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ORIGINAL RESEARCH ARTICLE

Light-Dependent A.C. Transport Properties of Zinc Oxide (ZnO)/Reduced Graphene Oxide (rGO) Heterostructure Device: A Signature of Electrical Memory

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Abstract

We report the light-dependent AC transport properties of an ITO/ZnO/rGO/Au heterostructure from impedance spectroscopy measurements carried out at room temperature in the frequency range of 20 Hz to 50 MHz under dark light, white light, and red laser light with variable intensities. It has been observed that impedance is decreased with an increase in illuminating light intensities. The equivalent circuits have been considered for fitting the experimental ac responses that permit the isolation of exact resistance–capacitance (RC) contributions which can be attributed to the interface region. The diameter of the semicircles in Nyquist plots were found to decrease with the increase in illuminated light intensities, indicating transfer of charge carriers at the ITO/ZnO and ZnO/rGO interfaces. Here, interface resistances and capacitances were found to decrease and increase, respectively, with increases in incident light intensities. *I–V* measurements of our device have been performed under dark and red laser illumination condition. From the *I–V* measurements of our device, a photocurrent has been found to be directly proportional to the incident photon energy, and resistive switching behavior was also prominent at a high biasing voltage under illuminated conditions. We have also shown that electrical hysteresis in our device depends on the biasing voltage along with the incident light intensity. We believe such observations of our fabricated device seem to be promising for light energy-dependent photodetectors for multipurpose use.

Keywords Zinc oxide · heterostructure · photocurrent · variable light intensities · impedance spectroscopy · Nyquist plot

Introduction

In the recent era, the part of semiconductor physics that is mainly based on thin films and their heterojunctions has drawn great attention of scientists due to their outstanding pertinency in the field of photodetectors, electrical memory devices, solar cells, and optoelectrical devices. Inorganic and organic material (rGO/ZnO)-based semiconductors, due to their excellent electrical conductivity and optical effect, have become significantly vital in recent technological applications.[1,2] Hence, investigations on the interface of the heterostructure explores their significant properties and applicability in solid-state physics. Graphene oxide is one of the auspicious transparent and conductive oxides with a band gap of 2 eV.[2] Zinc oxide (ZnO) is a compound semiconductor with a band gap of ~ 3.37 eV and exciton binding energy of 60 MeV.[1] Recently, a rGO-modified ZnO nanostructure has drawn the attention of researchers for its optoelectrical effect by tuning the band gap.

Many research groups have published articles based on the optoelectrical properties of nanostructured multilayer thin films and organic bulk structures using the impedance spectroscopy technique. Zhan et al.[1] revealed the enrichment of the photo-response due to the incorporation of rGO. Thus, the photo-transport mechanism is credited between the rGO and ZnO materials. Sahu and Pal[2] have shown that. under the illumination condition, the photocurrent in an organic photodetector increases with the increase in light intensity, which explains the fact that the bulk resistance decreases and the dielectric constant of the active materials increases. Lee et al.[3] have reported applications of a Schottky diode-based

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