follow very

shortly elsewhere in the literature, several interesting findings of the author would appear over the past few years, III -V semiconductor nanomaterials have stimulated research interests because of their importance in both fundamental research and future nano-electronic applications [2, 15, 16, 17]. So far, the focus has been on to which can be synthesized with assistance of metal or oxide catalysts using laser ablation[18] ,simple physical evaporation[16] or thermal decomposition[19,20].Single crystalline Ge nanowires have also been fabricated employing a liquid solution synthesis and furnace-laser ablation[21].Recently, semiconductor-compound nanowires such as GaAs, InAs and Ga InP[22, 23] has been synthesized. Nano crystals of III-V semiconductors such as GaAs and InP have also attracted a great deal of interest .These materials differ from other semiconductors in that they have less ionic lattices, Larger dielectric constants, Larger bulk exciton diameters, Smaller effective masses and Weaker Phonon coupling. However the author failed to come across any data about GaN doped Ferrites, in the literature. The uniqueness and practical importance of the compound III-V semiconductors used in the doping of ferrites (Spinel as well as Non-Spinel Types) stems from the fact that the ferrites display a variety of interesting properties and conspicuous characteristics in their dielectric magnetic and conductance mechanisms like Verwey's Hopping Transition Mechanism (VHTM)[24], (which was detected in the year 1913). As per Waltz VHTM is due to the intricate multi-particle system Fe_3O_4 with its various magneto-electronic interactions that are not completely understood as yet - although considerable progress has been achieved, especially during the last two decades. A series of uncertainties and erroneous statements [25] concerning the reaction order (is it one or two?) and type of the transition (multi-stage or single stage), characterizes the period of the last several years after its detection. A most inspiring conference organized in 1979 by Sir Nevill Mott in Cambridge, has brought out several anomalies that require both the quality control in the method of synthesis, as well as the details and variety of the characterization techniques in the study of the Mechanism. Dhanaraju et.al[26], in their FTIR studies reported interesting results about this mechanism in the case of Cu $_{(1-x)}$ Zn $_x$ Fe_2O_4 and Cu $_{(1-x)}$ Sb $_x$ Fe_2O_4 doped ferrites. Several doped ferrites are reported to be polar enough to be direct-band gap semiconductors, with the accompanying strong interactions with photons useful for optoelectronics and the low electron masses useful for high-speed electronics. But they are not so polar that they cannot be P-type doped or that they suffer from too-high defect densities. GaN and its alloys have played a major role in blue, green and ultraviolet light emitting devices, which are essential components of full-color displays, high density data storage systems and range of other applications [27]. In recent years, studies were reported in literature about (1) Thermal stability of GaN, quantitatively, over a wide range of temperature 500-1100^{o}C using RBS/channeling with depth resolution of 5-20 nm (2) Structural and optical properties of InGaN, that is used as light emitting medium and GaN based light emitting diodes and laser diodes[28].Rob W.J. Hollering, in his doctoral studies experimented on a set up devised by him ,to study about Photoluminescence & Hot carrier energy relaxation and Effect of a strong magnetic field on the energy relaxation of hot carriers in GaAs [29]. Nikoleynik's doctoral Thesis [30] studied the application of Metal Organic Vapour Epitaxy (MOVPE) method that offers the reproducible growth of high-quality, pure films with homogeneous properties over a large substrate area. These are used in blue-ray DVDs, displays, and traffic signals. It was then concluded that no growth technique is proven to achieve reliable, reproducible high-quality p-type materials. Production of wide band gap compound semiconductors like GaN, ZnSe had been established to pose several issues. Due to its wide and direct band gap, gallium nitride, GaN, is a promising candidate in semiconductor technology. The Zincblend modification of GaN is also receiving much attention in electronic and optoelectronic applications [31]. Bed Nidhi Pantha's Doctoral Thesis [32] aimed at the synthesis of Mg-doped In $_x$ Ga $_{(1-x)}$ N alloys by metal organic chemical vapour deposition (MOCVD) for III-nitride nanostructures and their devices. The potential of InGaN alloys as TE materials for thermo power generation has been investigated in the work. It was found that as in content increases, thermal conductivity decreases and power factor increases.

Spitzer, S.M.et.al,(1975) of Bell Laboratories, Murray Hill, designed an ac or dc 'GaP LED' array and fabricated it with a potential as a direct replacement for several tungsten filament lamps and as an illuminator[33].

S. J. Pearton et.al, (1993), reported studies about 'Dry and wet etching characteristics of InN, AlN, and GaN deposited by electron cyclotron resonance metal organic molecular beam epitaxy[34].

On the other hand several interesting studies on the magnetic and electrical properties of doped ferrites reveal their usefulness when suitably synthesized with (III-V)and (II-VI) Semiconductors . K. K. Bamzai et.al.,[35]in their detailed study on the Calcium substituted magnesium ferrite with composition ($MgCa_xFe_{(2-x)}O_4$, where x = 0.00, 0.01, 0.03, 0.05, 0.07) synthesized by ceramic technique & their structural and magnetic properties, on the basis of cation distribution , the magnetic behavior of the prepared composition was discussed in this work. The calculation of parameters such as saturation magnetization, coericivity and retentivity led to interesting conclusions, by them. Jingguo Jia et.al [36] reported about 'Exchange coupling controlled ferrite with dual magnetic resonance', in Ti-doped barium ferrite powders $BaFe_{(12-x)}Ti_xO_{19}$ (x = 0, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8). Interesting information about EMI absorption properties of such material were obtained in this study. This creates a curiosity as to attempt a systematic study of Electronic and Magnetic Properties of GaN

doped Ferrite, its Synthesis and its characterization. Detailed study into the available literature points out that such a study is yet to be attempted, and has good potential.

