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Photovoltaic effect of CdSe based nanocrystalline multilayered photoelectrodes in photoelectrochemical solar cells

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Abstract

Single layered and multilayered films of CdSe nanocrystals of different size have been prepared onto titanium substrate by pulsed electro deposition technique. These are used as photoelectrode in photoelectrochemical (PEC) solar cells. The electrolyte solution was kept at 80ºC during the deposition process. The current density was 7mA/cm^2. Various cell parameters like Isc, Voc, F.F., Po & η% are evaluated. It is found CdSe Single layer efficiency η=1.1% with P_3(1:2) duty cycle and CdSe multilayer efficiency η=1.64% with P_1(1:0/1:1) duty cycle.

Keywords:- Nanocrystalline CdSe Multilayer, Pulse electrodeposition, Photoelectrochemial solar cell

1. INTRODUCTION

The use of nanostructures in solar cells may enhance the efficiency and performance. In photo- electrochemical solar cells the junction formation is quite easy and polycrystalline films also work very well. Use of nanocrystallites has potential to provides high conversion efficiency since large area is available to absorb photons. The photo generated carriers have to travel over a short distance and the effective band gape can be tuned to absorb a particular photo energy range. In present work CdSe nanocrystalline single layer & multilayer of different crystal size have been prepared by pulse electrodeposition and their performance in PEC cells with sulfide/polysulfide electrolyte has been studied

1.1 EXPERIMENT

Single layer and multilayer of CdSe were prepared by pulse electrodeposition technique on titanium substrate from an aqueous acidic electrolyte $CdSO_4$ (0.5M) and SeO_2 (0.1M). Pulse voltage we have used an ON-OFF machine which is based on the operation of IC-555 in astable mode. Different duty cycles of ON-OFF machine were used for preparing samples of nanocrystalline single layered and multilayered. The electrolyte solution was kept at 80ºC during the deposition process. The current density was 7 mA/cm^2. In this way five samples of nanocrystalline CdSe single layer with different duty cycle on P_1(1:0), P_2(1:1), P_3(1:2), P_4(1:3) & P_5(1:4) have been obtained. For sample-I, P_1(1:0) means 15 minute continuously electrodeposition or 1 sec ON, 0 sec OFF at temperature 80ºC and total deposition time 15 minute, sample-II P_2(1:1) means 1 sec ON, 1 sec OFF& total deposition time 30 minute, sample-III P_3(1:2) means 1 sec ON, 2 sec OFF& total deposition time 45 minute, sample-IV P_4(1:3) means1 sec ON, 3 sec OFF& total deposition time 60 minute and sample-V P_5(1:4) means 1 sec ON, 4 sec OFF & total deposition time 75 minute and four sample of nanocrystalline CdSe multilayer with different duty cycle have been obtained. First CdSe was deposited for different duty cycle and dried in air for 24 hours. Then CdSe was deposited over it for different duty cycle. In this way four sample P_1(1:0/1:1)), P_2(1:1/1:2), P_3(1:2/1:3) & P_4(1:3/1:4) have been obtained. These were dried in 24 hours.

1.1.1 Photovoltaic study

Electrolyte solution for PEC solar cell was prepared by 1M NaOH, 1M Na_2S & 1M Sulphur**.** A graphite rod was used as a counter electrode and CdSe single or multi-layers prepared previously were used as photoelectrode. For illumination of photoelectrode a 50 Watt tungsten lamp was used. A potentiometer was connected in series with PEC cell. Varying the resistance of potentiometer, voltage and current were measured. Same process was repeated for all samples, and I-V characteristics were plotted and solar cell parameters- Open circuit voltage (V_{oc}), Short circuit current (I_{sc}), fill-factor (ff), Power output (P_O) & Efficiency (η) were determined.

2. RESULTS AND DISCUSSIONS

Duty cycle	Voc(mv)	Isc(μA)	Po(10^{-6} m.Watt)	F.F.%	η%
P_1(1:0)	151	142	4620	21	0.92
P_2(1:1)	184	102	4770	25	0.95
P_3(1:2)	212	82	5610	32	1.11
P_4(1:3)	235	92	5060	23	1.0
P_5(1:4)	204	71	4200	28	0.83

Table1. Solar cell parameters for single Layer electrodes.

