

electrolyte systems as the conducting medium. Various cells were devised for different x values of the electrode and characterized through the current-voltage and capacitance-voltage characteristics, power output curves and photo and spectral responses. Voltages and currents were measured with the sensitive 6 ½ digit HP make multimeter and 4 ½ digit nanoammeter. Three electrodes system was employed to measure the junction capacitance under reverse bias. The capacitance measurements were performed with a 4 ½ digit Aplab LCR-Q meter for the range of reverse bias from 0 to 1 V. The photo response was examined under a variable input intensity of 5 mW/cm² to 50mW/cm². Input intensities were noted with a Lutron-LX-101 (Taiwan) Lux meter. Spectral studies were undertaken for the range of wavelengths from 700 nm to 1300 nm with a photo spectrometer.

3. Results and Discussion

Electrochemical photoactive properties of Cd_{1-x}Hg_xTe thin film electrodes are presented in this paper. The as-grown films were synthesized using an universal chemical bath deposition process and are crystalline in nature, tightly adherent to the substrate support, rough in appearance and diffusely reflecting [6, 7]. The color of the samples changed from grayish-white to gray-black as Hg-concentration in the film was increased. This has indicated that Hg can be easily incorporated in the lattice of CdTe. The compositional analysis was therefore carried out on these films, which strengthens the above observations. Thus the terminal layer thicknesses of these layers were measured by an interferometric technique. It has been seen that the layer thickness decreased with addition of Hg-concentration in CdTe. This is shown in Fig.1. The details pertaining to the growth mechanism and kinetics have already formulated as a research article [6, 7].

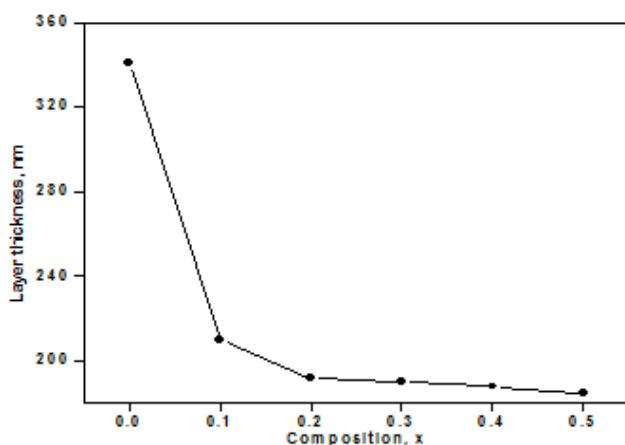


Figure 1: Variation of the terminal layer thickness with composition, x

First, the electrochemical cells were fabricated using these thin films as the photosensitive electrodes and different electrolyte systems and were illuminated by a white light source of 20 mW/cm². The short circuit photocurrents (I_{ph}) and open circuit photo potentials (V_{ph}) were then measured. It is found that the polysulphide electrolyte is a better choice for Cd_{1-x}Hg_xTe and rest of the studies was then carried using polysulphide electrolyte as an optimum choice. Figure 2 represents this optimum choice of an

electrolyte. The junction quality factors under illumination were then determined from the slopes of V_{ph} versus $\ln F_L$ were therefore constructed and these variations. The various values of n_L are listed in table-1.

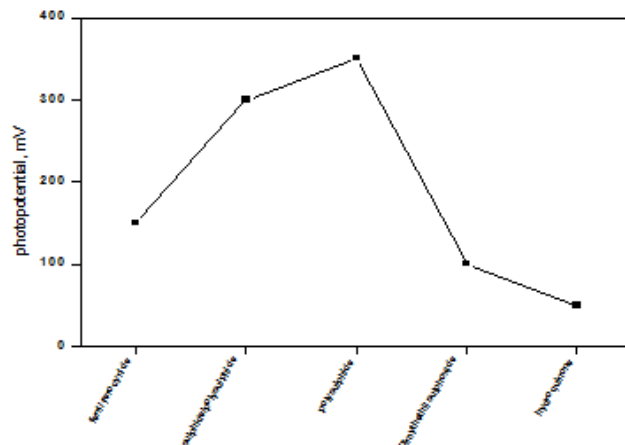


Figure 2: Choice of redox electrolyte for Cd_{1-x}Hg_xTe by the measurement of V_{ph}

An important characteristic of a photoelectrochemical cell is its power output curve. These curves were obtained for all the cell configurations and their diagrammatic representation is shown in Figure 3.