The GaN being a (III-V) semiconductor has conspicuous properties already established by several authors around the globe. Hence its usage as a dopant into ferrite should reveal very interesting and valuable traits to the product. GaN and its alloys are now also of interest due to their use in optoelectronic nanoscale devices as nanowires and nanorods [37, 38].

At the turn of the earlier century a number of authors [39-41, 42, 43, 44] have studied thermal stability of GaN. In our work, we have synthesized by taking III-V group elements. In that InN, AlN, GaN are having applications in Electronics, Electrical, Optical industries like applications in lighting and displays of all kinds, lasers, detectors, and high-power amplifiers. These applications stem from the excellent optical and electrical properties of nitride semiconductors. The parameters are imperative in determining the utility and applicability of this class of materials to devices. As AlN is having less solubility by nature, and InN work has already reported, the synthesis of GaN Ferrite is reported in this paper. GaN is a representative of its binary cousins, InN and AlN, and their ternaries along with the quaternary, is considered one of the most important semiconductors after Si. Because GaN is used in the form of a thin film deposited on foreign substrates, meaning templates other than GaN, a discussion of hetero epitaxial thin films is of paramount importance.

S.M. Crankshaw [45] in his doctoral thesis presented the experimental investigation of namely, vibrational modes – which are explored through polarization-dependent Raman scattering on single wurtzite GaAs needles. A splitting of the zone-center phonons as expected for the uniaxial crystal structure, were reported in his experimental investigation of a nonlinear optical process of GaAs needles. Study of Optical properties of GaN is reported by Chia-Chun Chen.et.al [46]. Gallium nitride (GaN) is one of the most exciting semiconductor materials with wide band gap of 3.45eV at 0K for wurtzite crystal structure, which already is industrially exploited as bulk crystalline material in microelectronic devices. Another form of GaN lattice is zinc-blende crystal structure with a band gap of 3.28 eV at 0K. Due to its wide band gap properties and emission capacity in a short wave radiation, GaN is the subject of intense research of near ultraviolet (UV) or blue emission and development of emitters, detectors and high-temperature microelectronic devices[46,47]. However, the recent advances in nanomaterial synthesis and the development of one-dimensional (1D) GaN nanowires will certainly offer unique semiconducting properties, which widen not only the scope of fundamental research but also its prospect of future application[48,49].In the present paper we have reported the synthesis of Gallium Nitride Ferrite at Nano level.

Oxides of Iron are abundant in earth crust and are available in different phases with different molecular weights and we have taken α-Fe_2o_3. Iron(III)oxide particles when taken at Nano range can enhance the electrical and Magnetic properties.The iron Oxide nanoparticles attract much attention due to its wide range of applications. The family of Iron (III) oxides consists of α-Fe_2O_3, β-Fe_2O_3,€ -Fe_2O_3,γ--Fe_2O_3.In that α-Fe_2O_3 is stable one[50].Alpha Fe_2O_3 is a canted anti-Ferromagnetic while β-Fe_2O_3 is a paramagnetic material and ,€ -Fe_2O_3,γ--Fe_2O_3 are Ferromagnetic[51].Generally the semi-conductor properties of Hematite are extremely useful in Solar energy Conversion and also play an important role in different applications of Health care[52].For the research purpose,Fe_2O_3 is an important semiconductor to study polymorphism ,magnetic and structural phase transitions of Nanoparticles.As Alpha Fe_2O_3 has Canted magnetism which means that the magnetic moments of the two magnetic sub-lattices do not fully cancel each other and results in a small magnetic moment value in the direction of basal plane.Alpha Fe_2O_3 is also an environment friendly N-type semi-conductor and thermodynamically most stable phase of iron oxide under ambient conditions[53]. When the iron Oxide can be incorporated into the interlayer of layered compounds as Semi-Conductor pillars shows excellent Photo-Catalytic activity.This .Alpha Fe_2O_3 is isostructural with corundum having a rhombohedrally centered Hexagonal unit cell based on a close packed oxygen lattice in which two-thirds of the Octahedral sites are occupied by Fe^{3+}ions.

Hematite shows very interesting Magnetic Properties.It exhibits Ferroagnetism in addition to anti-Ferromagnetism below the Neel temperature of 950 K.At temperatures known as Morin temperature around 260K ,Hematite is weakly Ferrimagnetic[54].

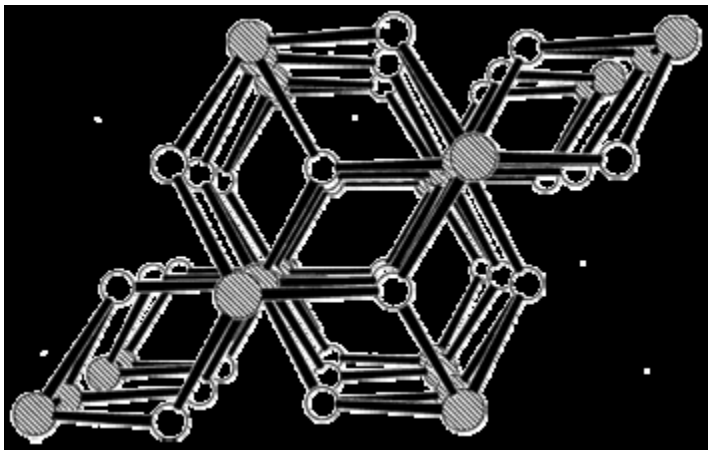

Fig 1: Crystal structure of α-Fe_2O_3, viewed onto the (0001) plane. Key: (Fe = shaded circles and Oxygen = white circles).

