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Chemical Synthesis and Optical Properties of ZnO Nanoparticles

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We report here a simple wet chemical process to synthesize ZnO nanoparticles. The morphology of the nanoparticles was observed in field emission scanning electron microscope. The nanoparticles have average diameter ~ 100 nm. The optical property of the synthesized ZnO nanoparticles was investigated using UV-visible absorption spectra. The synthesized nanoparticles exhibit strong absorption at ~ 279 nm. The band gap of the nanoparticles was calculated from the absorption spectrum and found to be 3.76 eV. Thus the synthesized ZnO nanoparticles will be useful in various optoelectronic applications.

Keywords: ZnO, Chemical-synthesis, FESEM, Absorption, Band-gap.

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1. INTRODUCTION

Zinc Oxide (ZnO) is a very well known material being investigated over the past decade due to their unique multifunctional properties [1]. ZnO is a high and direct bad gap semiconductor of band gap ~ 3.4 eV and large exciton binding energy of 60 meV at temperature. Due to this large band gap it exhibits photoluminescence in UV region [2]. However during growth of ZnO nanocrystals several defects states may be created in between the conduction band and valence band leading to the photoluminescence in visible region. There are various reports on the visible emission of ZnO nanostructures [3-6]. Varieties of synthesis methods such as electrochemical, pulsed laser deposition, sputtering, chemical vapour deposition have already appeared in literature [7-8]. Here, in this paper, we report a simple wet chemical method of synthesizing ZnO nanoparticles followed by typical morphological and optical characterization.

2. EXPERIMENTAL

The entire chemicals used in this synthesis process were of analytical grade and used as supplied (Merck). In a typical synthesis process 0.1 M of zinc acetate dihydrate was dissolve in 50 ml di-ethylene glycol and stirred vigorously at room temperature till the zinc acetate dissolve completely. After complete dissolution, the solution was stirred further in a constant temperature bath maintained at 100 °C for 1 hr. After the stirring the solution was cooled to room temperature and mixed with 100 ml of ethanol and stirred for 10 minutes. The solution was then filtered and washed 3-4 times by ethanol. The white precipitate was then dried in a furnace at 150 °C for further characterization.

Field emission scanning electron microscopy (FESEM) was carried out in ZEISS FESEM operating at 5 kV. For UV-visible (UV-VIS) spectroscopy a small amount of sample was dissolved in ethanol and ultrasonicated for 30 mins. The UV-VIS data were recorded in a Perkin-Elmer LS-45 spectrophotometer over the wavelength range 200 nm to 600 nm.

3. RESULTS AND DISCUSSIONS

Typical FESEM image of the ZnO nanoparticles is shown in Fig. 1. Spherical ZnO nanoparticles are found to form. The average diameter of the nanoparticles is found to be ~ 100 nm as calculated from FESEM.

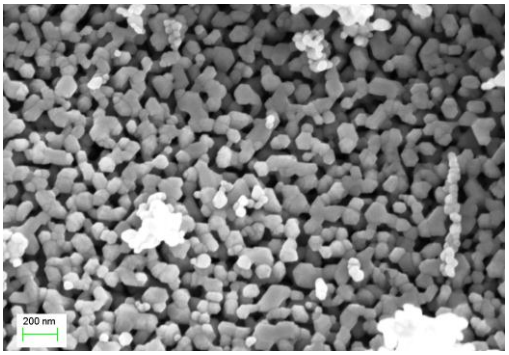

Fig. 1 – SEM image of ZnO nanoparticles

Typical UV-VIS absorption spectrum of the synthesized ZnO nanoparticles is shown in Fig. 2.

The nanoparticles exhibit strong absorption at ~ 279 nm. The band gap of the synthesized nanoparticles was calculated using Tauc equation [9]:

$$\alpha h\nu = D\left(h\nu - E_g\right)^n \qquad (1)$$

Here, $h\nu$ is the energy of the incident photon E_g, the band gap of the material, D is a constant. The transition data enables us the best linear fit in the band edge region for $n = 1/2$. Plot of $(h\nu)^2$ vs $h\nu$ is shown in Fig. 3.

By extrapolating the linear portion of the plot to the $h\nu$ axis, the band gap was calculated to be 3.76 eV. This band gap enhancement compared to bulk ZnO occurs due to quantum confinement effect.

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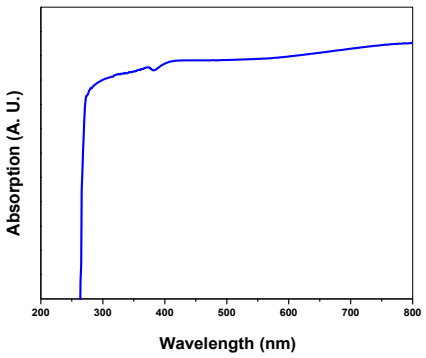

Fig. 2 – UV-VIS spectrum of ZnO nanoparticles

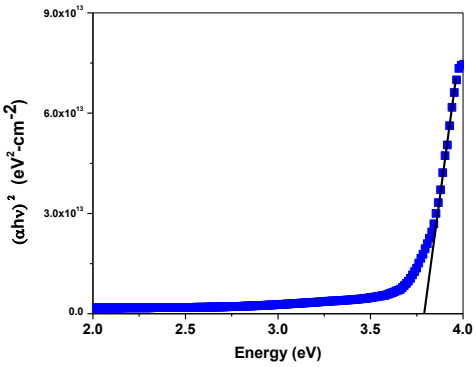

Fig. 3 – Tauc plot for determination of band gap

4. CONCLUSIONS

In conclusion, we have synthesized spherical ZnO nanoparticles of average diameter ~ 100 nm using a simple wet chemical synthesis process. FESEM image revealed the formation of spherical ZnO nanoparticles. The nanoparticles exhibit strong absorption at ~ 279 nm. The ZnO nanoparticles have band gap ~ 3.76 eV as calculated from the absorption data. This band gap enhancement occurs due to quantum confinement of carrier within the small dimension of the nanocrystals.

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