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Zinc Oxide Nanorods: Synthesis and Its Applications in Solar Cell

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ABSTRACT: *Nanosized materials have been an important subject in basic and applied sciences and these metal nanoparticles have been intensively studied within the past decade Synthesis of hexagonal shape zinc oxide nanorods is achieved by thermal decomposition process. The sample was characterized by uv-vis spectrophotometer, X-ray diffraction Scanning electron microscope. Zinc Chloride ($ZnCl_2$) was used as precursor with sodium hydroxide (NaOH) in 1:2 molar ratios for the preparation of zinc oxide nanoparticles by the wet chemical method. Further its application in solar cell. The results indicate that the as-prepared ZnO Nano-rods are uniform with diameters of 100–200 nm and lengths of about 1µm*

Keywords: *Nanostructures, Chemical Synthesis, UV spectroscopy, SEM, XRD, Solar cell*

I. INTRODUCTION

Nanotechnology is an emerging, highly interdisciplinary field; it has the ability to manipulate matter at an atomic scale. Nanotechnology can be useful in diagnostic techniques, drug delivery, sunscreens, antimicrobial bandages, disinfectant, and a friendly manufacturing process that reduce waste products. Nanorods and nanowires have recently attracted considerable attention towards scientific community because of their novel properties and potential technological applications; it is widely used in the field of catalyst [1], gas sensor [2], solar cell materials [3], antimicrobial materials [4], optoelectronics devices [5,6] etc. ZnO is as wide band gap (3.37eV) compound semiconductor materials with a large exciton binding energy of 60 meV, among several oxides semiconductor ZnO nanostructures is considered to be the best, it is clearly demonstrated in many studies that nanoparticles of ZnO have significantly higher antimicrobial effects then other metal oxide nanoparticles [7]. Currently, different nanostructure of ZnO have been reported such as nanorods, nanowires, nanocombs, nanorings, nanobridge, nanobelts, nanocages [8,9], etc and these nanostructures have potential applications in fabricating functional advanced Nano electronics devices. And a wide variety of techniques have been exploited to fabricate ZnO nanostructures. ZnO nanostructures can be grown either in solution or from gaseous phase, this includes the vapour transport process [10], the catalyst-assisted vapour-liquid-solid process [11], the metal- organic vapour phase epitaxial growth [12], spray pyrolysis [13], and hydrothermal methods [14, 15, 16] which are high temperature processing methods and require costly equipment.

In this paper, we are representing a simple, low cost and low temperature method with high yields of synthesizing ZnO nanostructures. Depending on the catalyst and reaction conditions, different shapes such as nanoparticles, nanoneedles, hexagonal nanoparticles (NPs), nanoflower like structures are obtained but in this case it is hexagonal nanoparticles of ZnO. These synthesized ZnO nanostructures were characterized using X-ray diffraction (XRD), Scanning electron microscope (SEM), UV-visible absorption spectrometer.

II. MATERIALS AND METHOD

Zinc acetate dihydrate, sodium hydroxide, potassium hydroxide and other reagents used were all analytical grade without further purification. Alcoholic media such as methanol, ethanol or propanol, is mostly used for the synthesis of ZnO nanostructures because in alcoholic media growth of oxide particles is slow and controllable [17], but in this study reaction is accomplished in both alcoholic and nonalcoholic media. In a typical synthesis, of ZnO nanorods is carried out by sol gel process, at 80-90^{0}C. Solution of zinc acetate dihydrate [$Zn\ (O_2CCH_3)_2(H_2O)_2$] was prepared by dissolving 2.195 g of zinc acetate dihydrate in 100ml distilled water/ethanol, and stirred in ambient atmosphere. Potassium hydroxide KOH 1.122g is dissolved in 10ml distilled water and was added to the above solution drop wise under continuous stirring. After few minutes solution turn into jelly form and a milky white solution was obtained, the mixture was then further heated for 3 h at 80-90^{0}C without stirring. The resulting suspension was centrifuged to retrieve the product, and the mixture was washed with distilled water in an ultrasonic bathwater and then the powder was dried at 70^o C over night and determined in terms of their structural, morphology and optical properties.

The crystalline structures of the products were characterized by X-ray diffraction (XRD) analysis using a JEOL JDX-3535 diffractometer. The absorbance spectra were recorded on a vision light UV-vis spectrophotometer. Size and morphology of the products were observed by scanning electron microscopy (SEM) which was taken on a JEOL JEM-2010 electron microscopy using an accelerating voltage of 200 kV in bright field and electron diffraction (ED) modes. A small drop of the ZnO powder re-dispersed by ethanol was dropped on a carbon film-coated copper grid. The sizes of ZnO were measured and averaged by several SEM images (n = 100).

III. RESULTS AND DISCUSSIONS

UV–VIS absorption spectra of the ZnO nanorods are shown in Fig. 3, it is well known that the bulk ZnO has absorption at 375 nm in the UV-visible spectrum [18]. The general morphologies of the synthesized ZnO nanorods were studied by scanning electron microscopy (SEM). A typical SEM image of the ZnO nanorods is shown in Fig. 1. The ZnO nanorods have an average diameter of 100 nm and show perfectly flat surfaces with hexagonal symmetry. The lengths of ZnO nanorods are about 1µm. Figure 1 also shows the morphology of the nanostructures obtained after the completion of the reaction with zinc acetate and potassium hydroxide/ sodium hydroxide at 90^0C by sol gel process. The image reveals short rod like ZnO nanostructures with an average diameter of 100 to 200 nm and length in micrometers. We have found variation in shape size and length in the nanorods; most of the nanorods are straight with a smooth surface having hexagonal structure at the end. And in some regions we have notice that bunch of nanorods are aligned together in different direction.

