

Employing rGO as an electron acceptor to enhance the photocurrent of p-Cu₂O

SPAUK Samarakoon, and CAN Fernando[#]

Nano-technology Research Laboratory, Department of Electronics, Faculty of Applied Sciences,
Wayamba University of Sri Lanka, Kuliyaipitiya, Sri Lanka

[#]nandanaf@phy.ruh.ac.lk

Abstract— A considerable photocurrent enhancement was found at the Cu/p-Cu₂O/rGO electrolyte interface in a photo-electrochemical cell with compared to that of Cu/p-Cu₂O electrolyte interface. The reason for that may be due to the efficient charge separation process provided at Cu/p-Cu₂O/rGO electrolyte interface. Here rGO (reduced graphene oxide) acts as an electron acceptor for the photo-generated charge carrier as it readily accept electrons from the conduction band of p-Cu₂O. rGO was synthesized using electrophoretic deposition technique. Fabricated samples were characterized using diffuse reflectance spectra, photocurrent action spectra and the time development of the photocurrent of photo-electrochemical cells.

Keywords— p-Cu₂O, rGO, electrochemical cell

I. INTRODUCTION

The high depletion and pollution problems of the non-renewable energy sources make researchers focus attention on alternative sources of energy, and solar energy appears highly promising. This energy is emitted from the sun and it can be directly converted into electric energy by photovoltaic effects by using a solar cell.

Cu₂O is a non-toxic and low cost p type material which has a bandgap around 2 eV [1]. There are several methods for the production of Cu₂O are by thermal oxidation, electrodeposition and by sputtering [2, 3]. For this study thermal oxidation has been used to fabricate p-Cu₂O layer, at a constant temperature of 300 °C for 30 minutes obtained by maintaining a heating rate of 100 °C min⁻¹ starting from room temperature in a furnace [4]. Here we study the utilization of rGO layer to improve the photostability of Cu₂O.

Carbon materials are being exploited as a smart support for engineering advanced materials for solar-to-energy conversion applications due to their thermal and chemical stability, high specific surface area etc. When fabricated with a semiconductor, Reduced Graphene Oxide (rGO) acts

as good electron acceptor that help to enhance charge separation within the semiconductor [5]. The electrophoretic deposition (EPD) technique is used to apply rGO layer among various deposition methods such as membrane filtration, dip coating, and spray coating. This method has many advantages such as high deposition rate, good thickness controllability, good uniformity, and simplicity of scale up coating [6]. The diffuse reflectance spectra, photocurrent development, photocurrent action spectra and FTIR spectra of the cell are discussed.

II. METHODOLOGY

A. Preparation of p-Cu₂O layer

Well cleaned Cu plates (3 cm × 1 cm) were inserted into the muffle furnace maintaining a normal air atmosphere during the oxidation process. A rate of 100 °C min⁻¹ was provided inside the furnace starting from room temperature. After reaching 300 °C it was furthermore kept constantly in 300 °C for 30 minutes and let it cool down again to the room temperature. Finally brownish red colored Cu₂O layer was appeared on the Cu surface.

B. Preparation of rGO layer

The Graphene Oxide (GO) used in this study was synthesized from purified natural graphite by the modified Hummers method [7]. Then GO was dispersed in distilled water and a solution of pH of 4 was made. Figure 1 shows the diagram of the EPD cell experiment. When 10 V DC voltage was applied between Pt plate and Cu plate, the GO platelets migrated towards the Cu plate (positive electrode). After deposition, samples were dried [6].

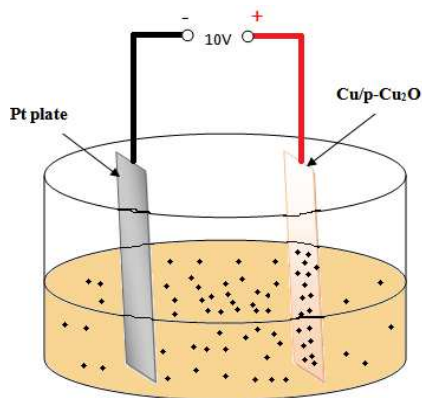


Figure 1. Experimental setup of the EPD technique

C. Characterization techniques

Diffuse reflectance spectra for Cu/p-Cu₂O and Cu/p-Cu₂O/rGO photoelectrodes were obtained by using SHIMADZU 1800 UV spectrophotometer. The photocurrent measurements were done using Hokuto Denko HA-131 potentiostat. Here a Pt plate was used as the counter electrode, an Ag/AgCl electrode was used as the reference electrode. (10⁻² M) Fe²⁺/ Fe³⁺ (10⁻² M) solution was used as the electrolyte.

iii. RESULTS & DISCUSSION

A. Photocurrent Response Curve

Figure 2 shows the variation of photo current for Cu/ p-Cu₂O/ rGO photoelectrodes fabricate with various rGO depositing times at electrolyte interface. It should be mentioned that bare Cu/ p-Cu₂O electrode produce 0.15 mAcm⁻² photocurrent at the electrolyte interface. With the increase of the rGO deposition time it can be seen that the photocurrent increases up to 0.2 mAcm⁻¹ in 25 seconds deposition period. Thereafter photocurrent decreases continuously with the increase of the rGO deposition time. It is well known that rGO can act as an electron acceptor [5]. Less rGO cannot separate electrons from p-Cu₂O efficiently, and more rGO would block light absorption [8].

