Electrical and Thermoelectrical studies of Aluminium doped Cadmium Selenide Thin films

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Abstract: Aluminium doped cadmium selenide thin films of varying composition 0.1 to 1.0 mol% have been deposited by deep coating method on clean glass substrate at room temperature. The electrical conductance was estimated via applying to probe technique. The conductance of sample will rise with temperature indicating semiconducting nature of the sample. Activation energy reduces up to 0.25mol% and enhances as aluminium amount increases. Thermoelectrical power estimation of sample in the range of 300 - 525 K. This indicates going up thermo electrical power along with enhancing temperature of every sample suggesting degenerate nature.

IndexTerms: **Conductance, Activation energy, Doping, Thin films**

I. INTRODUCTION

Thin samples perform in area of digital science, in formatics, optical deposition, optics,solar power transformation instruments , metallurgical deposition. [1,2] In thin coating semiconductor solar devices, the mainly semiconductor coated with crystalline or amorphous coating which were prepared or developed on electricity conducting materials, consisting of tin oxidecoated glass, graphite, metallurgical silicon or metal. A thin film of CdS, Si, GaAs, InP, CdTe and many others, may be synthesized onto the substrate by various techniques, like vapor growth, evaporation, plasma, plating etc. [3-11] But the semiconductor thickness is higher than the opposite of the absorptivity, the smaller part radiation will be transmitted; but the diffusion length is higher co mpare to coating breadth, the majority photo-generated carriers may be accumulated.

When solar radiations strike on semiconductors compounds, it produces electron and hole couples. Hence, electrical current is achieved. The movements of carriers carry power.[12] Ristova[13] et al reported silver insertion cadmium sulphide sample via applying an ion interchange technique. The surge of conductance in addition to simultaneous reduction of the photoconductivity was associated to the Ag rise in the sample.

Perna etal [14] reported cadmium selenide and zinc doped cadmium selenide on silicon templates. The samples develop polycrystalline in nature. Electrical conductvity suggests n-nature of pure and doped sample. Luminescence effectiveness of zinc doped cadmium selenide continues up to normal temperature; while luminescence of pure cadmium selenide is not quite visible exceeding 250 K.

When temperature is not extremely low, the semiconductor will carry out electrical energy because of motion of the negatively charged particles in conduction band in addition to holes present within valence band. Mobility is velocity of charged particles/ unit field. The carrier density of the electron or hole of semiconductors lie in the middle of 10^{-2} to 10^{18} $(\Omega cm)^{-1}$

Thermoelectric power became -ve for n-nature substances in addition to +ve for p-nature substances. It is frequently useful to make a decision of conduction type of semiconductors. It might too make use of thermoelectric power to realize the location of Fermi level.Dissimilarity in heat produced by applying potential difference is directly way comparative to temperature variation formed from diagonally of the semiconductor. The carrier density can be estimated applyingthermo electromotive force determination. Referring the signal of potentiometer connection attached at cold end of the thin samples, one might just establish out the sign of the most important charge flow and consequently the kind of semiconductors.

Mixture of dissimilar semiconducting materials was extensively examined.[15-16] Special properties like electronic parameters, mobility of carriers along with the typical gap energy are normally those which decide material steadiness. The calculation of the dimension in semiconducting nanocrystals, a variety of precise electrical and optical characteristics may be attained [17-18]

II. Materials and Methods

The templates applied for depositing the samples have been non-conducting non crystalline and roughly hundred percent radiation emitted amorphous plates of dimensions 74 x 24 x 19 mm. glass and conducting stainless steel plates are used as substrates. Every chemical applied in preparation have been analytical level. Ammonia, selenium powder, cadmium sulfate, sodium sulphite and trichloroacetic acid were utilized.

