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Short communication

Catalyst free single-step fabrication of SnO_2/ZnO core–shell nanostructures

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Abstract

Facile catalyst-free synthesis of SnO_2/ZnO core–shell nanowires and hierarchical nanostructures grown via a one-step carbon assisted thermal evaporation method under ambient pressure is reported. A white wool-like mass forms at the side and on top of a quartz boat during the process that was analyzed by field emission scanning electron microscopy (FESEM). X-ray diffraction patterns exhibit that the as-synthesized SnO_2/ZnO nanostructures consist of single phase of ZnO and SnO_2. Transmission electron microscopy (TEM) suggests that the wool-like mass contains core–shell type SnO_2/ZnO nanowires as well as hierarchical nanostructures. In the core–shell nanowires, SnO_2 forms the core, while ZnO is the shell. In the hierarchical nanostructures, hexagonal shaped ZnO branches grow on the ZnO shell layer at long growth duration. Both types of nanostructures formed in the quartz boat are suggested to grow by the vapor–solid (VS) mechanism. Structural characteristics of the nanostructures are discussed. These nanostructures may have potential applications in chemical gas sensors and photovoltaic devices.

Keywords: B. Electron microscopy; Hierarchical nanostructures; Carbon assisted thermal evaporation; SnO_2/ZnO core–shell nanowire

1. Introduction

Hybrid functional nanostructures assembled from nanorods, nanobelts, nanofibers, and nanowires, as nanoscale building blocks, offer tremendous potential for applications in gas sensors [1], solar cells [2], lithium-ion batteries [3], and photocatalysis [4]. In particular, core–shell and hierarchical nanostructures originating from nanowires, and nanorods of binary semiconducting metal oxides have attracted recent attention for device applications. Generally, a two-step method is a common approach to fabricate core–shell and hierarchical nanostructures. Core or trunk nanowires are fabricated in the first step. Shell or branch is grown on top of the core or trunk with either the same or a different material. To date, numerous heterogeneous core–shell and hierarchical nanostructures have been synthesized by two-step methods [5–8]. ZnO/SnO_2 is an important hybrid semiconducting metal oxide and a good candidate for core–shell and hierarchical nanostructures due to its unique physical and chemical properties, and wide range of applications [9–11].

Cheng et al. [12] synthesized hierarchical nanostructures with SnO_2 backbone and ZnO branches by combining carbothermal reduction and hydrothermal growth. The hybrid SnO_2–ZnO nanostructures exhibited an enhanced near band gap emission compared to pure SnO_2 nanowires. Park et al. [1] fabricated SnO_2-core/ZnO-shell nanowires by the thermal evaporation of Sn powder followed by atomic layer deposition. This core/shell nanowire showed remarkably enhanced sensor response under UV illumination. Jin et al. [13] synthesized ZnO-core/SnO_2-shell nanorods via a combination of thermal evaporation and atomic layer deposition. It exhibited high near band edge emission intensity for a shell thickness of 15 nm which was attributed to the formation of sub-wavelength optical resonant cavity in the nanorods.

In this work we report, for the first time, an efficient one-step carbon assisted thermal evaporation method for the synthesis of core–shell and hierarchical SnO_2/ZnO nanostructures. Carbon assisted thermal evaporation method is a vapor phase growth method for semiconductor nanostructures on various substrates. In the vapor phase growth methods, nanostructures grow via

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