

Electrical Resistivity, Thermoelectric Power and I-V Characteristics of Sb-Se Thin Films at Different Compositions.



U. P. Shinde, R. S. Gosavi

Abstract: Sb-Se thin films of varying composition have been deposited on glass substrates at room temperature. These films were annealed at temperature interval of 50 °K. The electrical resistivity (ρ) and thermoelectric power (α) of same films were measured. The resistance of semiconducting films decreases rapidly on heating showing negative temperature coefficient of resistance (T.C.R.). The composition dependent resistivity shows exponential change, sharp fall of resistivity may be attributed due to increase of metallic 'Sb' in Sb-Se thin films. The composition dependent activation energy of Sb-Se thin films has been calculated. The activation energy (ΔE) of semiconducting films was found to increase with selenium concentration. For different compositions thermoelectric power (α) increases upto 70 at. % of Se concentration and then slowly decreases. The I-V characteristics of Sb-Se thin films were measured using copper (Cu) contacts. The films show ohmic conduction for different applied voltages as well as various concentrations of Selenium (Se) in Sb-Se thin films.

Keywords: Sb-Se, substrate, composition, thin films, resistivity, activation energy, thermoelectric power, Voltage.

I. INTRODUCTION

The variation in electrical conductivity obtained by [1] on polycrystalline antimony triselenide was possibly caused by the presence of free 'Se' in the polycrystals. The electrical and the thermal conductivities of the melts of antimony doped antimony selenide was found to depend weakly on the concentration of the dopant [2]. The Sb_xSe_{1-x} alloys and annealed films with $x=0, 0.1, 0.7$ and 0.9 have hexagonal structure and orthorhombic structure for $x=0.3, 0.4$, and 0.5 . The value of the thermoelectric power was found to be 120 μV per degree for pure selenium and is always positive for $x=0, 0.1, 0.3, 0.4$ and 0.9 showing that structures are of p-type conduction, while for $x=0.5$ the thermoelectric power is negative and equals -440 μV per degree, i.e. of n-type conduction [3]. Sb_xSe_{1-x} (0.1, 0.2 and 0.3) alloy film films were prepared onto glass and quartz substrates by thermal evaporation technique. Structural, morphology and optical characteristics of the films were analyzed [4].

Revised Manuscript Received on May 30, 2020.

* Correspondence Author

U. P. Shinde*, Dept. of Electronic Science, L.V.H. Art's, Science & Commerce College, Panchavati, Nashik-422003 (M.S.), India.
upshinde_2008@yahoo.com

R. S. Gosavi, Dept. of Electronic Science, Art's, Science & Commerce College, Rahuri, Dist. Ahmednagar- 413705 (M.S.), India

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

The structural transformation and transformation kinetics of Sb_xSe_{100-x} films ($60 \leq x \leq 70$) were studied to investigate the feasibility of applying Sb_xSe_{100-x} alloys in phase-change nonvolatile memories. The transition temperature, sheet resistance and activation energy for transformation decrease as the amount of Sb increases in the Sb_xSe_{100-x} film [5]. The amorphous films are semiconductive, and their $E_g^{opt.}$ (0.28–0.35 eV) is decreasing with an increasing content of Sb [6]. From the survey of literature, I have undertaken the present investigation to correlate electrical properties of co-evaporated Sb-Se system with different compositions.

II. MATERIALS AND METHODS

A] Preparation of thin films by thermal evaporation technique:

Antimony-Selenium binary films have been formed on glass substrates kept at room temperature by evaporation of pure and antimony and selenium from two different sources, in a vacuum of the order of 10-5 torr. The antimony and selenium both were evaporated from tungsten filament and nichrome windings using mica sheets respectively. Both the elements were simultaneously heated, so as to mix the vapours of 'Sb' and 'Se' gave the required films. The films of different composition have been obtained [7-11]. The set of films thus formed were annealed at different temperatures from 373 OK to 523 OK with temperature difference of 50 OK for 8 hrs each, for the purpose of observing the temperature dependent electrical characteristics as well as uniform distribution of the components in the deposits. After annealing the films were used for composition dependent resistance and thermoelectric power measurement.

B] Measurement Parameters:

a] Resistance Measurement:

The resistance of the specimen measured by digital multimeter. The resistivity [7-10] (ρ) of the sample calculated by the relation,

$$\rho = (R b d) / l, \text{ ohm-cm} \quad \text{----- (1)}$$

Where l = length of the film in cm.

b = breadth of the film in cm.

d = thickness of the film in cm.

