Physica B 404 (2009) 1924–1928

Contents lists available at ScienceDirect

Physica B

journal homepage: www.elsevier.com/locate/physb

Low temperature synthesis of ZnO nanorods by using PVP and their characterization

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A R T I C L E I N F O

Article history:
Received 30 September 2008
Received in revised form
9 March 2009
Accepted 10 March 2009

Keywords:
Nanorod
ZnO
PVP
Solvent
Molarity
Polarity

A B S T R A C T

ZnO nanorods are prepared in large quantity at low temperature by using zinc acetate dehydrate and polyvinyl pyrrolidone (PVP) as precursor and capping, respectively. Dependency of morphology and diameter of ZnO nanorods on solvent polarity are investigated. It is observed that diameter of nanorods diminishes with reduction of the solvent polarity. The optical properties of the ZnO nanorods are investigated by UV–Vis spectroscopy. There is a blue-shift in the band-edge with changing of the solvent polarity. The influence of water value on the morphology and diameter of the ZnO nanorods is examined. It is shown that diameter of nanorods decreases by lessening water value; also a blue-shift is observed with decreasing diameter. Effect of Zn/PVP ratio on the ZnO nanorods arrangement is studied.

1. Introduction

Nanostructured materials have expected increasing attention due to their potential applications as active components or interconnect in nanoscaled electronic, optical, optoelectronic, electrochemical, and electromechanical devices [1]. It has a wide direct band gap (3.37 eV), large exciton binding energy (60 meV), excellent chemical, mechanical, and thermal stability, and biocompatibility [2]. ZnO nanomaterials have been widely studied for high-technology applications ranging from photonic crystals [3] to light-emitting diodes [4], photodetectors [5], photodiodes [6], and gas sensors [7].

Various processes have been employed to synthesize ZnO nanostructures, such as electrochemical deposition [8], hydrothermal [9], sputter deposition technique [10], and vapor method [11]. In contrast, wet chemical method is relatively preferred since it is easier, low-cost, and environment protective. We synthesize ZnO nanorods using chemical solution method. Polyvinyl pyrrolidone (PVP) is utilized to make ZnO nanorods from a zinc acetate precursor at a low temperature, since the PVP can be easily removed by burning the solid products [12,13]. In this work, effects of solvent, molarities, and PVP on the morphology and diameter of ZnO nanorods are investigated.

2. Experimental works

Zinc acetate dehydrate [$Zn(CH_3COOH)_2 \cdot 2H_2O$] and PVP are used in the experiments as precursor and capping, respectively. Water, methanol, and ethanol which have different polarities are used as solvents. First, $Zn(CH_3COO)_2 \cdot 2H_2O$ and PVP are dissolved in 50 ml DI water with 10/1 ratio (Zn/PVP). The solution is put on the hot plate and is stirred at 80 °C until little gel of zinc acetate and PVP is obtained. Then gel is dried in the oven for 12 h. Dried gel is calcined at 300 °C for 24 h in the furnace without special atmosphere. Samples are characterized by means of scanning electron microscopy (SEM, Philps) and X-ray diffraction (XRD) with Cu Kα radiation, wavelength $\lambda = 1.54178$ Å (XPERT: model 95).

3. Results and discussion

3.1. Effect of solvent on the morphology and diameter of nanorods

In this work, we use water, methanol, and ethanol as solvents for fabrication of the ZnO nanorods. Effect of the solvent polarity on the morphology and diameter of ZnO nanorods is investigated. The solvent polarity or solubility decreases for water, methanol, and ethanol, respectively. The photographs of the ZnO nanorods grown in different solvents are shown in Fig. 1(a–c). It is observed that we have smaller diameter of the nanorods with reduction of

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0921-4526/$ - see front matter
doi:10.1016/j.physb.2009.03.024

