Journal of Crystal Growth 310 (2008) 3621–3625

Contents lists available at ScienceDirect

Journal of Crystal Growth

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

Self-assembled zinc oxide nanostructures via a rapid microwave-assisted route

Matin Sadat Mohajerani, Mahyar Mazloumi, Aidin Lak, Amir Kajbafvala, Saeid Zanganeh, S.K. Sadrnezhaad *

Nanomaterials Research Group, Materials and Energy Research Center, 14155-4777, Tehran, Iran

ARTICLE INFO

Article history:
Received 14 October 2007
Received in revised form
8 April 2008
Accepted 28 April 2008
Communicated by H. Fujioka
Available online 8 May 2008

PACS:
81.10.Dn
81.16.Dn

Keywords:
A1. Nanostructures
A2. Growth from solutions
B1. Nanomaterials
B1. Oxides

ABSTRACT

Self-assembled ZnO nanostructures with various morphologies were prepared via a rapid and simple microwave-assisted technique. The spherical, raspberry-like and hollow spherical nanostructures were synthesized in the presence of triethanolamine (TEA) as a capping agent and in different adjusted pHs. The volumetric amount of TEA has affected the particle size and crystallite size of the obtained nanostructures significantly. The ZnO nanostructures were obtained due to self-assembly of Zn^{2+} ionic complexes, and the internal voids of the hollow spheres were formed by the Ostwald ripening mechanism. The obtained nanostructures were characterized by X-ray diffraction (XRD) analysis, scanning electron microscopy (SEM), transmission electron microscopy (TEM) and Fourier transform infrared (FTIR) spectroscopy. The optical properties of the synthesized materials were investigated by Raman spectroscopy.

1. Introduction

Controlled synthesis of semiconductor nanostructures strongly affects their physical and chemical properties, in terms of size, shape and crystalline structure [1,2]. Zinc oxide is an important multifunctional, intrinsic II–VI semiconductor material [3], with a direct wide bandgap (3.37 eV) and large excitation binding energy (60 meV) [4], used in many technological applications, including transparent conducting electrodes of solar cells [5], photocatalysts for degradation of organic pollutants in wastewaters and effluents [6], surface acoustic devices [7], UV lasers [8] and chemical and biological sensors [9]. Moreover, some morphologies of zinc oxide such as hollow spheres [10] and porous spheres can be introduced efficiently for professional medical applications like drug delivery [11] and gene delivery systems [12]. Various methods such as thermal evaporation [13], hydrothermal process [14], cyclic feeding chemical vapor deposition [15], chemical vapor deposition [16], metal-organic CVD [17] and template-directed growth [18] have been developed to synthesize different ZnO nanostructures. Most of the reported methods are limited due to their high production cost, long processing time and low growth rate [19]. Another limitation is the high temperatures needed to start reactions between preliminary materials [20].

Microwave irradiation has been developed rapidly in chemical synthesis of different inorganic nanoparticles ranges from metals e.g. Au, Pd, Ag and Pt [21,22] to oxides e.g. ZnO, TiO_2 and $BaTiO_3$ [23–28] and chalcogenides e.g. ZnS, ZnSe, CdSe, PbTe, PbSe and CdS [29–31]. Moreover, microwave heating was previously utilized to prepare zinc oxide microtubes, microrods, nanowires, nanobelts [19,28], flower-like and needle-like morphologies in 5–10 min via microwave heating [20]. In microwave processing, heat is generated internally within the materials, so an inverted temperature gradient occurs. The surfaces of materials are cooler than the interior and therefore the thermal losses are decreased [19]. Also electromagnetic fields related to the microwave irradiations increase the crystal growth rate [19], which culminates to fabrication of the materials in a short time. In addition to production methods, the kinetic conditions of the primary solution during the experimental procedures play an important role to reach the desirable morphologies [32]. Lee et al. [33] reported that different parameters such as reaction temperature, pH value and organic additives, can influence the kinetic growth condition in solution-based approaches. Previously, Pal et al. [4]

* Corresponding author.
E-mail addresses: matin.mohajerani@gmail.com (M.S. Mohajerani), mazloumi@merc.ac.ir (M. Mazloumi), sadrnezh@sharif.edu (S.K. Sadrnezhaad).

0022-0248/$ - see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.jcrysgro.2008.04.045