Chemical Deposition of CdS Films for Photoelectrochemical Solar Energy Conversion

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Abstract:

The properties of photochemical CdS film deposited on Cd substrates by chemical bath deposition method (in aqueous polysulphide solution) have been studied.

The output characteristics of the cells Cd/CdS/0.1MS,0.1 M Na_2S, 0.1 M NaOH /C have been measured. The maximum open circuit voltage and the short circuit current density have been observed as 0.39V and 315 μ A/Cm^2 respectively. This is done by illuminating with light intensity of 65mW/Cm^2 after doping with light.

The efficiency of photoelectrochemical (PEC) cells using such polycrystalline CdS films is a bout an order lower than that obtained with single crystal CdS.

Introduction:

The photo electrochemical (PEC) solar cell is an attractive alternative to well known solid-state devices because it is easy to fabricate and may be competitive in energy conversion applications (1-2) . In this regard, polycrystalline photo electrodes of different semi conducing materials have been investigated and tested (3-11). Different experimental techniques, such as thermal oxidation, chemical vapor deposition, electro deposition etc; have been used to prepare the polycrystalline electrodes (12-15). Studies on electrochemical (PEC) solar cells made with CdS electrodes with different electrolytes have already been carried out and are well documented (16-18). CdS is n – type semiconductor (Eg =2.4 eV) and shows a photovoltaic effect when dipped into an electrolyte which contains a red ox system (19).

photo electrochemical cell with CdS thin semiconductor electrode deposited on NESA substrate in polysulfide solution (1M each Na_2S, S, NaOH) and using (pt) as a counter electrode has been investigated by loutfy et al (16) , the Voc and Isc were found as (0.55 V) , (0.24mA/Cm^2) respectively by light intensity of 75 mW/Cm^2).

Purpose of this work is to investigate the performance of n-type polycrystalline CdS photo anode produced by chemical bath deposition of CdS film in acidic aqueous solution on cadmium substrate in PEC cell using polysulphide as electrolyte and C as a counter electrode: Cd/CdS/Na_2S, NaOH, S/C.

Experimental:

(I): Preparation of CdS films:

The thin CdS films described in this work were prepared according to the method suggested by mokrushin et al (20). The precipitation was made on (Cd) substrate as a cathode of area 0.25 Cm^2, versus (C) electrode as anode. Electrode etching was made by using dilute H_2SO_4 at room temperature; washed several time with distilled water and dried in air. The metallic substrate (Cd) plate was suspend vertically in aqueous solution of $CdSO_4$ containing thiourea $CS(NH_2)_2$ and NH_4OH . It was then heated with using magnetic stirrer in order to achieve uniform deposition for about 30 minutes.

(II): Photo electrochemical measurements:

Photovoltaic were measured in a Pyrex cell as shown in figure (1) with quartz window of 2 Cm in diameter.

Cell current – Voltage (I-V) curves were obtained by varying a load resistor between CdS and (C) electrode. The open circuit voltage and short circuit current were measured by digital multi-meter model (me-550) (Japan). A tungsten lamp of 200 W was used for illumination.

The total illumination level at the semiconductor electrode was adjusted to 65 mW/cm^2 through its window.

The PEC cell polysulphide electrolyte were prepared by dissolving of 0.1 M NaOH , 0.1MNa_2S and 0.1MS.

The effects of dopont LiOH on electrical property of films were studied.

