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Nanostructure sword-like ZnO wires: Rapid synthesis and characterization through a microwave-assisted route

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Abstract

Nanostructure sword-like ZnO wires with diameters of about 80–250 nm and the length of ∼1–4 μm have been synthesized by a fast, simple and template-free microwave-assisted method. X-ray diffraction (XRD) analysis, scanning electron microscopy (SEM), transmission electron microscopy (TEM), Fourier transform infrared (FT-IR) spectroscopy and room temperature photoluminescence (PL) measurements was used for characterization of the as-prepared products. The nanostructure sword-like ZnO wires have high crystallinity with the average crystallite size of about 53 nm and show a UV emission and a visible green band in their PL spectrum. The possible growth mechanism of the nanostructures along the ⟨0 0 2⟩ crystallographic direction and subsequent formation of wires were also investigated.

Keywords: Nanostructured materials; Oxide materials; Chemical synthesis

1. Introduction

Zinc oxide (ZnO) is the subject of various researches in various biomedical and optoelectronic applications including photo-detectors [1], catalysts [2] and transistors [3], due to its wide band gap (3.37 eV) and large exciton binding energy (60 meV) [4]. ZnO nanostructures are expected to enhance photo-to-electron efficiency, gas sensing and photonic performance due to the surface area increase and quantum confinement effect [5].

A wide range of research interest has been aroused on preparation of diverse morphologies of ZnO during the recent years [6–9]. Various physical and chemical processes, such as conventional sputter deposition technique [10], thermal evaporation process [11], sol–gel reaction [12] and solution growth process [13] can be used to synthesize ZnO nanostructures. Over the past few years, chemical vapor deposition [14], thermal evaporation [15] and hydrothermal process [16,17] have been the three major methods to prepare nano- or micro-scaled ZnO structures in various sizes and morphologies. It is well conceived that preparation of ZnO via chemical routes provides a promising option for its large-scale production. On the other hand, the chemical methods are more popular because of their cheapness, reliability, repeatability and simplicity.

One-dimensional (1D) ZnO nanostructures such as nanowires, nanorods and nanotubes have attracted remarkable attention due to a great deal of potential applications in data storage, advanced catalysts and photoelectric devices [18]. They have been prepared by different methods, such as thermal treatment, electro-deposition and chemical vapor deposition [19]. It is also reported that preparation of 1D ZnO nanostructures via wet chemical routes without involving catalysts or templates provides a promising option for large-scale production of well-dispersed materials [20].

Microwave-assisted synthesis of nanomaterials has been introduced as a very rapidly developing research area [21,22]. In conventional thermal processing, energy is transferred to the material through convection, conduction and radiation of heat from the surfaces of the material which results in temperature gradient formation [23]. In contrast, microwave heating leads to the direct interaction between microwaves and materials and this fact enables a uniform and fast heating of a sample [24]. This difference can result in many potential advantages for microwaves in processing of materials. Another fundamental difference between microwave heating and conventional heat-

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