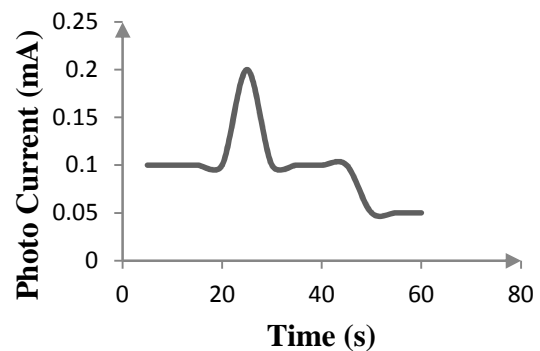


Figure 2. Photocurrent variations for various rGO deposition times

B. Diffuse reflectance spectra and photocurrent action spectra

Figure 3 shows the diffuse reflectance spectra of Cu/ p-Cu₂O and Cu/ p-Cu₂O/ rGO photoelectrodes. The wavelengths of p-Cu₂O and p-Cu₂O/rGO are 630 nm and 640 nm respectively. Here a relatively high absorption can be discovered if p-Cu₂O electrode is synthesized with a rGO layer. Therefore it can be said that additional absorption is occurred due to rGO layer.

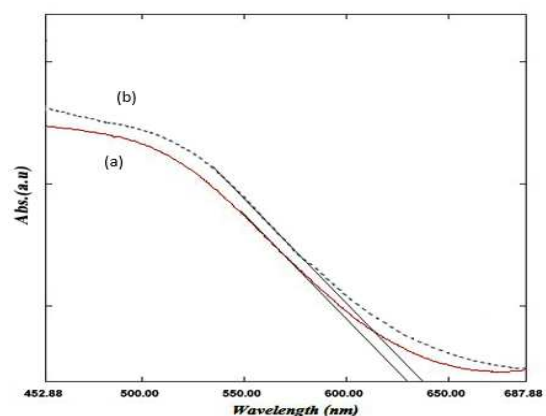


Figure 3. Absorption Spectra of (a). p-Cu₂O (b). p-Cu₂O/ rGO

Figure 04 shows a photocurrent maximum at the absorption edge observed in the diffuse reflectance spectra confirming that the photocurrent generation is due to the light absorption of p-Cu₂O semiconductor at electrolyte interface. For higher energy photons incident after absorption edge a photocurrent decrease can be observed. The highest enhancement is clearly observed as in figure 02

with rGO deposition time of 25 seconds at electrolyte interface.

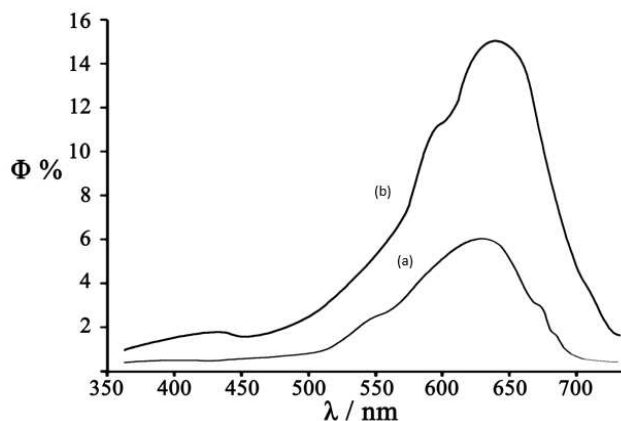


Figure 4. Photocurrent spectra of (a). p-Cu₂O (b). p-Cu₂O/rGO

IV. CONCLUSION

p-Cu₂O electrodes prepared from 300 °C with 100 °C heating rate is synthesized with rGO for 25 seconds produces the maximum photo current. 25 seconds is the optimum because less rGO layer has not enough strength to extract electrons from p-Cu₂O and more rGO layer cannot absorb visible light. To conclude, we can say that rGO can act as an electron acceptor to enhance the photo effect of p-Cu₂O due to the formation of p-Cu₂O-rGO junction.

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ACKNOWLEDGEMENT

National Research Council of Sri Lanka (NRC) is acknowledged for providing the equipment grant No-26 for this research program. Wayamba University research grants also acknowledge for this investigation due to providing chemicals.