Sodium selenosulphate (0.2 M) became applied selenide ion resource for synthesize of cadmium selenide samples. The mixture became ready by heating 3.0 g selenium fine particles accompanied by 9.0 g Na_2SO_3 in 100mL two fold purified water for 8 hour on 353 K. Mixtures became cool, filter to take out solid residue and put in storage in flask.[19]

10 mL of (0.2 M) cadmium sulphate solution were placed in 100 mL glass beaker. Trichloroacetic acid was added so that metal ions get complexed. 15 mL (5N) ammonia added in this beaker. Changeable quantity of aluminum cations as of 0.01 to 1.0 mol% became mixed. After that 10 mL of (0.2 M) sodium selenosulphate was mixed in reactive solution. With help of pH meter, pH of reactive solution was decided. This was detected to 10.21. Reactive solutions become kept in ice. Reaction components become stirred intensely preceding dropping non-conducting as well as conducting templates. Such templates maintained standing fairly sloped in glass container. Temperature of ice bath became now admissible to go up 298 K. Completion of reaction occurs in 4 hrs. Deposited templates were aloof.

III. Result and discussion

The technique consists of two or four probe. The two point technique is simple, easy to employ in addition to helpful for larger resistive sample. Using such approach, stable D.C. voltage is implemented among two rigid locations on exterior of the film sample . When uniform thin films is used, the electrical charge flow is represented by

$\sigma = (d/A)\ (I/V)$ ---------------------1

$A = tb$-----------------------------------2

Where t = thickness of the sample and b = width of thin film sample.

As temperature boost the number of carrier enhance abruptly. Hence, as the temperature increases electrical conductivity increases rapidly. The activation energy is estimated via utilizing mathematical representation;

$\sigma = \sigma_o \exp(-E_a/kT)$ ------------------------3

Wherein σ is conductivity of the thin films. $\sigma_o$is a factor depends on thin films properties like width, crystalline phase. $E_a$signifies activation energy of electrical conductivity, k is Boltzmann's parameters.

The electrical conductance of aluminium doped cadmium selenide samples on amorphous templates was estimated via applying two probe techniques. The conductance of samples will rise having raise in temperature, indicative of semiconducting nature of the sample. The deviation of log (conductivity) in opposition to opposite absolute temperature was represented in figure.1.The value of specific conductance was found to be $1.541 \times 10^{-7}\ (\Omega\ cm)^{-1}$ at 300K and 2.65×10^{-4}

$(\Omega\ cm)^{-1}$ at 525 Kfor 0.01 mol% of aluminum. Similarly, specificconductance was found to be$1.742 \times 10^{-7}\ (\Omega\ cm)^{-1}$ at 300 K and $2.724 \times 10^{-4}\ (\Omega\ cm)^{-1}$ at 525 K for 1.0 mol% of aluminum.The electrical conductance at 300 K enhance as the aluminum quantity raise upto 0.25 mol % and afterward magnitude reduce for greater amount. Up to 0.25 mol % inclusion of aluminum in the network consequences in diminish in border potential and enhancement in particle dimension that outcome in boost of carrier quantity in addition to mobility.[20] As ionic radii of aluminum ion is a lesser amount than cadmium ion, the assimilation may perhaps origin a dispersion method thus dropping mobility.[21] Higher than 0.25 mole % theconductance reduce, as progressively deformation is found in the crystal network, that consequences in raise in granule border dispersion, thus diminish the carrier flow.[22-23]

Activation energy is measured applying equation

$\sigma = \sigma_o \exp(Ea/kT)$ ---------4

Wherein σ_o is invariable

Activation energy became turn out to reduce upto 0.25 mol % and enhance as aluminum amount increase. The activation energieshave been estimated to 0.102 eV and 0.291 eV at lower and high temperature region for 0.01mol% aluminum dopant. Activation energies have been computed to 0.103 eV and 0.279 eV at lower and higher temperature region for 1.0 mol% aluminum dopant. The various electrical parameters are enlisted in table 1.

