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Room Temperature Ferromagnetism of La doped ZnO Nanorods

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Abstract: ***La-doped ZnO nanorods with different La concentrations (1 wt % and 5 wt%) were synthesized by novel wet chemical method and characterized by various sophisticated techniques such as XRD, UV–DRS, FESEM, EDS and VSM. This method is simple, calcination temperatures are not required and nanorods are prepared by low temperature. The XRD patterns of the La-doped ZnO nanoparticles indicate hexagonal crystal structure with an average crystallite size of 49.44 and 35.83nm .The XRD analysis showed hexagonal structure. Field Emission Scanning Electron Microscopy (FESEM) result reveals that the La doped ZnO nanoparticles are rod like shape. EDS analysis shows the incorporation of La ions in the ZnO lattice. The band gap of the nanoparticles is determined from UV-DRS. Magnetic studies reveal the ferromagnetic behavior in La doped ZnO nanorods.***

Keywords: Wet chemical method, Hexagonal, Nanorods, band gap, ferromagnetism

1. Introduction

One-dimensional nanostructures, such as nanorods and nanowires have attracted extraordinary attention for their novel physical properties and potential applications in constructing nanoscale electronic and optoelectronic devices [1–2].Recently rare earth ion doped II-IV semiconductor nanoparticles have received much attention because such doping can modify and improve optical properties of II-IV semiconductor nanoparticles by large amount [3-7]. ZnO is one of the most promising materials for executing this task. Due to its direct wide band gap of 3.37eV, ZnO has a wide range of applications in optoelectronic devices [8] such as light-emitting diodes, photo detectors and p-n homojunctions.

Dilute magnetic semiconductors has been attracting researchers due to their wide range of applications like spintronics devices such as spin-FET, spin-LED, nanoscale integrated magnetic memories and sensors etc [9] .These properties have opened up a number of new areas of applications for these materials in spintronics to increase the speed of data processing, high data storage density, non volatility of data storage and low energy consumption. The main challenge for this kind of materials is to preserve their magnetic character at room temperature (RT), to be useful for technological applications.

Doping with rare earth elements leads to many interesting properties of ZnO. In this article, it was reported that the La doped ZnO nanoparticles are synthesized by wet chemical method and the samples are characterized by XRD, FESEM, EDS, UV-DRS and VSM.

2. Experimental

2.1. Chemicals and reagents

All chemicals, purchased from Merck were analytically pure. For the synthesis of La doped ZnO nanorods the precursor used are Zinc Nitrate, CTAB, Lanthanum Nitrate and NaOH.

2.2. Wet chemical method

A novel wet chemical method has been used for the preparation of nanorods. This method is simple and the advantage of this method is calcination temperatures are not required and nanorods are prepared by low temperature.1M of zinc nitrate is dissolved in the presence of CTAB. To this 1 wt% and 5 wt % of Lanthanum nitrate was added. 2M of NaOH solution was heated to a temperature of 60^{o}C.Add the precursor solution in the NaOH solution, a white precipitate of La doped ZnO nanoparticles are formed. The prepared La doped ZnO nanoparticles are characterized by various techniques.

3. Results and Discussion

3.1. Structural Properties

Structural properties of La-doped ZnO nanorods are analyzed by XRD pattern.

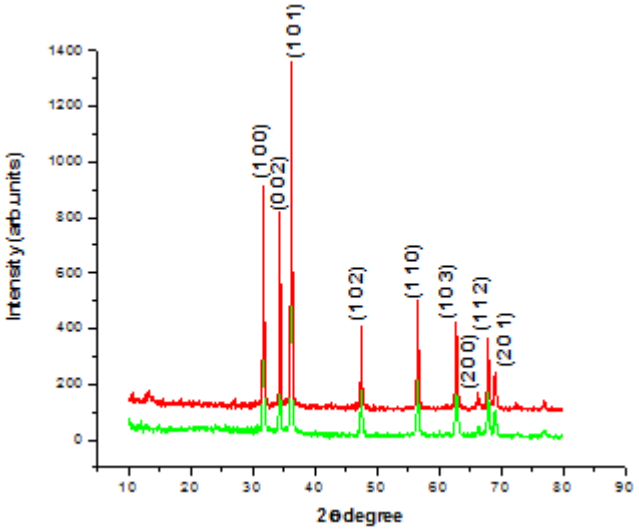

Figure 3.1: X -Ray Diffraction pattern

Figure 3.1 shows a typical XRD patterns for lanthanum doped (1 wt% and 5 wt %) ZnO nanorods. The strong intensities of diffraction peaks (100), (002), (101) (102)

