International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., S3, 2015

NCERFM-2015

ISSN: 2321-7758

ENHANCED THE STRUCTURAL AND ELECTRICAL PROPERTIES OF CDS ELECTRODES USING IRRADIATION FOR SOLAR CELL APPLICATION

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ABSTRACT

CdS binary thin films have been deposited on glass and fluorine doped tin oxide (FTO) glass substrates by trouble-free and cost effective chemical bath deposition method and the effect of electron beam irradiation on the structural and electrical properties of CdS thin films. The synthesized CdSe before irradiation nanoflakes-like and E-beam irradiated nanoflakes/nanoflower-like CdS thin films were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM) and field emission scanning electron microscopy (FE-SEM). The XRD pattern revealed the development of CdS with an hexagonal crystal structure in mutually case. SEM micrographs show that the nanoflakes and nanoflakes/flower-like morphology and grain size increase from 12 to 20 nm due to the electron beam irradiation. The solar to electrical conversion efficiency (η) of as deposited and irradiated CdS electrode are found to be 0.37% and 0.67%, respectively

Keyword: Thin film, XRD. FE-SEM, PEC etc

Introductions

Arduous search for something required for clean and cheap energy sources have increased extensive importance in the improvement of solar applications. In exacting, direct conversion of solar energy to electrical energy by using semiconductor photoelectrode has attracted much attention for many years. There is an urgent universal need for choice, renewable energy sources for mutually economic and environmental reasons [1, 2]. Individual exceptionally attractive source of energy is the sun, which continuously sends enormous quantities of light energy to the surface of the earth [3]. However, harnessing this energy requires the development of inexpensive materials systems capable of harvesting sunlight by efficiently capturing photon energy and then quickly separating and collecting the photoexcited charge carriers [4, 5]. Nanotechnology presents new opportunities to achieve higher solar energy conversion efficiencies at lower costs.

Among these alternatives, solar to electrical conversion systems have always been a fascinating and challenging frontier for science and techno-logical applications [2]. To generate chemical energy in a form that can be stored from solar energy is thus an important goal for the development of clean energy. One method for achieving this goal is the use of a photoelectrochemical (PEC) solar cell. Semiconductor liquid junction solar cells have attracted a great deal of attention in recent years due to the growing interest in solar energy conversion [3, 4]. To develop a useful PEC solar cell, a principal requirement is that the photoanode or photocathode should have a bandgap whose energy closely corresponds to the maximum light intensity in the visible spectrum to utilize the solar spectrum efficiently; second, the semiconductor electrodes must be stable with respect to photo-cathodic/photoanodic reactions [4, 5].

Several approaches have been explored towards the synthesis of nanocrystalline CdS nano-particles, Among these, cadmium sulfide (CdS), a II–VI semiconductor with a direct bandgap of 2.4 eV, has proven to be an tremendous photoactive and charge transport material in optoelectronic devices. Cadmium sulfide is therefore an appropriate choice as an acceptor in photovoltaic devices. The behaviour of solar cells in a radiation environment can be described in conditions of the changes in the manufacturing production

parameters of the devices. This advance limits the appreciative of the physical changes which happen in the device.

In present work, we are first time study the structural, optical and electrical properties of CdS thin films which dependence on irradiation. In present investigation, we report chemical synthesis of CdS nanoflakes. Further, these as deposited CdS and irradiated CdS films are characterized by means of structural, morphological and photoelectrochemical properties. The work is novel in the context that the like CdS and irradiated CdS for binary materials is developed by chemical bath deposited for the fabrication of solar cells.

Experimental details:

CdS thin films have been deposited using CBD as reported elsewhere [6]**.** We have used the similar methodology to obtain relatively thicker films. A precursor solution was prepared by
using 50 ml of 0.1M $CdSO_4 \cdot 6H_2O$, 50 ml of 0.1M thiourea and 5 ml of aqueous ammonia in 100 ml beaker. Fluorine doped Tin Oxide (FTO) coated transparent conducting glass was used as substrate with sheet resistance of 35-40 Ω/cm^2. Prior to deposition, FTOs were cleaned with ultra-sonic vibrations in acetone and de-ionized water respectively. Finally the FTO samples were placed vertically in the freshly prepared quiescent solution at 353K temperature and a time 15 min. The yellow CdS films deposited by chemical bath deposition method were homogeneous and well adherent to the substrates. The films were characterized for their structural properties by using Philips X-ray diffractometer PW-3710 (λ=1.54 Å) for copper (Cu-Kα) in 20–100° range. The surface morphology of the film was studied by field emission scanning electron microscopy (FE-SEM) using JEOL JSM-6360. PEC solar cell was fabricated using a two-electrode configuration, comprising FTO/CdS thin film as a photoanode, graphite as a counter electrode. The redox electrolyte was 0.5 M polysulphide ($NaOH:Na_2S:S$). The cell was illuminated with a 100 W tungsten filament lamp (intensity 30 mW/cm^2), for the measurement of short circuit current (I_{sc}) and open circuit voltage (V_{oc}).

