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Optical properties of ZnO nanowire arrays electrodeposited on *n*- and *p*-type Si(1 1 1): Effects of thermal annealing

O. Lupan [a,*,1], Th. Pauporté [a,*], I.M. Tiginyanu [b], V.V. Ursaki [b], H. Heinrich [c], L. Chow [c]

[a] *Laboratoire d'Electrochimie, Chimie des Interfaces et Modélisation pour l'Energie (LECIME), UMR 7575 CNRS, Chimie ParisTech, 11 rue P. et M. Curie, 75231 Paris, France*
[b] *Institute of Electronic Engineering and Nanotechnologies, Institute of Applied Physics, Academy of Sciences of Moldova, Chisinau MD-2028, Republic of Moldova*
[c] *Department of Physics, University of Central Florida, PO Box 162385 Orlando, FL 32816-2385, USA*

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ABSTRACT

Electrodeposition is a low temperature and low cost growth method of high quality nanostructured active materials for optoelectronic devices. We report the electrochemical preparation of ZnO nanorod/nanowire arrays on *n*-Si(1 1 1) and *p*-Si(1 1 1). The effects of thermal annealing and type of substrates on the optical properties of ZnO nanowires electroplated on silicon (1 1 1) substrate are reported. We fabricated ZnO nanowires/*p*-Si structure that exhibits a strong UV photoluminescence emission and a negligible visible emission. This UV photoluminescence emission proves to be strongly influenced by the thermal annealing at 150–800 °C. Photo-detectors have been fabricated based on the ZnO nanowires/*p*-Si heterojunction.

1. Introduction

ZnO is a II–VI group compound semiconductor with a hexagonal wurtzite crystal structure [1]. It has a wide and direct band gap of 3.37 eV at 300 K and a large free exciton binding energy of 60 meV [1]. Zinc oxide nanowires are the most promising one-dimensional (1D) nanostructures emerging as building blocks for active elements in various nanophotonics systems [2,3]. Low dimensional ZnO has been reported for use in short wavelength optoelectronic devices such as light emitting diodes (LEDs), optical switches, solar cells, field effect transistors, and in nanosensors applications [3–7]. It has unique physical and chemical properties, low-dimensional volume, high aspect ratio, light-matter interaction, cost-effectiveness and can be synthesized by a diversity of chemical and physical methods [3–9]. Among these, electrochemical deposition (ECD) [7,8,10–12] is a low temperature process compatible with different types of substrates [3,4,10] and produces highly crystalline nanowires/nanorods of excellent electronic quality. In this context many device structures, such as heterojunction [3,7,13], homojunction [14], and metal–insulator–semiconductor structure [15] were explored for concrete applications. As ECD can be easily scaled up for optoelectronic device fabrications [3,4,16,17], it is of great interest to develop a process for growing ZnO nanorod/nanowire arrays directly on *n*- and *p*-Si substrates considering the advantages of Si in integrated photodevices.

Recently, Baek and Lim [18] demonstrated the effect of Si wafer resistivity on the growth of ZnO nanorods by using −30 V cathodic potential. The effect of thermal annealing on ECD ZnO nanorod/nanowire arrays is not well documented. Only a few reports [19,20] of annealing effect on ZnO nanorod/nanowire arrays on Si substrates have been published. Ha et al. [20] reported the

* Corresponding authors. Tel.: +33 1 55 42 63 83; fax: +33 1 44 27 67 50.
E-mail addresses: oleg-lupan@chimie-paristech.fr, lupan@mail.utm.md (O. Lupan), thierry-pauporte@chimie-paristech.fr (Th. Pauporté).
[1] On leave from: Department of Microelectronics and Semiconductor Devices, Technical University of Moldova, 168 Stefan cel Mare Blvd., Chisinau, MD-2004, Republic of Moldova.

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