Thermoelectric power estimation of aluminum doped cadmium selenide sample in the range of 300-525K. This indicates going up thermoelectric power alongwith enhancing temperature of every sample suggesting degenerate nature. Temperature dissimilarity among the both ends of thin films origins transportation of mover from the warm to cold end. Consequently generating a potential difference that provides grows in thermovoltage transversely ends. Study of CdSe: Al samples, the -ve sign became linked to the cold part; consequently, the sample suggest n-nature conductance. Outcome of thermoelectric power measurement became denoted in figure 2. Figure indicates this parameter changes almost linear in smaller temperature region whereas for higher region it changes sharply.Up to 0.25mol %

dopant, the divergence is greater whereas for higher doping amount the divergence go diminish. Thermoelectric power was found to be 21.03 to38.91μv/K in the temperature range from 300- 525 K for 0.01 mol % dopant. For 1.0 mol% dopant sample, thermoelectric power alteration from 21.68 to 35.17μv/K was measured in the temperature 300 to 525K.

The linear character of plot became obtained. The quantity of carrier. [24] with corresponding to temperature is estimated applying equation log n = 3/2 log T – 0.005 P + 15.7198---------------5

For every dopant sample. At initial temperature (300K), the amount of carrier became turn out to be 3.472 x 10^{19} and 9.876 x 10^{19} at other extreme (525K) for 0.01mol% aluminum dopant. For 1.0mol% dopant, the magnitude of quantity of carrier became turn out to be 3.551 x 10^{19} at 300 K and 9.459 x 10^{19} at 525 K. Amount of carrier enhance as temperature mount. At lower temperature amount of carrier is little, although greater temperature amount of carrier enhance. Amount of carrier increases with dopant quantity up to 0.25 mol% aluminum, subsequently for greater doping level it reduces.

The expression 6 became utilized to turn out the mobility of carrier of each dopant sample. [25]

$\mu = \sigma/ne$------------------------6.

For 0.01mol% dopant, at initial temperature mobility of carrier became turn out to 0.019cm^2/V.sec while 149.4 cm^2/V.sec at 525 K. For 1 mol% dopant, at initial temperature mobility of carrier became obtained to be 0.020cm^2/V.sec at 300 K while 151.3 cm^2/V.sec at 525 K. As temperature rise, mobility too enhances. Mobility enhances for upto 0.25mol% aluminum dopant. The grain boundary potential became estimated via applying a chart pattern of log $\mu T^{1/2}$ with opposite temperature.Potential barrier height at granule border[26] reduces alongwith aluminum amount up to 0.25 mol%, however larger for greater than 0.25mol% dopant. The different thermoelectric parameters are enlisted in Table 2.

IV. Conclusion

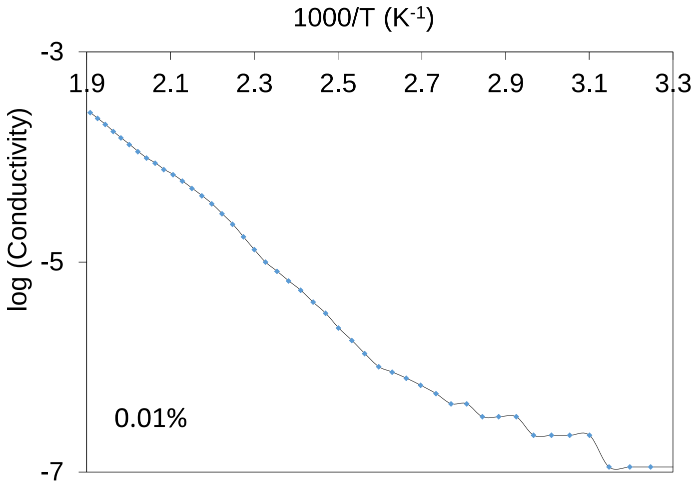
Amount of aluminum in cadmium selenide sample varies as of 0.25mol% electrical conductivity goes on surges. Higher than 0.25mol% it eases. Activation energy became turn out to reduce upto 0.25 mol % and enhance as aluminum amount increase. The entire aluminum dopant samples suggest n-nature conductance. Amount of carrier increases with dopant quantity up to 0.25 mol% aluminum, subsequently for greater doping level it reduces. Mobility enhances for up to 0.25mol% aluminum dopant. Potential barrier height at granule border reduces along with aluminum amount up to 0.25 mol%, however larger for greater than 0.25mol% dopant.

