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ScienceDirect
Ceramics International 41 (2015) 4861–4866
CERAMICS INTERNATIONAL
www.elsevier.com/locate/ceramint

Embedded ZnO nanorods and gas-sensing properties

Shahid Hussain[a,b,*], Tianmo Liu[a,b,*], Bin Miao[a,b], Muhammad Kashif[c], Nimra Aslam[d], Muhammad Rashad[a,b], Wen Zeng[a,b], Xianghe Peng[e]

[a]College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China
[b]National Engineering Research Centre for Magnesium Alloys, Chongqing 400030, China
[c]Department of Electrical and Electronic Engineering, University Malaysia Sarawak, Sarawak 94300, Malaysia
[d]Department of Physics, University of Sargodha, Sargodha 40100, Pakistan
[e]Department of Engineering Mechanics, College of Aerospace Engineering, Chongqing University, Chongqing 400044, China

Received 18 November 2014; received in revised form 7 December 2014; accepted 8 December 2014
Available online 13 December 2014

Abstract

Regular hexagonal embedded ZnO nanorods were successfully prepared by a simple hydrothermal method. The addition of urea as a homogeneous precursor was found to play a vital role in the embedding of secondary nanorods. The nanostructures were characterized by XRD, SEM, and EDS. The gas-sensing properties of secondary grown embedded nanorods were reported for formaldehyde, ethanol, methanol, acetone, and ammonia at different concentrations and temperatures. A higher response and greater selectivity toward formaldehyde than other gases was observed. A sharp response with the best recovery time was achieved at an optimum temperature of 200 °C.

Keywords: D. Embedded ZnO nanorods; Crystal growth; Urea; Gas response

1. Introduction

Unique nanoscale structures with high surface area have attracted extensive interest because of their performance and application in various fields of nanotechnology. The simple and large-scale preparation of nanostructured ZnO with a large surface area, high surface energy, and a strong diffusion and adsorption rate has gained popularity because of its low melting temperature as well as its exceptional physical and chemical characteristics. The surface-exposed nanostructures always exhibit higher performance in applications and have been extensively studied. TiO_2 nanostructures with the (001) and (111) exposed planes were found to have five times more photoreactivity than the (110) facets [1]. On the other hand, WO_3 nanoparticles with the (010) plane showed a higher sensitivity to $C_4H_{11}N$ than those with the (001) or (100) planes [2]. Similarly, the SnO_2 nanorods with low-energy (101) and (110) planes exhibited lower responses than the higher energy of the (221) and (111) planes of ZnO nanoplates and nanorods [3]. ZnO has a wide direct band gap of 3.37 eV and high excitation energy of 60 meV; this metal oxide semiconductor is the most researched and is fit for several applications, such as transparent conductive coating electrodes, solar cells, and gas sensors (both reductive and oxidative gasses) [4–7]. The more recent novel and promising ZnO nanostructures have captured significant attention because they favor their application in gas sensors [8,9].

In the present study, we developed a smart nucleation and growth approach to synthesize secondary embedded nanostructures. This two-step approach for hydrothermal growth allowed for the switching and boosting of experimental conditions that facilitate the cogent and controlled design of nanostructures. The secondary growth of ZnO nanostructures was discussed along with a plausible formation mechanism. We also examined the growth effects of the addition of urea on the gas-sensing

*Corresponding authors at: College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China. Tel.: +81 22 217 5933; fax: +81 22 217 5930.
E-mail address: shahidsargodha@gmail.com (S. Hussain).

http://dx.doi.org/10.1016/j.ceramint.2014.12.044
0272-8842/