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Abstract

Modern thin film solar cell based on the absorbing layers of CdTe and CIGS have achieved laboratories efficiencies close to 20%. In these solar cells CdS thin films are used as a buffer layer. Due to the narrow energy band gap of CdS (~ 2.4 eV) about 18% of the solar energy is absorbed in the buffer layer. Therefore, it is desirable to replace CdS window layer with another suitable material having wide energy band gap to transmit maximum solar energy to the active region of the device. Secondly, for industrial production of solar cells, it is required to replace CdS with a nontoxic buffer layer material. In most of the cases close space sublimation (CSS) is used to construct these thin film solar cells. But the process of CSS is not amenable to industrial manufacturing. Another problem associated with conventional CSS is that one cannot decouple source and substrate process environs. Therefore, alternate thin film fabrication technologies are also of interest.

The main focus of this thesis is to investigate some of the binary and ternary II-VI group semiconductor thin films such as ZnSe, ZnS, ZnS_xSe_{1-x} and $Mg_xZn_{1-x}O$ to explore the alternate of CdS for the photovoltaic applications. Thin films of these materials with appropriate properties are also desirable for various other applications. Ion-induced electron yield of ZnS thin films was also measured. In addition, a modified closed space sublimation system was developed to eliminate the purported disadvantages of CSS.

Thin films of ZnSe were deposited on soda lime glass by thermal evaporation and annealed in vacuum at various temperatures. XRD studies revealed that as-deposited films were polycrystalline in nature with cubic structure. The grain size and crystallinity increased, whereas dislocations and strains decreased with the increase of annealing temperature. The optical energy band gap estimated from the transmittance data was in the range of 2.60 to 2.67 eV. Similarly, refractive index of the films was found to increase with the annealing temperature. The RMS roughness of the films

increased from 1.5 nm to 2.5 nm with the increase of annealing temperature. Resistivity of the films decreased linearly with the increase of annealing temperature.

ZnS thin films were deposited by modified close spaced sublimation instrument on the glass substrates. The energy band gap of the films deposited at the substrate temperature of 150, 250 and 350 ^{o}C was 3.52, 3.58 and 3.63 eV respectively. These films were then bombarded with 2-10 keV energy pulsed Ar^{+} beam and their secondary electron yield was measured. The most important result of this study was that the electron yield of ZnS films having same composition was different. Monte Carlo simulations performed to interpret these experimental findings showed that the dissimilar electron yields of ZnS films is due to the combined effect of energy band gap, surface barrier potential and density of the films.

The ZnS_xSe_{1-x} films were deposited on soda lime glass substrates by thermal evaporation. XRD measurement showed that ZnS_xSe_{1-x} films are polycrystalline in nature with the preferred orientation along [111]. It was observed that the lattice constant decreases and the optical energy band gap increases with the sulfur content of the film. These results are in good agreement with the properties of ZnS_xSe_{1-x} films deposited by various other methods. Additionally, it was observed that the refractive index of a ZnS_xSe_{1-x} film decreases with increasing sulfur content. The results reported in this paper suggest that the lattice constants, optical energy band gap and refractive index of ZnS_xSe_{1-x} film can be tailored by changing sulfur content of the film.

$Mg_xZn_{1-x}O$ thin films were deposited on glass and quartz substrates by electron beam evaporation and effect of the Mg content of the film on its structural, optical and electrical properties were investigated. The structure, surface morphology, optical transmittance, band gap, refractive index and electrical resistivity found to depend on the Mg content of the film. The structure of the films having Mg content in the range of 1-0.74 was cubic, mixed cubic-hexagonal phases for $x = 0.47$ and hexagonal phase for $x = 0$. It was observed that the optical band gap increases from 3.30 to 6.09 eV, refractive index at 550 nm decreases from 1.99 to 1.75, transmittance increases from about 70% to 90% and electrical resistivity increases from 0.5 to 1.48×10^{6} Ω-cm with the increase of Mg concentration in the film from x = 0 to 1. Laser damage threshold of $Mg_xZn_{1-x}O$ thin films was also measured by using Nd:YAG laser.