

Synthesis and Effect of Laser Irradiation On Nanocrystalline $MgNiCuFe_2O_4$ Prepared By Sol-gel Method

Sopan Mansing Rathod

Associate Professor, P. G. & Research Dept. of Physics, Abasaheb Garware College, Karve Road, Pune, Maharashtra, India

Abstract: Nanocrystalline $Mg_xNi_{0.2}Cu_{0.8-x}Fe_2O_4$ ($x = 0.5$ & 0.6) ferrite material has been synthesized by sol-gel method for different compositions. The prepared materials were sintered at $400^\circ C$ for four hours, after that it was characterized by XRD, SEM, VSM and IR before laser irradiation. Then the prepared samples was irradiated by He-Ne laser of power $35mW$ with different time and after it was characterized to study the different properties of the samples by using X-Ray Diffraction (XRD). The Infrared Spectroscopy (IR) confirmed that the synthesized material is ferrite. The ferrite material may be plays vital role in biomedical sensor. The SEM shows surface morphology of the ferrite material. He-Ne laser irradiation on nanocrystalline ferrite materials shows remarkable changes like particle size decrease after irradiation of laser and coercivity of the sample changes. The lattices plane and bond length of the sample also calculated from XRD.

Keywords: He-Ne laser, nanocrystalline $MgNiCuFe_2O_4$, IR, XRD, UV, SEM.

I. INTRODUCTION

Spinel ferrites are an important class of compounds having large variety of electronic, magnetic and catalytic properties, an which is depends on the processing condition, sintering temperature ,time, chemical composition and type of additive ^[1].The Sol-gel auto combustion is simplest and speed up method to prepared nano ferrite^[2].The properties of nano ferrite particle are different from bulk material, because of that it is applicable in medical and engineering like targeted drug delivery, biomedical application and data storage devices as well as small size magnet ^[3-8]. This technique can be used for enhancing the structural and magnetic properties ^[9]. Sol-gel combustion route can be investigated nano structure, cation occupancy and magnetic behaviour ^[10]. In this research work investigated the effect of laser on nano-crystalline $Mg Ni Cu Fe_2 O_4$ materials.

II. EXPERIMENTAL PROCEDURE

Samples were prepared, $Mg_xNi_{0.2}Cu_{0.8-x}Fe_2O_4$ for ($x=0.5,0.6$) by sol-gel method. Materials are used AR grade pure nitrate of respectively by calculating stoichiometric ratio and mix appropriate amount of material in DI water. Then heat that materials at $75^\circ C$ on magnetic starrer for 20 min after that add liquid ammonia to maintain pH 7.Then maintain temp $100^\circ C$ up to material was ignited. Then prepared material was sintered at $400^\circ C$ for 4 hr and use this sintered powder for different characterization. The material was then irradiated by He-Ne laser with power $35 mW$ for 1 and 2 hrs. Then the material was again characterized by XRD to determine the grain size after irradiation. This technique can be used for enhancing the structural and magnetic properties

III. EXPERIMENTAL RESULTS

1) 1. X-Ray Diffraction

The phase formation behavior of spinel ferrites of was studied by XRD. Fig.1 shows the X-ray diffraction patterns of $Mg_xNi_{0.2}Cu_{0.3}Fe_2O_4$ & $Mg_{0.6}Ni_{0.2}Cu_{0.2}Fe_2O_4$ samples before and after irradiation by laser. From X-ray analysis the structure is spinel cubic⁸. After laser irradiation, the diffractogram indicates the formation of a distorted cubic structure beside the spinel cubic. This is reflected in the partial dissociation of the single phase cubic structure.Using the XRD data calculate lattice constant of all samples values are listed in Table1. From Table 1 lattice constant increases with increases in irradiation time. The crystallite size was calculated from Full Width at Half Maximum (FWHM) for all the peaks using Scherer formula:

$$t = \frac{0.9\lambda}{\beta \cos \theta} \text{-----} \quad (1)$$

β =full width at half maximum, θ = Bragg angle for the actual peak. The value of crystallite size is present in Table 1. Crystalline size decreases with increases in irradiation time. Fig 2 shows the typical scanning electron micrograph samples. From the SEM micrographs of the powders (Figure 2), the average grain size was ~47-11nm. The change in morphology can be related to the structure of samples. The UV-Vis spectrum show that the ferrite powder is identified by the charge transfer band at $\gamma_{max} = 530\text{nm}$. Figure3. The absorption coefficient, α of the nanoparticles has been calculated using the fundamental relations⁹. To estimate the energy band gap for the samples, the graph of $(\alpha h\nu)^2$ versus $h\nu$ has been plotted. The intercept of the line at $\alpha = 0$ gives the value of energy band gap. The values of energy band gap 2hr irradiation samples is 3.5eV. Fig.4 illustrates the infrared absorption spectrum for ($x=0.6$) after laser irradiation. The first absorption band ν_1 is related to intrinsic vibrations of octahedral groups.

