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Graphene controlled organic photodetectors

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ABSTRACT

Drop casting deposition technique was used to fabricate graphene oxide doped methylene blue (GO doped MB) photodiode, Al/p-Si/GO doped MB/Au. The effects of illumination on the current–voltage (I–V) characteristics of the Al/p-Si/GO doped MB/Au Schottky diode for optical sensing applications were explored. The reverse current of the diode in the reverse bias increases with the increasing illumination intensities. The obtained trends for both ideality factor and barrier height are in agreement, suggesting that they are both affected by GO doping. The photosensitivity of the photodiodes was investigated. The highest photosensitivity was observed for the diode having 0.03 GO:MB ratio with I_{photo}/I_{dark} ratio of 8.67×10^3 at 100 mW/cm^2 under 10 V. The rectification ratio was of the order of 10^4. In addition, the capacitance–voltage (C–V) and conductance–voltage (G–V) measurements of the diode were studied in the frequency range of 10 kHz–1 MHz. The measured values of the capacitance decrease with the increasing frequency. The decrease in capacitance was explained on the basis of interface states. The photoelectrical properties of Al/p-Si/GO doped MB/Au devices indicate that the prepared diodes can be used both as a photodiode and a photocapacitor in optoelectronic device applications.

1. Introduction

The graphite family is well researched material because of its inherent electrical, chemical and mechanical properties, along with its several practical applications [1]. Lots of attention has been given to the exploration of the properties of graphite such as graphene, graphene oxide (GO) and reduced graphene oxide (RGO), for several applications [2–4]. Graphene was discovered by mechanical exfoliation method [5], is a one-atom thick layer of graphite. Many researchers have explored the new world of graphene due to its unique and remarkable electronic properties [6–8], such as high carrier mobility, micron scale mean free path and high saturation velocity [9].

Numerous reports have pointed to extensive applications and proposed applications of graphene [2,10–13]. Other reported literature have shown the use of graphene in the development of solar cells and diodes [14,15]. Li et al. [14] used highly conductive semitransparent graphene sheets combined with an n-type silicon wafer to fabricate solar cells with power conversion efficiencies up to 1.5% at AM 1.5 and an illumination intensity of 100 mW cm^{-2}. Lv et al. [16] have used soluble graphene oxide to fabricate graphene films to measure their time-resolved photoconductivity, they observed higher photoconductivity with higher photon energy at same incident light intensity. Xia et al. [10] also used graphene to fabricate photodetectors, and suggested that the generation and transport of photo-carriers in graphene differ fundamentally from those in photodetectors made from conventional semiconductors because of the unique photonic and electronic properties of the graphene. They also demonstrated that the photo response of ultrafast transistor-based photodetectors made from single- and few-layer grapheme does not degrade for optical intensity modulations up to 40 GHz.

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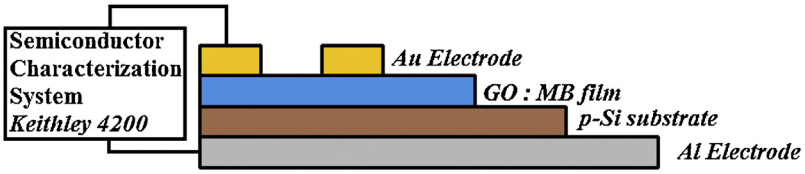

Fig. 1. Schematic diagram of the fabricated device.

Graphene oxide (GO) has emerged as a promising nanomaterial with tremendous potential for photonic applications because of its impressive optical properties [10]. Extensive reports have elaborated on the unique properties of GO such as controllable band gap and high transmittance compared to other graphene-derivatives [17,18]. It must be noted that these properties are essential in the application of optoelectronics. Al-Hartomy et al. [19] have studied the effect of graphene oxide on the diode characteristics of PEDOT-PSS/*p*-Si. It was observed that the diode with 0.1% of GO in the PEDOT:PSS–GO composition had highest photo response property. Also, the *I–V* characteristics of the fabricated diodes show strong dependence on composition of GO.

