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PHOTOCONDUCTIVITY STUDIES OF Ag_2S SEMICONDUCTING THIN FILM

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ABSTRACT
The present paper reports the semiconducting Ag_2S (silver sulphide) thin films were grown on the glass substrate by means of chemical bath deposition method (CBD). Films deposited at the 60^0 in bath containing aqueous solution of silver acetate , thiourea, TEA and ammonia. Silver acetate for silver ion source, thiourea for sulphur ion source, TEA is the complexing agent and ammonia for pH. Photocurrent,Dark current, excitation behavior and photoconductivity rise and decay studies has been done. In the excitation spectra photocurrent exist with the visible wavelength light. Quite good photosensitivity is observed in silver sulphide thin films.

KEYWORDS: Chemical Bath Deposition, Photoconductivity, Thin Films & TEA

INTRODUCTION

Silver sulphide is the sulphide of silver. This dense black solid constitutes the tarnish that forms over time on silver ware and other silver objects. Silver sulphide is insoluble in all solvents, but is degraded by strong acids. When formed on electrical contacts operating in an atmosphere rich in hydrogen sulphide, long filament known as silver whiskers can form. Silver sulphide has three forms, known as mono – clinic, acanthine; stable below 500^0C, body centred cubic so – called argentite, stable below 176^0C and a high temperature face – centered cubic form, stable above 586^0C (Greenwood, 1997). Silver sulphide is a photosensitivity materials. Silver sulphide show quite good photoconductivity behavior. Photoconductivity (PC) studies of I-VI compounds are quite important due to their broad applications in Xerography, photovoltaic solar energy conversion and thin film transistor electronics. Chemical deposition has been found to be quite useful since it presents low cost technique. The importance of such high photo response can be of technological value only when the responses are stable over longer duration. With this aim, stability in PC response was studied for a period of 1 year on Ag_2S films and the results of this study are presented in this paper. There has been increasing interest in the optical properties of semiconductor thin films because of their wide range of applications in science and technology. In recent years much attention has been shown in Ag_2S thin films due to its applications in optical and electronic systems such as photovoltaic cells, solar selective coatings, photoconducting cells, IR detectors, and high resolution optical memories (Wanger, 1953; Cope and Oldsmid 1965; Douglass, 1984; Wagner *et al.,* 2001).

Silver sulphide thin films is a functional material with applications in the contemporary advanced technologies extended over photoconductive and photovoltaic cells, solar selective coatings, ion selective electrodes and membranes to IR detectors, laser recording media etc. Silver sulphide thin films are very promising functional materials for many applications in different electronic components and devices like solar selective coatings, photoconductive and photovoltaic cells, infrared detectors, ion selective membranes and high resolution optical memories (Ezema *et al.*, 2007). CBD technique has been useful for many advantages. In CBD method no requirement for sophisticated instruments, minimum material wastage, economical way of large area deposition and no need of handling poisonous gases.CBD process uses a controlled chemical reaction to achieve thin film deposition by precipitation. The technology is based on slow controlled precipitation of the desired compound from its ions in the reaction bath solution. A complexing agent acting as a catalyst is usually employed to control the reaction in a suitable medium as indicated by the pH to obtain crystal growth.

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EXPERIMENTAL DETAILS

Chemical bath deposition method has been used to prepare the Ag_2S films. This method is based on slow release of Ag and S ions in aqueous basic bath of pH-10, Due to subsequent condensation of these ion Ag_2S are deposited on suitable mounted substrate. The deposition of Ag_2S films was done in a chemical bath prepared in a 50 ml beaker by addition of solutions of 7 ml of 0.1 M Silver Sulphide as a source of Silver, 25ml ammonia for pH alkaline medium, 7 ml of 0.1 M thiourea as source of sulphur and tri-ethanolamine (TEA) used as a complexing agentwith different quantity(2 ml for sample **a,**2.5 ml for sample **b,** and 3ml for sample **c**). Solutions of 0.1M thiourea and 0.1M silver sulphide were prepared from analytical grade chemicals. Film deposition was produced by precipitation followed by condensation on glass substrates. The films were prepared at a constant temperature of 60^{o}C in water bath for 1 hour. The photoconductivity excitation source was an incandescent bulb of 60 W. For PC studies co-planar electrodes of colloidal silver (1.5 mmwide, 24 mm long, with a separation of 2 mm) were painted and dried on the surface of the films. The photocurrents were measured using a nanoammeter at an applied voltage. The films were preserved in desiccators and the PC studies were made at different durations. The resultant films were homogeneous, well adhered to the substrate.

