Zinc Oxide Nanostructures – Current Status

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Abstract **– Development of ZnO nanostructures is of great importance for industrial applications. We analyze synthesis and properties control of zinc oxide, which are important in understanding the growth mechanism and further developing ZnO-based nanodevices. Also, we briefly review research activities and progress in developing improved control of technological processes for ZnO as nanomaterial. Recent reported applications of ZnO low-dimensional structures will be discussed.**

Keywords – nanomaterial; ZnO; nanostructures; synthesis.

I. INTRODUCTION

Semiconducting oxides nanostructures are of potentially wide fundamental and technological interests in science ranging from the quantum physics to nanooptoelectronics [1,2]. Bulk materials are of importance for making substrates of high quality and for enhanced devices with extended lifetime. However, size reduction to the nanometer scale causes quantization of density of states, which alters the intrinsic properties of crystalline materials. Research interest for investigation of the behavior of matter at nano-scale has accelerated the elaboration of a number of new advanced multifunctional materials with defined structure, morphologies and properties. These electronic, magnetic, piezoelectric or optical properties of the materials, ranging from micro to nano-scale, along with multifunctionality due to small size effect, have contributed extensively to different fields of device applications, especially for optoelectronics, medical diagnostics, and gas nanosensors. ZnO is one of technologically important materials, which presents significant practical and scientific importance for different areas including nanodevices for electronic and biomedical applications [1-4].

For example, ZnO exhibits various applications in gas sensors, electrodes for dye-sensitized solar cells DSSCs, light-emitting devices, luminescent materials, and thin-film transistors [1-12]. To present potential utilities of ZnO nanomaterial, we point out on some typical applications of ZnO low-dimensional structures in Table I (here we present our results only).

TABLE I. RECENT REPORTED APPLICATIONS ON ZNO LOW-DIMENSIONAL STRUCTURES (FEW RESULTS ONLY)

Authors	Year	Application	Refs
Lupan *et al.*	2007	Individual Tripod-Nanosensor	[5]
Lupan *et al.*	2008	Individual Nanorod-sensor	[6]
Lupan *et al.*	2008	Nano-photodetector	[7]
Lupan *et al.*	2009	Single tetrapod - microsensor	[8]
Lupan *et al.*	2010	Single Nanowire-nanosensor	[9]
Lupan *et al.*	2010	Nanowire-DSSC	[10]
Lupan *et al.*	2010	Nanowire-LED	[11]
Lupan *et al.*	2011	Tunable-LED	[12]

By correct understanding technological aspects, it is possible to solve difficulties in synthesis of stable doped zinc oxide due to low-doping efficiency, etc.

II. ZINC OXIDE NANOSTRUCTURES

A. Problems and Solutions

For stable device applications, a big problem is the lack of reproducible and reliable n- and p-type conductivity with shallow donor and acceptor states in zinc oxide, respectively.

It is expected that doping nanocrystals would lead to new physics and chemistry [13]. Similar to their bulk counterpart, doping of semiconductor nanocrystals by impurity atoms permits tailoring their behavior, which can enable their new application in nano-electronics and nano-optoelectronics [14]. However, multiple recent reports indicated that doping could be difficult for nanocrystals [14]. As it was mentioned earlier, simple addition of a transition metal compounds to the growth solution does not result in incorporation of dopants. Such problems could be due to the fact that the surface-bound dopants may have different geometries, and exchange coupling interactions with the semiconductor band electrons than substitutionally incorporated dopants have, and the target physical properties of the material may therefore be compromised. Enormous efforts have been directed to this area of research by different research groups worldwide. Therefore, it is important to perform more comprehensive study of the technical procedures over the synthesis technique in order to allow exact control over the defects, the type of conduction and the emission properties with the possibility to elaborate and fabricate nano-ZnO – based electrical, magnetic and optical nanodevices.

B. Growth of Zinc Oxide

Zinc oxide material posses several types of the fastest growth directions [1]. Due to different growth rates, the controlled synthesis of preferred nanoarchitecture for specific applications can be realized by a well control of the synthesis process [15]. The growth techniques for zinc oxide nanostructures can broadly be classified as:

a) solution phase synthesis and

b) gas phase synthesis.

In the solution growth procedures, the synthesis of the material is carried out in a liquid. In most of reports they are in aqueous solutions and the process is referred to as hydrothermal synthesis. As heterogeneous nuclea-