

Temperature- and time- dependent Hall effect studies on chemically deposited CuBiS₂ thin films

V. BALASUBRAMANIAN*, N. SURIYANARAYANAN^a, S. PRABAHAR, S. SRIKANTH, P. RAVI

Department of Physics, Tamilnadu College of Engineering, Karumathampatti, Coimbatore, India

^aDepartment of Physics, Government College of Technology, Coimbatore, India

Copper bismuth sulphide thin films have been prepared onto well cleaned glass substrates by chemical deposition method using copper nitrate, bismuth nitrate, sodium thiosulphate and EDTA as complexing agent. Studies of Hall effect show that the carrier concentration (n) decreases while Hall mobility (μ) increases with the increase of bath temperature and deposition time period.

(Received December 2, 2011; accepted February 20, 2012)

Keywords: Copper Bismuth sulphide, Chemical bath deposition, Carrier concentration, Mobility, Hall coefficient

1. Introduction

Metal chalcogenides have shown many potential and actual applications in optoelectronic, thermoelectric and photoelectric devices and solar selective coatings [1-8]. Group V-VI compounds are of continuous interest for investigators. Amongst these compounds, CuBiS₂ in thin film form is a promising candidate that can be prepared by various methods [9-12]. In these chemical bath deposition method is a simple, inexpensive and convenient for large area deposition [13-14].

The present work describes a chemical method for deposition of CuBiS₂ thin films from acidic bath on a glass substrates using Na₂S₂O₃ as a sulphur ion source. In this paper Hall effect investigation is made on chemically deposited CuBiS₂ thin films.

2. Experimental details

2.1 Preparation of thin films

0.2M Copper nitrate solution was added into 0.2M Bismuth nitrate solution in a beaker. To the above mixture 0.2M Sodium thiosulphate was added. Ultrasonically cleaned glass substrates were dipped in the reaction bath and the temperature of the bath was increased slowly. Films were prepared for different bath temperatures and different deposition time periods. To enhance uniformity and quality of the films, di sodium salt of EDTA was used as complexing agent [15].

2.2 Hall parameters

The standard Van der Pauw technique is employed to determine the Hall parameters. From the Hall parameters, one can determine the type of the charge carriers, carrier

concentration, mobility of the charge carriers and Hall coefficient of the films.

3. Results and discussion

Hall effect study is a powerful tool for knowing the electronic properties of Semiconductor. Hall measurements are done by Van-der Pauw method at room temperature using a magnetic field at 0.57 Tesla. The Hall effect can be described by means of the Hall Coefficient R_H . The sign of the Hall Coefficient R_H gives information with regard to the type of semiconductor (n or p type). Thin film samples of area one square cm prepared by chemical bath deposition method are used to carry out the Hall studies. Fig. 1, 2 & 3 shows the dependence of Hall coefficient, Hall mobility and carrier concentration of the CuBiS₂ thin films at different bath temperatures (40^oC, 50^oC, 60^oC and 70^oC). Fig. 4, 5 & 6 shows the dependence of Hall coefficient, Hall mobility and carrier concentration of the CuBiS₂ thin films at different deposition time periods (1 hour, 3 hours and 5 hours). The various temperature and time dependent electrical parameters of the CuBiS₂ thin films determined from the Hall Studies are given in Table 1, 2. Hall effect measurements show that the films exhibit n-type conductivity. It may be noted that the mobility increases with an increase of bath temperature and deposition time which may be due to the decrease in carrier concentration film. The above fact can be attributed to the improvement in the crystallinity of the films, which were well supported X-ray diffraction analysis [16]. This is associated with a decreased number of structural defects and increased crystal grain volume in the films higher thickness. It is observed that Hall coefficient increases while carrier concentration decreases with increasing bath temperature and deposition time. Similar observations have also been reported in AlSb films [17] and on Sb films and [18] oxidized in air.

