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Zinc oxide formation in galvanized metallic wire by simple selective growth method

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ABSTRACT

ZnO nanostructures were synthesized by a simple method of oxidizing metallic wire by direct electrical heating. A galvanized iron wire was used as the source of zinc. Several optical techniques were employed on the synthesized ZnO nanostructure such as photoluminescence, Raman and FTIR spectroscopy. The formation of ZnO nanostructures was confirmed from the spectra of different optical studies and also determined by XRD. SEM analysis shows the signature of nanorod formation on the surface of the wire. The oxidation state and ferromagnetic property of these oxidized metallic wires were discussed with the help of EPR spectrum. In summation to the properties studied, a growth mechanism was suggested based on the observations and method of the oxidation procedure.

1. Introduction

Zinc Oxide (ZnO) nanostructured materials have recently attracted tremendous attention due to their distinguished performance in electronics, photonics and optics [1–8] In specific, ZnO nanorods

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(NRs) are considered as suitable candidate for optoelectronic applications such as dye sensitized solar cells, optical switches, gas sensors and room temperature UV laser diodes due to their direct wide band gap energy of 3.34 eV with a large excitonic binding energy of about 60 meV at room temperature [9,10]. Numerous processes have been introduced to prepare ZnO nanostructures, such as hydrothermal method [11], electrochemical deposition technique [12], sputter deposition technique [13] and vapor methods [14]. But the above mentioned methods requires severe reaction conditions, such as high temperature, high vacuum and accurate gas concentration with flow rate. So the important role of the researcher is to find the simple and low cost, especially in ambient conditions growth methods for the synthesis of ZnO nanocrystals. Comparing with other synthesis process electrical current heating technique is relatively popular and easier, cost effective and environment productive. Ne et al. reported the formation of 1D ZnO nanostructures by oxidation of metallic Zn in various controlled atmosphere. This result suggests that oxidation of metallic Zn is feasible for the fabrication of 1D ZnO crystals with UV emission [15].

In this work, we focused on the formation of ZnO nanorods at room atmosphere by very simple and low cost electrical heating method. The main motivation of this work is to introduce novelty in both the method of synthesis and precursor material. The seedless, highly aligned and vertical ZnO nanorods were grown on the conducting substrate which was a challenging task by using a simple low cost method. In this present work, we have tried and succeeded to grow ZnO nanorods using a galvanized iron wire. The characterized seedless ZnO nanorods on iron wire were highly dense, perpendicular to substrate, grown along the (002) crystal plane, and also composed of single crystal, which are more favorable for opto-electronic devices. Here, the commercially available galvanized iron wire (coated with Zn) was used as a precursor material because of the limitations on the source availability and the synthesis was carried out in ambient conditions. Several factors play a vital role in the growth process, among them; we have investigated the impact of applied constant current with respect to time.

2. Experimental

The ZnO nanostructure has been synthesized from (zinc) Galvanized Iron wire by using direct electric heating method at room atmosphere. Galvanized iron wire with diameter of 0.40 cm was placed in-between two low resistive material of copper bolt mounted on a homemade wooden stand and connected to a dc power supply (300 W, TESTRONIX 92 D). The distance between the two ends is kept at 10 cm. A direct current was applied to the wire in an increasing manner and finally fixed at a maximum value of 5 A for a period of 30 s and 120 s. Prior to this step, the galvanized iron wires were annealed at 500 °C for 2 hours in inert atmosphere, to relieve any in-built strain incurred during the galvanization process. The grown samples were investigated in the as-prepared condition and

Table 1
The Raman frequencies (cm^{-1}) and assignment of vibrational modes for ZnO in the GI wire.

Symmetry modes	Wave number (cm^{-1})
E2	325–328
A1 (TO)	381
E1 (TO)	409
E2 (High)	436–455
A1 (Low)	530
A1	660

Table 2
The FTIR speaks (cm^{-1}) and assignment of functional groups for ZnO scratched from the surface of the GI wire.

Functional group	Wave number (cm^{-1})
E1(TO) → Zn–O stretching	420
A1(LO)	560