Available online at www.sciencedirect.com

ScienceDirect

Procedia Chemistry 19 (2016) 311 – 318

Procedia Chemistry

5th International Conference on Recent Advances in Materials, Minerals and Environment (RAMM) & 2nd International Postgraduate Conference on Materials, Mineral and Polymer (MAMIP), 4-6 August 2015

High Responsivity IR Photodetector Based on CuO Nanorod Arrays/AAO Assembly

Khaled M. Chahrour[a,*], Naser M. Ahmed[a] , M.R. Hashim[a,b] , Ahmad M. Al-Diabat[a]

[a] *Nano-Optoelectronics Research and Technology Laboratory, School of Physics, Universi Sains Malaysia, 11800 Penang, Malaysia*
[b] *Institute of Nano-optoelectronics Research & Technology Laboratory (INOR), School of Physics, Universiti Sains Malaysia, USM, 11800 Penang, Malaysia*

Abstract

Fast with high-performance CuO nanorod arrays IR photodetector was fabricated using CuO nanorod arrays/AAO assembly. The IR photodetector based on MSM with Al contact electrodes and its optoelectronic properties were examined. The CuO nanorod arrays used in the experiment were synthesized by DC electrodeposition method into Si-based/AAO template. The electrical performance and photoelectric response performance were studied, and the results showed that IR photodetector exhibited a high sensitivity to 808 nm infrared diode laser source. Both the response and recovery time were found to be fast; 0.19 and 0.15 s, respectively, which are shorter time compared to other IR photodetectors reported in the literature.

Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia

Keywords: CuO nanorods; self-assembly AAO; Electrodeposition; IR photodetector

*Corresponding author. Tel.:+601114419486; fax: +604-6579150
E-mail address: skhaled_66@yahoo.com

Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia
doi:10.1016/j.proche.2016.03.016

Nomenclature

AAO	anodic aluminum oxide	**NMOSs**	nanostructured metal oxides semiconductors
DC	direct current	**CuO**	cupric oxide
IR	infrared	**FESEM**	field emission scanning electron
G	current gain	**EDX**	electron dispersive x-ray spectrometer
I_{ph}	photo current	**XRD**	x-ray diffraction
I_d	dark current	**R**	light responsivity

1. Introduction

Among the available nanostructured metal oxides semiconductors (NMOSs), such as Fe_2O_3, NiO, CuO and ZnO. Cupric oxide (CuO) nanostructures were of particular interest of research, because of their interesting properties as a p-type semiconductor with a narrow band gap (1.4eV) and promising applications in lithium-ion batteries[1], solar cell[2], bio sensor[3], removal of inorganic pollutants[4] and photodetectores[5].

Several approaches have been used in the preparation of CuO nanostructures, such as chemical vapor deposition[6], hydrothermal[7], sol-gel method[8], laser vaporization[9] and AAO template synthesis[10]. Among these methods the AAO template synthesis is considered as a flexible and promising method, because of its simplicity and versatility, since it does not utilize expensive and sophisticated lithographic process for defining nanostructures[11]. In particular, AAO template is considered as an ideal template for synthesis of CuO nanorod arrays as it has good mechanical strength, thermal stability and self-assembled honeycomb array of uniformly sized parallel channels with good control of aligned nanorod dimensions at high density of pores (10^9-10^{11} cm^2)[12].

In this paper, we reported a low cost and efficient electrochemical deposition method was developed to prepare uniform CuO nanorod arrays embedded in Si-based AAO template. Moreover, CuO with relatively narrow band gap would be a perfect metal oxide that can be used to detect IR radiation. However, no report on the fabrication by using AAO template of aligned CuO nanorod arrays/AAO assembly IR photodetector based on MSM can be found in the literature. Electrical and optoelectronic properties of the fabricated device will be also presented and discussed.

2. Experimental Method

The CuO nanorod arrays / AAO assembly were prepared by the following experimental procedure. At first, a layer of thin Al film with a purity of 99.99% was deposited onto the Si substrate (p-type, 5 Ω cm, and <100> oriented) using e-beam evaporation in a high vacuum chamber (based pressure 7.5 x10^{-6} mbar, average deposition rate 10 Å s^{-1}). For one continuous run, the deposited Al film has a thickness up to 1μm. All samples were annealed at 400 °C for 2h in a conventional furnace under nitrogen ambient. The experimental results show that the use of 20 nm of a Ti interfacial layer prevented peeling-off the Al film from the Si substrate during anodizing process.

The anodizing process was carried out using a two-step method in 0.3M oxalic acid solution at 20 °C and anodizing voltage 50V. In this process, a specially designed electrochemical cell using a platinum rod as a cathode and the Si substrate as an anode. Afterward, the AAO template was immersed into a 5 wt% phosphoric acid solution at room temperature for 45 min to widen the nanopores and to remove the bottom barrier layer of AAO template.

The Cu nanorods were synthesized from aqueous solution prepared from 0.5M of Cu sulfate dissolved in 3M lactic acid. The solution's pH was adjusted around 6 using sodium hydroxide. The electrodeposition was performed potentiostatically, with Si-based AAO template serving as working electrode, platinum rod and $Ag/AgCl_{(sat)}$ as the counter and reference electrodes, respectively using EDAQ Model potentiostat at an applied potential of -1.2V for 5 min, the temperature was maintained at 65 °C. Upon completion, the Cu nanorod arrays/AAO assembly was rinsed