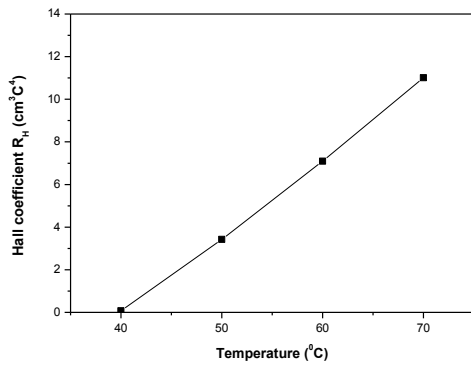


Fig. 1. Temperature dependence of Hall coefficient for CuBiS₂ thin films.

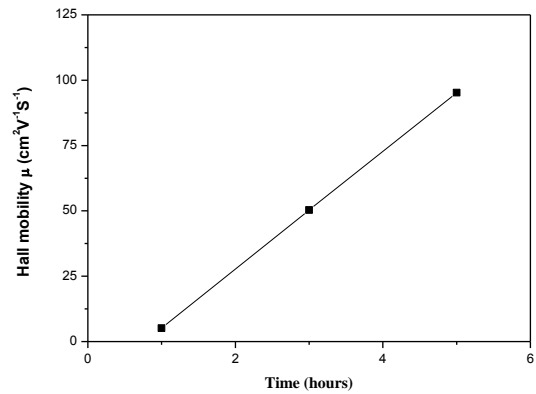


Fig. 5. Deposition time dependence of Hall mobility for CuBiS₂ thin films.

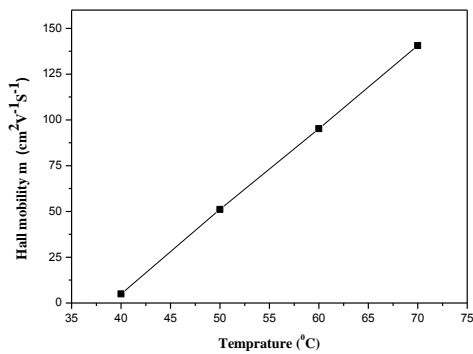


Fig. 2. Temperature dependence of Hall mobility for CuBiS₂ thin films.

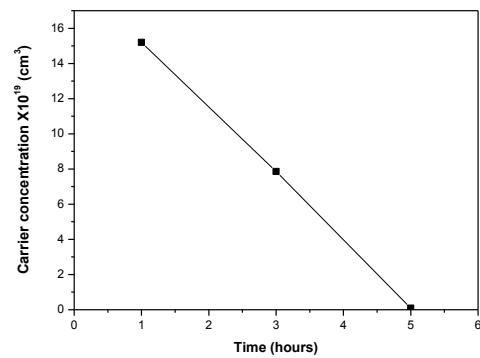


Fig. 6. Deposition time dependence of Carrier concentration for CuBiS₂ thin films.

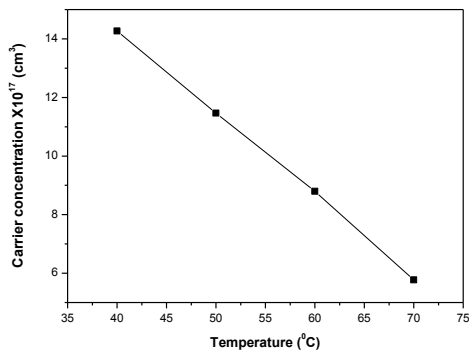


Fig. 3. Temperature dependence of Carrier concentration for CuBiS₂ thin films.

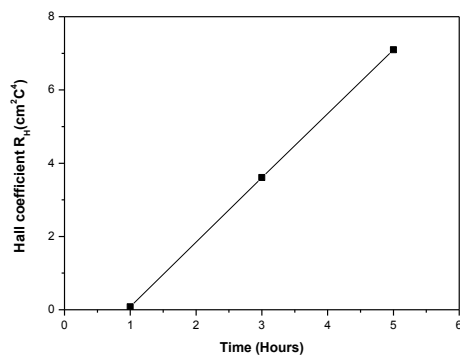


Fig. 4. Deposition time dependence of Hall coefficient for CuBiS₂ thin films.