(110) (103), (112) and (201) in the XRD pattern are corresponding to the hexagonal wurtzite structure of ZnO with the JCPDS card **No: 89-0510** and lattice constants a = **3.248 Å and c = 5.2051 Å,** indicates that the products obtained are high purity.

In addition, there is no evidence for additional peaks in the XRD pattern ,since Zn^{2+} is replaced by La^{3+} as the radius of La^{3+} (1.15Å) is much bigger than Zn^{2+} (0.88 Å). There is no separate phase formed for La loaded ZnO. Hence La^{3+} may be dispersed uniformly on ZnO nanoparticles. According to the Debye–Scherrer formula, the average grain size of the particles are calculated

D=0.9 λ/ β cos θ

The average grain size calculated for (1wt%, and 5wt %) La doped ZnO nanoparticles are found to be 49.44 nm and 35.83 nm respectively.

3.2 Morphological studies

The morphologies of the as prepared La doped ZnO nanoparticles are investigated using Field Emission Scanning Electron Microscope (FE-SEM).

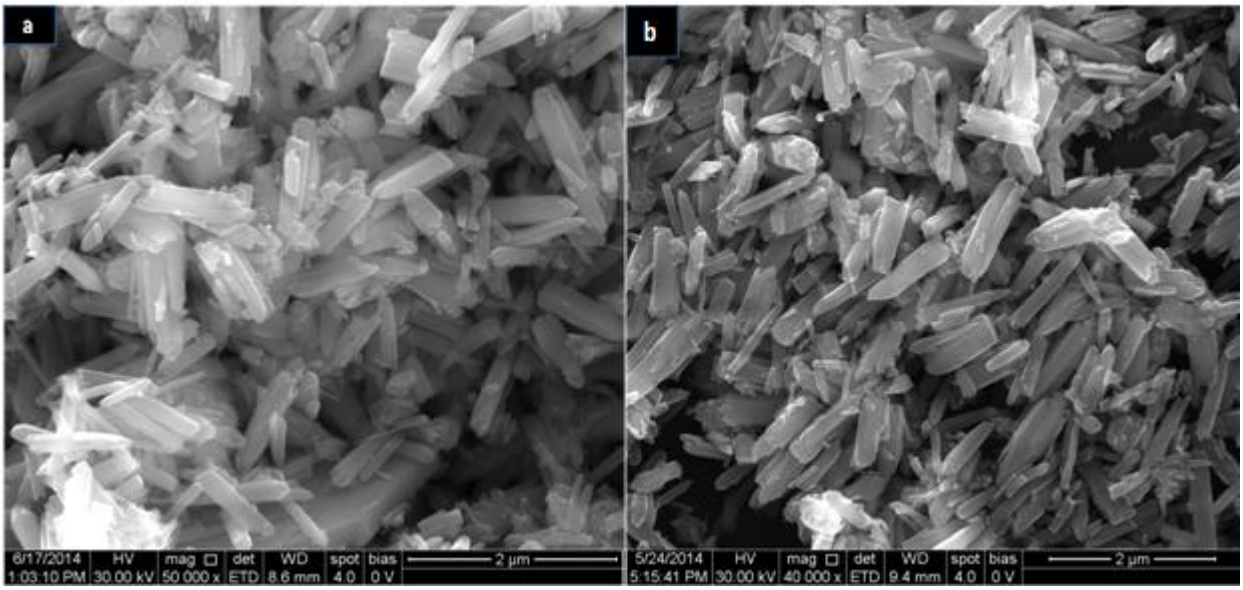

Figure 3.2.1: a) 1wt% b) 5wt% La doped ZnO nanoparticles

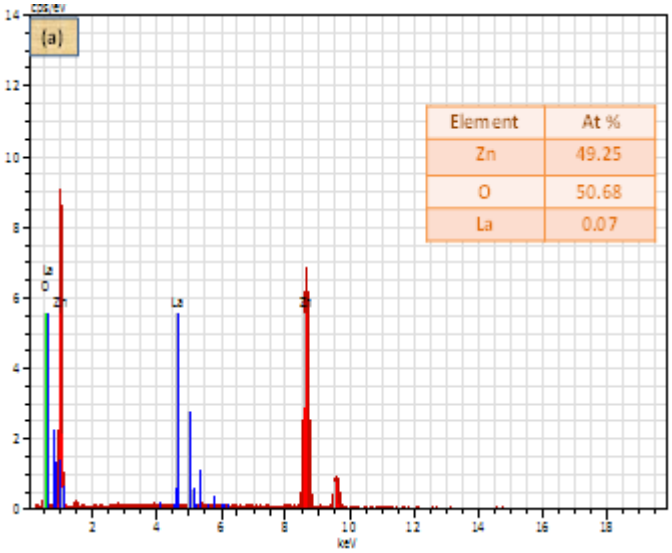

Figure 3.2.2: EDS spectrum

