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ZnO nanowire and nanobelt platform for nanotechnology

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ABSTRACT

Semiconducting zinc oxide nanowires (NWs) and nanobelts (NBs) are a unique group of quasi-one-dimensional nanomaterial. This review mainly focuses on the rational synthesis, structure analysis, novel properties and unique applications of zinc oxide NWs and NBs in nanotechnology. First, we will discuss rational design of synthetic strategies and the synthesis of NWs via vapor phase and chemical growth approaches. Secondly, the vapor–solid process for synthesis of oxide based nanostructures will be described in details. We will illustrate the polar surface dominated growth phenomena, such as the formation of nanosprings, nanorings and nanohelices of single-crystal zinc oxide. Third, we will describe the unique and novel electrical, optoelectronic, field emission, and mechanical properties of individual NWs and NBs. Finally, we will illustrate some novel devices and applications made using NWs as ultra-sensitive chemical and biological nanosensors, solar cell, light emitting diodes, nanogenerators, and nano-piezotronic devices. ZnO is ideal for nanogenerators for converting nano-scale mechanical energy into electricity owing to its coupled piezoelectric and semiconductive properties. The devices designed based on this coupled characteristic are the family of piezotronics, which is a new and unique group of electronic components that are controlled by external forces/pressure.

Contents

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1. Introduction

There are three most representing one-dimensional (1D) nanostructures that are being actively studied in nanotechnology: carbon nanotubes [1–5], silicon nanowires [6–9], and ZnO nanowire/nanobelts [10–12]. ZnO is one of the few dominant nanomaterials for nanotechnology. Based on bibliometric data from information-services provider Thomson Reuters [13], the number of publications and the cross-referenced areas based on ZnO nanostructures are as large and as important as literature in quantum computing, carbon nanotube, semiconductor thin films, and dark matter. This review focuses specifically on the synthesis, properties, device fabrications and novel applications of ZnO nanowire and nanobelts.

ZnO, as an important semiconducting material, has a wide range of applications in optics, optoelectronics, sensors, actuators, energy, biomedical sciences and spintronics (Fig. 1) [14]. ZnO exhibit the most splendid and abundant configurations of nanostructures that one material can form. We plan to cover the following three main contents in this review. First, we will demonstrate rationally designed synthesis of ZnO nanowires (NWs) via a vapor–liquid–solid (VLS) or vapor–solid–solid growth process, and chemical approach. Secondly, the vapor–solid process for synthesis of oxide based nanostructures will be described in details with consideration of the formation of Zn-terminated or O-terminated surfaces. We will illustrate the polar surface dominated growth phenomena, such as the formation of nanosprings [15] and nanorings [16] and nanohelices [17]. Third, we will describe the

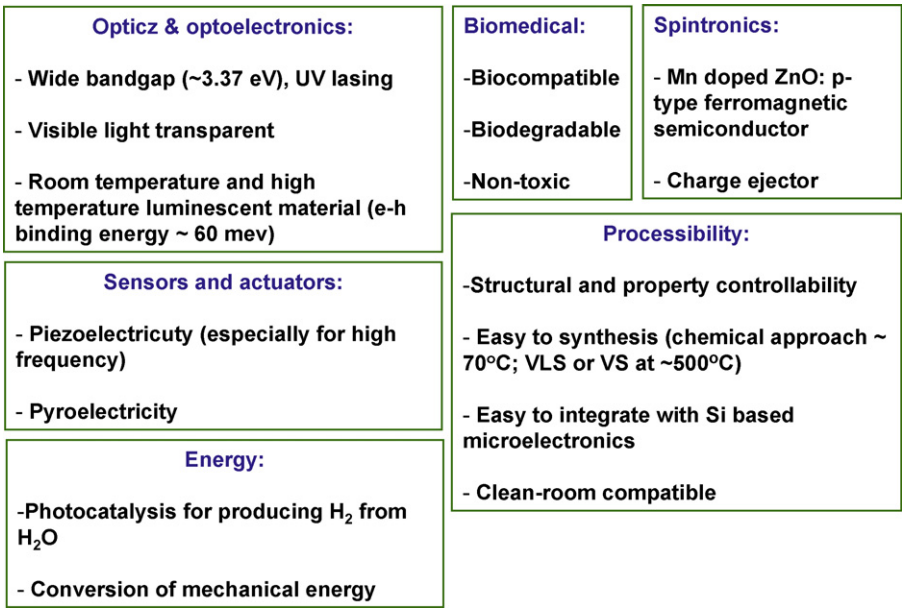

Fig. 1. A summary of applications and properties of ZnO.