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BRIEF COMMUNICATION

SEPTUM ELECTROCHEMICAL PHOTOVOLTAIC CELLS

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Septum electrochemical photovoltaic cells employing electrodeposited CdSe spectrum of 25 cm^2 area have been studied. A V_{oc} of 1.62V, J_{sc} of 7-9 $mA.cm^2$, FF of 0.59 and η of 8.97% were obtained.

Key words: Photoelectrochemistry, cadmium selenide septum cells, electrochemical photovoltaic cell

INTRODUCTION

The natural photosynthetic systems with pigmented bilayer membranes are the precursors for the septum photoelectrochemical cells first reported by Tien [1]. In a septum photoelectrochemical cell (Fig. 1), much larger outputs are possible than conventional PEC cells by a judicious choice of the two redox couples separated by the septum. Metal recovery from industrial wastes has been shown to be a potential application [2], the septum driving oxidation and reduction reactions in separate compartments. What limits a full realisation of these concepts to practical utilisation is the need to fabricate large area electrodes with higher efficiencies. The present effort is a step to fill this gap.

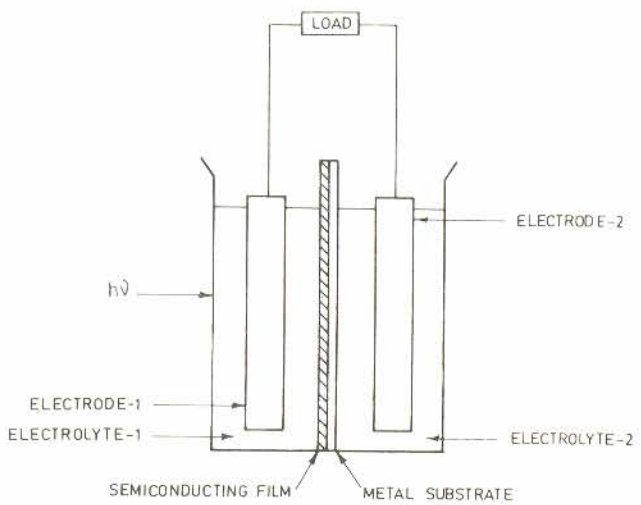

Fig. 1: Schematic diagram of the septum PEC cell

EXPERIMENTAL

CdSe films (5μm thick) were electrodeposited on Ti substrates (25 cm^2 area) using a selective plating technique with a current density of 80 $mA.cm^{-2}$ for 20 min at room temperature from a bath containing 0.5M $CdSO_4$ and 0.1M SeO_2 (pH $\sim$ 4). The films were sensitized at 823K in argon atmosphere and cooled at different rates.

The septum cell was constructed as follows: the semiconductor septum was mounted on a PVC partition with PVC solution. After drying, the chambers of the cell were filled with 1M polysulphide (photoexposed side) and different electrolytes like $CdCl_2$, $CuSO_4$, $CuCl_2$ and $Cu(NO_3)_2$ in the second compartment. Graphite was used as counter electrode in the photo exposed side and either graphite, Pt, Cu or Cd was the electrode in the other compartment.

RESULTS AND DISCUSSION

X-ray diffraction studies indicated polycrystalline CdSe corresponding to hexagonal structure. SEM studies on annealed layers revealed agglomeration of crystallites. A band gap of 1.65 eV was obtained from optical observation studies.

The septum cell of the following configuration.

C/Polysulphide/CdSe film/Ti/Electrolyte solution 2/Electrode 2

was studied under an illumination of 80 mW. cm^{-2}. Among all combinations, the highest photovoltage and photocurrent were obtained when $Cd/CdCl_2$ was used in the dark compartment. Table I shows the output parameters of the cells employing CdSe electrodes heat sensitized at 823K and cooled at different rates. From the Table, it is observed that the output parameters increase with the conductivity of the electrodes. Photoetching in 1:5 HCl for 60s under 80 $mW.cm^{-2}$ illumination and surface modification by dipping in 0.1M K_2CrO_4 for 15 min enhanced the output. Figure 2 depicts the power characteristics. Table II shows the better performance of the large area CdSe septum before and after K_2CrO_4 treatment, in comparison to even small area septums reported earlier [3-5].

