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ZnO:Ca MSM ultraviolet photodetectors

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ABSTRACT

Photoresponse of calcium doped zinc oxide (ZnO:Ca) metal-semiconductor-metal (MSM) UV detectors are reported. Photosensitive ZnO:Ca films exhibit high transparency in the visible region, show polycrystalline, hexagonal wurtzite structure, having c-axis preferred growth. Noticed redshift of 60 meV in the optical band gap for ZnO:Ca (3 wt%) thin film is attributed to increased crystallite size. Improved n-type conductivity in ZnO with Ca doping is due to increased carrier concentration, MSM photodetector fabricated with, 3 wt% Ca doped ZnO exhibit higher responsivity of 3.05A/W at 365 nm UV illumination. Transient response measurements show reasonably fast switching with a rise and fall time of 15s and 26s respectively. The obtained results suggest, ZnO:Ca can be used as active material in the fabrication of UV photodetectors.

1. Introduction

Ultraviolet (UV) photodetectors are widely used in various applications such as space communication, flame detection, air quality monitoring, missile plume detection, biological and chemical analysis, lithography aligners etc [1–4]. Wide band gap semiconducting materials such as GaN, AlGaN, diamond [5], and II–V compounds [6] are extensively studied in the fabrication of UV photodetectors. However, the search for high performance and low-cost materials in optoelectronic devices led to the development of a new class of UV photodetectors. Among them, zinc oxide (ZnO) has gained considerable attention of researchers because of its high exciton binding energy, wide band-gap, environmental stability, high transparency in the visible region, non-toxicity, biocompatibility, low-cost and abundance [7–12].

The characteristics of ZnO based MSM devices were studied by S.I. Inamdar et al. [13] and found the suitability of these devices in UV detection. Z. B. et al. [14] fabricated the ZnO film based ultraviolet photodetectors by RF sputtering technique and noticed attractive photodetection. Influence of solution concentration on the performance of ZnO MSM photodetectors was reported by K. Y. rajpure et al. [15]. Sheikh et al. [16] reported ZnO Nanorod visible blind Ultra-violet photodetector. Several attempts have been made by the researchers to improve characteristics of ZnO based ultra-violet photodetectors by doping with different elements. Gambavale et al. [3] reported improved photoresponse and fast photoswitching characteristics of Al doped ZnO based UV photodetector. S singh et al. investigated the influence of Al doping on transient characteristics of ZnO based UV detectors [17]. Detailed study on photoresponse of ZnO:Ga based UV detector was carried out by Shinde et al. [18]. Optoelectronic properties of UV detectors based on sol–gel deposited ZnO:Ga were demonstrated by Chien et al. [19]. Effect of Mg doping on photoresponse of ZnO based UV detectors was studied by C.Y. Zhao et al. [20]. J. Wu et al. [21] reported fabrication and characterisation of sol-gel derived Mg incorporated ZnO UV PDs with inter-digital electrodes. Transient response characteristic of Mg-doped ZnO nanorod based ultra violet metal-semiconductor-metal photodetectors were investigated by S. Young et al. [22]. However, characteristics of Calcium doped ZnO MSM photodetectors are rarely been reported. In the present study, we report the fabrication and study of ZnO:Ca thin films based UV sensitive MSM photodetector.

2. Experimental

ZnO and ZnO:Ca thin films were synthesized by using chemical spray pyrolysis technique. Zinc acetate dihydrate ($C_6H_6O_4Zn{\cdot}2H_20$) and calcium acetate ($C_4H_6CaO_4.xH_2O$) were used as precursors for the deposition process. ZnO precursor solution of known molarity was prepared by dissolving the required quantity of $C_6H_6O_4Zn{\cdot}2H_20$ in the mixture of 2-propanol and deionized water of volume ratio 1:2. Further, few drops of hydrochloric acid (HCl) were gradually added to avoid precipitation. Resulting mixture was stirred for 2 h to obtain a homogeneous solution.

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