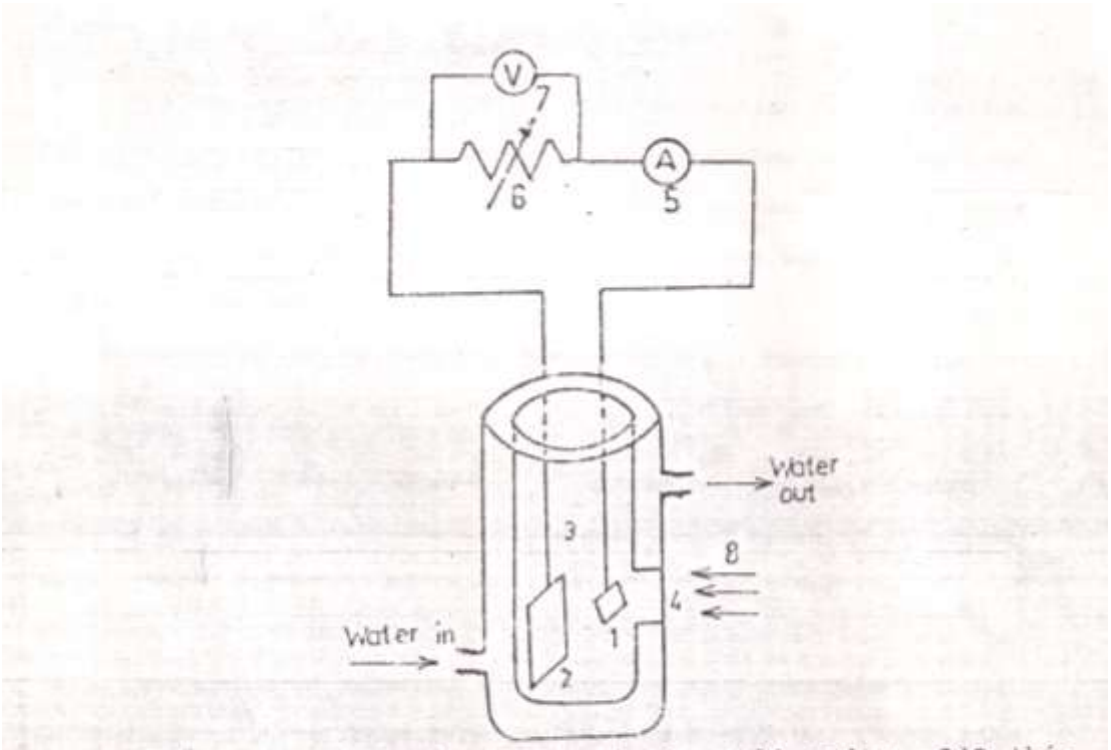


Figure 1. The Photoelectrochemical cell using CdS thin film. (1) CdS photoanode, (2) platinum counter electrode, (3) polysulphide electrolyte, (4) glass window, (5) Ammeter, (6) external resistance, (7) D. C. microvoltmeter (8) incident light.

Results And Discussion:

The optimization of chemical bath deposition condition for CdS thin film on (Cd) substrate was carried out by varying several parameters, which are well known to have great effects on the performance and stability of electrode and ultimately on the conversion efficiency of the PEC cell.

These physical and chemical parameters are: concentration of Thiourea, temperature of bath deposition, time of deposition and the effect of LiOH as a do pant.

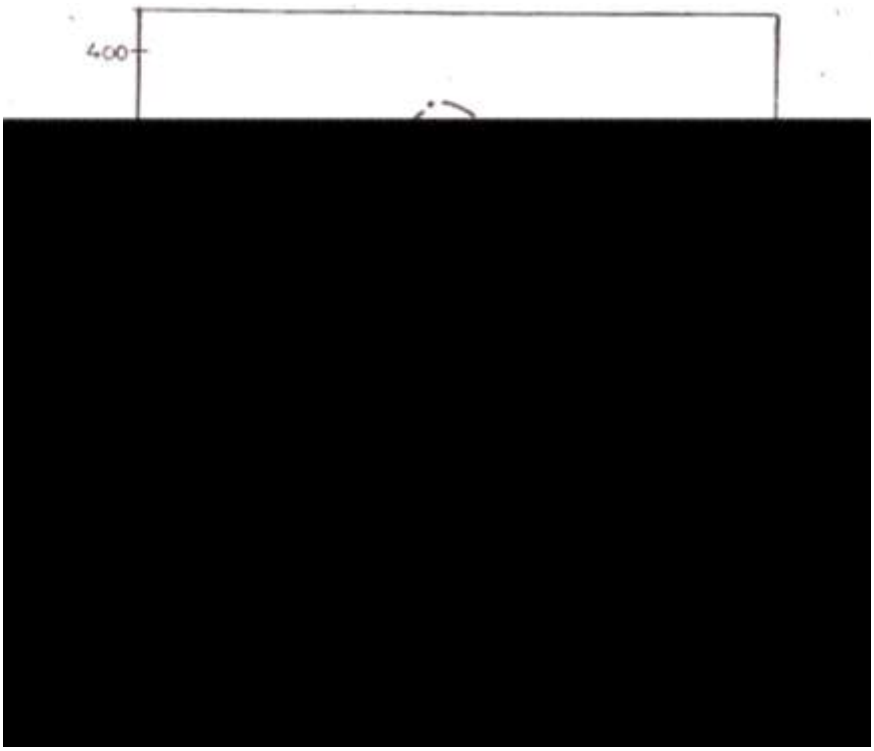
Figure 2 shows the effect of concentration of Thiourea on the Voc of CdS PEC cell, the results were found to be in agreement with that reported by Naman et al (11), for the performance of CdS as PEC solar cell. It is observed that the CdS films performance depends strongly on the concentration of CS $(NH_2)_2$ during the deposition, i.e the maximum Voc is obtained at 1 molar $Cs(NH_2)_2$. The maximum Voc of these cells is about an order of magnitude lower than that obtained by loutfy et al (16) and Naman et al (11).

