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Nanofabrication and characterization of ZnO nanorod arrays and branched microrods by aqueous solution route and rapid thermal processing

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Abstract

This paper presents an inexpensive and fast fabrication method for one-dimensional (1D) ZnO nanorod arrays and branched two-dimensional (2D), three-dimensional (3D) – nanoarchitectures. Our synthesis technique includes the use of an aqueous solution route and post-growth rapid thermal annealing. It permits rapid and controlled growth of ZnO nanorod arrays of 1D – rods, 2D – crosses, and 3D – tetrapods without the use of templates or seeds. The obtained ZnO nanorods are uniformly distributed on the surface of Si substrates and individual or branched nano/microrods can be easily transferred to other substrates. Process parameters such as concentration, temperature and time, type of substrate and the reactor design are critical for the formation of nanorod arrays with thin diameter and transferable nanoarchitectures. X-ray diffraction, scanning electron microscopy, X-ray photoelectron spectroscopy, transmission electron microscopy and Micro-Raman spectroscopy have been used to characterize the samples.

Keywords: ZnO nanorod; Branched microrods; Nanofabrication; Transferable nanoarchitectures

1. Introduction

ZnO is a key functional material exhibiting near-ultraviolet emission, transparent conductivity, semiconducting, magnetic, and piezoelectric properties. It has a wide direct band gap (3.37 eV), large exciton binding energy (60 meV), excellent chemical, mechanical, and thermal stability, and biocompatibility [1,2]. Zinc oxide has extensive commercial use during the past 100 years [3], with important applications in opto-electronics, nano/microelectronics, sensors, transducers, and biomedicine.

Recently, one-dimensional (1D) zinc oxide materials and differently shaped ZnO nanocrystals have attracted considerable attention due to their unique properties that strongly depend on their size and morphologies [4] and their possible use as building blocks in near-future nanodevices [5,6]. 2D- and 3D-shaped ZnO nanocrystals will play a significant role as the novel functional units of electronic, electromechanical and optoelectronic devices [7–10], and nanosensors [5,6,11–13].

Novel synthesis routes of ZnO nanorods for solar cells and chemical sensing applications are currently being developed. The latest research efforts are directed towards obtaining alternative, lightweight, flexible nanodevices [14,15]. A number of publications address dye sensitized solid-state solar cells, which are currently the most stable and efficient excitonic solar cells for large-scale solar energy conversion [14,16–17]. In these cells, 1D ZnO nanorods with high carrier mobility can serve as direct conduction pathways for the excitons. The synthesis of a porous

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