Journal of Alloys and Compounds 497 (2010) 325–329

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

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

# Microwave-assisted synthesis of narcis-like zinc oxide nanostructures

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ARTICLE INFO

*Article history:*
Received 17 February 2010
Received in revised form 2 March 2010
Accepted 2 March 2010
Available online 9 March 2010

*Keywords:*
Zinc oxide nanostructures
Microwave synthesis
Electron microscopy

ABSTRACT

Through a fast, simple, low cost, surfactant-free and convenient microwave-assisted route, narcis-like ZnO nanostructures (10–15 nm size) with flower diameters in the range of 1–2.5 μm were synthesized. X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), Fourier transform infrared (FTIR) spectroscopy and room temperature photoluminescence (PL) measurements were used to characterize the produced ZnO nanostructures. The principle raw materials – ammonium hydroxide ($NH_4OH$) and zinc acetate dihydrate [$Zn(CH_3COO)_2\cdot 2H_2O$] – were both inexpensive. The method was fast, simple and surfactant-free capable of producing larger quantities of zinc oxide nanostructures. Formation mechanism of narcis ZnO nanostructures has been studied due to the self-assembly of small form ZnO clusters in microwave treated precursor.



## 1. Introduction

Zinc oxide (ZnO) is an exceptionally important intrinsic semiconductor with a wide direct band gap of 3.37 eV and large excitation binding energy of 60 meV at room temperature [1]. This material has attracted considerable attention because of its catalytic, electrical and optical properties. ZnO-based materials have been used extensively in solar cells, catalysts, transparent conducting films, ultraviolet-protection films, sensors, light emitting diodes and laser diodes [2–5].

Rapid progress has been attained during recent years concerning preparation of ZnO nanostructures including nanowire [6], nanorods [7,8], nanoribbons [9,10], nanotubes [11], multipods [12], hollow spheres [13], sword-like nanowires [14] and flower shaped nanostructures [15–18] by various hydrothermal procedures [19–21], low-temperature chemical aqueous solution [22,23], chemical vapor deposition (CVD) [24] and metal–organic CVD [25,26] methods.

Expensive raw materials, complex process control and sophisticated equipment are principle drawbacks of previously devised large-scale nanostructured ZnO production methods. Traditional approaches require, for example, economically prohibitive high temperatures. Solution based methods yield, on the other hand, nanostructures of better crystal quality at preferably lower growth temperatures without using metal catalysts or templates. The latter is clearly much easier and more economical to practically perform. From the appearance of first reports on microwave-assisted liquid-phase organic synthesis in 1986 [27,28], the applications of microwave heating for chemical synthesis of new materials have rapidly grown [29–38]. Microwave heating has been accepted as a promising way for volumetric rapid warming, high reaction rate and short reaction time as compared to the conventional heating processes [34–38]. Microwave irradiation has, therefore, been developed and widely used in such fields as molecular sieve preparation [29], inorganic complex oxide formation [30,31], organic reaction performance [32], plasma chemistry [33], analytical chemistry [34], catalysis [35] and recently nanocrystalline materials preparation [14,36,37].

Thongtem et al. [14] synthesized nanostructure ZnO powders via microwave-assisted heating. They showed that this is a seedless and template-free fast route for the production of ZnO nanostructures. The process eliminates the complicated synthetic procedures and shortens the reaction time ending with desirable ZnO wire [14].

The present paper describes the synthesis of narcis-like ZnO nanostructures via a chemical solution route using a relatively short period of microwave (90 s). This is found to be a fast, simple low cost, and surfactant-free route for obtaining large quantities of zinc oxide nanostructures. The synthesized product is characterized by

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doi:10.1016/j.jallcom.2010.03.057