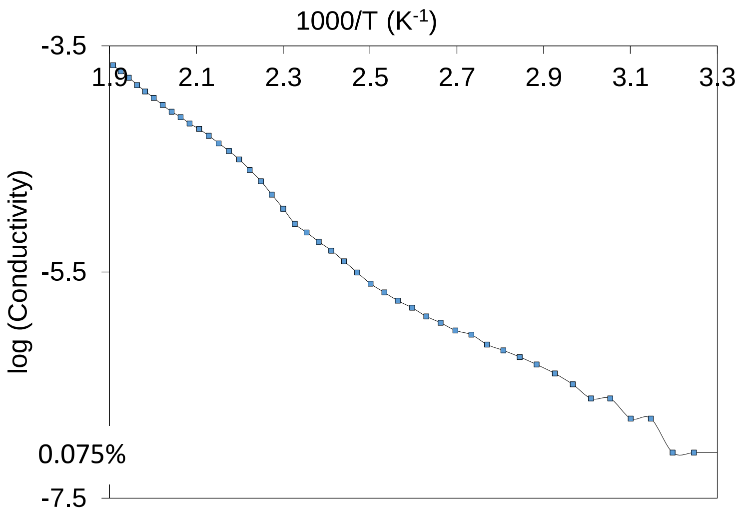
No.	Composition	Specific Conductance $(\Omega\ cm)^{-1}$		Activation Energy (eV)	
		300 K (10^{-7})	525 K (10^{-4})	LT	HT
1	0.01	1.541	2.731	0.102	0.291
2	0.025	1.794	2.846	0.096	0.282
3	0.05	2.012	3.217	0.090	0.273
4	0.075	2.295	3.632	0.084	0.268
5	0.1	2.535	4.353	0.077	0.259
6	0.25	2.795	5.033	0.071	0.251
7	0.5	2.265	4.424	0.081	0.260
8	0.75	1.973	3.912	0.093	0.269
9	1.0	1.742	2.724	0.103	0.279

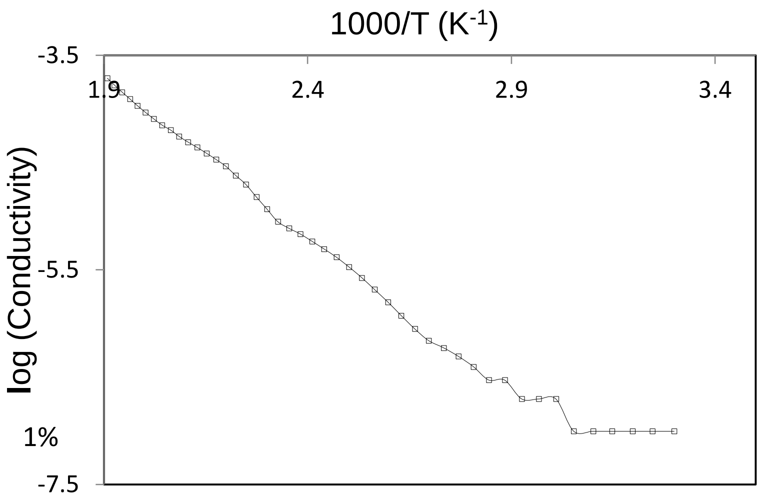
Table 1. Electrical parameters of aluminum doped cadmium selenide.

