Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings 11 (2019) 830–832

www.materialstoday.com/proceedings

2nd International Conference on Emerging Materials: Characterization and Application (EMCA-2017)

Graphene Oxide Based P-N Junctions

Pranay Ranjan[a*], Atul Kumar[a], Jayakumar Balakrishnan[a], Ajay D. Thakur[a]

[a]Department of Physics, Indian Institute of Technology Patna, Bihta -801106, India

Abstract

We demonstrate the use of graphene oxide (GO) in making p-n junctions. Two variants of p-n junctions made using GO are reported. In one of the variant, we deposit a layer of GO on aluminium zinc oxide (AZO) and study the junction properties using current-voltage (I-V) characteristics. In the other variant, we reduce the GO deposited on a glass substrate to obtain reduced graphene oxide (rGO) and make a GO-rGO bilayer p-n junction. The photovoltaic response of this GO-rGO bilayer is reported. These two approaches provide an inexpensive route to make p-n junctions for realizing GO based electronic devices.

Selection and peer-review under responsibility of Conference Committee of the 2nd International Conference on Emerging Materials: Characterization and Application (EMCA-2017).

Keywords: graphene oxide; diode; solar cell

1. Introduction

Graphene Oxide (GO) is a promising material for electronic applications. Recent demonstration of making high quality graphene using microwave reduction of GO [1] has opened new vistas. Controlling the degree of reduction has the possibility of tuning the carrier density and type (p-type, n-type). It is of contemporary interest to explore the possibility of making p-n junction based on GO. The GO is prepared by modified tour method. Characterisation of prepared is done by XRD, Raman, FTIR, UV and XPS. The layer of GO is prepared by doctor blading. The rGO (reduced grapheme oxide) is prepared by reduction of GO film. The prepared GO film is kept in UV illumination for 12 hour to convert it in rGO. Observed bandgap of GO is 3.2eV which decrease with the reduction of GO film. This tune of bandgap in GO and rGO is utilised to form a photovoltaic device [2].

* Corresponding author. Tel.: 9801116623
E-mail address: pranjan@iitp.ac.in

Selection and peer-review under responsibility of Conference Committee of the 2nd International Conference on Emerging Materials: Characterization and Application (EMCA-2017).

2. Experimental

GO was synthesized using a modification of Hummers approach [4-6] with $KMnO_4$ and mixture of H_2SO_4 and H_3PO_4 as the oxidizing agent and hydrogen peroxide and deionized (DI) water ice for reaction termination. We explored the temperature and time reaction coordinates over a wide variety of values to arrive at conditions which lead to an elimination of the requirement for expensive filtration membranes. After successive washing and decantation cycles in DI water, ethanol and HCl, the sample is dried to obtain a foam of GO. This is dispersed in DI water and spins coated to make GO films. Reduction of GO films is implemented by exposing the as grown films to 4 Watt, 365 nm UV lamp for 10 hours to obtain the reduced graphene oxide (RGO) film. Another layer of GO was coated on this RGO film using suitable physical mask to make a diode like bilayer. The current voltage characteristics were obtained using Keithley 2420 sourcemeter.

3. Results and Discussion

Bilayer p-n junctions based on GO were fabricated using the following two approaches: a) a layer of GO were deposited on aluminium zinc oxide (AZO) coated glass leading to a GO-AZO bilayer, and b) a layer of GO was deposited on a glass substrate and exposed to ultra-violet (UV) light to achieve partial reduction. On top of this another layer of GO was deposited to make a GO-rGO bilayer. Using Silver paste a point contact is drawn from the individual layers of the bilayer structures. These were used in a) and b) above to obtain the current-voltage (I-V) characteristics of the junction formed across the bilayer. The resulting current-voltage behaviour was obtained in the range of +2 volt to -2 volt with a knee voltage of 0.57 volt for the AZO-GO bilayer as shown in Fig.1. We observed rectifying behaviour and fitted the obtained curve with the ideal diode curve to study its various parameters. Ideality factor of 9.3 at room temperature was obtained [3]. In the IV curve of the solar cell the cross over point of the X-axis is the Open circuit voltage V_{oc} and cross over point of Y-axis is the short circuit current J_{sc}. Efficiency (η) of the solar cell is calculated by the formula

$$\eta = \frac{Voc * Jsc * FillFactor}{IncidentPower}$$

where FF (fill factor) is calculated by

$$F.F = \frac{V\max * \mathrm{Im}ax}{Voc * Jsc}$$

V_{max} and I_{max} are the voltage and current values at the maximum power. Incident power is the illumination intensity of the solar simulator and the area of the exposure of the cell. We have used a Photoemission technology solar simulator (1sun and 1.5AM filter).