The following equation can be considered for the formation of silver sulphide thin films

$[Ag(TEA)]^{2+} \longleftrightarrow Ag^{2+} + TEA$

$SC(NH_2) + OH^- \longrightarrow CH_2N_2 + H_2O + SH^-$

$SH^- + OH^- \longleftrightarrow S^{2-} + H_2O$

RESULT AND DISCUSSION

(a) <u>Dark Current</u> Fig 1.1 represents the behavior of the dark current with applied voltage for Ag_2S photoconductors. In all the cases a linear behavior is observed.

(b)<u>Photocurrent</u> Fig 1.2 show the rise and decay curves for Ag_2S films prepared in a constant temperature water bath. The bath was made constant at 60^{0}C. All the films reported here are prepared at this temperature. The deposition time for the films was 1 hour. The rise and decay curve have been found to be similar. It is characterized by fast rise in the beginning followed by saturation. The initial increase in the photocurrent upon illumination is due to photo carries generation. The slowly increasing part is when recombination becomes dominant. Decay rates appeared to be slower in Ag_2S thin films. The decay of photo excited electron prolonged by thermal excitation from traps to the conduction band may be taken responsible for the slow decay of the photocurrent.

(c)Excitation Spectral Studies

Spectral studies provide quite useful information. The excitation spectra in which plot of photocurrent is considered against wavelength or frequency of the exciting light, gives information about the nature of light near the absorption edge or different from the absorption edge. Fig 1.3 shows the excitation spectra of undoped Ag_2S thin films. The band gap value obtained for Ag_2S=1.945 eV in accordance with the standard value of Ag_2S.

The peak value of samples is 6400Å

$$E = h\nu = \frac{hc}{\lambda}$$

$$E = 6.64 \times 10^{-34} \times 3 \times 10^{8} / 6400 \times 10^{-10} J$$

$$E = 1.945 \text{ eV}$$

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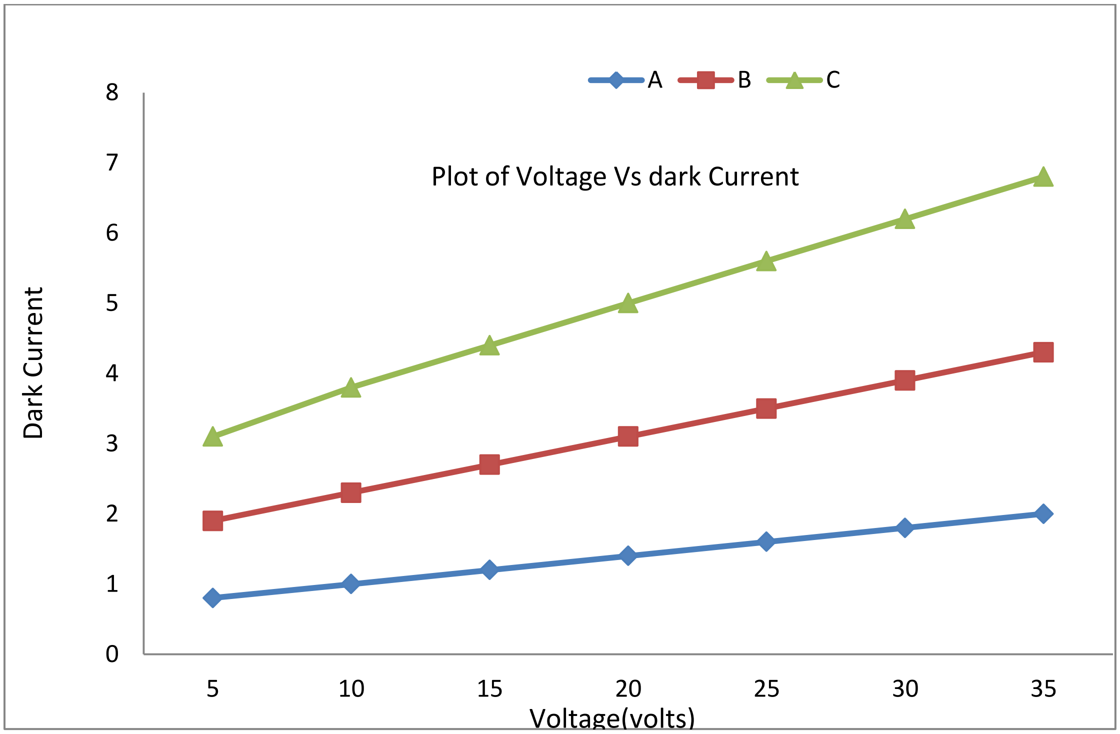