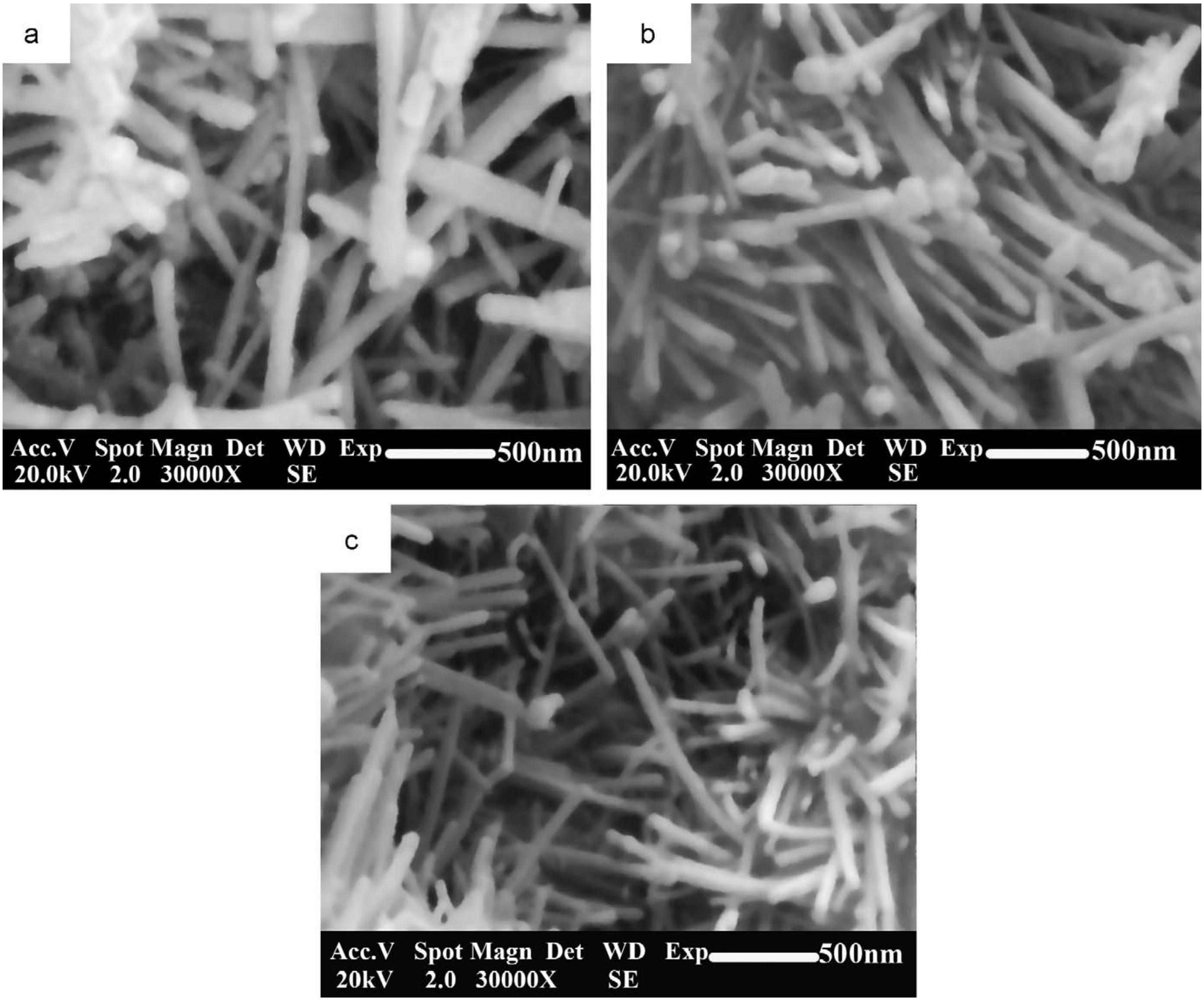

Fig. 1. SEM images of ZnO nanorods produced in: (a) water, (b) methanol, and (c) ethanol.

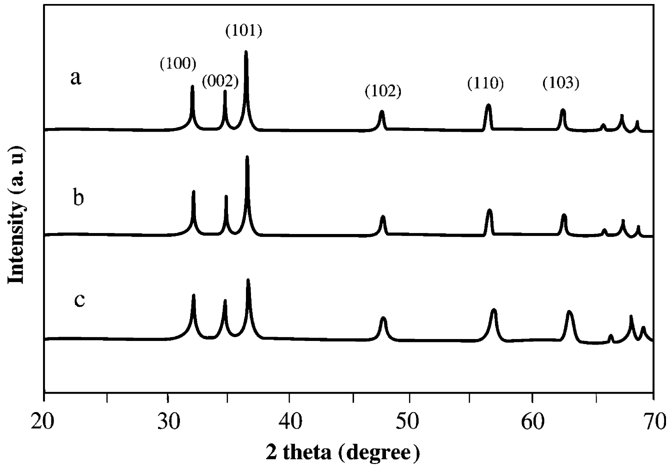

Fig. 2. XRD pattern of ZnO nanorods produced in: (a) water, (b) methanol, and (c) ethanol.

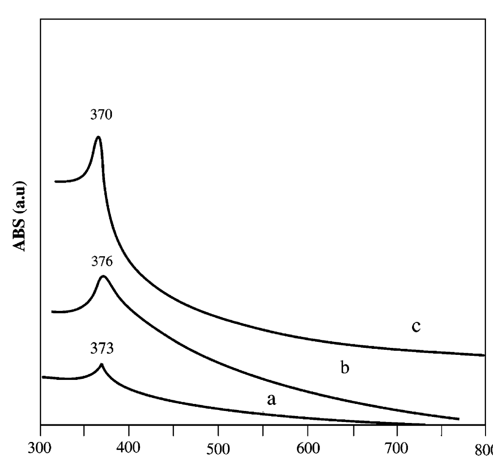

Fig. 3. Absorption spectra of ZnO nanorods prepared in various solvents: (a) methanol, (b) water, and (c) ethanol.