

Pulse Plated Copper Indium Gallium Telluridean Photochemical Cells

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ABSTRACT

Copper indium Gallium Telluride films were deposited for the first time by the pulse electro- deposition technique at room temperature and at a constant potential of -0.75 V(SCE). The films exhibited single phase. Photochemical cells (PEC) were constructed and their load characteristics were studied.

Keywords

Thin films, Solar cells, Pulse electrodeposits, I-III-VI₂ semiconductors, and chalcopyrite

1. INTRODUCTION

Cu-III-VI₂ chalcopyrite semiconductors are feasible candidates for application as photo detectors [1], photo- voltaic cells [2] and light- emitting diodes [3]. Among Cu-based chalcopyrite, a high efficiency of 19.9% has been achieved for Cu(In,Ga)Se₂ (CIGS) based-thin film solar cells with small areas (1 cm^2) [4]. There has been increasing interest in the material properties of I-III-VI, compounds whose energy gap lies between 0.9 and 3.5 eV, as they exhibit great potential for the manufacture of electro-optical devices [5]. Though I-III-Se₂ compounds have received much attention in recent years, there are relatively fewer studies on I-III-Te₂. Earlier no reports on CuInGaTe₂ show a direct band gap semiconductor with an energy gap of 1.23 eV. Bulk CuInGaTe₂ exhibited p-type conductivity due to shallow acceptors [6] with a hole concentration of about 10^{18} cm^{-3} at room temperature [7]. In this work, the pulse electrodeposition technique was employed for the first time [11] to deposit CuInGaTe₂ (CIGT) films for applications of solar cells.

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2. EXPERIMENTAL PROCEDURE

Photoelectrochemical (PEC) cells were prepared using the films deposited on titanium substrates heat treated at different temperatures. The films were lacquered with polystyrene in order to prevent the metal substrate portions from being exposed to the redox electrolyte. These films were used as the working electrode. The electrolyte was 1 M polysulphide (1 M NaOH, 1 M Na₂S, 1 M S). The light source used for illumination was an ORIEL 250 W Tungsten halogen lamp. A water filter was introduced between the light source and the PEC cell to cut off the IR portion. The intensity of illumination was measured with a CEL suryamapi, whose readings are directly calibrated in mWcm^{-2} . The intensity of illumination was varied changing the distance between the source and the cell. The power output characteristics of the cells were measured by connecting the resistance box and an ammeter in series and the voltage output was measured across the load resistance. The photocurrent, dark current and output voltage were measured with a HIL digital multimeter.

3. RESULT AND DISCUSSION

The CIGT photoelectrodes of different concentrations were dipped in the electrolyte and allowed to attain equilibrium under dark conditions for about 10 minutes. The dark current and voltage values were noted. The cells were then illuminated by the light source and the current and voltage were measured for each setting of the resistance box. The photocurrent and photovoltage were calculated as the difference between the current under illumination and the dark current, and voltage under illumination and dark voltage respectively.

PEC formed with the as deposited films of different composition did not exhibit any photoactivity. Hence, they were post heat treated in argon atmosphere at different temperatures in the range of 400 - 525°C. The power output characteristics of the PEC cells made using the photoelectrodes of different composition deposited at 50 % duty cycle and post heat treated at different temperatures is shown in Fig.1-6 from the figures, it is observed that the PEC output parameters, viz., open circuit voltage and short circuit current were found to increase for the electrodes heat treated up to a temperature of 500°C. Photoelectrodes heat treated at temperatures greater than this value exhibited lower open circuit voltage and short circuit current due to the reduction in thickness of the films as well as the slight change in stoichiometry. Hence, further studies were made only on the films heat treated at 500°C. Among the films of different composition, the films with composition CuIn_{0.9}Ga_{0.1}Te exhibited the highest photo output; hence further studies were made on the films of this composition. The power output characteristics of the CuIn_{0.9}Ga_{0.1}Te electrodes heat treated at 500°C were studied at different intensities of illumination in the range 20-100 mWcm^{-2} . The effect of photoetching on the PEC

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performance was studied by shorting the photoelectrode and the graphite counter electrode under an illumination of 100 mWcm^{-2} in 1:100 HCl for different durations in the range 0 – 100 s. Both photocurrent and photovoltage are found to increase up to 60 s photoetch, beyond which they begin to decrease. Photoetching leads to selective attack of surface states not accessible to chemical etchants. The decrease in the voltage and current beyond 60s photoetching can be attributed to separation of grain boundaries due to prolonged photoetching [7].

