ABSTRACT

The direct conversion of sunlight into electricity using photovoltaic properties of suitable material is an elegant energy conversion process. The major key issue in this area of research is low cost manufacturing processes. Thin film solar cells have many advantages including low-cost processing, light weight and flexibility in comparison to the conventional silicon-based solar cells. CuInS$_2$ thin film is one of the most promising ternary chalcopyrite materials for the solar cell absorber. Therefore, investigations have been made on the effect of suitable dopants on the physical and optoelectronic properties of CuInS$_2$ and Sb, Zn, Bi materials and polyol assisted, which are motivated to find their suitability in developing efficient and low cost solar cells and it is used the low cost spray pyrolysis technique. It also gives the available literature review on CuS$_2$, SbCl$_3$, ZnCl$_2$, InCl$_3$ and BiCl$_2$ films, their materials properties and preparation techniques. The aim and scope of the present thesis is also elaborated.

CuInS$_2$ thin films were deposited by spray pyrolysis on glass substrates from aqueous solution of CuCl$_2$, InCl$_3$, and thiourea (SC(NH$_2$)$_2$) using compressed air as the carrier gas. At first, aqueous solution (0.1M) of these salts were prepared. Then they were mixed with appropriate portions in
order to have copper to indium molar ratio (Cu/In=1.25) and sulfur/copper ratio (S/Cu) fixed at 1 in the solution. The Copper (II) chloride and Indium (III) chloride were mixed and then thiourea solution was added. The solutions were prepared by dissolving in de-ionized water. The resulting solution is doped with SbCl$_3$, ZnCl$_2$, BiCl$_2$ (0.01, 0.02, and 0.03M) and 10ml ethylene glycol. Finally the solution is sprayed using spray rates of 2ml/min in air on glass substrates (2.5X 2.5cm) heated at different substrate temperatures from 300ºC - 400ºC.

The X-ray diffraction (XRD) patterns of sprayed films are recorded using the XPERT-PRO Goniometer scan diffractometer with CuKα radiation. The compositional analysis is carried out using energy dispersive X-ray spectroscopy (EDAX). The optical transmittance spectra are recorded in double beam Beckman Ratio Recording spectrophotometer. The surface morphology of the film is investigated using a Jeol, JSM-6390, JM-Spot size 35. Photoluminescence (PL) spectra of the films are recorded using a Cary Eclipse instrument in fluorescence emission scan mode. The resistivity and conductivity studies are carried out by four probe method.

The un-doped, Zinc and ethylene glycol assisted thin films show polycrystalline growth of CuInS$_2$ thin films along (112) preferred plane in the temperature range 300-350ºC. At 375ºC and above the film becomes amorphous. But polycrystalline growth is suppressed along (112) preferred by Sb and Bi doping.
EDAX reports confirm that in all the doped film stoichiometry is achieved when oxygen is taken into account. But ethylene glycol assisted films show better purity with no other impurities. In all the films presence of Cu, In, S and its corresponding dopants are confirmed.

About 90% light transmission occurs in the case of ethylene glycol assisted CuInS$_2$ thin films when compared to un-doped and Sb, Zn, Bi doped samples. The optical absorption coefficients in all doped films are found to be in the order of $10^4$-$10^5$ cm$^{-1}$. Hence, it can be used as an efficient solar absorber and other photovoltaic applications. The optical band gap energy ($E_g$) slightly increases with increase of temperature in all doped samples due to the development of defects and disorders in the film.

Better photoluminescence property is observed in the Zn doped samples, which shows a broad spectral peak emission centered at 500nm (Blue and Green band) in the visible region. PL emission is suppressed by Bi doping.

Electrical studies show the semiconducting nature of thin films and an evolution of P to N type conductivity is observed.

With these enhanced properties, it is possible to construct an efficient solar cell absorber and other photovoltaic devices.