IJRSET DECEMBER 2016 Volume 3, Issue 12 Pages: 23-26
ISSN 2394-739X
International Journal for Research in Science Engineering and Technology

EFFECT OF ETCHING TIME OF PS ON THE EFFICIENY OF CLALPC/PS DSSC

[1] K. Gangadevi, [1] R. Srinivasan
[1]Department of Physics, Thiagarajar College, Madurai – 625 009, India

ABSTRACT: The nanostructured porous silicon (PS) samples were prepared by electrochemical anodic dissolution of doped silicon (p-Si) for (100) orientations at constant current density of 30mA/cm^2 for etching times 10, 20, 40 and 60 min. Then these samples were sensitized with chloroaluminium phthalocyanine (ClAlPc) to fabricate Dye-sensitized solar cells (DSSCs). The diffuse reflection spectra (DRS) curves of sensitized porous silicon (ClAlPc/PS) had a wide absorption range of 450–750 nm, due to ClAlPc as a sensitizer in PS. The bandgap measurements from UV- Vis and photoluminescence measurements are in the range of 1.5 to 1.8 eV. The photocurrent and photovoltage of the cells were measured with an active area of 1 cm^2 using Keithely source meter in the condition of illumination (80 mW cm^{-2}). The open circuit voltage (V_{oc}), short circuit current (J_{sc}) and fill factor (FF) of the DSSC were calculated and analyzed. The sensitized sample prepared at 30mA/ cm^2 for etching time 60 min with 48% of HF shows better conversion efficiency of 2.8 %.

Keywords: [Porous silicon; HF concentration; DSSCs.]

1. INTRODUCTION

In recent years, dye-sensitized solar cells (DSSCs) are attracting widespread academic and commercial attention for the conversion of sunlight into electricity because of their low cost and high efficiency [1]. Porous silicon (PS), a nanostructured material, has attracted considerable attention as a measure to enhance the optical properties of silicon (Si). The formation of PS layers on crystalline Si (c-Si) wafers using electrochemical etching (ECE) exhibits photoluminescent and electroluminescent properties similar to those of semiconductors with direct energy gap [2]. A highly porous PS layer can enhance the efficiency of solar cells by increasing light trapping into the active region [3]. The chloroaluminum phthalocyanine (ClAlPc) compound and some of its derivatives display a number of interesting characteristics among pigments[4]. Due to high photoactivity and charge generation efficiency in addition to a strong absorbance in the visible range, the films of these complexes could be used as active layers in solar cells and organic electronics devices [5-10].To improve the device performance various nonplanar phthalocyanine materials used as electron donors in organic photovoltaics have been reported [11-12]. The ClAlPc which is the halogenated derivative of Pc having more solubility (0.001M) on which much works is not reported to the best of our knowledge. In this work, we demonstrate the use of porous silicon (P-Si) as photoanode in

DSSCs with platinum as counter electrodes. Here we used, The ClAlPc as a sensitizer.

2. EXPERIMENTAL

Samples used in this study are boron doped crystalline Silicon (c-Si) wafers (thickness 517 μm and resistivity 0.2- 0.5 Ω cm) grown by Czochralski (CZ) method in (100). The porous samples were prepared by electrochemical anodic dissolution of doped silicon (p-Si) in various concentrations of hydrofluoric acid, H_2O and ethanol with platinum electrode as cathode. The electrolyte was prepared by mixing HF, H_2O and ethanol in 1:1:2 ratios. The porous layers on the surface of these samples (p-type c-Si) were prepared at a constant current density of 30 mA/cm^2 for etching periods of 10, 20, 40 and 60 minutes. The ClAlPc material was prepared in laboratory from 20 g of phthalonitrile, 5 g of $AlCl_3$ which was refluxed in 100 ml of quinoline for 2 hr. The product was filtered and then the resulting precipitate was washed sequentially in toluene, carbon tetrachloride and acetone. The product was then dried at 70 ºC. The prepared ClAlPc Dye (0.1g) was mixed in 5ml (0.001M) of ethanol. The resultant mixture is used as a sensitizer of porous silicon substrate for which Doctor Blade technique was used. The prepared samples were characterized by UV – DRS and PL techniques. The prepared samples of Ps/ClAlPc photoanode with different porosities were used to fabricate DSSCs.