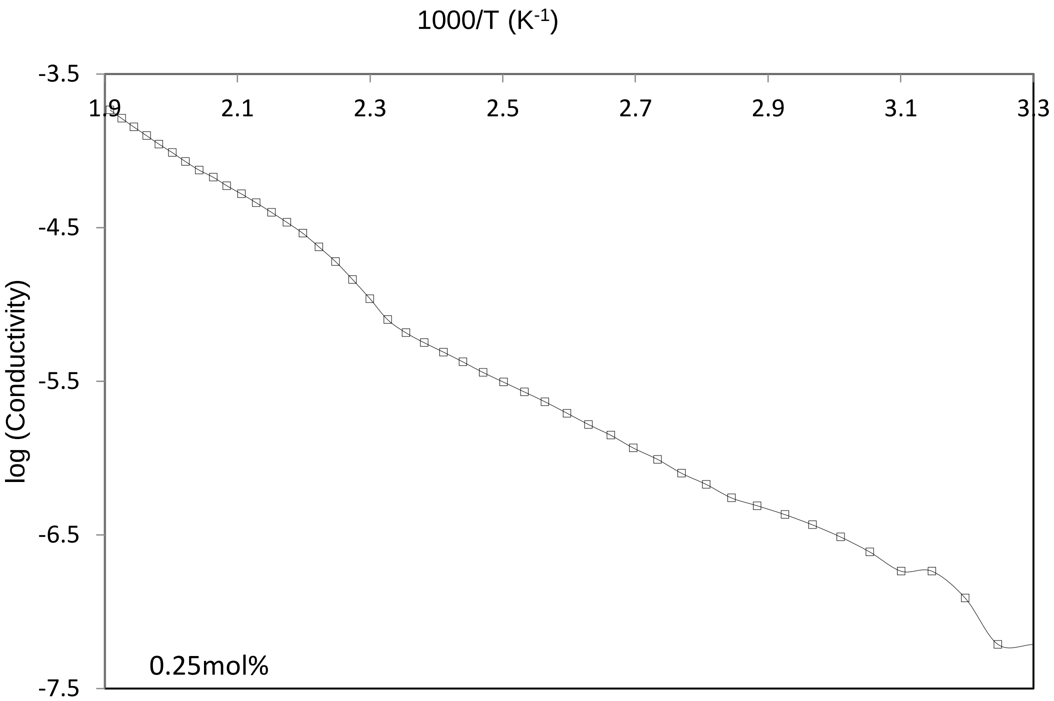
No.	Composition	(P) (μV/K)		N		μ (cm^2/V.sec)		Φ_B (eV)
		300 K	525 K	300 K (10^{19})	525 K (10^{19})	300 K	525 K	
1	0.01	21.03	38.91	3.472	9.876	0.019	149.4	0.436
2	0.025	22.47	40.11	3.591	10.01	0.021	151.6	0.428
3	0.05	23.54	41.29	3.627	10.15	0.022	154.2	0.421
4	0.075	24.99	43.22	3.689	10.37	0.025	157.7	0.414
5	0.1	26.87	45.78	3.769	10.68	0.027	160.6	0.406
6	0.25	28.99	48.74	3.862	11.05	0.029	163.7	0.399
7	0.5	25.58	43.15	3.714	10.37	0.026	159.1	0.411
8	0.75	23.93	39.53	3.644	9.946	0.023	155.5	0.422
9	1.0	21.68	35.71	3.551	9.459	0.020	151.3	0.430

Table 2. Thermoelectric power parameters of aluminum doped cadmium selenide.

