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Structural characterization and photoluminescence properties of zinc oxide nano particles synthesized by chemical route method

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ABSTRACT

Nanostructures, crystalline Zinc oxide powder were synthesized by mixing Zinc chloride (0.04M) and sodium hydroxide (0.08M) using chemical route method. 0.001M molar concentrations of TEA (Tri ethanolamine) in aqueous solution used to the growing reaction solution. The powder samples are annealed at 190 °C. The experimental results indicate a successful growth of Zinc oxide in solid form which is not observed ever before. XRD, SEM, TEM and PL were performed to characterize the morphology, growth and optical nature of the samples. The some Rod and particle like morphology of zinc oxide has been examined by transmission electron microscopy. The particle size was found to vary from 7 to 21 nm. The room temperature PL spectra exhibits low intensity UV emission peak at 407 nm and blue emission band around 484 nm.

1. Introduction

In recent, ZnO has emerged as one of the most studied material. This is a wide band gap semiconductor having wurtzite structure (Islam & Podder, 2008). ZnO nanostructures have attracted a lots of research interest due to their unique structure and size dependent electrical, optical and mechanical properties. It has promising applications such as an inexpensive, anticorrosive n-type semiconductor, transparent conductive contacts, solar cells, gas sensors, short-wavelength laser diode, light-emitting diodes and thin film transistor (Vijayan et al., 2008). ZnO have attracted considerable attention because they can be tailored to possess high electrical conductivity, high infrared reflectance and high visible transmittance by applying different coating techniques. Consequently it is added into various material and product, including plastic ceramic, glass cement rubber lubricants, paints, ointment, sealant pigment, foods, batteries, fire retardant etc (Widiyastuti et al., 2014; Zhiwei et al., 2010). As compared to other oxide material such as ZrO_2, Y_2O_3,

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Gd_2O_3, CeO_2, Y_2SiO_5 and etc; ZnO material is much cheap and easily available material (Dubey, Agrawal & Kaur, 2015; Tamrakar, Upadhyay, Bisen, 2014; Tamrakar, Bisen, Upadhyay & Bramhe, 2014; Tiwari, Kuraria & Tamrakar, 2014; Tamrakar, 2013; Tamrakar & Bisen, 2013; Tamrakar, Bisen, Robinson, Sahu, & Brahme, 2014).

In the form of one dimensional nano wires/nano rods/ nanotubes or two dimensional nano plates/nano sheets, it has been widely accepted as the building blocks for nanodevices. In view of this point, controlled growth of nanostructure in term of size, shape and orientation is a prerequisite, and a large amount of intensive research has been conducted to prepare desired ZnO architectures (Cao & Cal, 2008).

Till today, many different techniques to produced nano range phosphor such as spray pyrolysis (Santana, Vacio & et al., 1999), plasma-enhanced chemical vapor deposition (Kim & Kim, 1999), sol gel (Bao, Gu, & Kuang, 1988), sputtering (Subramanya, Naidu, & Uthanna, 2000); solid state reactions (Tamrakar, Bisen, Upadhyay & Tiwari, 2014; Tamrakar, Bisen, & Brahme, 2015; Sahu, Bisen, Branhe, Wanjari and Tamrakar, 2015a, 2015b), co-precipitation (Bisen, Sharma, Brahme, & Tamrakar, 2009) and combustion (Tamrakar, Bisen and Sahu, 2014; Tamrakar, Bisen, and Brahme 2014a, 2014b, 2014c) etc have been used, but in recent times much interest has been generated around the chemical route technique (Dubey et al., 2014; Ezema and Azogwa, 2003). The technique is simple cost; effective, reproducible and the material are readily available (Ezema, Ekwealor, Osuji, 2007; Ezeme & Okeke, 2002; Ezema et al., 2007).

In this paper, we report that the very low concentration of complexing agent is responsible for synthesis of nanopowder which is not observed ever before and also reported observation of surface morphology and the result of optical characterization of ZnO nanopowder The photoluminescence studies were investigated in detail.