The uniformly distributed rod shaped particles were observed from the FESEM image of La doped ZnO nanoparticles. The typical length of the nanorods is in the range of 0.89–1.13 µm, while the diameters are in the range of 0.23- 0.26 µm. In EDS spectrum, numerous well-defined peaks were evident related to Zn, O and La which clearly support that the synthesized nanorods are composed of Zn, O and La.

No other peak related to impurities was detected in the spectrum which further confirms the purity of the compound. The atomic % of Zn, O and La is 49.25, 50.68 and 0.07 respectively, which reveals deficiency of oxygen, such oxygen deficient materials useful for the photocatalysis which possesses more active centers.

3.3 Optical properties

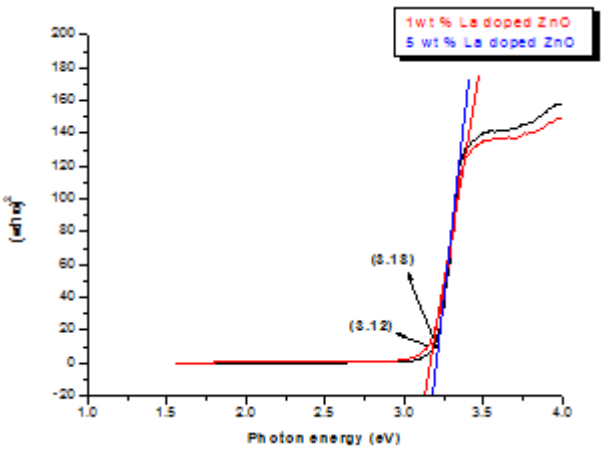

Figure 3.3: Plot of $(\alpha h\upsilon)^2$ vs hυ for La doped ZnO nanorods

The band gap of La doped ZnO nanorods for 1 wt% La doped ZnO nanorods and 5 wt% La doped ZnO nanorods are found to be 3.12 and 3.18 which is lower than the band gap

of bulk ZnO . As the La concentration increases the average grain size decreases and hence the band gap increases.

