One step synthesis of ZnO nanoparticles and their characterization

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ABSTRACT
Zinc Oxide (ZnO) nanoparticles were synthesized by one step chemical method on glass substrates using aqueous zinc nitrate. Structural studies by X-ray diffraction (XRD) explored that the ZnO exhibits the hexagonal crystal structure. Scanning Electron Microscopy (SEM) result displays porous type of morphology. The spectrum shows sharp absorption band edge at 371 nm, corresponds to optical band gap of 3.07 eV. The room temperature photoluminescence spectrum exhibits, a dominant, sharp, strong ultraviolet emission peak centred at 392 nm and suppressed deep level emission (green emission at 514 nm) indicates good crystal quality and optical properties.

KEYWORDS: ZnO nanoparticles, XRD, SEM, UV-Visible.

INTRODUCTION

ZnO has a wide and direct band gap of 3.36 eV at room temperature, a higher exciton binding energy (60 meV) which assures more efficient exciton emission at higher temperatures [Kong et. al. 2006]. ZnO has fairly high refractive index [Dong et. al. 2008] and some advantages over other oxide materials due to its unique combination of attractive properties such as non-toxicity, good optical, electrical behaviour and its low cost [Yoo et. al. 1998]. As transparent conducting oxide, ZnO film find many practical applications in optics viz coatings, sensors, IC components for telecommunication, solar cells, laser diodes [Islam et. al. 2009], active channel material in thin film transistors development because of its exhibiting n-type semiconductive characteristic [Kathirvel et. al. 2009] and luminescent material, surface electro-acoustic wave device, UV laser, thin film gas sensor [Studenikin et. al. 2000]. The present paper reports one step preparation of ZnO nanoparticles and their structural, microscopic and optical properties.

MATERIALS AND METHODS

Preparation of ZnO nanoparticles : ZnO nanaparticles were prepared chemically using aqueous zinc nitrate solution on glass substrates at 400 ^{0}C.

Characterization of ZnO nanoparticles : The structural, surface morphology, optical properties of ZnO were carried out using Rigaku X-ray diffractometer with CuK$_\alpha$ radiations, scanning electron microscopy (SEM) JEOL JSM-6360, UV-VIS spectrophotometer (Shimadzu spectrophotometer model UV-1800) respectively.

RESULTS AND DISCUSSION

Structural properties

The crystallographic structure of the ZnO nanoparticles was examined by X-ray diffraction technique. Fig. 1 shows XRD pattern of ZnO. The crystal planes (hkl), are indicated for every diffraction peak. The diffraction peaks (002), (101), (102) and (103) indicate that the deposited ZnO thin film has hexagonal structure [JCPD Card No. 38-1451].

The grain size was calculated from the X-ray diffraction data by using well known Scherer's relation (Tarwal et. al. 2010):

$$D = \frac{0.9\,\lambda}{\beta \cos\,\theta} \qquad (1)$$

where, D is the grain size, λ is the x-ray wavelength $1.54060A^0$, β is the corrected full width half maxima, θ is the angle at which the maximum peak occurs.

