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EFFECT OF NEGATIVE AND POSITIVE FIELD ON P-TYPE CUINTE FILMS HAVING EXCESS COPPER AND INDIUM

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Abstract

Significant effect of negative and positive field on transport properties of semiconductor ternary chalcopyrite are investigated. This paper will review a new type of relation which is presented for Silver- Mica- CuInTe2 films, MIS structure. , interface due to application of gate field. Studies of the variation of Hall Co-officient and Hall Mobility with temperature at various gate field for well defined P-CuInTe2 films MIS structure, also variation of effective field effect mobility with temperature, $\mu_{FE}\alpha T^{\delta'}$,$\delta'$ ~0.7.

KEYWORDS: ternary, chalcopyrite, MIS structure, Hall Co-officient, Hall Mobility, gate field

Introduction

$CuInTe_2$ is a copper ternary chalcopyrite compound semiconductor of family A^{I}-B^{III}-X^{VI}_2, They are direct band gap semiconductor which is in optimal range for terrestrial solar energy [1-4]. Various investigation have reported the physical, optical and electrical properties of $CuInTe_2$ [5-8]. Most of the work has been reported on either single crystal or bulk polycrystalline specimens. In order to interpret the surface properties thus influence results from the fact that the field produced by surface charge penetrates to a great depth in the semiconductor and thus effects the electrical transport phenomena. Transport properties of semiconductor ternary chalcopyrite crystal have drawn considerable interest due to their potential application in electronic devices [9-12].

MIS Structure

Field effect has proved to be a powerful tool in studying surface phenomena, this electric field can be produced in a number of ways. A simple way to active this is to fabricate a metal- Insulator/ 0xide- semiconductor (MIS/MOS) structure and to apply a capacitive field. The MIS structure was first employed in the study of surface properties of thermally oxidized silicon by Terman [13], Lehovac and Slodskoy [14].

The MIS/MOS structures have potential applications in electronic and for studying fundamental from narrow band-gap semiconductors are becoming important in monolattic infrared imaging application, MIS structure has received much attention due to its application in solar cell, the existence of the thin insulator (<40 A^o) improves the open – circuit photovoltage and the dark current [15-17].

Experimental

This films of $CuInTe_2$ 1μm thicknesses were thermally evaporated from the above charge in stoichiometric as well as In excess 2at% and Cu excess 2at% , [18,19]. The variation of Hall co-efficient with temperature (log R_H vs 1/T) at various gate field for well defined p-$CuInTe_2$ films in MIS structures given in **Figures 1,2,3.**

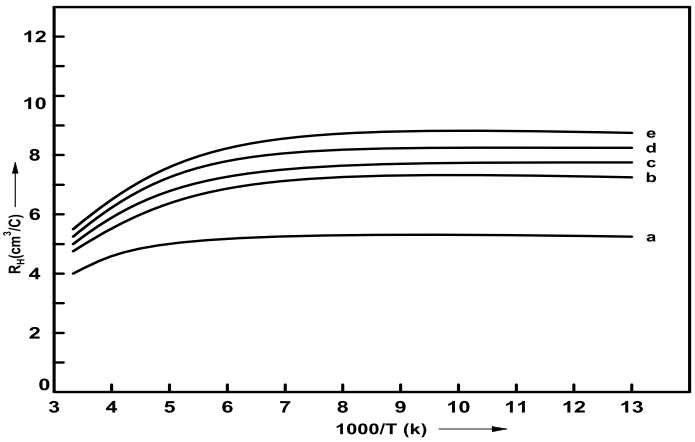

Figure 1: Variation of LogR_H vs 1/T for p-$CuInTe_2$ thin films at various gate field

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a) -2×10^5 V Cm^{-1} b)-1×10^5 V Cm^{-1} c)Zero d)+1×10^5 V Cm^{-1} e)+2×10^5 V Cm^{-1}

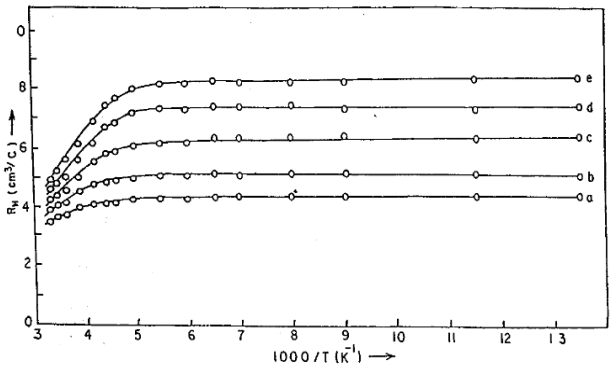

Figure 2: Variation of LogR$_H$ vs 1/T for p-CuInTe$_2$ thin films having 2at.% excess copper at various gate field a) -2×10^5 V Cm^{-1} b)-1×10^5 V Cm^{-1} c)Zero d)+1×10^5 V Cm^{-1} e)+2×10^5 V Cm^{-1}