Figure 3 shows the effect of temperature of chemical bath deposition on the Voc at the CdS films. The effect of temperature on the output of PEC cells which depend on several parameters, such as the hole diffusion length, optical absorption coefficient at semiconductor, photon flux incident on the semiconductor liquid interface are charge transferred par ion discharged at the electrode (21-24).However these effects are found to be complicated function of all these physical properties of the semiconductor and electrolyte (21, 24). The general shape of the curve in figure 3 is similar to those obtained by other worker (23), the result is indicate that the maximum Voc can be obtained at a temperature of 100C.

The I-V characteristics of the PEC which have been studied at a temperature of 30 are shown in figure 4. It shown that the Isc increase from 280 μ A/Cm^2 due to addition of LiOH.

The characteristics of PEC cell based on films are significantly controlled by deposition techniques and conditions (25).

Table 1 shows the comparison of the Isc , Voc ,the effect of Temp. Efficiency of PEC cell fabricated from polycrystalline CdS obtained from this work and other worker results.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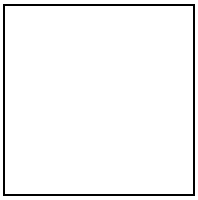

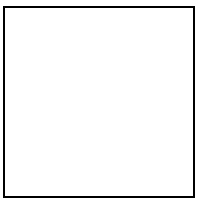

Table 1: Comparison of the cell performance by different methods.

Method of CdS films preparation Temp. of bath deposition C° **Temp. of bath deposition C°**	**Light intensity (mW/Cm^2)**						
On glass/SnO2 ------ 75 0.14 0.590 ----- ------	75	0.14	0.590	-----	-----	16	on Ti on Ti
on Ti	-----	65	1.20 °	0.532	-----	0.031	11
on stainless steel	-----	65	0.80	0.486	-----	0.21	11
On Cd 100 ° 100	65						
At 3mA/Cm^2 for 10 min.(Ti substrate)	------	75	0.12	0.320	-----	-----	16
At 3mA/Cm^2 for 20 min.(Ti substrate)	-------	70	0.22	0.410	0.30	0.37	25
At 3mA/Cm^2 for 25 min.(Ni substrate) ------- -------	70	0.18	0.200	0.17	0.008	25	**Electrodeposition from aqueous solution Electrodeposition from aqueous solution**
Slurry painting :							
CdS/RuO_2(on glass)	------	70	0.95	0.510	0.40	0.26	25

Conclusion:

(1): It is clear from Figures 1 & 2 that the concentration of Cs $(NH_2)_2$ and Temperature of bath deposition affects the duality of CdS films for (PEC) solar cell.

(2): LiOH decreases the resistance of the films with out affecting the energy levels at CdS/0.1M each S.Na_2S, NaOH interface the results shown in figure 3.

(3): From Table 1, it shows that the output performance of the (PEC) cell using Cd substrate is a bout lower than the Ti and stain steel substrate.

(4): The highest efficiency of the PEC polycrystalline CdS thin films photo electrode is about and order lower than single crystal of CdS.

References:

1- Rajeswar,k.,Singh,P,. Dubow.J./ Electrochemical acta, 23,1117-1144 (1978).