Table 1 : composition, Grain size and lattice constant

Composition	Grain Size(nm)	Lattice Constant(°A)
A). $Mg_{0.5}Ni_{0.2}Cu_{0.3}Fe_2O_4$	47	8.16
4		
1hr Laser Irradiation	24	8.38
2hr Laser irradiation	23	8.40
B).	22	8.36
$Mg_{0.6}Ni_{0.2}Cu_{0.2}Fe_2O_4$		
2hr Laser irradiation	11	8.75

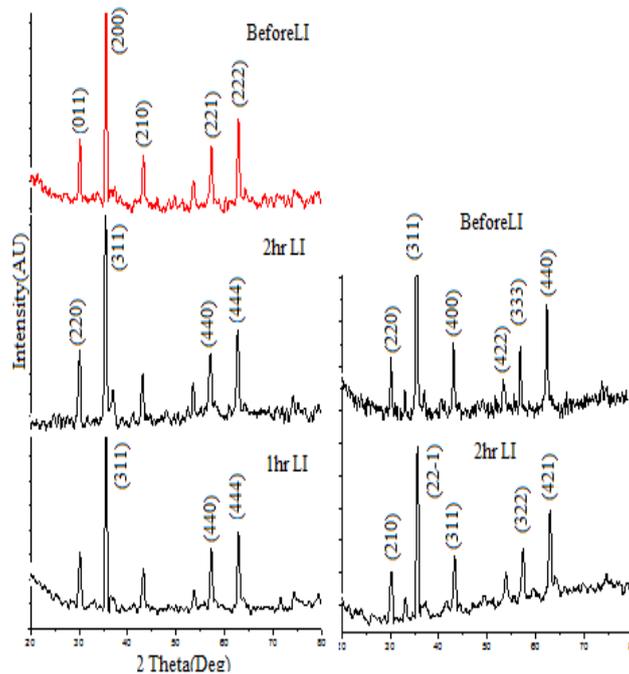


Figure 1. XRD of $Mg_xNi_{0.2}Cu_{0.8-x}Fe_2O_4, x=0.5, 0.6$ and Laser Irradiation

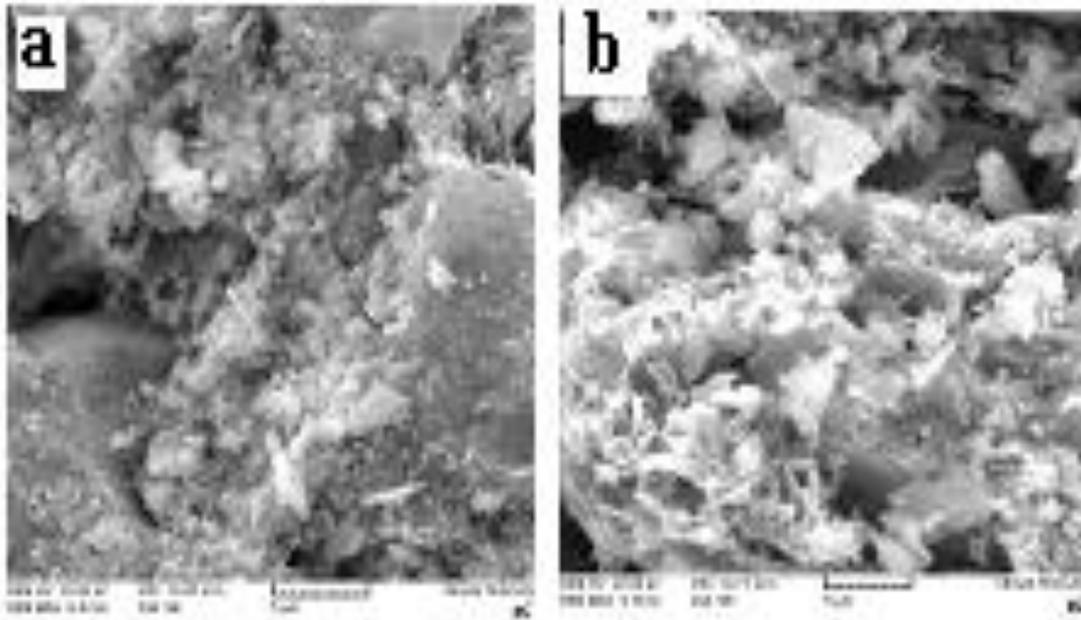


Figure 2. SEM of $Mg_{0.5}Ni_{0.2}Cu_{0.3}Fe_2O_4$ a) before irradiation b) after irradiation