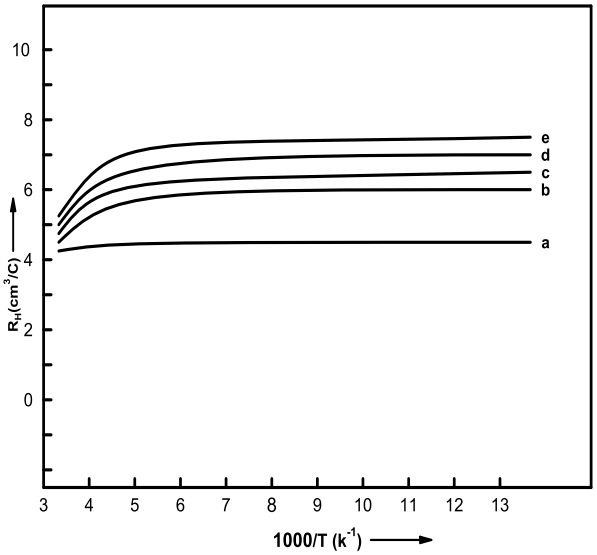

Figure 3: Variation of LogR$_H$ vs 1/T for p-CuInTe$_2$ thin films having 2at.% excess Indium at various gate field a) -2×10^5 V Cm^{-1} b)-1×10^5 V Cm^{-1} c)Zero d)+1×10^5 V Cm^{-1} e)+2×10^5 V Cm^{-1}

It is find from these figures that in the absence of any gate field, the values of R_H for as grown films practically constant in low temperature range 77-170^{o}K, showing the behavior of a typical degenerate semiconductor. R_H found to decrease with the rise of temperature at higher temperature 170 ^{o}K. The decrease of R_H can be attributed to the fact that contribution due to grain-boundary potential starts above 170^o K. Where as for the films having Cu in excess the value of R_H remains constant in the low temperature 77- 180 ^{o} K and for In excess the value is 77- 200 ^{o} K.

The variation of Hall mobility μ_H as a function of temperature (log μ_H vs 1/T) at various gate field for as-grown p-type CuInTe$_2$ thin film and also for the films having 2at% excess Indium **Fig.4**. and thin films with 2at% excess Copper **Fig. 5**. It has been observed that the value of μ_H for p-type CuInTe$_2$ thin films temperature decrease with negative gate field, while the effect of a positive gate field is to increase the μ_H This type of variation of the μ_H with various gate fields can be due to the fact that the gate field causes a change in the free carrier consideration. μ_H increases with increase of temperature at any gate field, which can be attributed to the concentration of the grain boundary scattering mechanism.

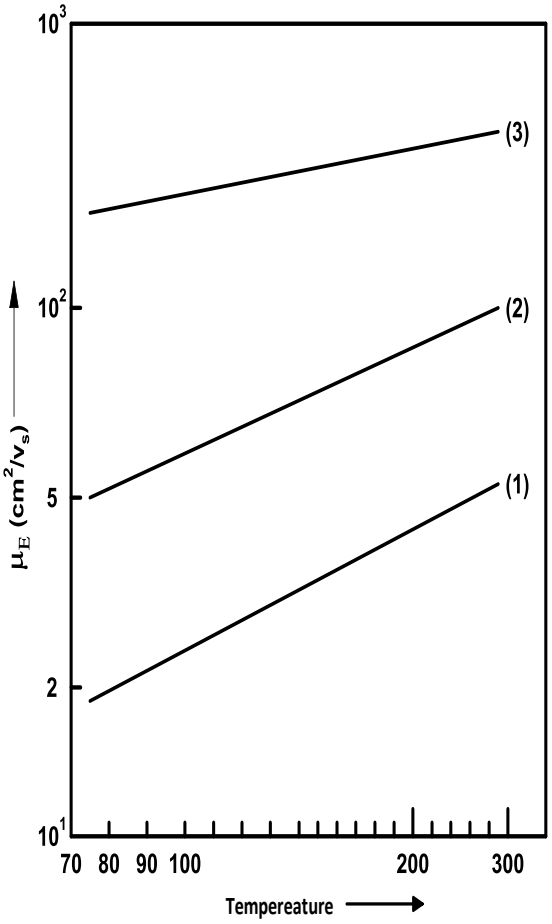

Figure 4: Variation of field effect mobility μ_{FE} with temperature (Log μ_{FE} vs Log T) for 1) as-grown 2)2at.% excess Copper 3)2at.% excess Indium

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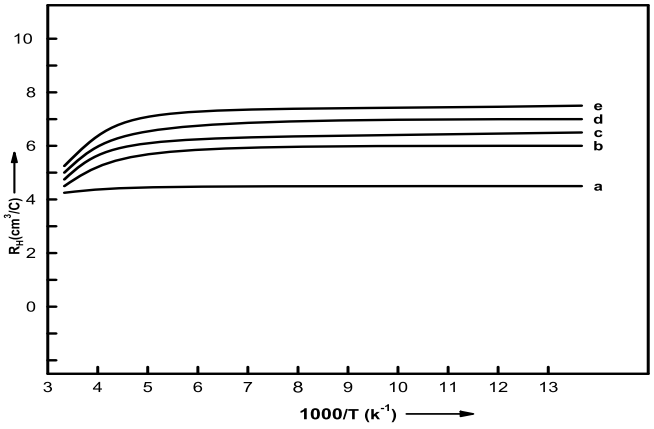

