Volume : 5 | Issue : 11 | November 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Original Research Paper

Resistivity, Hall Coefficient and Carrier Concentration of Cuinse$_{2(1-X)}$S$_{2x}$ Thin Films by Spray Pyrolysis

Physics

KEYWORDS :

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ABSTRACT

The I-III-VI2 group semiconductors are of great importance due to their applications in solar cell fabrication. Spray pyrolysis is a very cheap and inexpensive method of depositing thin films of large area. We have deposited CuInSe2(1-x)S2x on glass substrate at 3500C by varying the proportion parameter x by this method. Resistivity, Hall coefficient and carrier concentration were measured at room temperature by Van-der Pauw Hall method. From these results we conclude that resistivity and Hall coefficient increases as composition parameter x increases. While Hall mobility and carrier concentration decreases as x increases. The resistivity, Hall coefficient and carrier concentration fallow the parabolic variation.

Introduction

The I-III-VI$_2$ group material, ternary chalcopyrite compound is the leading semiconductor materials due to low cost and abundance of the constituent element. In view of the important part played by the effect in the study of conduction processes, a few introductory remarks will not be out of place concerning it and its relation to electrical conductivity. The experiment technique to measure the resistivity and Hall mobility of substance in the form of thin films is discussed and is utilized to measure resistivity and Hall mobility of CuInSe$_{2(1-x)}$S$_{2x}$ films deposited by spraying method.

CuInX$_2$ belong to the I-III-VI$_2$ group of semiconducting compound where x = Se/S/Te. These materials crystalline with the chalcopyrite structure and can be regarded as valance analogous of the II-VI compounds. CuInX$_2$ has recently attracted a lot of interest because of its potential for use in solar cells [1] and photovoltaic detectors [2]. The electrical properties of CuInX$_2$ have been described by several authors and it appears that the conductivity type is established through defect doping mechanism. The electrical properties of I-III-VI$_2$ compounds are belived to be dominated by the presence of intrinsic defects such as Cu, In and Se/S/Te vacancies and interstitials.

In this work, a thin films of CuInSe$_{2(1-x)}$S$_{2x}$ have been studied. We represent characteristics obtained from CuInSe$_{2(1-x)}$S$_{2x}$ thin films which shows its resistivity, Hall coefficient, mobility and carrier concentration as a function of composition. There are several method to prepare such films. We have chosen spray pyrolysis due to simple, inexpensive method.

The resistivity and Hall coefficient of this thin film was measured by Van-der Hall Pauw method [3]. The thickness of thin films was measured by Michelson interferometer. Ohmic contacts to the films were established by indium solder (no flux). All readings were taken at room temperature. Temperature of the substrate was measured by precalibrated copper-constantan thermocouple.

Experimental Details

Aqueous solution of CuCl$_2$ + InCl$_3$ + thiourea + Selenourea of 0.003 M each was filled into the spraying apparatus. The substrate was heated at 325 ^{0}C and it maintained to be constant at the time of spraying. As mechanical oscillated of the nozzle was not available, the spraying apparatus was oscillating to and fro by hand to avoid the formation of droplets on the substrate. This spraying was done till sufficient deposition of CuInSe$_{2(1-x)}$S$_{2x}$ had been taken place on the substrate uniformly. Since thiourea and selenourea are taken in excess to avoid the deficiency of sulphur and selenium [4-7], we write CuInSe$_2$/CuInS$_2$ as CuInSe$_2$/CuInS$_2$ by repeating the same procedure for such five thin films of CuInSe$_{2(1-x)}$S$_{2x}$ of various compositions (x = 0, 0.25, 0.50, 0.75 and 1.0) of thiourea and selenourea are prepared.

Measurement of Resistivity, Hall Mobility and Carrier concentration

The resistivity, Hall mobility and carrier concentrations measured at room temperature for CuInSe$_{2(1-x)}$S$_{2x}$ thin films of different composition were shown in table 1. The calculated resistivity, Hal coefficient, Hall mobility and carrier concentration of thin films were plotted against compositions shown in figure 1,2,3,4 respectively.