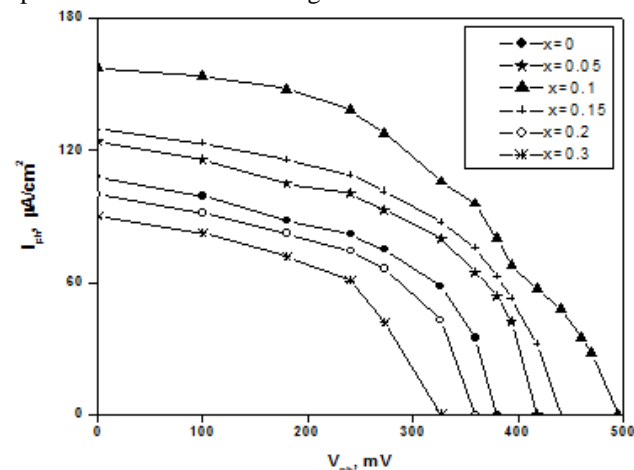


Figure 3: Power output characteristics of few of the typical cells

The curves deviated from their rectangular shape and rounded off due to the series resistance effect. The different performance parameters such as V_{ph} , I_{ph} , $\eta\%$, $ff\%$, R_s , and R_{sh} were then determined and are cited in table-1. It appears that the conversion efficiency, η and form factor, ff improved significantly by the addition of Hg (0.1%) in to CdTe. Obviously, for this cell, I_{ph} and V_{ph} are larger than enhanced and ff . Compared to the solid-solid junction, performance of these cells is poor. The reasons are many: the materials resistance that forms series resistance of a cell, dark color of the electrolyte and absence of the post preparative treatments are some of the adverse. The enhancement in I_{ph} and V_{ph} can be understood from the increase in crystallite size and solar photon absorption volume and decrease in materials resistance due to Hg incorporation in CdTe [8, 9]. Table-1 shows composition dependence of the crystallite size and materials resistance (R_s) which is self explanatory of the performance. As regards the solar absorbance, it has been found that the

photon absorbance coefficient (α) is highest of all for a cell with the electrode composition $x = 0.1$. The spectral response studies were also carried out for these cells. I_{ph} was noted for different incident wavelengths. It has been seen that the absorption edge shifted towards higher wavelength. The enhancement in the short circuit photocurrent, I_{ph} can be correlated directly to the decreased series resistance R_s , of a cell and increased absorption by the electrode material. In this case R_s decreased by approximately an order and can be explained as usual [6, 7]. The room temperature electrical conductivities of these materials were therefore measured. The electrical conductivity (σ) vs composition (x) spectra are shown in Figure 4.

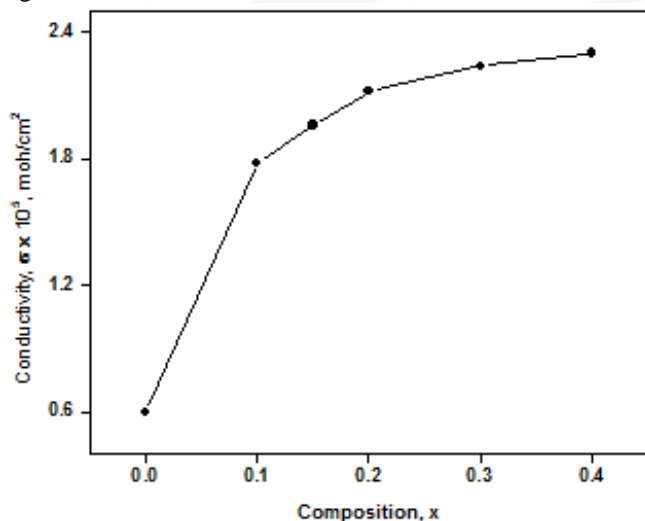


Figure 4: Electrical conductivity vs composition

It is seen that the bulk conductivity (which contributes mainly to R_s of a cell) increased with x up to $x = 0.1$ and then it becomes insensitive to further increase in x [11]. The conductivity modulation can also be correlated with the decreased bandgap of $Cd_{1-x}Hg_xTe$ films and the enhanced crystallite size. The crystallite sizes were therefore determined for all the compositions by an X-ray diffraction technique.