M.A.Rana in his Doctoral work made a very important investigation of Thermal stability of GaN quantitatively, over a wide range of temperatures of 500-1100ºC using RBS/channelling with depth resolution of 5-20 nm. Structural and optical properties of InGaN, used as light emitting medium in GaN based light emitting diodes and laser diodes, are also studied. For this, RBS/channelling, x-ray diffraction spectrometry and Photoluminescence were used. He used Monte Carlo simulations (the major technique used for defect analysis of crystals) to study the effects of lattice translations and rotations on ion channelling,. He established that Defects in such materials control basic processes and affect electronic and optical properties and all the defects found in crystals can ultimately be resolved into lattice translations and rotations. Annealing experiments were performed on GaN layers, (over a wide range of temperatures (500-1100^{0}C). It is concluded that 700-800ºC is the critical temperature range for GaN at which lattice disruption starts to occur. No decomposition was detected for temperatures up to 800^{0}C. Decomposition in the near-surface region increased rapidly with the further increase of temperature, resulting in a near-amorphous region (500nm) for annealing at 1100^{0}C. Bearing this in mind as a very important finding ,we preferred the temperature sused for the annealing of the GaN doped ferrite [55].

II. Experimental

2.1 Raw Materials

The Synthesis of the chosen Nanomaterials for the study was done at National Chemical Laboratory, Pune, INDIA. Gallium Nitride ferrite powders were synthesized by the sol–gel method from the starting raw materials. Gallium Nitride (GaN) and Iron (III) Oxide (Fe_2O_3) obtained from Sigma Aldrich which is 99.99% pure. Citric acid, Ammonia, and Deionized water were used as ancillary raw materials. These were procured from E-Merck, and were eventually purified using prescribed standard chemical procedures.

2.2 Synthesis of the Samples

The following are the steps involved to synthesize the compound by Sol-Gel technique-

- Take the appropriate proportions of GaN and Fe2O3,let it be solution 1.
- Dissolve Citric acid in required amount of water let it be solution 2.
- Now,mix solution 2 to solution 1.
- Stir the solution for three hours under 90ºC-95ºC.
- Adjust pH value to 7 by adding Ammonia.
- After 3 hours,a Gel is obtained.
- Calcinate the Gel under 400ºC for 4 hours.

Initially, GaN and Fe_2O_3 powders were taken in 1:2 ratio and required amount of citric acid was added and mixed well. Here the solution was kept inside hot oil bath and was heated under magnetic stirrer at 90-95˚C under high RPM for 3 hours so that heat energy is distributed equally throughout the beaker. Then the pH of the solution was adjusted to 7 by adding Ammonia. This pH value is an important factor in determining the Nano Characteristics. As the pH Value increases the size increases and weight losses are found to be small [56,57]. After 3 hours Gel was formed. This Gel was heated under 400˚c for 4 hours and the required powder collected in a beaker.

Fig 2. Oil bath & magnetic stirrer cum heater, with precise temperature control and provision for monitoring the number of revolutions per minute .The outer trough contains the oil where the heat energy is distributed equally maintained to the inner beaker

III. Characterization Techniques

The phase identification and grain distribution of the sintered samples were identified using X-ray Diffractometer (XRD) (Philips: PW1830), at University of Hyderabad, A.P. India and Scanning Electron Microscope (SEM) (SEM Hitachi- S520), FT-IR (Schimadzu Perkin-Elmer 1310 at I.I.C.T., Hyderabad, A.P., INDIA was used to ascertain the metal-oxygen and metal-metal bond in the prepared ferrite sample.

IV. Results And Discussions

4.1 X-Ray Diffraction Analysis

The crystallographic information Crystallite size, lattice constant, (a); X-ray density, (Dx) were found using indexed XRD patterns of the studied samples. XRD patterns were recorded using X-ray diffraction analysis at room temperature using CuKα (λ=1.5406 Aº) radiation with 2-theta in the range of 20˚ to 80˚. X-ray diffraction for gallium nitride ferrite has been done for (X=1 and X=5) . All the characteristic peaks are shown in the fig(2.1) show good crystalline structure. The peaks for x=1 are indexed as (111),(210),(211),(222),(321),(400),(330),(331). Similarly, the peaks for x=5 indexed as (111),(210),(211),(220),(310),(222),(231),(400),(330),(331),(422) which resembles the characteristic of simple cubic structure. The highest peak indication which appeared at and 2θ=33.55^o and 2θ=33.51^o in both X=1 and X=5 respectively is due to the presence of α-Fe2O3[58].Lattice parameter 'a' for all the samples has been calculated by interplanar spacing (d_{hkl}) and 2-theta values using the standard relation

$$\sin^2\theta = \left(\frac{\lambda^2}{4a^2}\right)\left(h^2+k^2+l^2\right)$$

by mathematical method [59,60]. The lattice parameters a, c, d_{hkl} are calculated from the below formula.

$$\frac{1}{d^2} = \frac{h^2+k^2}{a^2} + \frac{l^2}{c^2} = \frac{4\sin^2\theta}{\lambda^2}$$

The lattice constant value varies from a=6.197Aº to a=6.257Aº.The increase in lattice constant is due to the increase in the concentration of GaN(for X=5). The atomic radius of GaN is more than the atomic radius of Fe_2O_3 and larger radius atoms replaces smaller atoms, thus the increase in lattice constant can be justified. Peak broadening (FWHM) used to determine Crystallite size by using Debye-Scherrer formula.

$$\mathbf{D=}\ \frac{0.89\lambda}{\beta\cos\theta}$$

The values of the parameters confirms the presence of tetrahedral sites in the compound.The calculated value of particle size is found to be in the range of 20nm-46nm. The volume of unit cell can be calculated by using

$$V = a^2C$$

As the concentration of GaN is increased more number of atoms that are occupying the unit cell increases thereby the volume of unit cell also increases.

