C H A P T E R - VI

SUMMARY AND CONCLUSION

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The range of thin film application is so vast that it extends from micrometer dots in microelectronics to coatings of several square meters on window glasses. Polycrystalline thin films of metals, metal oxides and metal chalcogenides find wide spread applications in industrial technology. To rapid progress in thin film micro and nano materials has given birth to whole new technology of junction devices and integrated circuits of monolithic and hybride types. As Cadmium Sulphide is one of the suitable semiconductor which has wide applications in photoconductor, Solar cells, photoelectric cells, photoresistors, transistors, image magnification etc., and recently in light activated valves for larger screen liquid crystal displays.

Thin films can be prepared by various chemical and physical methods such as chemical bath deposition, spray pyrolysis, electrodeposition, painting, sintering, dipping, sputtering, co-evaporation, electroless, anodization, electrophoresis etc. Amongst these chemical bath deposition has many advantages; it is simple, inexpensive, sophisticated instrumentation and other expensive equipments are not required, starting chemicals are commonly available and cheap. Films can be deposited on any insoluble substrate to which the solution has free access, preparative parameters are easily controllable, the films formed are uniform, reproducible and tightly adhere to the substrate.

The present investigation deals with the chemical bath deposition of CdS films with various Cd:S volume ratios and with Al and Cu doped CdS thin films and their photoconducting properties. All the films were characterised by XRD, optical Transmission and SEM. The Cd:S volume ratio in deposition bath was optimised to get maxium photoconductivity. The effect of annealing on the band gap, particle size and microstructure of the film was studied. The optimised samples were doped with 0.1 wt% Al and Cu seperately and the effect of doping on photoconducting properties of CdS film was studied in air as well as in vacuum (10^{-3} Torr). The present work is divided in to six parts. Chapter I is introductory in nature. It includes a brief survey of chemically deposed CdS films followed by the scope of the present work. The theoritical background of chemical bath deposition and photoconductivity are outlined in Chapter-II. Section 2.2A includes chemical bath deposition technique and section 2.2B gives some aspects of photoconductivity.

Chapter III reports on the chemical bath deposition of CdS films with various Cd:S volume ratio films from aqueous alkaline bath, their characterisation and study of the photoconducting properties. The films have been deposited from various baths containing 0.1 M Cadmium Chloride and 0.1M Thiourea having different Cadmium to Thiourea volume ratio from '5' to '1'. No considerable change in thickness have been observed. The characterisation of the films showed that the films with Cd:S volume ratio '5' has band gap (2.47 eV), and polycrystalline in nature with small (31A^{o}) particle size and non-uniform surface. For photoconductivity study ohmic contacts to CdS were made by silver paste. The photoconducting properties were carried out in air at intensity of light 5 x 10^{3} lux showed that, the films with Cd:S volume ratio '5' were more photoconductive having dark conductivity 2.2. x 10^{-4} mho cm^{-1} , light conductivity 8.5. x 10^{-4} mho cm^{-1} and light to dark conductivity ratio as 3.86. This may be due to Sulphur deficiency in films. Spectral response showed the shifting of peak towards shorter wavelength for increased Cd:S volume ratio. The peak response for Cd:S volume ratio '5' was found to be 450 nm. The photoconducting rise and decay curves showed the increased photocurrent for each successive cycle of excitation. This increase in photocurrent was due to desorption of oxygen molecules which were physically adsorbed on the surface of the CdS films during deposition and then becomes chemisorbed. The rise and decay curves showed more increased photocurrent for Cd:S volume ratio as '5' as compaired to other samples. Nature of log of photocurrent versus log t plot sowed the presence of shallow and deep traps. From above results it was concluded that the films with Cd:S volume ratio as '5' in deposition bath are good photoconductive.