R = Resistance of the film in ohm.

b] Measurement of Thermoelectric Power (α):

Thermoelectric Power (α) was measured by differential method. The temperature difference (ΔT) was established between the two ends of the sample and the thermal emf was noted. The temperature difference (ΔT) of 10 OK between two ends of the sample was kept constant for above room temperature.

The variation of emf with temperature is expressed by

$$\alpha = \Delta V / \Delta T, \text{ mV} / 0\text{K} \quad \text{-----} (2)$$

Where ΔV = The differential emf.
 ΔT = The temperature difference between the ends of sample.

c] I-V measurement:

The current (I) flowing through the film sample was measured by sandwiched between 'Cu' electrodes with different applied voltages.

III. RESULTS AND DISCUSSION

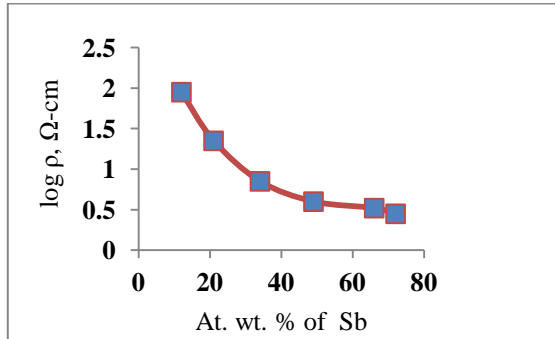


Fig.1: Plot of resistivity (ρ) versus at.wt.% of Sb in Sb-Se thin films at room temperature.

Fig. 1 shows variation of resistivity (ρ) with at. wt. % of 'Sb' of semiconducting Sb-Se thin films at room temperature. It is seen that ' ρ ' decreases exponentially with increase of 'Sb' concentration. This sharp fall of resistivity may be attributed to increase of metallic 'Sb' in Sb-Se thin films.

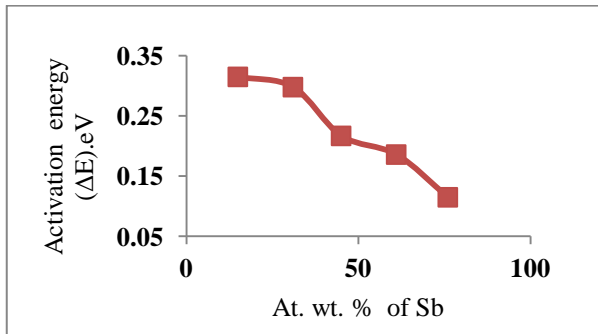


Fig.2: Plot of activation energy (ΔE) versus at.wt.% of Sb in Sb-Se thin films at room temperature.

Fig.2 shows variation of ΔE with at. wt. % of 'Sb' in Sb-Se thin films. the increased concentration of 'Sb' in Sb-Se thin films decreases ΔE , because of trap centers in the forbidden energy gap shifts towards conduction band with addition of 'Sb' into 'Se' causing lower energy of activation of carriers.

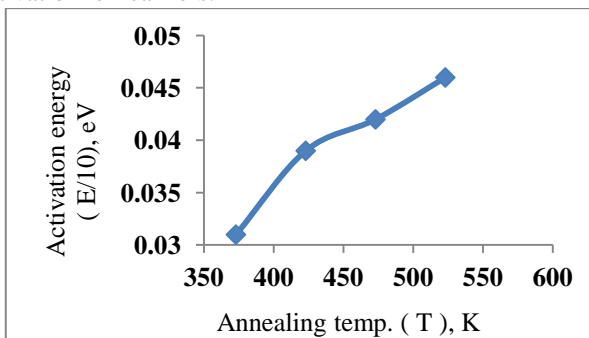


Fig. 3: Plot of activation energy (ΔE) versus annealing temperature Sb-Se thin films.

From fig.3, it is observed that activation energy of Sb-Se thin films of nearly 50 % of atomic weight, increases with increase of annealing temperature. Due to increase of annealing temperature, the components of the film material uniformly distributed over the entire area of the film and there by removal defects.

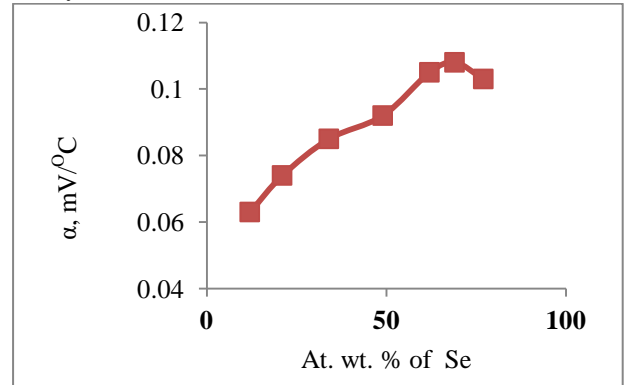


Fig 4: Plot of thermoelectric Power (α) versus at.wt.% of (Se) of thin films.