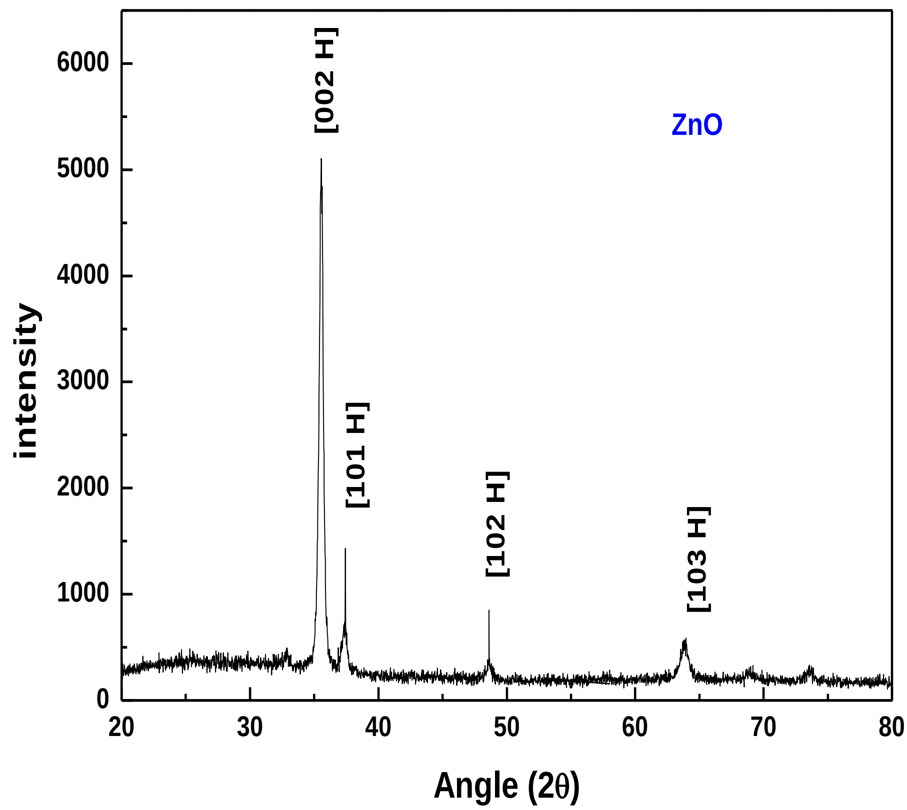

Fig 1: X-ray diffraction pattern of ZnO nanoparticles.

Surface morphological analysis - Surface morphology of ZnO nanoparticles was studied using Scanning Electron Microscope (SEM). Fig.2 shows SEM micrograph of ZnO agglomerated nanoparticles .

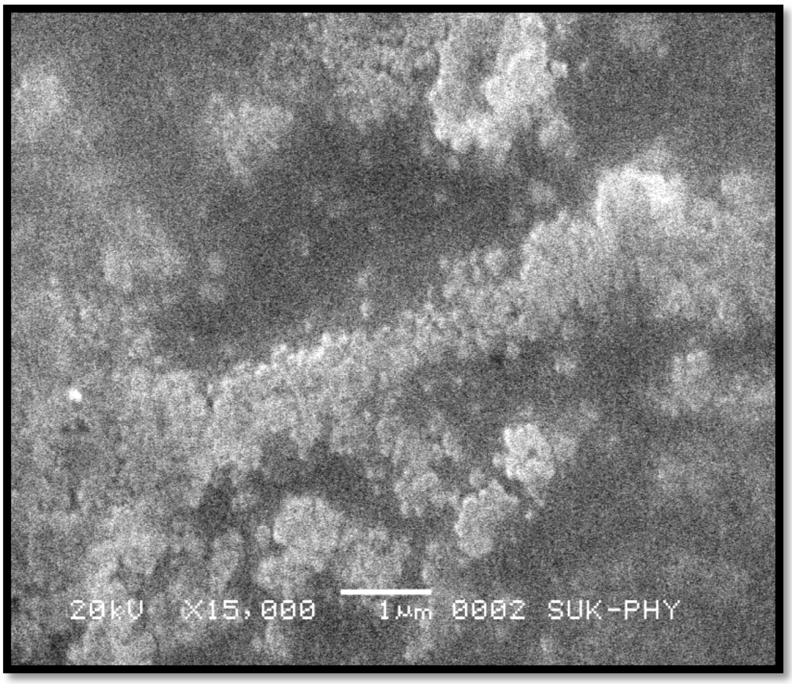

Fig 2: Scanning Electron Microscopy of ZnO nanoparticles.

Optical studies

Optical spectra of as deposited ZnO thin film was recorded in the range of 300 - 1100 nm wavelength range shown in Fig.3. The spectrum reveals that deposited ZnO film has low absorbance in visible region, which is a characteristic of ZnO. The relation between the absorption coefficient (α) and photon energy (hυ) for direct allowed transition is given by Eq. (4) [Tarwal et. al. 2010; Myoung et. al. 2002]:

$$\alpha h\vartheta = A(h\vartheta - Eg)^{\frac{1}{2}} \quad (4)$$

Extrapolation of the linear part of this plot (Fig.4) intercepts to the x- axis and gives the value of band gap energy E_g. The band gap of ZnO was to be found 3.07eV.

