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Composition dependent thermoelectric Power (α) of Ag-Te thin films as a function of temperature and thickness.

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Abstract: *Silver –Tellurium thin films of varying compositions and of fixed thicknesses have been formed on glass substrates in a vacuum of the order of 10 $^{-5}$ torr. The films were annealed at constant temperature for 6 to 8 hours, after annealing the temperature dependent thermoelectric power (α) of the films has been evaluated. The phase change of Ag-Te thin films was found to be composition dependent at room temperature and independent on thickness. The thermoelectric power (α) for both p-type and n-type materials for a fixed thickness have been carried out with a constant temperature difference of 10 ^{0}K employing three temperature method.*

Keywords: *Ag-Te, glass substrate, thin films, composition, thermoelectric power, temperature.*

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I. INTRODUCTION

The Silver–Telluride is a I-VI narrow band gap compound semiconductor . The phase transition temperatures as observed during the above semiconductor to metal transition of Ag_2Te reported [1].The electrical and structural properties of silver telluride stoichiometric films have been measured as a function of temperature [2]. Aliev and Nikulin [3] have studied the thermoelectric power of silver telluride in the low temperature ranges from 2 ^{0}K to 90 ^{0}K in order to study the drag effect on carriers in silver telluride. Thermoelectric power of silver telluride increases with increasing temperature from 300 ^{0}K to 415 ^{0}K confirming the degeneracy of carriers [4]. Silver telluride exhibits p-type semiconducting behavior [5,6].

A number of materials are known which show a phase transition at a relatively low temperature. Ag_2Te has a phase transformation at 423^{0}K. The phase transformation with increasing temperature was characterized by decrease in both the density of free carriers and their mobility, with resultant large decrease in dark conductivity [7,8]. The phase transformation in Ag_2Te corresponds to an increase in the band gap from 0.67 eV in the low temperature region to 0.98 eV in high temperature region.

However these compounds are less investigated in the form of thin films of different compositions. From this point of view, I report the measurement of temperature and composition dependent thermoelectric power for different thicknesses.

II. EXPERIMENTAL DETAILS

Thin films of Ag-Te for the measurement of thermoelectric power were prepared by the three temperature method [9-14]. Ag-Te films of different compositions and different thicknesses were prepared by vacuum deposition of the constituent elements Ag (99.999% pure) and Te (99.99% pure). Silver metal and tellurium powder were evaporated from two different preheated conical mica baskets which in turn heated externally by nichrome wire. The films were prepared on glass substrate kept at room temperature in a vacuum of the order of 10^{-5} torr . The films obtained were annealed at ~ 423 ^{0}K for 6 to 8 hours for the purpose of uniform distribution of the components of the deposits. The method employed to determine the composition of the film were similar to those reported earlier [11-13]. The composition of Ag from Ag-Te films was determined by employing absorption spectroscopy [15] at 350 nm.

The film thickness (d) was measured by multiple beam interferrometry [16] and gravimetric method [11-14] using the relation,

$$d = \frac{M}{g \times A}\ cm$$

Where

A = surface area of the film
M = Mass of the film
g = the density of the film material = $x_1 g_1 + x_2 g_2$

where g_1, g_2 and x_1, x_2 are densities and atomic fractions of Ag and Te elements respectively.

III. RESULTS AND DISCUSSION

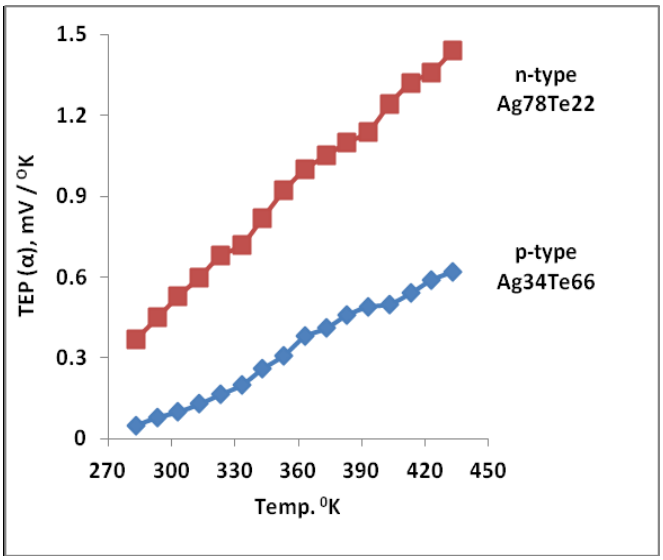

Fig.1: Plot of thermoelectric Power (α) verses Temperature of Ag-Te thin films for different compositions at thickness d~3200Å.

Thermoelectric power (α)studies are made on Ag-Te deposits of different compositions and thicknesses in the temperature range of 273 to 433 ^{0}K, employing differential technique [17-19] with constant temperature difference of 2^0K and 10^0K , in low temperature region (273 to303 ^{0}K) and high temperature region (303 to 433^{0}K) respectively.
In general the thermoelectric power (α) can be expressed as

$$\alpha = \Delta V/\Delta T, \text{ mV/ } ^0\text{K} \qquad \text{---------- (1)}$$

Where
'ΔV' is the differential emf and 'ΔT' the differential temperature.

