

Growth and properties of complex ZnO nanostructures

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Abstract

Zinc oxide (ZnO) nanostructures are one of the most promising photonic materials due to their wide band gap (3.37 eV) and larger exciton binding energy (60 meV) larger than other semiconductor materials such as ZnSe (22 meV) and GaN (25 meV). The exotic nature of ZnO makes it a valuable material for various applications, for instance, sensors, room temperature UV lasers, solar cells, photocatalysts, field effect transistors, nano-resonators and nano-cantilevers, and so on. It is generally believed that the properties of nanostructured materials are strongly dependent on their shapes and sizes. In this endeavor, recently scientists are inclined to pay much attention on the fabrication of materials with specific morphologies because of the expectation of novel properties. For the use of specific applications, so far variety of ZnO nanostructures are already fabricated and reported in the literature. Fabricating hierarchical nanostructures consisting 1D ZnO moieties in a controllable manner is required to improve the performance and to broaden the application, but one still faces remarkable challenges. Here, we present the growth and optical properties of hierarchical ZnO nanostructures composed of hexagonal ZnO nanorods synthesized by the simple thermal evaporation process using metallic zinc powder in the presence of oxygen. The hexagonal nanorods are grown over the six-facets of core nanorod. The typical lengths and diameters of the grown nanorods are about 1.5-2 μm and 30-40 nm respectively. The detailed structural characterizations by HRTEM, XRD and SAED confirmed that the as-grown ZnO branched structures are single crystalline and all the nanorods in the branched structure is grown along the [0002] direction in preference. In addition to this, high yield synthesis and structural and optical characterization of ZnO nanocombs synthesized onto different substrates have also been demonstrated in this paper. Morphological investigations revealed that the branches (teeth) of the nanocombs have uniform and nicely attached along one side of the ribbon-like stem and are arranged in a proper manner. Room-temperature photoluminescence (PL) spectrum of the grown nanostructures are exhibiting a dominated, sharp and strong UV emission with a suppressed deep level emission indicating the good crystallinity and optical properties for as-grown ZnO nanostructures. Vapor-solid mechanisms have been proposed for the formation of the as-grown ZnO nanostructures.