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Short Communication

Ultrasonic induced photoluminescence decay in sonochemically obtained cauliflower-like ZnO nanostructures with surface 1D nanoarrays

Mahyar Mazloumi [a], Saeid Zanganeh [a], Amir Kajbafvala [a], Parisa Ghariniyat [a,b], Shadi Taghavi [a,c], Aidin Lak [a], Matin Mohajerani [a], S.K. Sadrnezhaad [a,*]

[a] Nanomaterials Research Group (NanoMERC), Materials and Energy Research Center, 14155-4777 Tehran, Iran
[b] Department of Materials Science and Engineering, Iran University of Science and Technology, Tehran, Iran
[c] Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland

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ABSTRACT

Cauliflower-like ZnO nanostructures with average crystallite size of about 55 nm which have surface one dimensional (1D) nanoarrays with 10 nm diameter were successfully fabricated through a simple sonochemical route. X-ray diffractometry (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and room temperature photoluminescence (PL) characterizations were performed to investigate the morphological and structural properties of the obtained nanostructures. It has been shown that the synthesized cauliflower-like ZnO nanostructures irradiated UV luminescence and a green peak in visible band. Ultrasonic post-treatment of the particles for about 2 h increased the density of surface defects resulted in an increase in the green emission intensity.

1. Introduction

Zinc oxide (ZnO) is a versatile semiconducting material with a wide and direct band gap (3.37 eV) and large exciton binding energy (60 meV) [1] which results in efficient excitonic emission at room temperature and unique optical, acoustic, electronic [2] catalytic, photocatalytic [3] and sonocatalytic [4] properties which make it a relevant choice for optoelectric devices [4], solar cells [5], sensors [6], varistor and electroluminescent devices [1].

Diverse ZnO morphologies such as nanoparticles [7], nanotubes [8], nanowires [9,10], nanorods [11], hollow spheres [12] and flower-like nanostructures [13] have been produced through different synthesis approaches, during the last years. The green chemistry synthesis methods through the utilization of ultrasonic irradiation have been used extensively to generate novel materials with unusual properties as well as much smaller sizes and higher surface areas, in comparison of those reported by other methods [14–17]. The novel condition in sonochemistry arises from acoustic cavitation occurred by the formation, growth and implosive collapse of bubbles in a liquid which results in the extremely high temperatures (>5000 K), pressures (>20 Mpa) and very high cooling rates (>10^{10} K/s) proper for performing the chemical reactions [14–17]. Here, we introduce a facile sonochemical route to prepare cauliflower-like ZnO nanostructures.

Physical, electronic, optical and chemical properties of semiconducting nanomaterials have markedly influenced by engineering the band gap [5] and preparation conditions [2,18]. The photoluminescence (PL) technique has been extensively used to investigate the surface characteristics and structure of metal oxides [3]. Particle shape, size, temperature and synthesis methods were previously shown to be effective on the PL spectrum of ZnO nanostructures [19–24]. Recently Yadav et al. [25] have investigated the photoluminescence alteration of ZnO nanostructures during the sonochemical preparation method. There are rare reports addressing the influence of ultrasonic post-treatment on photoluminescence properties of optical materials [26,27]. Wang et al. [26] have shown recently that ultrasonic post-treatment affect the UV–Vis, photoluminescence and electroluminescence spectra of ZnS:Cu,Cl phosphors. However, to our knowledge there is no report exhibiting such behavior in ZnO nanostructures. In this investigation we have prepared cauliflower-like ZnO nanostructures through a novel sonochemical method firstly and then have investigated the effect of ultrasonic post-treatment on the photoluminescence properties of the obtained ZnO nanostructures.

2. Experimental procedure

In a typical synthesis process, 80 ml of water and triethanolamine (TEA, $C_6H_{15}NO_3$) mixture (10 vol.% of triethanolamine) was

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

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