XRD pattern of synthesized ZnO nanostructures by sol gel reaction at 90°C is shown in Fig. 2. All peaks of the obtained product are corresponding to the hexagonal wurtzite structure of Zn reported in many research works [19,20].In Fig. 2, the detected peaks are at 2θ values of 31.7°, 34.4°, 36.2°, 47.5°, 56.6°, 62.8° corresponding to the following lattice planes: (100), (002), (101), (102), (110), (103), respectively. The growth process of ZnO NWs can be controlled through the chemical reactions. All of these reactions are in equilibrium and can be controlled by adjusting the reaction parameters, such as precursor concentration, growth temperature, and growth time, to push the reaction equilibrium forward or backward. The size of the nanostructure can be controlled by using stabilizing agents which prevent the growth of the nanostructure, the growth mechanism of the Nanotubes is explained in many research works, and it is found that crystal size grows with increasing in reaction time at an appropriate temperature. High quality of ZnO nanopowder was obtained after completion of the reaction. In most of the sol gel synthesis process, zinc acetate and urea is used in 1:7 molar ratio at higher temperature 500-800^0C for the growth of one dimensional nanostructure there is two well explained mechanism accepted for the growth of one dimensional nanostructures, viz. the vapour-liquid-solid (VLS) and vapour-solid (VS) mechanism. The VLS mechanism is a catalyst assisted process, in which the metal catalyst particles act as a liquid forming agent, while in this process no catalyst is used.

The results indicate that ZnO nanorods have been successfully prepared by chemical reaction at low temperature.

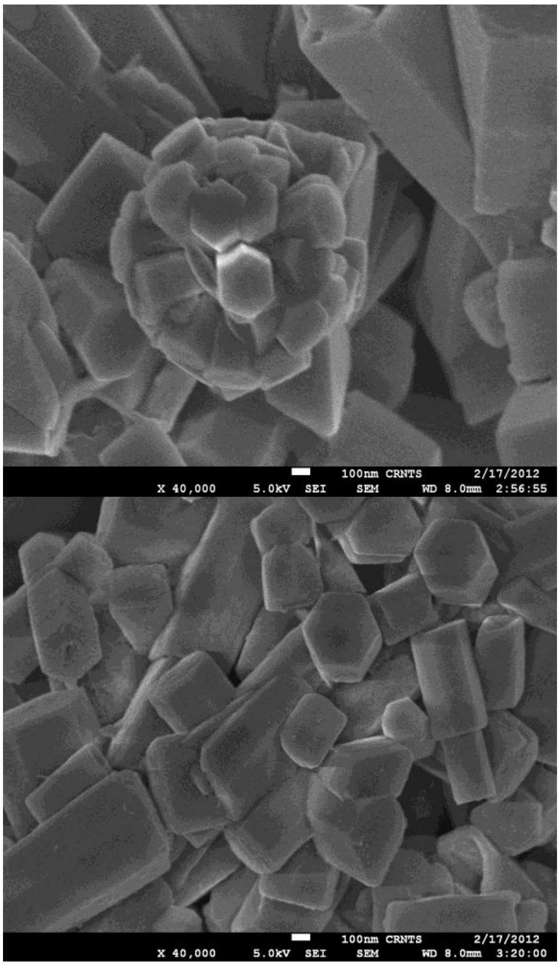

Figure 1. The SEM images of the ZnO nano-rods

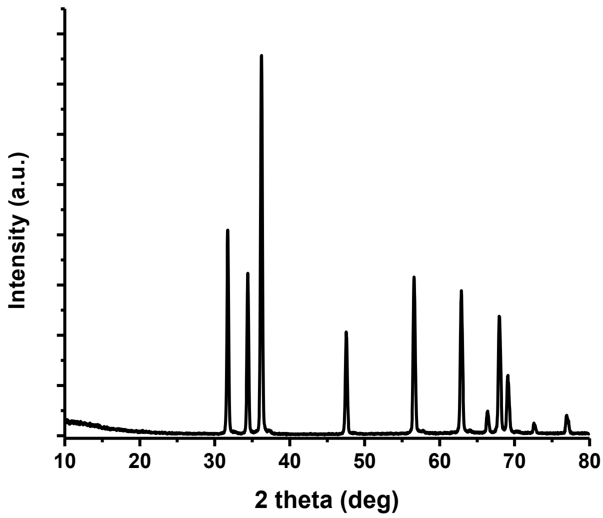

Figure 2. XRD pattern of ZnO nanorods

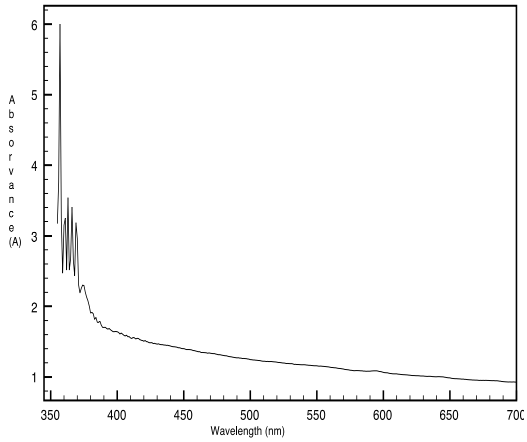

Figure 3. UV-Vis absorption spectra for ZnO nanoparticles

IV. CONCLUSION

Hexagonal ZnO nanorods were synthesis successfully without using any capping agent through sol gel process at 80-90^o C. Zinc acetate dehydrate and zinc chloride was used as the zinc source. Absolute ethanol and water both are taken as a solvent, the synthesized ZnO nanorods prepared with deionized water have the diameter of 100-200nm.

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