Figure 5: Variation of Log μ_H vs 1/T for p-$CuInTe_2$ thin films having 2at.% excess copper at various gate field a) -2×10^5 V Cm^{-1} b)-1×10^5 V Cm^{-1} c)Zero d)+1×10^5 V Cm^{-1} e)+2×10^5 V Cm^{-1}

The values of grain boundary potential e $Ø_B$ have been obtained at various gate field, are shown in **Table 1**. it may be seen from this table that the value of e $Ø_B$ increases with the increase of negative gate fields, whereas the effect of a positive gate field is opposite. The increase in e $Ø_B$ suggests that the contribution of grain boundary scattering increases with the increase of negative gate field.

Table1: The Value of grain boundary potential for various gate field

S.No.	Applied gate field $\times 10^5 V / Cm^2$	e φ_b (meV) for p-$CuInTe_2$		
		As – grown	2at . % Excess Cu	2at . % Excess In
1.	-2.0	68.7	42.1	34.4
2.	-1.0	63.1	40.8	32.9
3.	Zero	50.9	39.0	30.0
4.	+1.0	47.2	37.7	28.2
5.	+2.0	45.6	35.8	25.2

The d . c . conductivity data for various gate field at different temperature has been analysed to calculate the effective field effect mobility μ_{FE} as a function of temperature [20]. By considering the value of the total charge induced at the interface as a function of applied gate field. It may be observed from figures, that the slope of the curves, for any given temperature, vary with the applied field. The maximum slop of (σ-Q_s) curves were calculated the effective field effect mobility μ_{FE} with temperature (log μ_{FE} vs log T) is shown in Fig. 5. it can be observed that the value of μ_{FE} rises with the increase of temperature in accordance with the relation $\mu_{FE} \propto T^{\delta'}$. the value of δ' calculated from the temperature variation of μ_{FE} is found to be 0.7 indicates that charge fast interface traps and the surface states charge scattering are the dominating scattering mechanisms. It can be observed from related figure that the value of μ_{FE} is high for 2at. % Indium excess $CuInTe_2$ thin film. To study the effect of surface states with temperature, the value of excess charge in the space-charge region ,e |Δp| was calculated. The value of e |Δp| for these films at different temperatures are shown in **Table 2**.

Table2: The Value of Induced charge for defiance temperature

(The Total induced charge = 10.5 $\times 10^8 c Cm^{-2}$)

S.No.	Temperature (°K)	$e\|\Delta N\| \times 10^8 c Cm^{-2}$ p-$CuInTe_2$		
		As – grown	2at . % Excess Cu	2at . % Excess In
1.	77	6.6	6.8	8.3
2.	100	7.0	6.8	8.8
3.	120	6.5	7.2	9.1
4.	170	7.1	6.9	8.5
5.	232	6.0	7.3	7.6
6.	295	6.0	7.0	8.3

It can be seen from this table that the values of (e |Δp|) are nearly constant with temperature and a very little contribution of change in occupation by the surface state and traps with temperature, to the temperature dependence of μ_{FE}.

Conclusion

As grown thin films of $CuInTe_2$ evaporated in vacuum are found to be p-type polycrystalline with large number of 112-oriented grains. It is also seen that the crystalline nature of the films improved with, increase In- contents. Resulting in p-type conductivity, that the composition of as grown charge to be, $Cu_{0.9}In_{1.0}Te_{2.1}$ which is near to the desired stoichiometric and it have a very small excess Te. The electrical, measurement σ , R_H in these In–excess films show that monotically, increase, throughout the temperature range 300 to 77 °k. the study of temperature variation of conductivity show that the dominant conduction in the films up to 2at.% excess In-content is variable range hopping at temperature 200-77 °k while grain boundary activation is more predominant at higher temperature the value of activation energy E_σ, for as-grown film, is 58.4 meV and for 2at% excess Indium

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content is 50.99 meV where it decreases by increase of excess of In-concentration and the value of grain boundary barrier potential e $Ø_B$ is more for as-grown thin films. The value of $Ø_B$ is found to decrease with the increase of excess In-content suggesting the possibility of shortening of grain boundaries with the addition of excess Indium concentration. Know the study of the field effect on MIS structure of p-type $CuInTe_2$thin films revealed that the effect of positive gate field was to deplete the majority charge carriers, while the effect of negative gate field was to accumulate the charge carriers. The study of effective field effect mobility on p-$CuInTe_2$ as-grown, and addition of In, Cu in excesses e.g. 2at%, MIS structure revealed that the surface state charge scattering mechanisms dominate the scattering processes. Finally, it has been seen there is not any change in the occupancy of the surface states in these films.

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