When the unit cell volume, calculated from the lattice parameters, is multiplied by the measured density of the substance it gives the weight of all the atoms in the cell. The density value can be calculated as follows where A is the sum of number of molecules per unit cell in that phase.

$$\sum \quad A = \rho \frac{V}{1.66042}$$

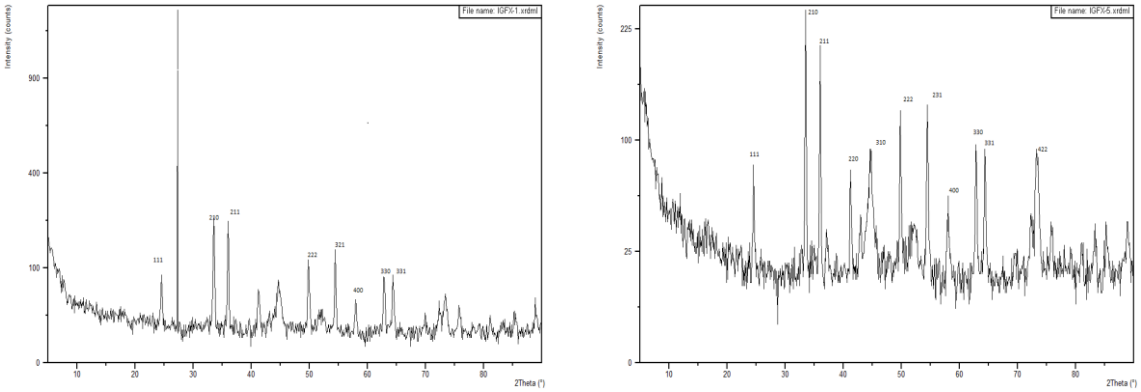

Fig 3. Graphs of X-Ray analysis for X=1 and X=5 at 400º C respectively.

The value of α-Fe_2O_3 by different synthesis procedures reported in literature are a=5.034A^o and c=13.745A^o.According to our evaluation from the XRD data ,with our samples synthesized in NCL, Pune, we found them to be a=6.197 A^o ,c=6.2420 A^o for X=1 and a=6.257 A^o C=6.2526A^o for X=5.

When alpha $Fe_2O_3$is taken in the synthesis of Gallium Nitride doped Ferrite, the compound restructured into Tetrahedral Configuration as per reported values in the table below. This conclusion stands confirmed by earlier findings from literature [50,53].

The below is the tabular form of the parameters analyzed from XRD patterns.

Table 1. XRD Parameters analyzed from XRD

S.No	Name of Parameter	Value for X=1	Value for X=5
1.	Crystallite Size	20-46nm	20-46nm
2.	Inter Atomic Spacing 'a'	6.197 A^o	6.257 A^o
3.	Parameter 'c'	6.2420 A^o	6.2526 A^o
4.	Inter Planar Spacing	2.21478 A^o	2.0598 A^o
5.	Volume of unit cell(cm^3)	241.208	244.793
6.	Density(gm/ cm^3)	1.6756	1.6511
7.	c/a Ratio	1.007	0.999

4.2 Scanning Electron Micrograph

The morphology and grain size was analyzed using SEM (JEOL-instrument JSM-6490A). The Morphology and average grain size was calculated from Scanning Electron Microscope (SEM) for $Ga_{(2x+2)}N$ $Fe_{2(49-X)}O_3$. Both the samples gives the confirmation of Nano-crystallites. The grain size calculated was found in good agreement with studied sample. The Micrograph obtained shows that the particles were not of same size and they are ranging from 4 nm-40 nm.Also the size and shape of Nanoparticles depend on the preparation technique [61]