From the plot we conclude that the resistivity and Hall coefficient increases as percentage of Se increases (S-decreases). While Hall mobility and carrier concentration decreases as percentage of Se increases (S- decreases). Our calculated values of CuInSe$_2$ and CuInS$_2$ were well agree with several workers [5-9].

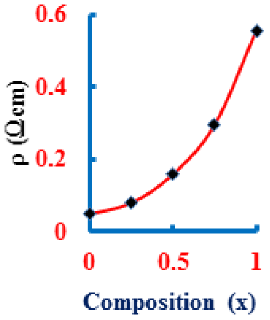

Fig.1. Composition parameter (x) vs Resistivity (ϱ)

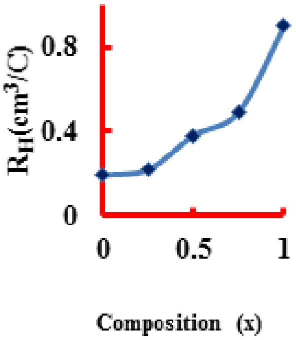

Fig. 2. Composition parameter (x) vs Hall Coefficient (μ_H)

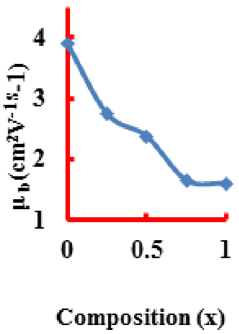

Fig.3 Composition parameter (x) vs Hall Mobility (μ_b)

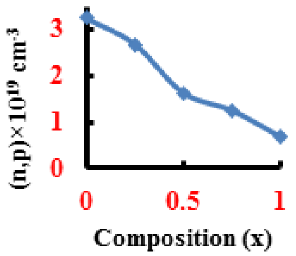

Fig. 4. Composition parameter (x) vs Carrier Concentration (n,p)

Results and Discussion

It is observed that as the composition parameter changes from 0 to 1, the resistivity of the films is changing from 0.49 ohm-cm to 0.5565 ohm-cm. Also the Hall coefficient is found to increases with parameter x. For x = 0, R_H = 0.192 cm^3/C while for x = 1, R_H = 0.897 cm^3/C. Hall mobility as well as carrier concentration decreases with increase in composition parameter 'x'. None of these four variations are found to be linear. It appears that Vegard's law which is true for binary-compound is not applicable to quarternary compound. The mechanism appears to be for from simple.

As the linear variation is not observed one can go in for parabolic variation [12] represented by the equation,

$$P = a + bx + cx^2$$

Where a, b, c are the constant, x- is the composition parameter and P- is the parameter such as resistivity, mobility and carrier concentration.

Thus spray pyrolysis is a simple and inexpensive method for the production of the solid films which is suitable for scientific studies and for many applications in technology and industry.

Table.1 The resistivity, Hall Coefficient, Hall mobility and carrier concentrations measured at room temperature for $CuInSe_{2(1-x)}S_{2x}$ thin films of different composition parameter (x)

composition Parameter (x)	Resistivity ϱ (Ω-cm)	Conductivity σ ($\Omega^{-1}cm^{-1}$)	Hall Coefficient (R_H)= cm^3/C	Hall Mobility = σR_H	Carrier Concentration (n, p) = 1/ R_H e
x = 1	0.5565	1.796	0.897	1.61	0.696×10^{19}
x = 0.75	0.296	3.37	0.4924	1.66	1.26×10^{19}
x = 0.50	0.159	6.259	0.3804	2.381	1.64×10^{19}
x = 0.25	0.08	12.5	0.220	2.75	2.689×10^{19}
x = 0	0.049	20.31	0.192	3.90	3.25×10^{19}

Acknowledgements-

Author would like to express his thanks to the Principal, S. K. Porwal College Kamptee for providing research facilities in the Department of Physics.

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