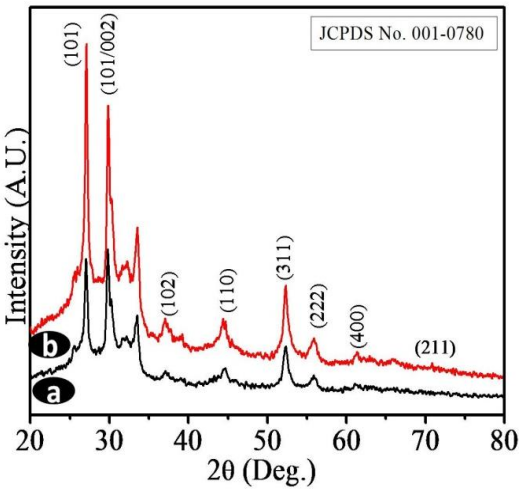

Fig. 1 (a, b) X-ray diffraction patterns of as deposited and irradiated CdS thin films

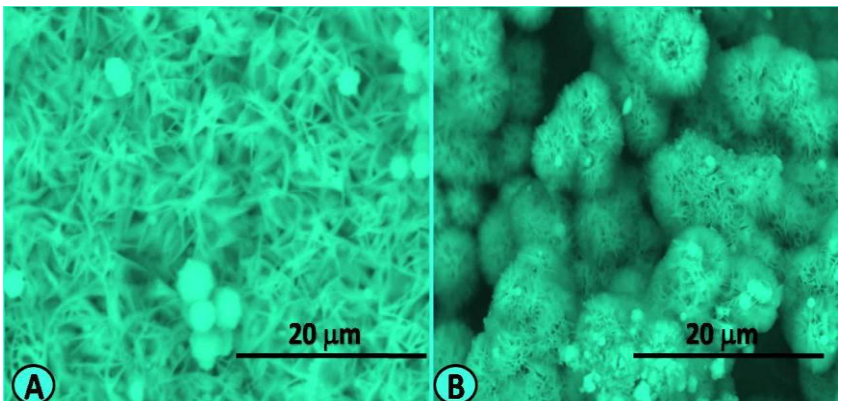

Fig. 2 (a, b) SEM images of as deposited and irradiated CdS thin films at different

RESULT AND DISCUSSION

X-ray diffraction patterns were used to investigate the crystilinity modify before and after electron beam irradiation. Fig. 1 (a, b) shows XRD patterns of CdS before and after irradiation with 7 MeV electrons. Sharp reflections were observed at approximate angles of 27.19, 29.96, 37.16, 44.33, 52.39, 55.82, 61.36 and 70.93° and correspondingly indexed as (101), (002), (102), (110), (311), (222), (400) and (211) respectively. These are characteristics of hexagonal CdS. The full width at half maximum of (101) diffraction was used to estimate the average size of CdS crystallites by Scherrer's formula. The average crystallite size of as deposited CdS was calculated to be 12 nm. When the sample was irradiated with 7 MeV electrons, the average crystallite size of like structure of irradiated CdS was found to be 15 nm respectively, which is more than that of as deposited sample [7]. This shows that the average crystallite size of CdS increases under irradiation with electron irradiation. The peak intensity increases after electron beam irradiation [8]. Increase in particle size after irradiation is due to induced disorder in the structure, increase in particle size after irradiation.

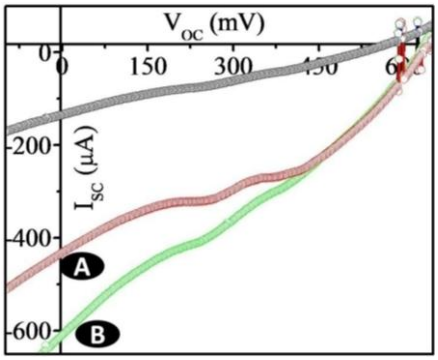

Fig. 3 The J-V characteristics of as deposited CdS (a) and irradiated CdS thin films (b) in dark and in the light illumination

The surface morphology of the chemically deposited CdS thin film and effect of irradiation on CdS thin films was investigated by scanning electron micrograph. Fig.3 (A1-A3) shows the SEM image of CdS thin film and effect of electron beam irradiation on CdS thin film. From the SEM micrographs, observed the entire coverage of nanoflakes-like morphology all over the substrate. Remarkable examination was noticed as deposited CdS thin films was processed with effect of irradiation with respect to formation of innovative nanostructures such as small flowers-like morphologies all over the substrate having grains size about 10 nm respectively. Fig. 2 (A, B) showed that the interconnected nanoflakes and nanoflakes /nanoflowers, which is useful for transformation of ions in electrolyte. Fig.3 (B) showed that the interrelated nanoflakes /nanoflowers, which may be due to electron beam irradiation. This was found to be very constructive for conversion of ions in electrolyte.

The light energy harvesting aspects of nanoflakes (NFs) and nanoflakes/nanoflowers (NFFs) were evaluated using a liquid junction photoelectrochemical cell with pure CdS and irradiated CdS electrodes as the photoanode films under light illumination of 30 $mW \cdot cm^{-2}$. The counter electrode was graphite and the electrolyte consisted of 0.5 M polysulfide electrolyte (Na_2S:S:NaOH) in deionizer H_2O. Figure 3 The short-circuit current density (Jsc), open-circuit potential (Voc), fill factor (FF), and conversion efficiency (η) of asdeposited CdS (NFs) and irrdaited CdS (NFFs) sensitized cells are 450 μA cm^{-2}, 0.62V, 0.32 and 0.37 % and 624 A cm^{-2}, 0.65V, 0.42 and 0.67%, respectively [9, 10]. When both electrode are combined sequentially in a co-sensitized structure, synergistic improvement in Jsc and Voc is observed with a slight change in ff (0.42), leading to a high conversion efficiency of 0.67 %.

Conclusions:

In summary, as-deposited CdS sample as a photoanode and irradiated CdS films as a photoanode for photo electrochemical cell has been prepared by using a trouble-free, rapid and effective chemical bath deposition method. X-ray studies showed that as deposited and irradiated CdS films are polycrystalline in nature. There is a drastic modification in surface morphology with electron beam irradiation. These results

imply that chemical bath deposition and electron beam irradiation techniques was facile and suitable for the different materials for miscellaneous applications.

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