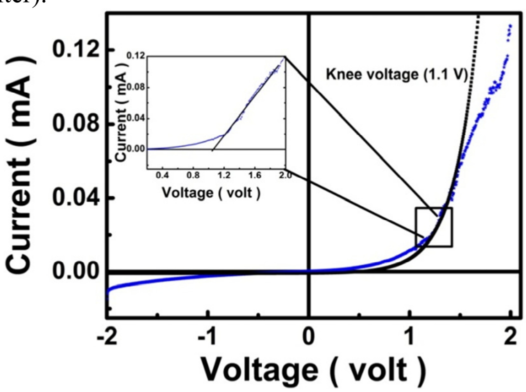

Fig. 1: Current voltage (*I-V*) characteristics of graphene oxide deposited on AZO substrate. Blue and black lines represents experimental values obtained and ideal behaviour of diode respectively

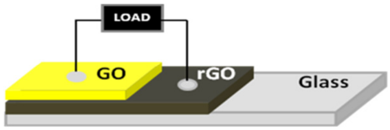

Fig. 2: Schematic of the rGO-GO solar cell.

Figure 2 shows a schematic diagram of the GO-rGO solar cell. The I-V characteristic of GO-rGO showing the photovoltaic behaviour upon illumination with 1.5AM 1sun solar simulator is shown in the inset panel of Fig.3. An open circuit voltage (Voc) of 0.55 volt and a short circuit current (Isc) of 2.4µamp were found. The main panel of Fig. 3 shows the power voltage curve of rGO –GO solar cell. From the power voltage curve we calculated the V_{max} and I_{max} values which are used to estimate the fill factor. The FF of the device is found to be 32.9%.

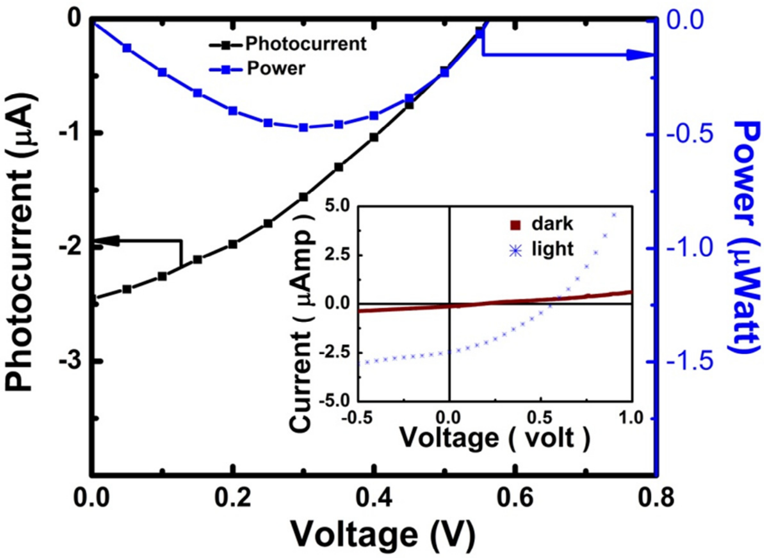

Fig. 3: Calculated power-voltage characteristic of bi-layer GO-rGO along with Illuminated IV curve.

4. Conclusion

We observed rectifying behaviour for the AZO-GO bilayer and GO-rGO bilayer. In addition GO-rGO bilayer exhibits photovoltaic characteristics.

References

[1] Voiry et al. High-quality graphene via microwave reduction of solution-exfoliated graphene oxide. Science 2016; 353; 1413.
[2] Yin Z, Zhu J, He Q, Cao X, Tan C, Chen H, Yan Q, Zhang H. Graphene-Based Materials for Solar Cell Applications. Adv. Energy Mater., 2014, 4: 1300574.
[3] Peter W. Physics of solar cell. Wiley: 2009, ISBN: 978-3-527-40857-3.
[4] M. Hirata, T. Gotou, S. Horiuchi, M. Fujiwara, M. Ohba, Thin-film particles of graphite oxide 1: High -Yield synthesis and flexibility of the particles, Carbon 2004 42:2929–2937
[5] S. H.William, R. E. O_eman, Preparation of graphitic oxide, J. Am. Chem.Soc. (1958) 80:13391339.
[6] D. C. Marcano, D. V. Kosynkin, J. M. Berlin, A. Sinitskii, Z. Sun , 390 A. Slessarev, L. B. Alemany, W. Lu, J. M. Tour, Improved synthesis of graphene oxide, ACS Nano. (2010) 4:48064814