2- Kar,.S., Rajeshwar, K., singh, P., Dubow,J., Solar energy , 23,129-139 (1979).

3-Hodes, G.,Nature, 265,19-30 (1980).

4- Razzin,G.,peraido Bicell,l.,Scrosati, b. ,J, electro-chem. Soc.,133,351-352 (1886).

5-Hodes,G.,Manassen, J., Nature,261,403-404 (1976).

6- Cahen,D., hodes,G., Manassen, J., electroche. Soc., 125, 10,1623-1626 (1978).

7- Heller,A., Schwart, g., P., Miller, B., J., J., Electro-chem, 125, 1156-1160 (1978).

8- Hodes, G.,Manassen, J., Cahen,D.,Solar energy Material, 4,373-381 (1981).

9- Ellis,b.,Kaiser,W.,Wrigton,s.,J.Am. Chem.Soc., 1635-1637 (1976).

10-Heller,a.,Solar Energy, 29,153-162 (1982).

11- Naman,S.,A.,Akber,H.,S.,Srivastava,B.,B., J,Solar Energy Reaseach, 1,1,37-48 (1983).

12- Akber ,H.,S.,Abdulkadier,A.,Buni,M.,J.,Solar Energy Reseach ,6,1,49-56 (1988).

13- Miller ,B.,Heller,A.,Nature,262, 680-681 (1976).

14- Ma, Y,. Bube,H., J.,Electrochem.Soc. , 124 , 9, 1430-1435 (1977).

15- Aushana, A., M., Aliwi , S., M., Third Arab international Solar Energy Conference , (6-16) –(6-12) (1988).

16- Loutfy, R., O., Micltyre , D.,K., Hsiao, C., k.,Solar Energy Material , 5,221-228 (1981).

17- Heller ,A.,Chang, K.,C., Miller, B., J., Electrochem. Soc. 124 , 5, 697-700 (1977).

18- guyomard, D.,Heriem , M.,Solar Energy ,4,157, (1981).

19-gerisher,H., Electroanaytical Chemistry and Interfacial electro- Chemistry ,58 . 263-274 (1975).

20- mokrushine , S., g., Thchev,Yu.,D., Kollid Zh ,23 , 438 (1981), Colloid J. (U.S.S.R.) 23, 366 (1961).

21-gerisher ,h., J.,Electroanalytical – chem. 82,133-138 (1977).

22- lokhande C.D. and s.H. Pawar , Solar Energy Matrial ,7,313-318 (1982).

23- Skyllas ,M,J.F., Kazacos , McCcann and D., Hareman, Solar Energy Matrial , 4, 215-222 (1981).

24- Gerisher ,H., Electroanalytical Chem. And interfacial Electrochem. 58, 263-274 (1986).

25-Bharadway , R.,C., Jadhar , C,M., Taquikhan , M,M ., Solar Cells , 12,371, (1984).

26- Salah m., Aliwi , Ashur, M., A., J. Solar Enaergy Research , 5,1,55-69 (1987).

27- McCann ,J.,F., Kazacos , M.,S., J.Electroanal. Chem. , 119,85,(1981).

تحويل الطاقة الشمسية باستخدام أغشية CdS متعدد البلورات في خلايا الكهروكيميائية الشمسية

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الملخص:

يتضمن البحث قياس اداء الخلسة الكهروكيميائية الشمسية باستخدام مادة شبه موصلة CdS كقطب ضوئي المرسبة على شكل طبقة رقيقة وناعمة على صفيحة الكادميوم وبتقنية الترسيب الكيميائي (Chemical Bath Deposition) مع محيط مائي لمحاليل متعدد الكبريدات (Polysulphide) واستخدام قطب مضاد من الكرافيت.

كما تم دراسة تأثير هيدروكسيد اللثيوم LiOH على خصائص المادة الشبه الموصلة CdS .وقد وجد اعلى فولتية للدائرة المفتوحة وتيار الدائرة القصيرة للخلية هي (0.39 V) و ([ ] A/Cm^2 315) على التوالي باستخدام مصباح التنكستن بشدة ضوء 65 ملي واط / سم^{٢}.