3.4 Magnetic Studies

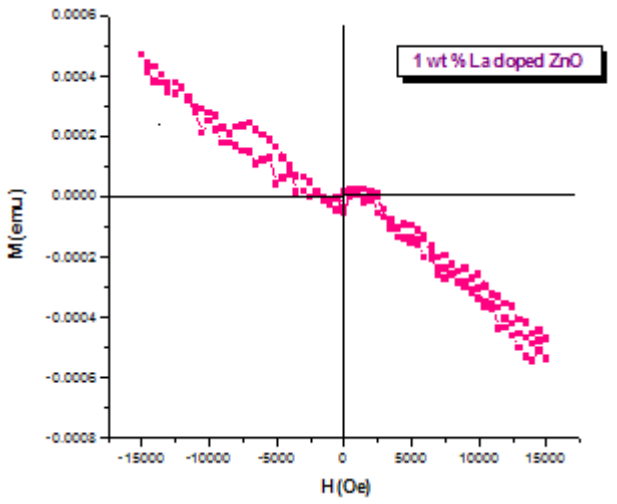

Figure 3.4.1: M-H curve of 1 wt % La doped ZnO

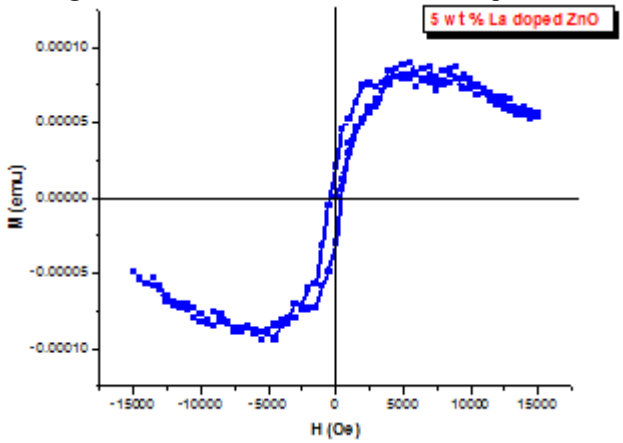

Figure 3.4.2: M-H curve of 5 wt % La doped ZnO

The magnetic behavior of the La doped ZnO nanoparticles are measured at room temperature (300 K) using a magnetic field (H) in the range of -15 KOe to 15 KOe is depicted in Fig.3.4.1-3.4.2.The M–H curve for the 1 wt % La doped ZnO nanoparticles shows a negative moment with increasing field indicating a diamagnetic behavior. When the La doping concentration is increased, ferromagnetic behavior at room temperature is obtained .Thus 5 wt % La doped ZnO nanorods can be used for spintronics applications.

4. Conclusion

La doped ZnO nanorods were successfully synthesized by wet chemical method. XRD results revealed the hexagonal wurtzite structure of the La-doped ZnO nanorods. No evidence for additional peaks in the XRD pattern was identified. The UV–DRS spectra showed that the band gap values increased in the range 3.12, 3.18 eV as doping concentration increases. It can be seen from the FESEM image, that nanorods are grown in very high density, uniform size and distributed randomly. Room temperature ferromagnetism was observed for 5 wt % La doped ZnO nanoparticles will find many interesting applications in spintronics devices.

References

[1] Hu J, Odom TW, Lieber CM, ***Acc. Chem. Res,***Vol. 32, PP. 435-445, ***(*1999).**
[2] Dekker. C, ***Phys. Today***, Vol. 52, PP. 22-28, **(1999).**
[3] C. M. Jim, J. Q. Yu, L. D. Sun, K. Dou, S. G.Hu, S.H.Haung, ***J.Lumin***, Vol.315, PP. 66-67, **(1996).**
[4] H. S. Kaushik, Anuradha Sharma, Mamta Sharma, ***International Journal of IT, Engineering and Applied Sciences Research (IJIEASR)***, Vol. 3, No. 1, **(2014).**
[5] Ping Yong, Mengkai Lu, Guangjum Zhou, Duo Rong, Yuan and Dong Xu, ***Inorganic Chemistry Comm***, 734, **(2001).**
[6] A. P.Alivisatos, ***Nanocrystals and quantum dots Science,*** 271, 933, **(1996).**
[7] V.Jungnickel, F.Henneberger, ***J. Lumin***, 70, 238, **(1996).**
[8] M.Chamarro, C.Gaurdon, P.Lavallard, ***Photoluminescence polarization of Semiconductor nanocrystals***, 70, 222, **(1996).**
[9] Zhao L, Lu P.F, Yu Z.Y, Guo X.T, Shen Y, Ye H, Yuan G.F, Zhang. L, ***J Appl Phys***, 108, 113924– 113930, **(2010).**