On the other hand, methylene blue (MB) is a blue cationic dye that belongs to the phenothiazine organic family. The absorption of

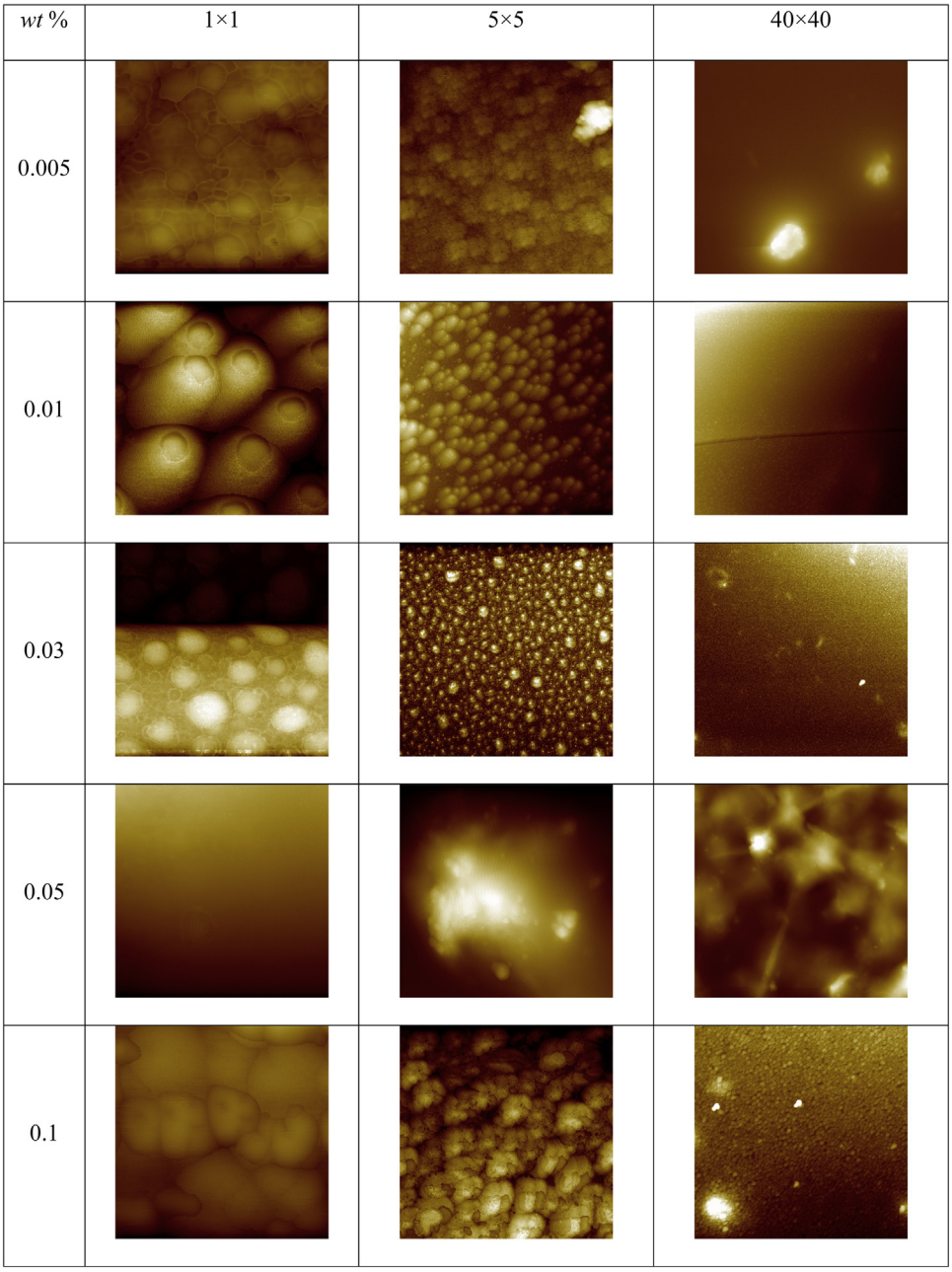

Fig. 2. AFM Images of GO doped MB samples.