3. RESULTS AND DISCUSSION

3.1. Photoluminescence

Photoluminescence (PL) emission spectra for all the above PS samples and ClAlPc/PS were recorded at room temperature using a spectroflurophotometer (ISS USA).The PL spectra of PS prepared at constant current density of 30mA/cm^2 for 10, 20, 40 and 60 min shown in Fig.1 and PS/ClAlPc are shown in Fig.2. Initially the UV absorption measurements were carried out and they are in the range of 1.5 eV to 2.0 eV. The band gap of PS calculated by UV absorption and PL emission spectra for different etching parameters is given in Table 1and the agreement is quite good. For the PS sample, the PL intensity increases with increasing etching time. It is observed that the band gap PS is slightly blue shifted with increase in etching time for constant current density. This shift in band gap (band gap widening) is because of quantum confinement due to reduction in the size of the Si nanocrystallite for increasing etching time [13]. And also the blue shift PL emissions of PS are slightly blue shifted with increase in etching time, which could be due to the decrease in nanocrystallites of silicon with increase in porosity of the samples [14].

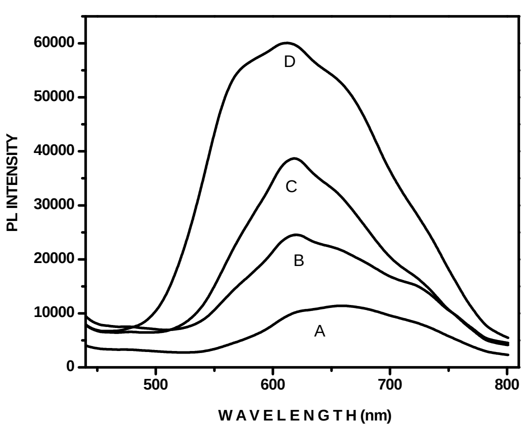

Figure 1-Photoluminescence spectra for the PS samples prepared at (30mA/cm^2, 48% HF) (A) 10 mins (B) 20 mins (C) 40mins (D) 60mins

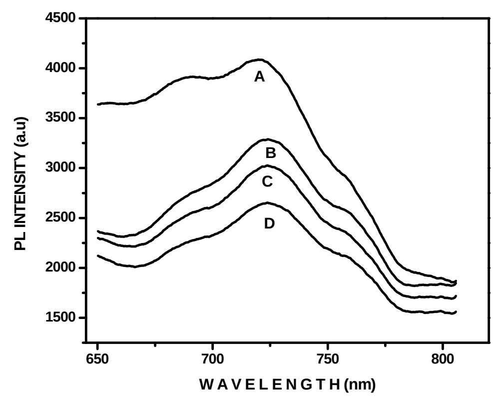

Figure 2- Photoluminescence spectra for the ClAlPc/PS samples prepared at (30mA/cm^2, 48% HF) (A) 10 mins (B) 20 mins (C) 40mins (D) 60 mins

Samples prepared with electrolytic concentration of 30mA/cm^2	Band gap in eV			
	PS		ClAlPc/PS	
	PL	UV	PL	UV
A (10 minutes)	1.81	1.805	1.5949	1.594
B(20 minutes)	1.91	1.891	1.6464	1.691
C (30 minutes)	2.01	1.981	1.7182	1.712
D (40 minutes)	2.02	2.053	1.7646	1.776

Table 1- Bandgap values from PL and UV measurement for PS and ClAlPc/ PS samples

3.2. I-V Measurement:

Prepared solar cells (1 cm^2 size) were characterized by current - voltage (I–V) characteristics. Photocurrents and voltages were measured using a Keithley source meter 2400, with a 80 W halogen lamp and AM 1.5 G, and the light intensity was adjusted . Quality of the solar cell is determined by a parameter called solar cell efficiency that is simply defined by a ratio:

$$\eta = \frac{P_{max}}{P_L}, \quad (1)$$

where P_{max} is the maximum solar cell power and P_L is power of the incident light. So, solar cell efficiency and Pmax are associated by a linear dependence. At constant power of incident, light change in P_{max} reflects peculiarities in solar cell efficiency and quality of the cell as well. Maximum power created of solar cell can be simply found by measuring its I-V characteristic under external biasing as well as measuring current of illuminated solar cell without bias and voltage changing loadings [15].