2. Experimental procedure

2.1. Synthesis of ZnO nanopowder

0.04M aqueous solution of zinc chloride mixed with 20 ml of 0.08M aqueous solution of sodium hydroxide (All AR grade 99.9% pure). 8 ml of 0.001M aqueous solution of TEA added after in growing reaction solutions. Keep the reaction solution for 18–24 h. The powder was washed many times (more than 8 times) with triple distilled water, filtered and dried in sunlight. After this it is annealed at 190 °C in a furnace. The color of powder is white. Reaction mechanics is as follow (Eya, Ekpunob & Okeke, 2005; Eya, Ekpuno & Okeke, 2005; Widiyastuti et al., 2014; Taunk, Das, & Bisen, 2015).

$$ZnCl_2 + TEA \leftrightarrow Zn\,(TEA)^{2+}\,2Cl^-$$

$$Zn\,(TEA)^{2+} \leftrightarrow Zn^{2+} + TEA$$

$$NaOH + OH^- \leftrightarrow Na^+ + 2OH^-$$

$$Zn^{2+} + 2OH^- \leftrightarrow Zn\,(OH)_2$$

$$Zn\,(OH)_2 \leftrightarrow ZnO + H_2O$$

2.2. Measuring instruments

We have characterized by employing scanning electron microscopy (SEM), XRD and Transmission electron microscopy (TEM). SEM was used for morphological characterization of sample. The surface morphology of the white precipitate was determined by scanning electron microscope (SEM) JSM-7600F. The structural parameters of the powder were determined using X-ray diffraction technique. The XRD patterns were recorded with Bruker D8Advanced X-ray diffractometer using a Cu Ka radiation source ($\lambda = 1.54056$ Å). The X-rays detected using a fast counting detector based on Silicon strip technology (bruker Lynx Eye detector) (Tamrakar, Kowar, Uplop, & Robinson, 2014; Tamrakar, Bisen & Bramhe, 2014c; Tamrakar, Bisen, Upadhyay, 2015; Tamrakar, Bisen, Sahu, & Brahme, 2014f; Tamrakar, Tiwari, Kuraria, Dubey & Upadhyay, 2015). Particle diameter and surface morphology of ZnO were determined by Transmission Electron Microscope using Plilips CM −200. The photoluminescence (PL) emission and excitation spectra were recorded at room temperature by use of a Shimadzu RF-5301 PC spectrofluorophotometer.

3. Result and discussion

3.1. X-ray diffraction (XRD) studies

To identify the crystal structure of ZnO, we performed XRD analysis. Fig. 1 shows XRD pattern of the ZnO annealed at 190 °C. Eya reported that hydrated part removed when sample is annealed 402 K (Eya et al., 2006). The X ray diffraction were record in the range 20°–80°; most of the diffraction peaks can

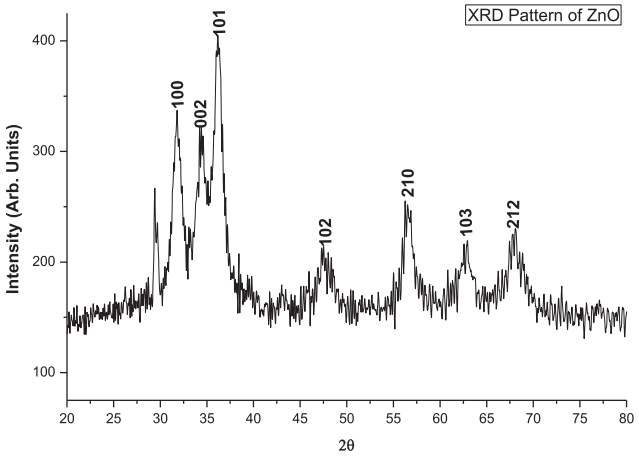

Fig. 1 – XRD patterns of the ZnO annealed at 190° C.