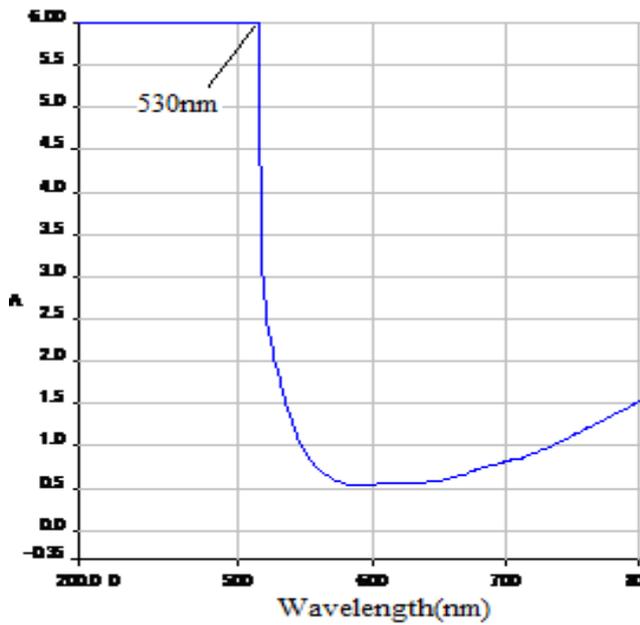


Figure 3. UV of Laser Irradiation for 2 hr

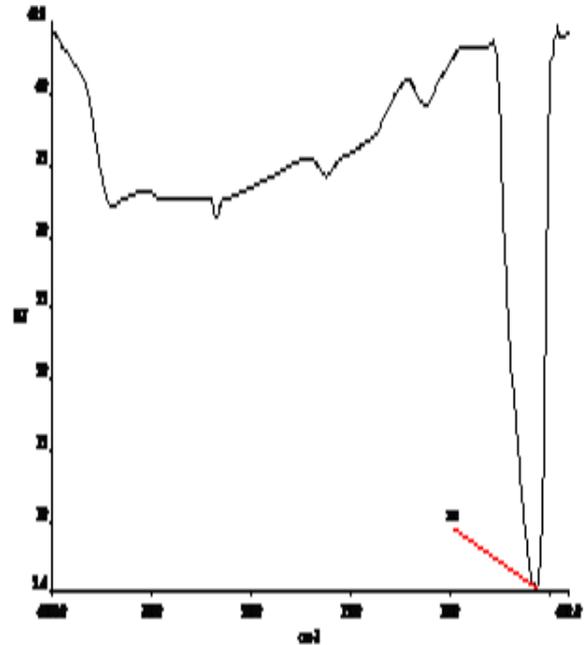


Figure 4; IR Spectra of $Mg_{0.6}Ni_{0.2}Cu_{0.2}Fe_2O_4$.

IV. CONCLUSION

From the above results we conclude that in $Mg_xNi_{0.2}Cu_{0.8-x}Fe_2O_4$ where $x=0.5, 0.6$ after laser irradiation average grain size of the material decreases as the percentage of the composition changes simultaneously there is change in the lattice constant of the material. From SEM result due to less resolution specific morphology was not determined. Infra-red gives the sharp peak at 560cm^{-1} gives information about formation of ferrite material because it is characteristic band of ferrite. From UV spectroscopy the band gap energy of ferrite material is 3.5eV . The energy band gap shows the material is semiconductor.

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BIOGRAPHY



Dr RATHOD SOPAN MANSING

Associate Professor

Recognized Research Guide [Physics] Of University Of Pune And Srt Marathwada University Nanded

Research Interest: Material Science, Nano Ferrites, Laser Physics

Organization: P. G. & Research Center, Department Of Physics, Abasaheb Garware College Karve Road Pune - 4

Mailing Address: Department Of Physics, Abasaheb Garware College, Karve Road, Pune -4 Maharashtra, India