Chapter-IV deals with the effect of Aluminium doping on the photoconducting properties of CdS films prepared with optimised Cd:S volume ratio. For deposition of the films in aqueous alkaline medium, 0.1 M $CdCl_2$ and 0.1 M Thiourea solution were mixed in bath with appropriate volume to maintain the Cd:S volume ratio '5' and to it, 0.1 wt% $Al_2(SO_4)_3$ solution was added. The bath was heated at 65^{o} c for 90 minutes. The results of Al doped films were compaired with that of undoped films. The characterisation of doped films showed no significant change in band gap (2.42 eV) which may be due to the less doping percentage. The XRD and SEM microstructure for doped film showed increased (68 A^{o}) grain size and uniform surface with improved crystallinity respectively. The dark and photoconductivity measurements were carried out in air as well as in vacuum at light of intensity of 10^{3} lux. Photoconductivity of doped sample (3.7 x 10^{-4} mho cm^{-1}) was found to be increased than undoped (2.65 x 10^{-4} mho cm^{-1}) sample in air while significant improvement has been observed in vacuum. In vacuum (10^{-3} Torr) the photoconductivity of doped (1.1 x 10^{-3} mho cm^{-1}) sample was larger than undoped (4.4 x 10^{-4} mho cm^{-1}). This increased photoconductivity of Al doped sample may be due to further increase in Sulphur deficiency. Spectral response peak was shifted towards shorter wavelength (425 nm) for Al doped sample. Photoconducting rise and decay curves for Al doped films both in air and vacuum were more pronounced than undoped one. The rise time 't_r' and decay time 't_d' were (0.08 sec and 0.5 sec) for Al doped and (0.1 sec and 0.3 sec) for undoped samples. The plots, log of photocurrent versus log t and log of photocurrent versus time showed the presence of shallow and deep trap levels. Lux-ampere charactristic showed that at intensity of light, the increase in photocurrent for Al doped film is more than undoped one. From all above results, it is concluded that the photoconductivity of CdS film with 0.1 wt% Al doping is increased.

The Chapter V describes, the deposition of 0.1 wt% Cu doped films, their characterisation and effect of Cu doping on photoconducting properties of CdS films. For deposition of Cu doped films, 0.1 wt% CuCl solution was added to the bath. The characterisation of Cu doped films showed no significant change in thickness as well as band gap (2.49 eV). XRD study showed that doped films are polycrystalline with improved (70 A^{o}) grain size than undoped (31 A^{o}) one. SEM microstructure of doped film showed uniform surface. Silver paste showed good ohmic contact. Dark and light conductivities of Cu doped film were measured in air as well as in vacuum (10^{-3} Torr). The photoconductivity of Cu doped sample was found to be less (6.3 x 10^{-5} mho cm^{-1}) as compaired to undoped (2.65 x 10^{-4} mho cm^{-1}) one in air. The photoconductivities for both samples were found to be increased in vacuum than in air with the photoconductivity of Cu doped (1 x 10^{-4} mho cm^{-1}) sample is less than that of undoped (4.4 x 10^{-4} mho cm^{-1}) one. Spectral peak response of doped sample was shifted towards longer wavelength (475 nA) side as compaired to (450 nA) for undoped sample. This decrease in photoconductivity may be due to addition of monovalent impurity (Cu) causing reduction in coduction band electrons. The photoconducting rise and decay curves showed less increase in photocurrent for doped sample as compaired to undoped one. Log of photocurrent versus log t and log of photocurrent versus time plots showed that both the shallow and deep traps are present. Lux-ampere characteristics studied in vacuum showed that at any intensity of light, there is less increase in photocurrent for Cu doped sample as compaired to undoped sample. The lux-ampere characteristic was found to be sublinear in nature. From all above results, it is concluded that the photoconductivity of CdS film decreased with 0.1 wt% of Cu doping.

From above summaries, it is concluded that the photoconducting properties are improved when CdS films are prepared with Cd:S volume ratio as in deposition bath and with 0.1 wt% Al doping. Whenever photoconductivity of CdS film decreased with 0.1 wt% Cu doping.