CHAPTER 6

SUMMARY AND SUGGESTIONS FOR FUTURE WORK

6.1 SUMMARY OF THE PRESENT INVESTIGATIONS

This chapter presents the brief report of the work done during the investigation on the deposition conditions of CdS by chemical bath deposition, CdS (pure, Zn and In doped), CdTe, CuInSe$_2$ by electrodeposition and fabrication of CdS/CdTe, CdS/CuInSe$_2$ and CdS/InP solar cell structures by electrodeposition technique and their characterisation studies.

Brief history of thin film solar cell development and its fabrication methods, performance analysis and the scope of the present research work have been reviewed.

Investigations have been carried out to understand the fundamental parameters like concentration of the solution, pH and temperature of the bath solution involved in the chemical bath and electrodeposition of CdS. It was confirmed that the pH of the solution plays a major role in the quality of the chemical bath deposited CdS films. To obtain the precise control over the pH of the solution during the deposition, the bath chamber was successfully modified and used.

CdS thin films have been deposited using chemical bath deposition on glass and by electrodeposition techniques on ITO/Glass and SnO$_2$:F/Glass substrates. Structural, optical and electrical properties have been analyzed for
as-deposited and annealed films. XRD studies on chemical bath deposited (CBD) CdS reveal that the changes in cadmium ion concentration in the bath solution resulted in the change of crystallization from cubic to hexagonal phase. Minimum electrical resistivity with optimum band gap and refractive index values are observed for the annealed films deposited with 0.8 M Cadmium ion concentration, which is suitable for solar cell fabrication.

XRD studies on electrodeposited (ED) CdS revealed the hexagonal polycrystalline deposition. Annealing studies resulted in the increase in lattice parameter values due to the enlargement in the CdS lattice and decreases the band gap value when compared to as deposited films. The variation of optical constants n, k, ε' and ε'' were studied for both as deposited and annealed films.

Zn doping in CdS decreases the lattice parameter values, increases the band gap and resistivity in both the as-deposited and annealed films. Indium doped CdS films exhibit higher optical absorption than the pure. With the increase in indium doping band gap value initially increases and thereafter decrease.

The II-VI binary CdTe and I-III-VI₂ ternary CuInSe₂ have been successfully electrodeposited under potentiostatic condition. The voltammograms have been drawn to identify the CdTe and CuInSe₂ co-deposition regions. Structural, optical and electrical properties have been extensively studied for CdTe and CuInSe₂ thin films deposited on SnO₂:F coated glass substrates. XRD analysis on CdTe results in the cubic phase with (111) predominant plane of crystallisation. XRD analysis on CuInSe₂ indicated the structural transition from Chalcopyrite (tetragonal) to Sphalerite (cubic) according to the variations in film composition. As deposited films at 90°C and annealed films at 350°C under nitrogen atmosphere exhibit the crystallization of single phase CuInSe₂. Band-gap of the CdTe films deposited under same
conditions varies with thickness and electrode potential due to the progressive modification of the film composition during the growth. Cu-rich CuInSe₂ film showed higher optical absorption co-efficient and lower band gap value than In-rich film. Resistivity and type of the CdTe films depend on the electrode potential as it influences the Cd/Te and Cu/In ratios.

CdTe and CuInSe₂ thin films were successfully electrodeposited on CdS/SnO₂:F/Glass substrates and their structural, optical properties have been studied using XRD and UV-Visible spectrophotometer. CdS thin films were also electrodeposited on p-type InP substrate towards the fabrication of CdS/InP solar cell structure. Current - Voltage characteristics have been carried out under the illuminated conditions for the electrodeposited Glass/SnO₂:F/CdS/CdTe/Au-Cu, Glass/SnO₂:F/CdS/CuInSe₂/Ag and CdS/InP/Au:Zn solar cell structures and they resulted in 5.2 %, 2.1 % and 1% conversion efficiencies respectively.

6.2 SUGGESTIONS FOR FUTURE WORK

Further research work can be focused on the fabrication of Glass/SnO₂:F/CdS/CdTe/Au:Cu solar cell structure by controlling the stoichiometry, morphology and post deposition treatment of the CdTe films to improve the interface and better efficiency. Realization towards the optical confinement of the solar cells by replacing CdS with CdₓZn₁ₓS thin films can be done to get higher efficiency. Better results and understanding may be obtained through probing CdS/CuInSe₂ solar cell operation and its associated interface. Optimization of the interface fabrication and interdiffusion for Glass/SnO₂:F/CdS/CuInSe₂/Ag structures towards the higher efficiency through the identification of proper temperature treatment procedure can be done. Interface studies may be carried out for the electrodeposited CdS/InP/Au:Zn solar cells to understand the junction properties for the further improvement in efficiency.