CONCLUSIONS

Noteworthy features of this report are the large area (25 cm^2) CdSe electrodes, novel plating technique, higher output parameters of fill factor (0.59), open circuit voltage (1.54V) and efficiency (8.97%), as against those reported for cells even with small area (1.0 cm^2) slurry coated and electrodeposited septums. The improvement observed may partly be due to the postdeposition argon treatment that has not been hitherto used.

The rate of cooling in argon atmosphere has a profound influence on the output parameters. Improvements in efficiency are expected by changing the deposition conditions, suitable doping and modifying and further optimizing heat treatment procedures.

TABLE-I: Output parameters of septum cells employing CdSe electrodes (25 cm^2) cooled at different rates

Sl. No.	Cooling rate (deg. min^{-1})	Conductivity ($ohm^{-1}.cm^{-1}$) × 10^{-3}	V_d (V)	V_l (V)	V_{oc} (V)	J_d ($mA.cm^{-2}$)	J_l ($mA.cm^{-2}$)	J_{sc} ($mA.cm^{-2}$)	FF	η (%)
1.	80	1.0	−0.15	0.60	0.75	−0.018	0.972	0.99	0.29	0.30
2.	50	8.33	−0.50	0.75	1.25	−0.392	0.308	2.70	0.38	1.60
3.	35	50	−0.50	0.85	1.35	−0.340	4.060	4.40	0.40	3.04
4.	17.5	100	−0.51	0.85	1.36	−0.360	5.540	5.90	0.45	4.51
5.	7.0	200	−0.40	0.98	1.38	−0.320	6.080	6.40	0.68	7.49

$V_{oc} = V_l - V_d$; $J_{sc} = J_l - J_d$

TABLE-II: Comparison of performance of large and small area CdSe septum cells

Preparative method	Area (cm^2)	V_d (V)	V_l (V)	V_{oc} (V)	J_d ($mA.cm^{-2}$)	J_l ($mA.cm^{-2}$)	J_{sc} ($mA.cm^{-2}$)	FF	η (%)	Ref.
Selectively plated	25	−0.4	0.968	1.368	−0.32	6.08	6.4	0.68	7.49	Present work
Selectively plated and K_2CrO_4 treated	25	−0.415	1.20	1.62	−0.34	7.56	7.9	0.59	8.97	Present work
Electrodeposited	1.0	–	–	1.06	–	–	15.0	low	3.50	[3]
Slurry coated	1.0	–	–	1.2	–	–	6.32	–	–	[4]
Pellet	1.0	–	–	1.8	–	–	7.0	0.32	6.0	[5]

$V_{oc} = V_l - V_d$; $J_{sc} = J_l - J_d$

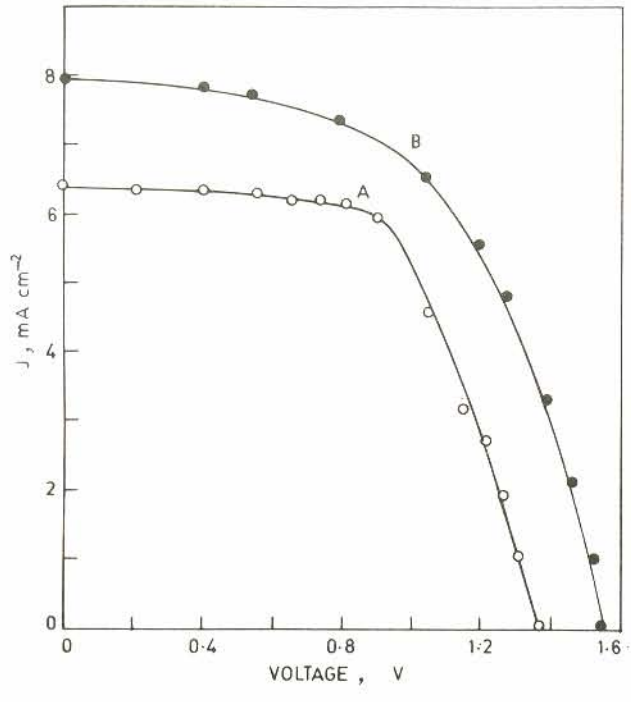

Fig. 2: Power characteristics of the CdSe septum cell under an illumination of 80 mW.cm^{-2}
(A) Untreated = ff = 0.68, η = 7.49%
(B) K_2CrO_4 treated = ff = 0.59, η = 8.97%

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