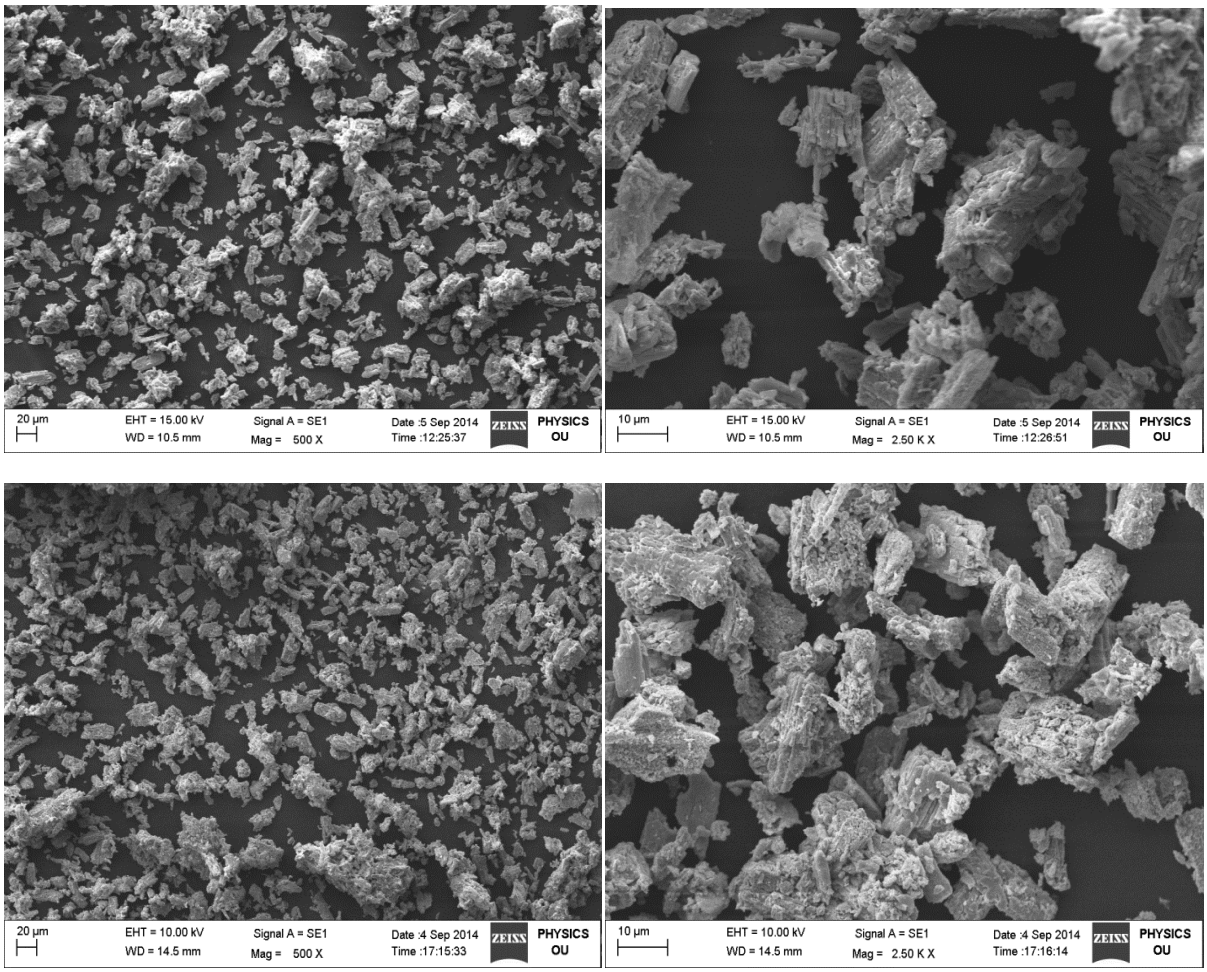

Fig 4. SEM Pictures of two specimens (X=1 and X=5) at two magnifications

4.3 Fourier Transform Infrared Spectroscopy

Infrared spectroscopy enables us also to obtain information about real crystalline microstructure and interior interactions of the semiconductor solid solutions .Infrared spectroscopy is associated with vibration energy of atoms or group of atoms in a material. The infrared region has prime importance for the study of compounds. Since the IR spectra contain large number of bands, the possibility that two compounds have the same infrared spectrum is exceedingly small. Due to this reason IR spectrum is called the "finger print" of a molecule. If two compounds give super imposed spectra, it means they are one and the same. The IR spectrum of nanoparticles differs considerably from that of the bulk counter part. An overall estimation of the particle size and shape can also be made with the help of IR spectroscopy. In the case of nanoparticles, the surface to volume ratio is very high, when compared to bulk form. This is the reason for the distinguished features exhibited by nanoparticles. The number of atoms that constitute the surface can influence the vibrational spectra of nano particles. Infrared absorption in small crystals has been studied in detail in many materials. FTIR spectroscopy is mainly used to identify the elements and the phase of the elements [62].The various bending and stretching vibrations occur at certain quantized frequencies .When infrared radiation of the same frequency is incident n the molecule, energy is absorbed and the amplitude of that vibration increases correspondingly. When the molecule reverts to the ground state the energy is released in the form of heat. Fourier Transform Infra-Red (FT-IR) spectra have been recorded using Schimadzu Perkin-Elmer 1310 FT-IR spectropho-tometer with KBr pellets as the KBr does not react in the range 4000 – 400 cm–1.

Fig 5. FT-IR setup used for analysis of sample

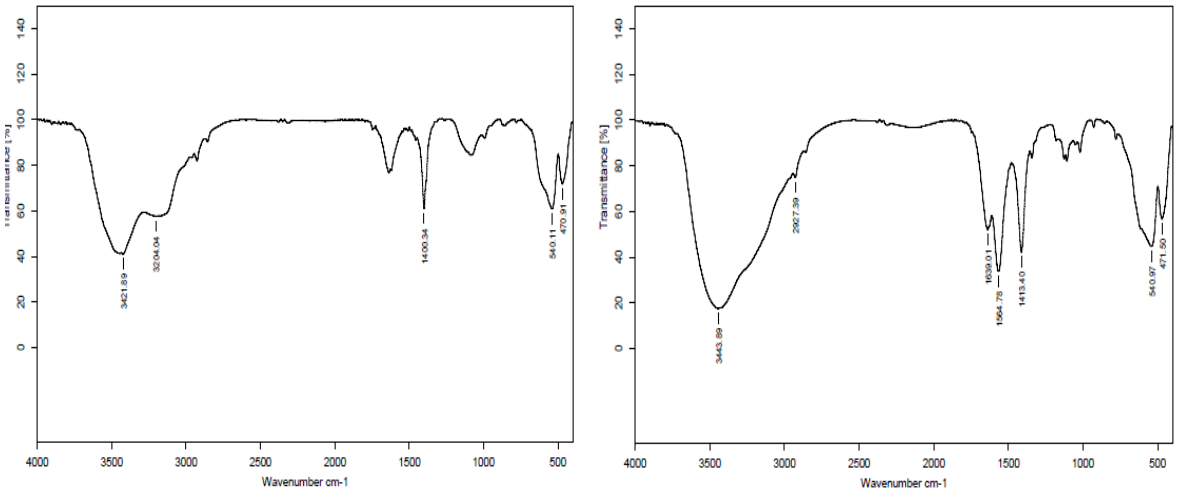

Fig 6. FT-IR graphs for the specimens x=1 and x=5

In the FT-IR spectrum synthesized at 400 ºC, for X=1 there is a peak between 3400-3200 due to the OH stretching of water .It is also confirmed by its bending vibration that gives intense sharp peak at 1400.34cm-1[63] . The weak band at approx. 1400 cm^{-1} suggested the presence of some strongly adsorbed NH_3 molecules or -NH_2 groups[64,65]. The peaks at 540 and 470 attributed to Fe-O-Fe stretching and GaN and Ga-O vibrations.