4. Conclusions

The electrochemical photovoltaic cells were formed and the behavior of these cells was examined with a special emphasis given to the photoelectrode composition, x . The dark I-V and C-V characteristics showed presence of the recombination centers surface states at the electrode / electrolyte interface. The PEC cell performance under light excitation is found to be optimum for a cell formed with electrode composition, $x = 0.1$ and is solely due to the increased flat band potential, increased photoelectrode absorption, improved crystalline structure of the photoelectrode material and decreased series resistance of a cell.

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References

- [1] M. Neumann-spallart and G. Tamizhmzni, C.Levy-Clement and N.Boutry-forveille, "Physical properties of electrochemically deposited cadmium mercury telluride films" *Thin Solid Films*, **169** (1989) 315
- [2] M.A.Herman and. Pessa, " $Hg_{1-x}Cd_xTe-Hg_{1-y}Cd_yTe$ ($0 \leq x, y \leq 1$) heterostructures: properties, epitaxy, and applications", *J.Appl. Phys.*, **57** (1985) 2671
- [3] W.E. Spicer, D.J.Friedman and G.P.Carey, "The electrical properties of metallic contacts on $Hg_{1-x}Cd_xTe$ ", *J.Vac. Sci. Technol.* (1988) 2746
- [4] C.Levy-Clement, R. Triboulet and R.Tenne, "Photoelectrochemical properties of the Cd rich $Cd_xHg_{1-x}Te$ alloy", *Sol. Ener. Mat.* **17** (1988) 201. A 6(4)
- [5] M.H. Rais, C. A. Musca, J. Antoszewski, J. M. Dell, B.D. Nener and L.Faraone, "Characterization of dark current in novel $Hg_{1-x}Cd_xTe$ mid-wavelength infrared photovoltaic detectors based on n-on-p junctions formed by plasma-induced type conversion ", *J. Cry. Growth*, **214/215** (2000) 1106
- [6] S. H. Mane, V.S. Karande, V.B. Pujari, J.S. Dargad and L.P.Deshmukh, "A study of cadmium mercury telluride (CMT) thin films structures: Some physical observations and Characteristics", *J. Mat. Sci: Mat. In Elect.*, **16** (2005) 733
- [7] S. H. Mane, V.S. Karande, V.B. Pujari, J.S. Dargad and L.P.Deshmukh, "Studies on Nanocrystalline (Cd, Hg) Te Detector Thin Films" National Seminar on Science and Technology of Thin Films (NSSTTF), 16-17 Oct.2004, R.S. College, Latur, M.S. India
- [8] P.D.More and L.P.Deshmukh, "Photoelectrochemical investigations of n- $CdSe_{1-x}Te_x$ thin film electrodes", *Mat. Chem and Phys.* **80** (2003)586
- [9] V.B. Pujari, S. H. Mane, V.S. Karande and L.P.Deshmukh, "Mercury-Cadmium Selenide thin film layers: structural, microscopic and spectral response studies," *Mat. Chem. Phys.* **83** (2004) 10
- [10] S. Chandra Photoelectrochemical Solar Cells, : (ed.) D.S. Campbell, Gordon and Breach Science publishers, New York, 1985
- [11] V.B. Pujari, V.B. Gaikwad, E.U. Masumdar, P.D.More and L.P.Deshmukh, "An electrochemical visible radiation detector with pseudo-binary $Hg_xCd_{1-x}Se$ thin films", *Turk. J. Phys.* **26** (2002) 407

Table 1: The performance parameters of the various n-Cd_{1-x}Hg_xTe (0 ≤ x ≤ 0.5) electrolyte cells

x	n _L	V _{ph} [mV]	I _{ph} [μA/cm ²]	η	ff%	R _s [Ω]	R _{sh} [KΩ]	V _{ΦB} [V]
0	1.85	375	108	0.07	38	1625	7.03	0.54
0.005	1.69	390	115	0.09	39	1470	7.14	0.60
0.01	1.56	405	118	0.1	39.7	1250	7.50	0.67
0.05	1.45	415	124	0.12	40	1041	7.81	0.78
0.075	1.35	470	147	0.14	42	751	8.68	0.88
0.1	1.27	495	157	0.17	43	650	9.38	0.96
0.15	1.31	420	132	0.11	40	873	8.13	0.82
0.2	1.4	355	100	0.06	39	1654	6.72	0.74
0.3	1.5	325	90	0.05	38	1700	6.52	0.64
0.5	1.63	310	82	0.04	37	1815	6.20	0.51

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