Fig 1.1

(d)Trap depth calculation studies

The observed decay curves are hyperbolic in nature by resolving these decay curves, two straight lines have been found to represent such curve. The resolved curve for Ag_2S (sample a) are shown in fig 1.4. From these straight lines the value of the probability term p have been calculated using $s=10^{11}$ sec^{-1} values of E has been calculated corresponding to different values of p. the value of trap depth is found to be E_1=0.70eV, E_2=0.67eV. These results in accordance with the range of silver sulphide thin films observed by earlier workers. For calculating the values of p and E we have using formula

$p=slope/log_{10}e$ and $E=kt \times log(p)\times(1/log_e)$

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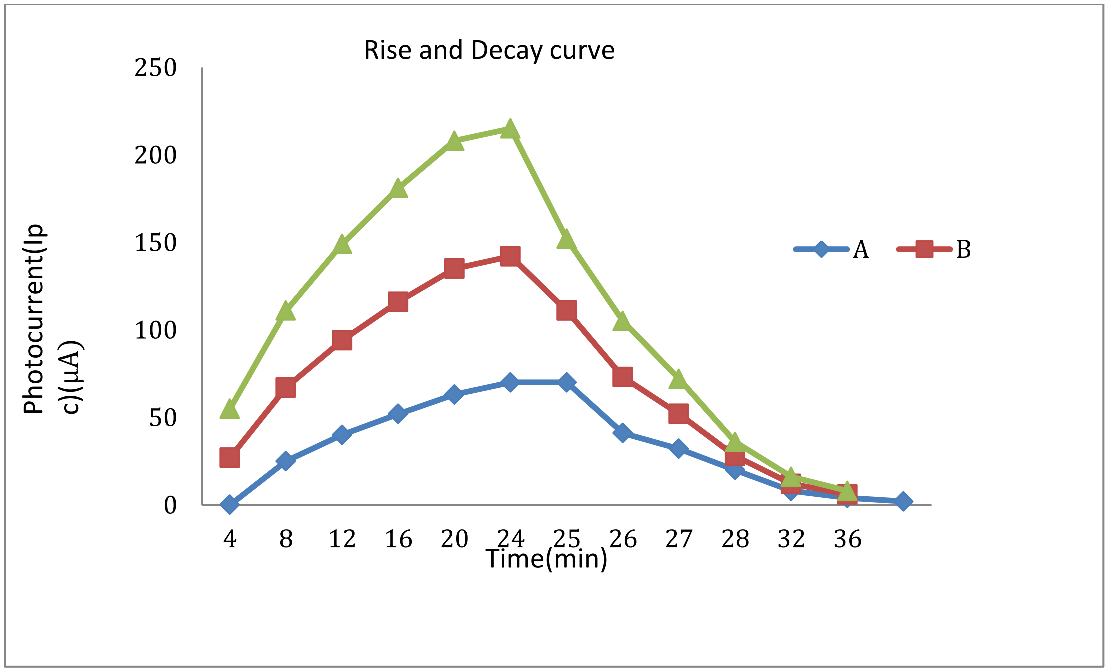