Table 2. FT-IR Results for x=1

S.No	Band Position Cm^{-1}	Assignment (X=1)
1.	3421 &3204	O-H Stretching
2.	1400	O=C=O
3.	540 & 470.91	Fe-O-Fe and Ga-N& Ga-O vibration

Similarly for x=5 there is a peak between 3443 and 2927 due to OH-stretching of water.It is also confirmed by its bending vibrations that are medium and strong varying at 1639,1564,1413 which gives the presence of some strongly adsorbed NH_3 molecules or -NH_2 groups[57,58]. The absorption bands at 1639,1564,1413 3443 cm^{-1} normally comes from carbondioxide and water which generally nanomaterials absorbed from the environment due to their mesophorous structure. The peaks are observed 540 and 470 cm^{-1} similar to X=1 is attributed to Fe-O-Fe stretching and GaN and Ga-O vibrations.

Table 3. FT-IR Results for x=5

S.No	Band Position (Cm^{-1})	Assignment(X=5)
1.	3443	O-H Stretching
2.	1639	O-H Bending Vibration
3.	1564 &1413	O=C=O Stretching Vibration
4.	540&471	Fe-O-Fe Stretching Vibration and Ga-N and Ga-O vibration.

V. Conclusions

A series of Gallium Nitride with substitution of ferrite element Ga_{2X} N Fe $_{2(49-X)}O_3$was synthesized by sol-gel method for x=1 and x=5.The effect of substitution of gallium nitride was studied. X-Ray diffraction confirms the tetrahedral configuration. The range of Nanoparticles were calculated using debye-scherrer formula and found to be 20nm-46nm.The lattice constant value increases with increase in concentration of Gallium Nitride. The average grain size was calculated using SEM and found to be in good agreement with XRD. The FT-IR

Plots for both samples are in good agreement with the previous literature.

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References

[1]. Rao, C.N.R, Muller.A. and Cheetham A.K. Eds. Chemistry of Nanomaterials (Wiley-VCH,Weinheim, 2004).
[2]. Rao C.N.R. and Cheetham. A.K., Science and Technology of Nanomaterials, Journal of Materials Chemistry,vol.11,2001, pp.2887.
[3]. Rotello V, A text book on Nanoparticles, (Springer international edition, Published by Springer , ISBN 10: 146134770X / ISBN 13: 9781461347705).
[4]. Dae-Hyeong Kim, Nanshu Lu, Roozbeh Ghaffari and John A Roger, Inorganic semiconductor nanomaterials for flexible and stretchable bio-integrated electronics,NPG Asia Materials ,vol.4,2012.
[5]. Tripathi Ramna, Kumar Akhilesh, Bharti Chandrahas and Sinha T. P., Dielectric relaxation of ZnO nanostructure synthesized by soft chemical method, Current Applied Physics, vol.10, 2010,pp.676-681.
[6]. G. Conte, M.C. Rossi , S. Salvatori , F. Spazian, G. Vitale , P. Ascarelli, TransportProperties of CVD diamond elucidated by DC and AC conductivity measurements,Diamond and Related Materials,13, 2004 ,pp.277.
[7]. Shuji Nakamura, Gerhard Fasol, Stephen J. Pearton, The Blue Laser Diode : The Complete Story, Springer, 2nd edition, 2000.
[8]. Iwasa, Naruhito; Mukai, Takashi and Nakamura, Shuji U.S. Patent 5,578,839 ,Light-emitting gallium nitride- based compound semiconductor device,1996.
[9]. Kovac.J., Peternai.L., Lengyel.O, Advanced light emitting diodes structures for optoelectronic applications, Thin Solid Films ,433, 2003,pp.22–26 .
[10]. Nakamura, S.; Senoh, M.; Mukai, T. P- GaN/N-InGaN/N-GaN double-heterostructure blue-lightemitting diodes, Japan Journal of Applied Physics,32,1993,pp. L8−L11.
[11]. Nakamura, S. InGaN-based laser diodes (In Japanese), Nikkei Electron,602,1994,pp.93.
[12]. Nakamura. S, Mukai.T, Senoh.M, Candela, Class high-brightness InGaN/AlGaN, Double heterostructure blue-light-emitting diodes, Applied Physics Letters, Vol 64,1994, 1687–1689.
[13]. Nakamura, S., Fasol .G, The Blue Laser Diode: GaN Based Light Emitters and Lasers, Springer Berlin, Germany,1997, pp. 216.
[14]. Lei Chen et.al,(2010), "Review- Light Converting Inorganic Phosphors for White Light-Emitting Diodes - Materials 3, 2010, pp.2172-2195
[15]. D. P. Yu, C. S, Lee, I, Bello, X. S. Sun, Y. H. Tang, G. W. Zhou, Z. G. Bai, Z. Zhang, and S. Q. Feng, Synthesis of Nano-scale silicon wires by excimer laser ablation at high temperature, Solid State Communications. Vol.105, 1998, pp. 403.
[16]. A. M. Morales and C. M. Lieber, A laser ablation method for the synthesis of crystalline semiconductor nanowires, Science 279, 1998, pp.208–211.
[17]. H. P. Maruska, J. J. Tietjent, Band structure and Reflectivity of GaN, Applied Physics Letters, 15, 1969,pp.327.
[18]. G. Fasol ,Room temperature blue Gallium Nitride Laser-diode,Science 272, 1996, pp.1751-1756.
[19]. D. P. Yu, X. S. Sun, C. S. Lee, I. Bello, S. T. Lee, Synthesis of Boron Nitride Nanotubes by means of excimer laser ablation at high temperatures, Applied Physics Letters, Vol.72, 1998,pp.1966-1968.
[20]. Wagner, R. S. & Ellis, W. C. Vapor-liquid-solid mechanism of single crystal growth, Applied Physics Letters, Vol.4, 1964, pp.89-90 .
[21]. G. A. Bootsma, H. J. Gassen, A Quantitative study on the growth of silicon whiskers from silane and germanium whiskers from germane , Journal of Crystal Growth. Vol.10,1971, pp.233-34.
[22]. J. R. Heath, F. K. LeGoues, A Liquid Solution Synthesis of Single-Crystal Germanium Quantum Wires, Chemistry Physics Letters. Vol.208, 1993, pp. 263.
[23]. S. Tsukamoto, Y. Nagamune, M. Nishioka, Y.AraKawa, Fabrication of InGaAs strained Quantum wires using selective MOCVD growth on SiO_2 –Patterened GaAS Substrate,Sixth International Conference, IEEE Conference Publications, 1962, pp.61-62.
[24]. WojciechTabis, Structural changes in the vicinity of Verwey Transition observed with various X-Ray diffraction methods,AGH University of Science and Technology, Krakow, Grenoble 2010.
[25]. F.Walz, The Verwey transition-a topical review, Journal of Physics:Condensed Matter, Vol. 14, 2002,R285-R340.
[26]. Dhanaraju,M.K.Raju,V.Brahmaji Rao,S.BangaraRaju, Verwey's Hopping Transition Mechanism in relation to Dielectric studies of Zn & Sb substituted Cu ferrites,International Journal of Science and Technology (IJST) – Vol. 1 ,issue 5 ,2012, pp.275- 285
[27]. Jeff Y Tsao, A book on World of Compound Semiconductors (Sandia National Laboratories,2004),pp.1-191.
[28]. MA Rana Ion Channelling Studies of defect formation in GaN and related materials, National University of Singapore, 2005.
[29]. Hollering, R.W.J., Picosecond photoluminescence studies on hot carrier energy relaxation, Radboud University, Nijmegen, 1986.
[30]. Nikolay Oleynik ,MOVPE Growth and Characterisation of ZnO Properties for Optoelectronic Applications, University Magdeburg 2007.
[31]. A.Mahmood, L. Enrique Sansores and S. Muhl ,Band Structure and Bulk Modulus of GaN ,Superficies y Vacío. Vol.9, 1999,pp.259-262.
[32]. Bed Nidhi Pantha , Epitaxial growth of III-nitride Nanostructures and applications for visible emitters and energy generation, Kansas State University, Manhattan, Kansas U.S.A 2009.

