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Activation energy and density of states of CdTe thin films from temperature dependent *I*–*V* measurements

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ABSTRACT

I–*V*–*T* measurements performed on thermally evaporated CdTe films sandwiched between Aluminum electrodes have been reported over the temperature range of 220–440 K. *I*–*V*–*T* characteristics reveal an ohmic behavior at low biases followed by a SCLC mechanism indicating an exponential distribution of traps. The characteristic temperature of these traps has been estimated at 380 K. The density of these traps and their activation energy has been found to 1.18×10^{23} m^{-3} eV^{-1} and 0.5 eV respectively.

1. Introduction

Interest in the study of thin films of CdTe mainly stems from their application in CdTe/CdS solar cells [1,2]. CdTe and CdS make an ideal pair for solar cell application. CdS with a band gap of 2.4 eV is a suitable window material and permits a large part of the solar spectrum to reach the absorber. CdTe on the other hand, with a direct band gap of 1.45 eV is a near ideal absorber material [3]. Spectral output of the sun peaks at 1.43 eV hence, CdTe is optimally matched to absorb maximum solar power. The fact that CdTe is a direct band gap material helps too, as it does not require much thickness of the material for the solar radiation to be absorbed completely. Most of the solar photons are absorbed in a thickness of 1–2 μm from the interface with the window material [4].

The as deposited CdS films are n-type while the as deposited films of CdTe are p-type, CdTe thus forms a natural pn junction with CdS. The p-type conductivity of CdTe has been attributed to Cd deficiencies which are produced during film preparation and which act as acceptors [5].

To realize an efficient solar cell several material parameters of CdTe must be optimized. This requires careful characterization of the CdTe films themselves. A study of the temperature dependent current voltage characteristics)*I*–*V*–*T*) is a simple but a very useful technique to characterize the current transport mechanisms. Temperature dependent space charge limited conduction particularly can yield information regarding the traps density and possibly the thermal activation energy of the traps [6].

2. Experimental

Al/CdTe/Al sandwich structures were used to study the *I*–*V*–*T* behavior of CdTe films. The geometry of the samples used is shown in Fig. 1. A strip of Aluminum was first evaporated as a base electrode from a tungsten helical filament onto a pre-cut microscope slide. Prior to evaporation, the microscope slides were thoroughly washed in a detergent and dried under hot air. These were subsequently degreased in methanol, dried under a hot air blower and immediately loaded into the Edwards 306 thermal coating unit. CdTe (Cadmium Telluride) films were fabricated onto microscope slides by thermal evaporation in a vacuum better than 10^{-5} Torr. 99.999% pure granular CdTe supplied by Alfa Aesar was evaporated from molybdenum boats. An Edwards FTM7 film thickness monitor was used to monitor the thickness of the CdTe films during evaporation. Finally, the structure was completed by evaporating counter electrodes of Aluminum on top of the CdTe layer. The area of CdTe sandwiched between electrodes was 9 and 12 mm^2. Electrical contacts were made to the device by using silver paste.

The samples were mounted in an Oxford DNV-1liquid nitrogen cryostat whose temperature could be set between 77 K and 450 K by using an Oxford ITC-4 temperature controller. A Leybold PT-50 vacuum stack was used to evacuate the cryostat. Current voltage measurements were performed on a Fluke 3606 Automatic Programmable RCL meter.

3. Results and discussion

3.1. Current–voltage–temperature characteristics

I–*V*–*T* behavior of a typical sample is shown in Fig. 2 for a 500 nm thick film.

The data has been plotted as log *I* vs. log *V* to ascertain any power dependence of current on voltage. It can be seen that the *I*–*V*–*T* relationship can be divided into two distinct regions separated by an

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