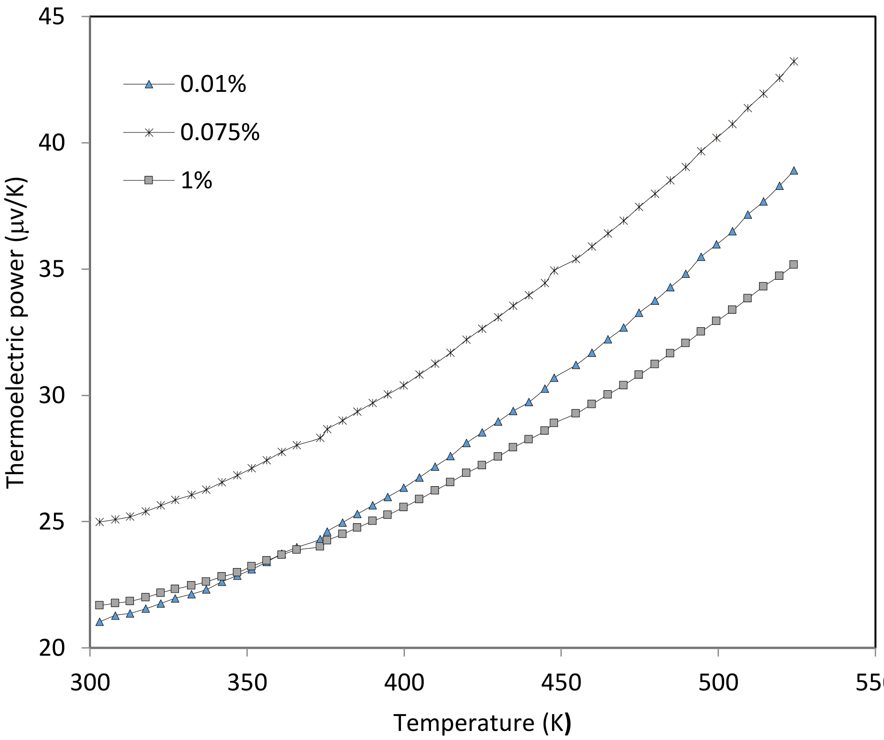

1000/T (K-1)
-3
-5
-7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
log (Conductivity)
0.01%


1000/T (K-1)
-3.5
-5.5
-7.5
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
log (Conductivity)
0.075%


1000/T (K-1)
-3.5
-5.5
-7.5
1.9
2.4
2.9
3.4
log (Conductivity)
1%



Dia. 1: Electrical conductivity of aluminum doped cadmium selenide.



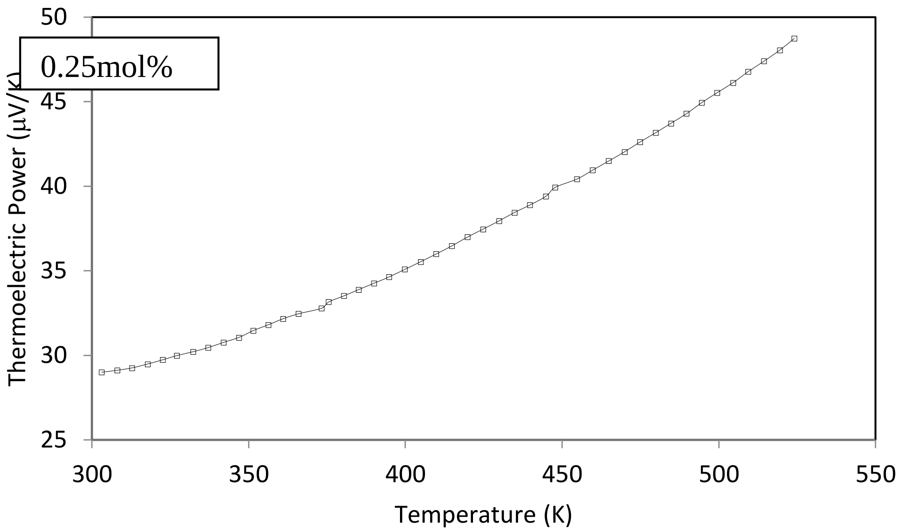


Fig 2. Thermoelectrical power measurement of aluminum doped cadmium selenide.

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VI. References

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