Fig 1.2

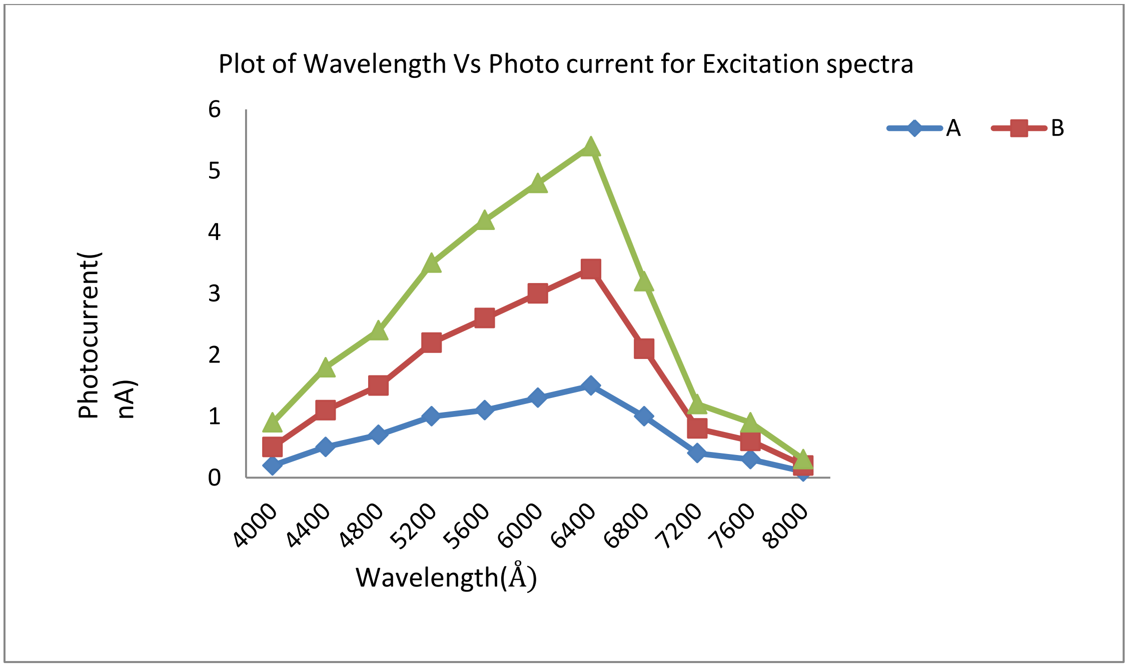

Fig 1.3

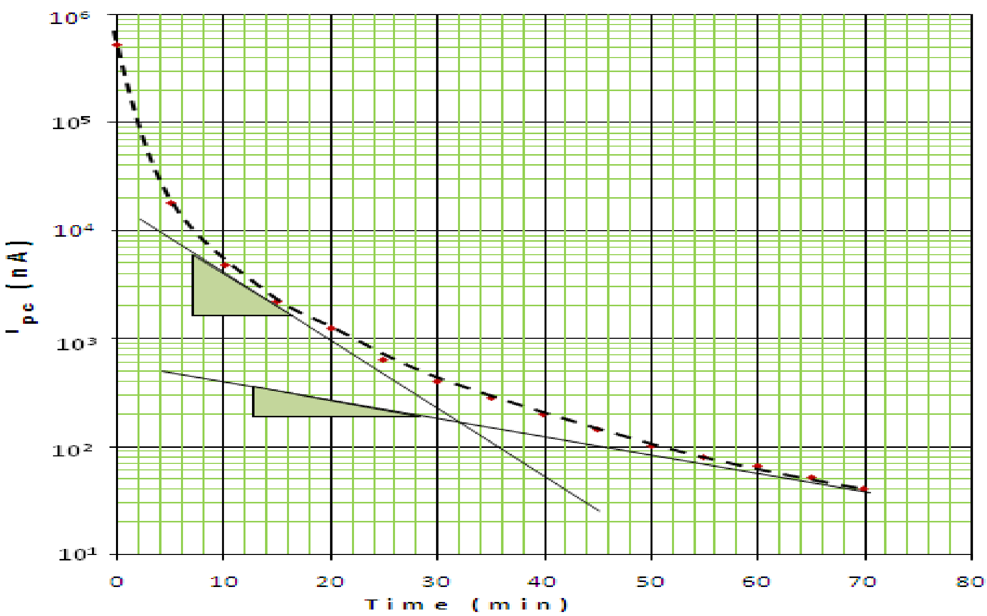

Fig 1.4 peeling off the hyperbolic curve of sample a

CONCLUSION

The silver sulphide thin film prepared by chemical bath deposition technique shows quite good Photoconductivity properties. In the present work silver sulphide thin films have been successfully prepared by chemical bath deposition technique using silver acetate ammonia- thiourea system. The dark current studies shows linear behavior between applied voltage and current, rise and decay studies reflect information that the generation of photocurrent in silver sulphide thin films is very fast and decay rates appeared to be slower in Ag_2S thin films. The deposited thin films are found to be good photosensitive material. The excitation spectra of Ag_2S thin films show the band gap value is 1.945 eV. The value of trap depth is found to be E_1=0.70eV, E_2=0.67eV.

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