Samples prepared with electrolytic concentration of 30mA/cm^2	PS/ClAlPc 48% of HF
A (10 minutes)	0.83
B(20 minutes)	1.23
C (30 minutes)	1.68
D (40 minutes)	2.84

Table 3- Conversion Efficiencies of the DSSCs prepared by ClAlPc / PS samples

We suggest that this remarkable increase in power occurs because of better absorbance of incident light and because of the better collection of excited charge carrier, by dye molecules present in the porous silicon structure.

4. CONCLUSION

Nanostructured porous silicon (PS) samples were prepared at a current density of 30mA/cm^2 for etching periods 10, 20, 40 and 60 minutes. Then these samples were characterized using UV -DRS and PL emission technique. The band gaps are calculated and compared. The band gap slightly increases with increase in etching time. To study the effect of dye sensitizer, on these samples, the surface of these PS samples was sensitized with derivative of Chloroaluminum Pc (ClAlPc). The dependence of absorption and emission intensities on these samples indicate that ClAlPc /PS prepared at current density of 30mA/cm^2 for etching time of 60 min indicate that it is good absorber of radiations and can be used for solar cell application. The efficiency of the DSSC was 2.8%.

ACKNOWLEDGMENT

The authors acknowledge the University Grant Commission (UGC), India, for financial support in the form of Major research project (F.No.**41-941/2012 (SR)**).

REFERENCES

[1]. Regan, B. O'.; Gratzel, M. Nature 1991, 353,737.

[2]. T.L. Canham, Appl. Phys. Lett. 57 (1990) 1046.

[3]. O. Bisi, S. Ossicini and L. Pavesi, Surf. Sci. Rep., 38 (2000) 1.

[4]. Leznoff, C. C., Lever, A. B. P., Eds.; Phthalocyanines: Properties and Applications; VCH: New York, 1993; Vol. 1, 1993; Vol. 2, 1993; Vol. 3, 1996; Vol. 4.

[5]. Kamat, P. V. Chem. Rev. 1993, 93, 267.

[6]. Gritzner, G.; Kuta, J. J. Pure. Appl. Chem. 1984, 56, 461.

[7]. Minshi An, Soonwha Kim, and Jong-Dal Hong, Bull. Korean Chem. Soc. 2010, Vol. 31, No. 11

[8]. R. O. Loutfy, A.M. Hor, and A. Rucklidge, J. Imaging Sci. 31, 31 (1987).

[9]. F. Santerre, R. Côté, G. Veilleux, R. G. Saint-Jacques, and J. P. Dodelet,J. Phys. Chem. 100, 7632 (1996).

[10]. A. Ioannidis and J. P. Dodelet, J. Phys. Chem. B 101, 901 (1997).

[11]. Y. Sakakibara, R. N. Bera, T. Mizutani, K. Ishida, M. Tokumoto, and T. Tani, J. Phys. Chem. B 105, 1547 (2001).

[12]. M. Brumbach, D. Placencia, and N. R. Armstrong, J. Phys. Chem. C 112, 3142 (2008).

[13]. R. Prabakaran, R. Kesavamoorthy and Alok Singh, Bull.Matter. Sci. 28, 219-225 (2005).

[14]. M. Jayachandran, M. Paramasivam, K.R. Murali, D.C. TrivediandM.Raghavan, MaterPhys. Mech.4,143 (2001).

[15]. M. E. Azim-Araghi, E. Karimi-Kerdabadi, M. J. Jafari, Eur. Phys. J. Appl. Phys. 55, 30203 (2011).