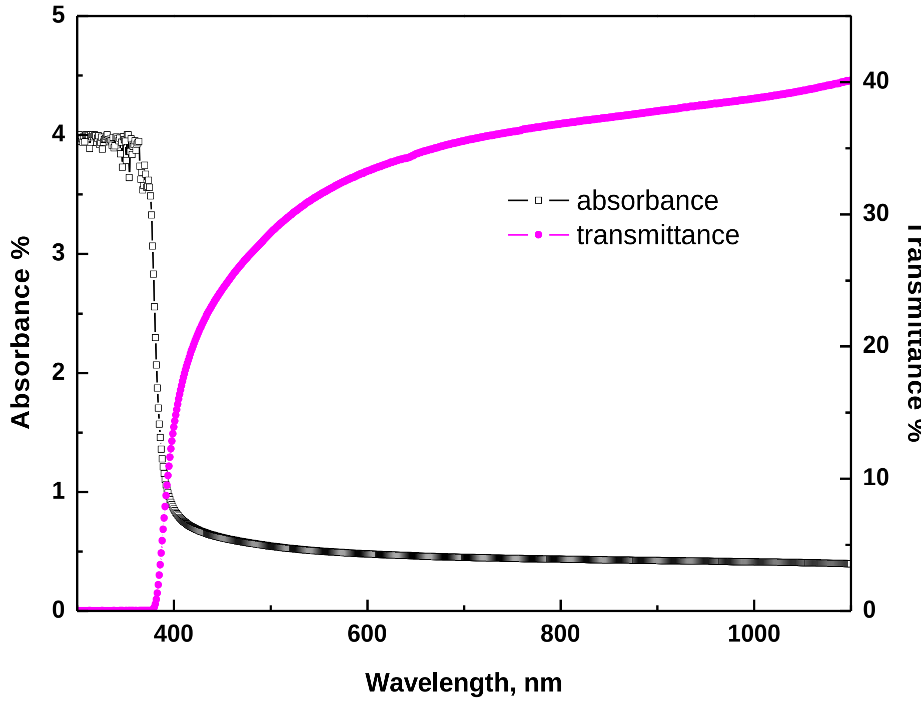

Fig 3: Optical absorbance and transmission of ZnO nanoparticles.

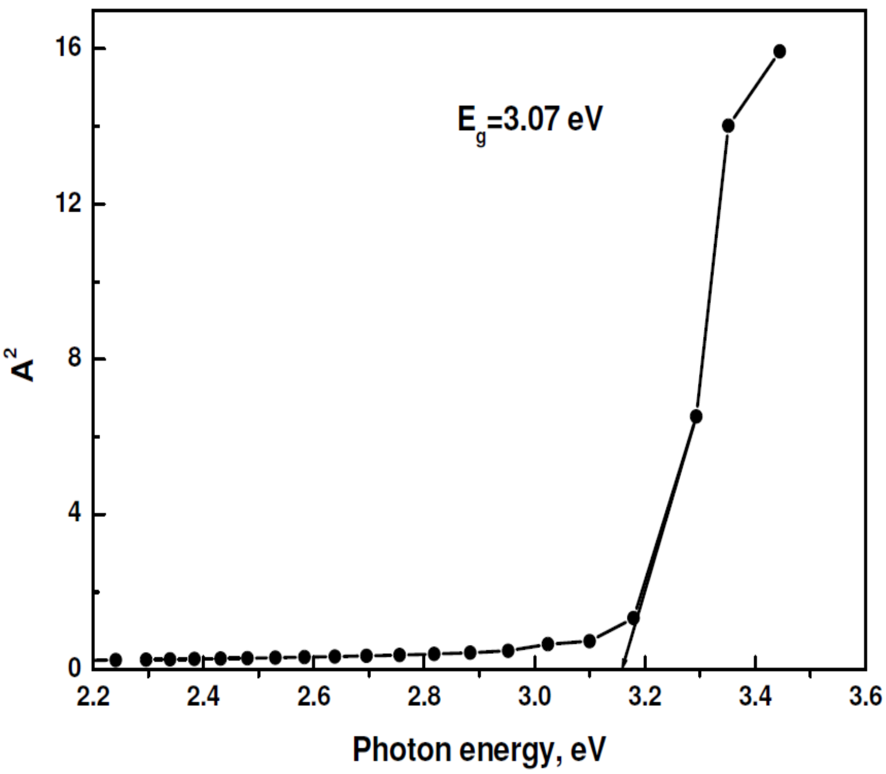

Fig 4: Plot of A^2 Vs hυ for ZnO nanoparticles.

CONCLUSIONS

Nanoparticles ZnO have been successfully prepared by one step chemical method on to glass substrates at 400 ^{o}C from an aqueous zinc nitrate. The X-ray diffraction analysis showed that ZnO exhibit hexagonal crystal structure along (002). SEM showed that agglomerated nanoparticles. Optical properties revealed that ZnO have direct band gap of 3.07 eV.

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