Fig.1 shows plot of 'α' versus temperature of Ag-Te thin films for different compositions with constant thickness. From fig.1 it is observed that there is liner dependence of TEP on temperature, our observations for linear dependence of 'α' on temperature for all the films, irrespective of its nature (p-type or n-type) is in agreement with bulk thermoelectric power**,**

$$\alpha_B = (\pi^2 K_B^2 T/3e E_F)(U+V). \text{----------(2)}$$

Where

α_B - Bulk thermoelectric power
U= $(d\ln \lambda_B / d\ln E)_{E\text{-}Ef}$ is the rate of change of mean free path with the energy evaluated at the Fermi energy.
V= $(d\ln A/d\ln E)_{E\text{-}Ef}$ is the rate of variation of the Fermi surface area with the energy evaluated at the Fermi energy,
e- Charge (in magnitude and sign) of the carrier.
K_B- Boltzmann constant and T is the temperature in Kelvin.

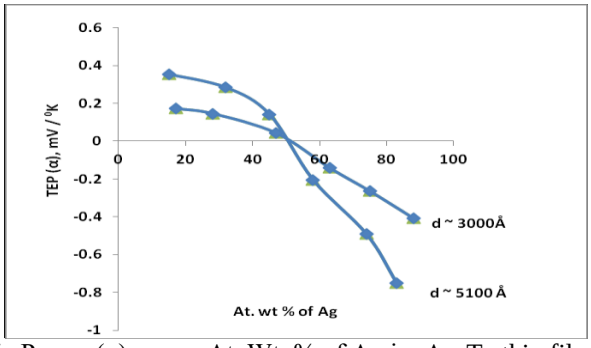

Fig.2: Plot of thermoelectric Power (α) verses At. Wt. % of Ag in Ag-Te thin films at different thicknesses at room temperature .

Fig.2 shows variation of TEP (α) with at. wt. % of Ag at room temperature. It is seen that p-type deposits are converted to n-type at about [Ag] ~ 54 at. wt. %.

It is interesting to note that TEP (α) is found to be changing with composition of the deposits irrespective of thickness (d) and temperature range of studies. The films containing [Ag]< 54 at.wt.% show p-type behavior , while those with [Ag] > 54 at.wt.% exhibit n-type behavior. In other words Ag-Te deposits deficient in 'Ag' are p-type while those with excess of 'Ag' are n-type. Similar observations are reported by Taylor and Wood [20] on thin films of Ag_2Te. The semiconducting Ag-Te deposits of different compositions have narrow band gap with a carrier concentration equal to about 10^{18} cm^{-3}, regardless of the type of carriers, method of preparation and purity of initial components. The semiconducting phase having [Ag]>54 at.wt.% exhibit mixed metallic covalent bond nature hence the material behaves as degenerate semiconductor. The TEP (α) of a metal and /or degenerate semiconductor is given by [21]

IV. CONCLUSIONS

From the present investigation it is observed that Ag-Te deposits with excess of 'Te' exhibit p-type behavior and those with excess of Ag exhibit n-type behavior, therefore it is concluded that the nature of carriers is dependent on composition of the film.

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REFERENCES

[1] Damodara Das V and Karunakaran D, J Phys Chem Solids 46 (5) (1985) 551.
[2] Paparoditis C, J Phys (France) 25 (1964) 226.
[3] Aliev S A, Nikulin E I, Inorg. Mater. 13 (1977) 607.
[4] Damodara Das V and Karunakaran D, Phys. Rev. B 30(1984) 2036.
[5] Chuprakov I S and Dahmen K H, Appl. Phys. Lett. 72(1998) 2165.
[6] Sun Y and Salamon M B, Appl. Phys. Lett. 82 (2003)1440.
[7] Appel J and Lautz G T, Physica, 20(1954) 1110.
[8] Miyazawa H and Sugaike S J, Phys Soc Japan,12(1957) 312.
[9] Damodara Das and Raja Sekar, Thin Solid Films 116 (1984) 163.
[10] George J and Palson T I, Thin Solid Films (Switzerland) 27 (1985) 233.
[11] Shinde U P, Inter J of Engg & Sci Invention. 2013, 2, 12, 28.
[12] Nikam P S and Borse R Y, Indian J Phys, 74A (4), (2000) 419.
[13] Shinde U P and Aher H S, Arch. Appl. Sci. Res. 2015, 7, 4, 71.
[14] Hirde J P and Teburkar Y D, Indian J Pure and Appl Phys 28 (1990) 583.
[15] Charlot G, Colorimetric Determination of Elements , Elsevier Publishing Co- Amsterdam, (1964) 381.
[16] Tolansky's S, Multiple Beam Interferrometry, (Oxford University Press Ltd), London (1948).
[17] Rajagopalan N S and Ghosh S K, Physica, 29 (1963) 234.
[18] Goswami A and Koli S S , Procc of International Symposium on "Basic Problems in Thin Films Physics" Calusthal- Gottingen, (1965) Sept 6-11.
[19] Goswami A and Ojha S M , Thin Solid Films, 20(1974) 307.
[20] Taylor P F and Wood C, J of Appl Phys 32(1961) 1.
[21] Ziman J M , Electrons and Phonons,[Clarendon,Oxford,1962] 397.

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