[33]. Spitzer, S.M., Schumaker, N.E., Koszi, L.A. ,North. J ,Multijunction AC or DC integrated GaP light emitting diode array, Electron Devices, IEEE Transactions Vol.22 ,Issue.9, 1975,pp 701 - 706 .

[34]. S. J. Pearton, C.R. Abernathy, F. Ren, J.R. Lothian, P.W. Wisk, and A. Katz, Dry and wet Etching Characteristics of InN,AlN,and GaN deposited by Electron Cyclotron Resonance Metalorganic Molecular beam Epitaxy, Journal of Vaccum Science and Technolgy A,Vol.11, No.4, 1993,pp.1772-1775.

[35]. K. K. Bamzai, Gurbinder Kour,Balwinder Kaur and S.D.Kulkarni, Preparation ,and structural and magnetic Properties of Ca substituted Magnesium Ferrite with composition $MgCa_x Fe_{2-}xO_4$(X=0.00,0.01,0.03,0.05,0.07), Journal of Materials, Vol 2014, 2014.

[36]. Jingguo Jia, Chuyang Liu, Ning Ma, Gaorong Han, Wenjian Weng and Piyi Du, Exchange coupling controlled ferrite with dual magnetic resonance and broad frequency bandwidth in microwave absorption, Science &Technology of Advanced Materials, IOP Publishing,vol. 14,issue.4,2013 .

[37]. Y. Huang, X. Duan, Y. Cui and C. M. Lieber, Gallium Nitride Nanowire Nanodevices Nano Letters 2, 2002,pp.101-104 .

[38]. Weiqiang Han, Shoushan Fan, Qunqing Li, Yongdan Hu, Synthesis of Gallium Nitride Nanorods Through a Carbon Nanotube–Confined Reaction, Science ,vol.277, 1997 pp.1287-1289.

[39]. M. E. Lin, B. N. Sverdlov, and H. Morkoç, Thermal stability of GaN investigated by low-temperature photoluminescence spectroscopy, Applied Physics Letters, vol. 63, issue. 26, 1993, pp. 3625–3627.

[40]. C.B. Vartuli, , S. J. Pearton, J. W. Lee, J. Hong, J. D. MacKenzie, C. R. Abernathy, and R. J. Shul, ICl/Ar electron cyclotron resonance plasma etching of III–V nitrides , Applied Physics Letters, Vol. 69, 1996, pp. 1426.

[41]. O.Ambacher, Ms Brandt, R.Dimitrov, T.etzer, M.Sutzmann, RA Fischer,Thermal stability and desorption of GroupIII nitrides prepared by Metal Organic Chemical Vapour Deposition, Journal of Vaccum Science and Technolgy. B vol.14, issue.6 ,1996 ,pp. 3532 -3542.

[42]. T. Onozu ,R.Miura,S.Takami,M.Kubo,A.miyamoto,Y.lyechika,T.Maeda, Investigation of thermal annealing process of GaN layer on sapphire by molecular dynamics, Japanese journal of Applied Physics part-1 , 39 (7B), 2000, pp. 4400-44.