From fig. 4, it is interesting to see the variation of (α) with at. wt.% of (Se), as the 'Se' concentration increases the TEP ' α ' increases then remains constant because of stoichiometry (Sb_2Se_3) of the films achieved.

From fig. 5, it is seen that the films obeys Ohm's law ($I \propto V$). The observed ohmic dependence of current on voltage at low fields can be explained on the basis that in the sample studied, bulk limited current exceeds the space charge limited current.

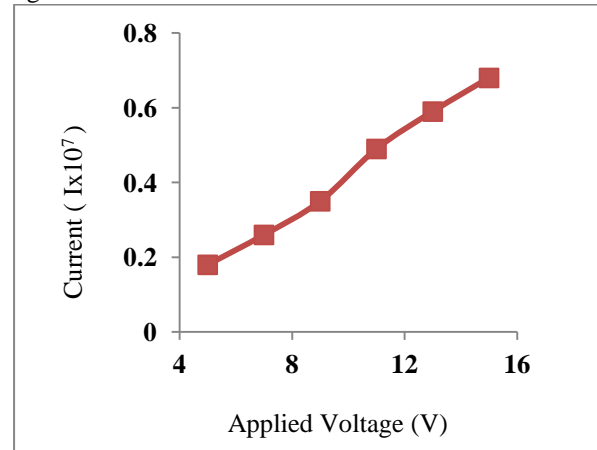


Fig.5: Plot of current (I) versus applied voltage (V) for different compositions of Sb-Se thin films.

IV. CONCLUSION

These films showed temperature dependent semiconducting behavior. The resistivity and activation energy decreases with increase of composition of 'Sb' in Sb-Se thin films, while the activation energy increases with increase of annealing temperature of the films. It is interesting to see the variation of (α) with at.wt.% of (Se), as the 'Se' concentration increases the TEP ' α ' increases nearly up to 70 % then it remains constant because of stoichiometry (Sb_2Se_3) of the films achieved. The I-V characteristics shows Ohmic conduction for any concentration.

ACKNOWLEDGEMENT

The authors are greatly thanks to the Management authorities of M. G. Vidyamandir Panchavati Nashik-03 and The Principal, L.V.H. Arts, Science and Commerce College Panchavati Nashik for providing laboratory facilities to do this work.

REFERENCES

1. M. V. Kat & S. D. Shutov, Vchenye Zapiski Kishinev Univ, 39(1959) 45.
2. V. N. Sokolov, Sov Phys Semicond, 18 (1984) 495.
3. H. A. Zayed, A. M. Abo-Elsoud, A. M. Ibrahim and M. A. Kenawy J of Phys D: App Phy, 28, 4 (1995) 770.
4. A. H. Ammar A. A. M.Farag & M. S. Abo-Ghazala, J of Alloys and Comp 694 (2017), 752-760.
5. M. J. Kang, T. J. Park, D. Wamwangi, K. Wang, C. Steimer, S. Y. Choi & M. Wuttig, Microsystem Technologies 13, 2 (2007) 153-159.
6. L. Hromádko, J. Přikryl & M. Frumar, Thin Solid Films, 31(2014) 17-21.
7. J. de Klerk & E. F. Kelly, Rev Sci Instrum 36 (1965) 506.
8. P. S. Nikam & R. Y. Borse, Indian J Phys 73A (1999) 205.
9. P. S. Nikam & R. R. Pawar, Indian J Pure and App Phys 23 (1995)171.
10. U. P. Shinde, Inter. Jour. of Eng Science Invention 2, 12 (2013) 28.
11. N. S. Rajagopalan and S. K. Ghosh, Physica, 29 (1963)234.

AUTHORS PROFILE



Dr. Ugalal P. Shinde, M.Sc. Ph.D.Associate Professor, Research Guide and Head Department of Electronic Science at L.V. H. Arts, Science and Commerce College, Panchavati, Nashik-422003 (M.S)He has 32 years of teaching experience. Published 27 Research papers in various Journals. Presented 8 papers in an International conferences and attended several National and State level conferences.



Dr. Rajendra S. Gosavi, M.Sc. Ph.D.Associate Professor and Head Department of Electronic Science and Physics, Loknete Ramdas Patil Dhumal, Art's, Science & Commerce College, Rahuri, Dist. Ahmednagar- 413705 (M.S.).He has 30 years of teaching experience. Published 01 Research paper in Journal. Presented 8 papers in an International conferences and attended several National and State level conferences.