Formation of hierarchical ZnO nanostructures “nanocombs”:
Growth mechanism, structural and optical properties

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Abstract

ZnO nanocombs have been fabricated in high yield via a thermal evaporation process on Si(111) substrate by using metallic zinc powder and oxygen as source materials for zinc and oxygen, respectively, without the use of catalyst or additives at low-temperature. Morphological investigations revealed that the nanocombs were grown in high density overall the whole substrate surface. The branches (teeth) of the nanocombs are uniform and nicely attached along one side of the ribbon-like stem and are arranged in a proper manner. X-ray diffraction patterns confirmed that the grown nanostructures were single-crystalline and possessed a wurtzite hexagonal phase. Room-temperature photoluminescence (PL) spectrum of the grown nanostructures is exhibit a dominant, sharp and strong UV emission with a suppressed deep-level emission indicating good crystallinity and optical properties for the as-grown ZnO nanocombs.
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1. Introduction

With a wide band gap (3.37 eV) and high exciton binding energy (60 meV), a wurtzite hexagonal phase II–VI semiconductor ZnO has attracted considerable attention because of its wide range of applications and research interests. The high breakdown strength and high exciton binding energy of ZnO make it an attractive material for ultraviolet laser diodes [1–3] at room temperature. As a multifarious and voguish material, ZnO has versatile applications in catalysts, chemicals and biosensors, hydrogen storage, field emission devices, surface acoustic wave devices, decontamination agents, dye sensitized solar cells, etc. Due to its non-centrosymmetric nature, it exhibits a piezoelectric property which is very important for the fabrication of electromechanical coupled sensors, actuators and transducers. Thus far, a number of fabrication techniques have been employed to grow a variety of ZnO nanostructures, and these are reported in the literature. These include nanowires [4–7], nanostars [8], nanorods [9], hexagonal nanocolumns [10], nanotubes [11], nanobelts [12], nanobows [13], nanorings [14], nanospheres [15], nanoflowers [16], hexagonal nanosheet networks and nanodisks [17], and so on. In addition of these morphologies, some hierarchical ZnO nanocombs have also been reported in the literature. For instance, Xu et al. synthesized a ZnO nanocomb on Au-catalyzed silicon substrate by using a mixture of ZnO and graphite powders by a VPT method at 1100 °C [18]. Manzoor and Kim fabricated the ZnO nanocombs on Au-coated silicon substrate at 925 °C by using the thermal evaporation method [19]. Lao et al. also reported the formation of ZnO nanocombs on polycrystalline Al2O3 substrate by thermal evaporation of ZnO at 1400–1450 °C [20]. In all the cases mentioned above, for the growth of ZnO nanocombs either high-temperature or...