

Characteristics of pulse plated CdSe_xTe_{1-x} thin films

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Semiconducting compounds CdSe, Cd(SeTe) are suitable for the conversion of solar energy into useful electric energy through photovoltaic devices. CdSeTe is a promising semiconductor which is used for various applications like optoelectronic devices, solar cells etc. in the case of mixed compounds such as CdSe_xTe_{1-x}, the optimal direct bandgap of 1.40 eV to 1.70 eV can be achieved by changing the value of x which in turn changes the optoelectronic properties. In the present work, CdSe_xTe_{1-x} films have been pulse plated from an acidic solution at different duty cycles.

CdSe_xTe_{1-x} films were deposited using a conventional three electrode cell with graphite as anode, conducting substrates like titanium, tin oxide on glass as cathode, and SCE as reference electrode. The deposition bath consisted of an aqueous solution of 0.1M CdSO₄, 10⁻² to 10⁻³ M SeO₂ and TeO₂. The pH of the solution was adjusted to 2 by adding dilute sulphuric acid. The deposition was carried out at room temperature for one hour at -700 mV(SCE) under potentiostatic conditions. The duty cycle was varied from 50 % to 6.25 % for all compositions of CdSe_xTe_{1-x}. The thickness of the films was estimated by the gravimetric method. The films were characterized by x-ray diffraction studies using JOEL model JDX-8030 and Cu K α radiation. Optical absorption studies were carried out for the films deposited on conducting substrates with a Hitachi UV-VIS-NIR spectrophotometer. Conductivity of the films was measured by using two probe technique.

The x-ray diffraction pattern of the as deposited CdSe_xTe_{1-x} films, irrespective of duty cycle, exhibited cubic structure. After heat treatment in argon atmosphere at 475°C for 10 min, the crystal structure changes to hexagonal. Peaks corresponding to (100), (002), (101), (110), (103), (112) and (210) along with one Cd line and one Ti line are observed. The composition of the films were measured by EDAX studies.

The optical absorption spectrum indicated a bandgap shift from 1.42 eV to 1.70 eV as the composition of the CdSe_xTe_{1-x} varied from 0 to 1. Absorption coefficient of 10⁴ cm⁻¹ was obtained for the films. The power output characteristics was studied for the photoelectrochemical (PEC) cells made using the pulse plated CdSe_xTe_{1-x} films of different composition with and without pulse reversal at an intensity of 60 mW cm⁻². It was observed that better V_{oc} and J_{sc} are obtained for the composition CdSe_{0.66}Te_{0.34} compared with all the other compositions, hence pulse reversal as well as photoetching studies were carried out on the films of this composition. It is observed that both the current and voltage are found to increase upto a photoetching time of 40s, beyond which both are found to decrease. Hence a photoetching time of 40s was used for studying the load characteristics. After the photo etching treatment the photovoltaic parameters are found to increase. To check reproducibility about 20 films were prepared under each condition. For the pulse plated CdSe_xTe_{1-x} films, in general, taken at random from different batches, V_{oc} varied from 10 % to 13 % and J_{sc} from 6 % to 16 % at 60 mW cm⁻² illumination.

The voltage and efficiency values obtained with the cells studied in this investigation are lower than the values reported for slurry coated ones due to

the lower thickness in this case. The values are comparable with the data reported on electrodes prepared by conventional electrodeposition. The efficiency and current density values are higher than the earlier reports.

The capacitance of the films was of the order of 10⁻⁶ F. Using Mott-Schottky relation, the curves were drawn between 1/C² against V for the films prepared with various duty cycles. A linear variation is observed which indicates that the impurities are uniformly ionised and extrapolation of the line to the x-axis yields a flat band potential of -980 mV (SCE). The Mott-Schottky plots indicate 'n' type behavior. From the slope of the plot, carrier density of 4x10¹⁶ cm⁻³ is obtained. A peak quantum efficiency of 0.51 was obtained at 1.60 eV agreeing well with the bandgap of the film obtained from optical absorption measurements.

The results of this investigation indicate that the output parameters are found to be better than the values obtained. This points to the possibility of obtaining efficient electrodes for application in photo electrochemical cells.