

Characteristics of Nanocrystalline CdTe films

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The nanophase films with average grain size ranging from about 5 to 50 nm exhibit properties that are often rather different and improved compared to those of conventional bulk materials. Nanocrystalline films are recently gaining importance due to their interesting characteristics. CdTe nanocrystalline films have been earlier prepared by solution synthesis and electrodeposition using non-aqueous solvents. Alternating current plating technique has also been used for the deposition of CdS nano films. In this work, we report results on CdTe nanocrystalline films deposited on gold coated glass substrates by the dc pulse electrodeposition technique using different duty cycles. Pulse electrodeposition has the advantage of employing high current density for a small fraction of a second. Also during the OFF time unfavourable nucleation centers are dislodged and hence the nature of the deposit is superior compared to conventional electrodeposition.

The deposition bath consisted of 0.5 M CdSO₄ and 0.1 M of TeO₂ (concentrations of the constituents selected on the basis of our earlier work). Glass substrates were first boiled in chromic acid for 5 hours, they were then washed thoroughly in triple distilled water and finally cleaned with acetone. These substrates were mounted in a vacuum evaporation unit. Gold was evaporated under a vacuum of 10⁻⁵ Torr. After evaporating gold for 2 minutes, the substrates were taken out and used as cathode in the electrodeposition bath (the thickness of the evaporated gold film was 0.5 μm). Gold coated glass substrates were kept in the electrolyte maintained at 100°C. A constant current density of 275 mAcm⁻² was used. The deposition was made for 10 min with a constant ON time of 1s and the OFF time was varied from 1s to 15s. The thickness of the films were estimated by gravimetric method. The films were characterized by x-ray diffraction studies using JEOL JDX- 8030 x-ray diffraction unit and CuKα radiation. Optical absorption studies were carried out for the films with Hitachi UV-VIS-NIR spectrophotometer. The samples were examined at room temperature using a Philips Analytical EM 400T TEM operating at 100 kV.

X-ray diffraction studies indicated hexagonal structure with peaks corresponding to (100), (002), (101), (110), (103) and (112) along with one Au line. The crystallite size was estimated from the x-ray diffraction pattern by using Scherrer's formula, it was found to be in the range 10 to 30 nm. All the films irrespective of the duty cycle, have preferential orientation in (002) direction and the peak corresponding to this orientation is found to increase in intensity as the duty cycle decreases (i.e for longer OFF times). This is due to the fact that longer OFF times result in improved nucleation and crystallization as enough time is available for the species to settle down in the nucleation sites before the next set of species reach the cathode during the next ON pulse.

Optical absorption studies were made on the films. A plot of (αhv)² vs hv exhibited a linear behaviour indicating the direct band nature of the films. The band gap value varies in the range 1.50 – 1.99 eV as the duty cycle is varied from 50 % to 6 %. As the duty cycle is decreased, a reduction in size of the particle is observed which results in a change in the band gap value.

The films coated on gold was peeled off from the glass substrate as a foil which was then mounted on the TEM copper G-30 mesh grid. From the TEM images, it is observed that the grain size decreases with decrease of duty cycle. TEM image of the films deposited at 50 % duty cycle indicated large size particles ~ 50 nm. TEM image of the film deposited at 15 % duty cycle, indicate nanocrystals of size 25 nm. As the duty cycle is further decreased to 6 %, nanocrystals of size ~ 10 nm are observed. These results agree well with the results obtained from XRD studies.

A novel, simple and efficient method for obtaining nanocrystalline CdSe films has been demonstrated. The crystal size is found to vary with duty cycle. Further small size crystallites can be obtained by increasing the deposition current density. Better crystallinity can be achieved by pulse reversal during the OFF time. Further work is in progress towards achieving this goal.