CdS Thin Film Photoelectrochemical Electrodes: Combined Electrochemical & Chemical Bath Depositions

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Absract

Nano-sized CdS films were deposited onto FTO/glass substrates by different techniques, namely: electrochemical (EC), chemical bath (CB) and electrochemical followed by chemical bath (EC/CB) deposition techniques. The latter technique is examined here for the first time. Scanning electron microscopy (SEM), X-Ray diffraction (XRD), photoluminescence spectra (PL) and electronic absorption spectra were studied for different films. Photo-electrochemical (PEC) characteristics of different films, such as photo (J-V) plots, dark (J-V) plots, conversion efficiency and stability, were all investigated.

Films prepared by different methods showed different SEM images. Electronic absorption spectra for different films were not much different except in PL intensity values.

PEC characteristics for different films showed different behaviors. The EC/CBD films showed higher light-to-electricity conversion efficiency than EC films, but lower efficiency than CBD counterparts. Moreover, the EC/CBD films showed higher values of JSC with time, than either EC or CBD counterparts, which gives an idea about the advantage of the new described films.

The deposited films were modified by annealing at 250oC under N2. Cooling of preheated films to room temperature was performed by a gradual slow process. The effect of annealing & slow cooling on film characteristics, such as XRD, SEM, PL, electronic absorption spectra were all measured for different films. Photo-electrochemical characteristics of different films, such as: open-circuit voltage (Voc), current density (Jsc), photo (J-V) plots, efficiency and stability, were studied. Films treated by annealing & slow cooling showed higher conversion efficiency than their un-treated counterparts.

SEM images showed that annealing increased the grain size of CdS nano particle in

cases of CBD, EC and EC/CBD. XRD measurements showed that annealing lowered the crystallite size for EC-CdS films, whereas annealing enhanced the crystallite size for both CBD-CdS and EC/CBD-CdS films. Photoluminescence spectra were not affected by annealing except in PL intensity values.

In each prepared CdS film, annealing enhanced PEC characteristics, by increasing conversion efficiency and stability. On the other hand, the annealed EC/CBD showed higher conversion efficiency and stability than either the annealed EC or CBD films.

On the other hand, the higher conversion efficiency of both annealed CBD-CdS and EC/CBD-CdS films than non-annealed counterparts coincided with SEM topography, XRD spectra and PL intensity results. XRD patterns showed enhancement in crystallite size for both annealed CBD-CdS and EC/CBD-CdS films. SEM images showed homogenized layers with more ordered and uniformly packed coagulates for annealed films. In addition, PL spectra for annealed films exhibited higher emission values than non-annealed films. This is because annealing enhances the particle characteristics, giving more uniform and compact surface and consequently higher PL intensity.

The results indicate that the new CdS nano-films, prepared by EC/CBD technique, are advantageous over other earlier known types.