[43]. Saarinen, K., Suski, T., Grzegory.I., & Look, D. C. , Thermal Stability of Isolated and Complexed Ga Vacancies in Gan Bulk Crystals, Physical Review B, vol. 64,issue.23, 2001.

[44]. M. Kuball, M. Benyoucef, B. Beaumont and P.Gibart, Raman mapping of epitaxial lateral overgrown GaN: Stress at the coalescence boundary, Journal of Applied Physics. Vol. 90, 2001,pp. 3656.

[45]. S.M. Crankshaw, Spectroscopic Characterization of III-V Semiconductor Nanomaterials, University of California, Berkeley, U.S.A 2009.

[46]. C. C. Chen, C. C. Yeh, C. H. Chen, M. Y. Yu, H. L. Liu, J. J. Wu, Catalytic growth and characterization of gallium nitride nanowires , Journal of American Chemical Society,Vol. 123, Vol. 123, 2001, pp.2791-2798.

[47]. J Zhang, X.S Peng, X.F Wang, Y.W Wang, L.D Zhang, Micro-Raman investigation of GaN nanowires prepared by direct reaction Ga with NH_3 , Chemistry Physics Letters, Vol. 345, 2001,pp.372-376.

[48]. M. Q. He, P. Z. Zhou, S. N. Mohammad, G. L. Harris , .B. Halpern, R. Jacobs, W.L. Sarney and L. Salamanca-Riba, Growth of GaN Nanowires by direct reaction of Ga with NH_3, Journal of Crystal Growth. Vol. 231, 2001,pp. 357-365.

[49]. W. S. Shi, Y. F. Zhang, N. Wang, C. S. Lee, S. T. Lee, Synthesis and microstructure of gallium phosphide nanowires, Journal of Vaccum Science and Technology B 19,2001,pp.1115.

[50]. Mahesh Patange, Jeevan Jadhav, Somnath Biswas , Magnetic properties of monodisperse α- Fe2O3 nanoparticles synthesized via a chemical precursor" Carbon – Science and Technology 5/3, 2013,pp. 285 – 288.

[51]. Akbar, Shakeel, Hasanain, S.K., Azmat, Nasia, and NadeemM, Synthesis of Fe_2O_3 Nanoparticles by New Sol–Gel Method and their Structural and Magnetic Characterization, arXiv:cond-mat/0408480v1. (cond-mat.mtrl-sci).

[52]. M. Chirita, I. Grozescu, Fe2O3–Nanoparticles,Physical Properties and Their Photochemical And Photo electrochemical Applications, Chemical Bulletin Vol.54 ,issue.68, 2009 , pp.1.

[53]. Pooja Dhiman, Amit Kumar and M. Singh , Solution combustion preparation of Fe_2O_3-nano-flakes: Synthesis and characterization, Advanced Material Letters Vol.3,issue 4, 2012, pp. 330-333.

[54]. Prof. Nora H. de Leeuw ,Computational Studies of the interaction of pollutants with iron oxides, Department of Chemistry,University College of London 2011.

[55]. M.A.Rana, Ion Channelling Studies of Defect formation in GaN And Related materials,National University of Singapore ,2005.

[56]. K.Praveena,K.Sadhana,S.Srinath and S.R.Murthy ,Effect of pH on the structural and magnetic properties of nano crystalline $Y_3Fe_5O_{12}$ by aqueous co-precipitation method,Material Research Innovations, Vol.000,2013.

[57]. T.Kim, S.Nasu, M.Shima, Growth and magnetic behavior of bismuth substituted yittrium iron garnet nano particles, Journal of Nanoparticle Research , Vol 9 ,issue.5, 2007, pp. 737-743.

[58]. Muhammad Waseem ,Sajida Munsif ,Umer Rashid , Imad-ud-Din, Physical properties of a-Fe2O3 nanoparticles fabricated by modified hydrolysis technique, Applied Nanoscience,Vol.42014,pp.643–648.

[59]. R. Zboril, M. Mashlan and D. Petridis, Iron(III) Oxides from Thermal Processess –Synthesis, Structural and Magnetic Properties, Mossbauer Spectroscopy Characterization, and Applications,Chemistry of Materials Vol. 14, 2002, pp. 969.

[60]. R. M. Cornel and U. Schwertmann, The Iron Oxides. Structure, Properties, Reactions and Uses VCH, Weinheim ,1996.

[61]. Mitra, S., Das, K., Mandal,,Chaudhuri.S ,Synthesis of a α-Fe_2O_3 nano crystal in its different morphological attributes: growth mechanism, optical and magnetic properties, Nanotechnology,Vol.18 ,issue.27,pp.9

[62]. T. R. Yang, H. E. Horng, H. C. Yang, I. J. Jang, W. N. Kang, and S. S. Yom, Infrared properties of Single Crystal $MgAl_2O_4$, a substrate for high-temperature superconducting films,Physica issue.1440,1994, C 235-240.

[63]. V.Ganesh, S.Suresh, M.Balaji,K.Baskar ,Synthesis and characterization of nanocrystalline gallium nitride by nitridation of Ga-EDTA complex, Journal of Alloys and Compounds, Vol. 498, Issue. 1, 2010,pp. 52– 56.

[64]. Jerzy F. Janikt and Richard L. Wells, Gallium Imide, {Ga(NH)3/2}n, a New Polymeric Precursor for Gallium Nitride Powders, Chemistry of Materials,1996,pp.2708-2711.

[65]. Mohammed M. Rahman, Sher Bahadar Khan, Aslam Jamal, Mohd Faisal and Abdullah M. Aisiri, Iron Oxide Nanoparticles ISBN: 978-953-307-913-4, InTech.