Room temperature synthesis of needle-shaped ZnO nanorods via sonochemical method

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Abstract

Single crystalline needle-shaped zinc oxide nanorods were synthesized via sonochemical methods using zinc acetate dihydrate and sodium hydroxide at room temperature. Morphological investigation revealed that the nanoneedles are of hexagonal surfaces along the length. The typical diameter and length vary from 120 to 160 nm and 3 to 5 μm, respectively. Sonication time appears to be a critical parameter for the shape determination. Detailed structural characterization confirmed that the nanorods are single crystalline with wurtzite hexagonal phase. A standard peak of zinc oxide was observed at 520 cm⁻¹ from the Fourier transform infrared spectroscopy. The ultra-violet visible and room temperature photoluminescence (PL) spectroscopic results demonstrate that the synthesized material has good optical properties.

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1. Introduction

The II–VI semiconductor ZnO with its known properties is a promising material for the wide range of advanced technological applications. The high exciton binding energy, high chemical stability and low growth temperature makes it an excellent candidate for room temperature UV lasing [1,2] application. The crystal morphology and size is believed to have significant effect on the chemical/physical properties, therefore, these days much emphasis is given on the synthesis of novel nanostructure. Variety of ZnO nanostructures (one-dimensional) are reported in the literature synthesized by techniques such as physical vapour, anodic-alumina membrane template, hydrothermal, chemical vapor deposition and so on [3–9]. However, simple and mild routes for the synthesis of high quality ZnO still need to be explored. The structure of the synthesized product is becoming a key factor for its application to nano-devices. For example, structure complexities such as rods, wires and branched structures may be useful for interconnects in future nano-devices. Similarly the composite of ZnO with optical material (e.g. CdO) can be a tool for tailoring the band gap and optical properties. For example, Wang et al. reported the synthesis of quasi-aligned ZnCdO single crystal nanorod for fabrication of heterojunction or superlattice, as a key element in ZnO based light emitters and detectors [10,11].

In recent years, with the fast development of ultrasound technology in chemistry, sonochemical method is being used in preparation of many materials. The ultrasound causes high-energy chemistry via the process of acoustic cavitation: the formation, growth and implosive collapse of bubbles in a liquid. During cavitation, intense local heating of the bubbles occurs for a very short time (few microseconds) resulting in high-velocity interparticle collisions, the impact of which can be used for synthesis [12]. The very high temperature and very short times of cavitational collapse makes sonochemistry a unique interaction of energy and matter. This method has been used for the synthesis of metal carbonyls, metal oxides and metal oxide–polymer nanocomposite materials [12–15]. However, a little work is reported on the growth of ZnO nanostructures by sonochemical method. For example, Hu et al. synthesized linked ZnO rods by microwave-assisted sonochemical methods at 90 °C using zinc nitrate and hexamethylenetetramine (HMT) [16]. Similarly, Zhang et al. synthesized ZnO by sonochemical method using the zinc acetate dihydrate in paraffin oil at 280–300 °C [8]. However, in