Table.1 Temperature dependence of Hall coefficient, Hall mobility and Carrier concentration for CuBiS₂ thin films.

Temperature (°C)	Hall coefficient R_H ($\text{cm}^3 \text{C}^{-1}$)	Hall mobility μ ($\text{cm}^2 \text{V}^{-1} \text{S}^{-1}$) $\times 10^1$	Carrier concentration $n(\text{cm}^3) \times 10^{17}$
40	0.0723	0.5002	14.270
50	3.4205	5.1155	11.466
60	7.0970	9.5220	8.7960
70	11.010	14.062	5.7700

Table. 2. Temperature dependence of Hall coefficient, Hall mobility and Carrier concentration for CuBiS₂ thin films.

Deposition time (hours)	Hall coefficient R_H ($\text{cm}^3 \text{C}^{-1}$)	Hall mobility μ ($\text{cm}^2 \text{V}^{-1} \text{S}^{-1}$) $\times 10^1$	Carrier concentration $n(\text{cm}^3) \times 10^{19}$
1	0.0799	0.5152	15.20
3	3.6093	5.032	7.858
5	7.097	9.5220	0.0879

4. Conclusions

From the above study, it is concluded that CuBiS₂ thin films prepared with different bath temperature and deposition time period by CBD are found to be n – type semiconductor. It is also observed that the Hall coefficient (R_H), Hall mobility (μ) increases and carrier concentration (n) decreases with the increase of bath temperature and deposition time period.

Acknowledgements

Authors are grateful to Prof. K. Ramamurthy, Department of Physics, Bharathidasan University for active support and providing facilities.

References

- [1] V. V. Killedar, C. D. Lokhande, C. H. Bhosale, Thin solid films, **289**, 14 (1996).
- [2] S. Prabahar, V. Balasubramanian, N. Suriyanarayanan, N. Muthukumaraswamy, Chalcogenide Letters, **7**, 49 (2010).
- [3] R. S. Mane, B. R. Sankapal, C. D. Lokhande, Material Research Bulletin, **35**, 587 (2000).
- [4] H. Mizogushi, H. Hosono, N. Ueda, K. Kawazoe, Journal of Applied Physics, **78**, 1376 (1995).
- [5] N. Suriyanarayanan, S. Prabahar, S. Srikanth, V. Balasubramanian, D. Kathirvel, Archives of Physics Research, **1**, 81 (2010).
- [6] L. Huang, P. K. Nair, M. T. S. Nair, Thin Solid films, **268**, 49 (1995).
- [7] K. Akamatsu, S. Deki, Nanostructured Materials, **8**, 1121 (1998).
- [8] G. Kongtantatos, L. Levina, J. Tang, E. H. Sargent, Nano Letters **8**, 4002 (2008).
- [9] K. C. Mandal, O. Gavadogo, Journal of Materials Chemistry, **1**, 301 (1991).
- [10] J. R. Lince, Journal of Materials Research, **5**, 218 (1990).
- [11] S. Prabahar, M. Dhanam, Journal of Crystal Growth, **285**, 41 (2005).
- [12] S. Prabahar, V. Balasubramanian, N. Suriyanarayanan, N. Muthukumaraswamy, Journal of Ovonic Research, **5**, 207 (2009).
- [13] P. S. Sonawane, P. A. Wani, L. A. Patil, Tanay seth, Materials Chemistry and Physics, **105**, 157 (2007).
- [14] S. H. Pawar, A. J. Pawar, P. N. Bhosale, Bullutin of Material Science, **8**, 423 (1986).
- [15] P. S. Sonawane, L. A. Patil, Materials Chemistry and Physics, **105**, 157 (2007).
- [16] V. Balasubramanian, N. Suriyanarayanan, S. Prabahar, S. Srikanth, Chalcogenide Letters, **8**, 637 (2011).
- [17] S. M Patel, A. M. Biradar, Indian Journal of pure applied Physics, **21**, 418 (1983).
- [18] P. S. Nikam, R. R. Pawar, Indian Journal of pure applied Physics, **23** 171 (1985).

*Corresponding author: balavelusamy81@gmail.com