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Table2. Solar cell parameters for Multilayer photoelectrodes.

The fig.(1) and fig. (2) show the V-I characteristic of solar cells with different single layer and multilayer photoelectrodes respectively. The solar cell parameters with different sample are given in table I & II. It is observed that single layer gives best result for duty cycle P_3(1:2) with efficiency η=1.1%, F.F.=32%, Po=5610 x10^{-6} (m.watt) and the multilayered of CdSe all parameters of higher for P_1(1:0/1:1) duty cycle with maximum efficiency η=1.64%, Po=8260x10^{-6} (m.watt). Variation of efficiency of single layer and double layer with different duty cycle are shown in fig. (3) and effect of light intensity on efficiency (η%) with P_1(1:0/1:1) duty cycle are shown in fig.(4). All parameters are higher for multilayer and efficiency increase with increasing light intensity. In general V_{oc}, I_{sc}, P_O, FF & η% all decrease with higher duty cycles. It is clearly observed that CdSe multilayer give better result compared to single layer.

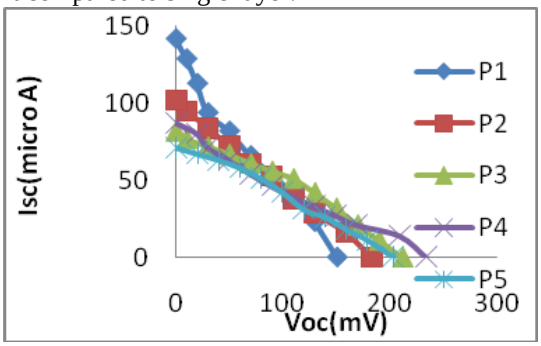

Fig.1.V-I characteristic of CdSe singlelayer film

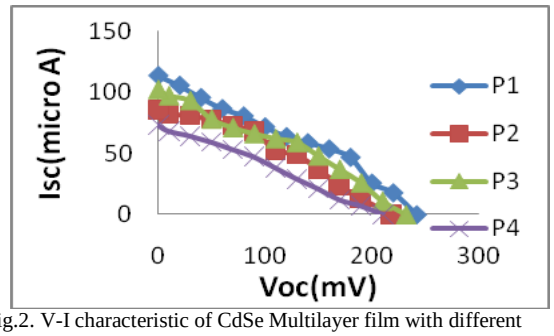

Fig.2. V-I characteristic of CdSe Multilayer film with different duty cycles.

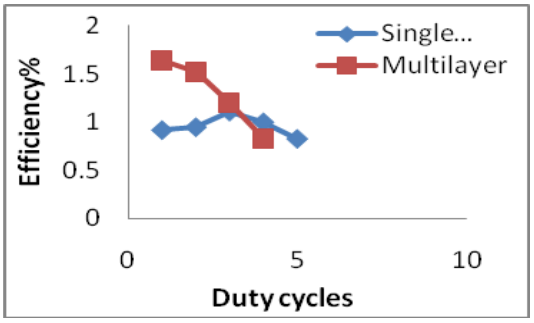

Fig.3. Effect of duty cycles on Efficiency of single & Multilayer CdSe nanocrystal based PEC cell

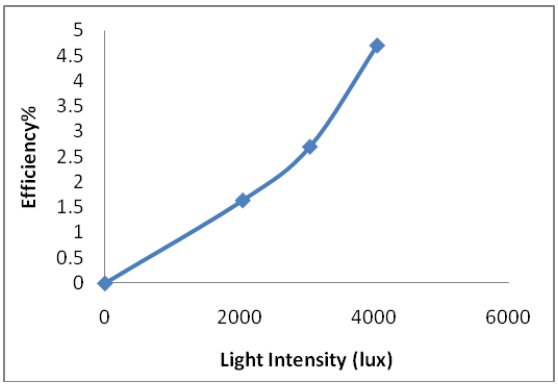

Fig.4. Effect of light intensity on Efficiency(η%) of P1(1:0/1:1) duty cycle

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