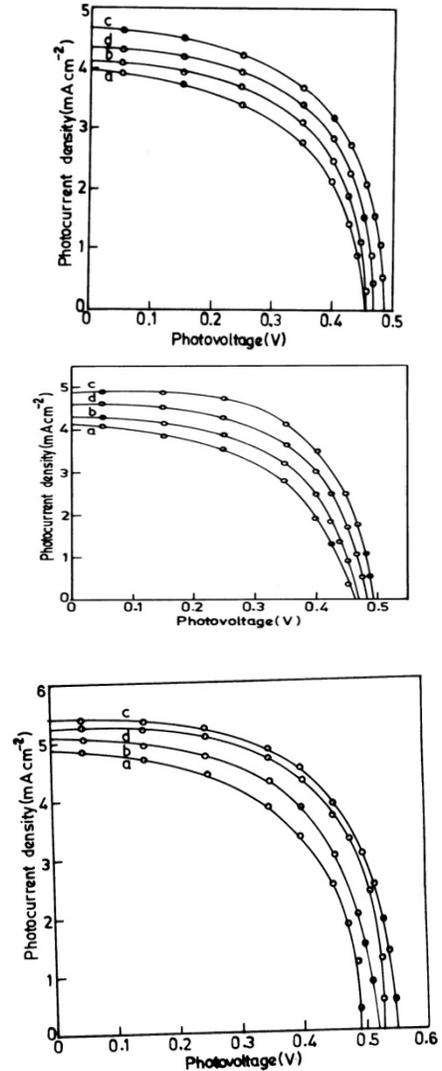
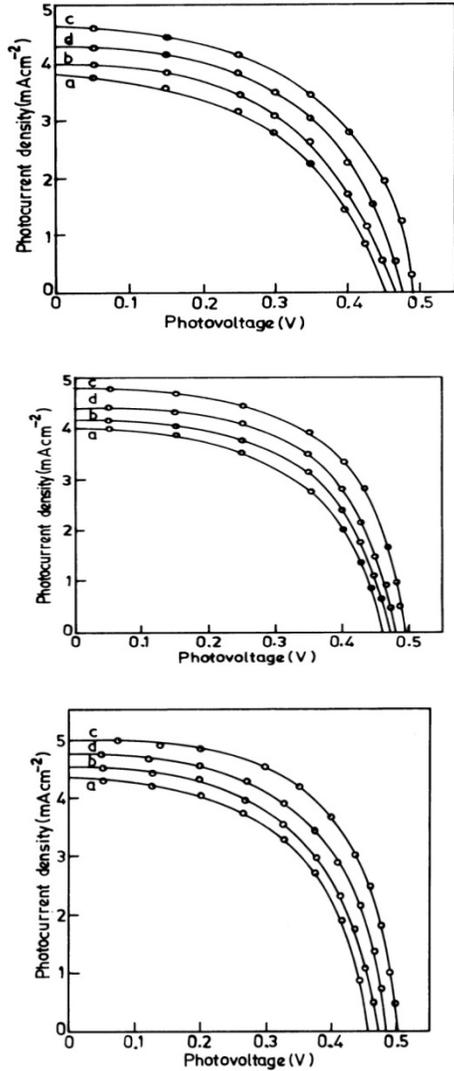


Fig 1-6: Load characteristics of $\text{CuIn}_x\text{Ga}_{1-x}\text{Te}$ electrodes post heat treated at different temperatures (a) 400°C (b) 450°C (c) 500°C (d) 525°C . (where $x=0.1$)

4 CONCLUSIONS

The results of this work clearly points to the possibility of depositing single phase nano-crystalline CuInGaTe_2 films. Photoelectrochemical cell studies were made for the first time on CIGT films of different composition. $\text{CuIn}_{0.9}\text{Ga}_{0.1}\text{Te}$ exhibited maximum photo output. So this films can be used in hetero-junction photovoltaic devices as an alternative to CIGS based solar cells. It can also be used in photo-luminescent devices. The pulse plating technique can be scaled up for large area devices.

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