Study influence of thickness and electrode material on some electrical properties of ZnSe thin films prepared by thermal evaporation in vacuum

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دراسة تأثير السمك ومادة المسرى الكهربائي(القطب)على بعض الخصائص الكهربائية لأغشية ZnSe الرقيقة المحضرة بالتبخير الحراري في الفراغ

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الخلاصة :

حضـرت أغشـية ZnSe الرقيقـة باسـتعمال طريقـة التبخيـر الحـراري فـي الفـراغ (10^{-5}Torr) وبسـمك $(1000,2700,4000)A^0$ وتغييـر مـادة المسـرى الكهربـائي(القطـب)علـى قواعـد زجاجيـة بدرجـة حرارة (373K) ودراسة بعض الخصائص الكهربائية عند هذه الدرجة الحرارية . تبين الخطوط البيانية العلاقة الخطية بين التيار والفولتية حيث أظهرت النتائج زيادة في قيمة التيار والتوصيلية الكهربائية بزيادة السمك وتغير مادة المسرى الكهربائي (القطب) من الألمنيوم إلى النحاس .

الكلمات المفتاح : الأغشية الرقيقة ، السلينايد،المسرى الكهربائي، تيار التوصيلية و الفولتية.

Abstract

Thin films of Zinc Selenide ZnSe have been prepared by using thermal evaporation in vacuum technique (10^{-5}Torr) with thickness (1000, 2700, 4000) A^0 and change electrode material deposited on glass substrates with temperature (373K) to study some electrical properties at this temperature . The graphs showed linear relationship between current and voltage and the results have shown an increase in the value of current and electrical conductivity with increase in the thickness and change in electrode material from Aluminum to Copper.

Key words: Semiconductors, ZnSe, Thin films, Electrode, Current Conductivity, Voltage.

Introduction

Among the II - VI compound semiconducting materials, ZnSe is used as a window layer for the fabrication of thin film solar cells. It is mainly used as a protective of thin film solar cells. And as a protective and antireflection coating for infrared-operating electro chromic thermal-control surfaces due to its large electro chromic thermal-control surfaces and its large band gap permits a large number of photons to reach the absorbed layer [1]. The synthesis of binary metal chalcogenides of group II - VI semiconductors in a nano crystalline form has been a rapidly growing area of research due to their important non-linear optical properties, photo luminescent and electroluminescent properties, crystalline size effect or quantum size effect, and other important physical and chemical properties [2]. Zinc selenide is a p-type II - VI semiconducting material with a direct and wide band gap of (2.7eV) at room temperature. Such a property makes ZnSe very interesting for optical devices emitting in the blue spectral region [3]. Due to their interesting electrical and optical properties, ZnSe thin films have been extensively studied. They are suitable candidates for red, blue and green light-emitting diodes, photovoltaic devices, laser screens, thin film transistors, photo electrochemical cells, and dielectric mirrors [4]. A broad variety of techniques have been used for the deposition of ZnSe films, such as metal organic chemical vapor deposition (MOCVD) [5], RF magnetron sputtering [6], molecular beam epitaxy (MBE) [7], metal organic vapor phase epitaxy (MOVPE) [8] and vacuum evaporation [9].

Electrical and structural properties of ZnSe thin films were studied by chaliha, .Borah, sarmah&Rahman [10], S. Venkatachalam, et.al, studied electrical, optical and structural[9].

The main task was the effect of thickness and electrode material on electrical properties include (voltage, current) and electrical properties of ZnSe thin films which were prepared by using the thermal evaporation in vacuum.

Experimental

Zinc selenide thin films has been prepared as a thin films by thermal evaporation in vacuum technique (10^{-5}Torr) were deposited on to well cleaned glass substrates by using ultrasonic path with substrate temperature (T_s=373K) and thickness (1000, 2700, 4000)A^0, films thickness was measured by using optical interferometer method .

In order to measure the electrical properties, ohmic contacts are needed. It was obtained by aluminum and copper wire of high purity (99.999%) under vacuum. The evaporation process was started at a pressure of (10^{-5}Torr). The best condition for good ohmic contact was satisfied by a layer of (250nm).

The electrical measurements of ZnSe films have been done. The D.C electrical conductivity has been measured as a function of temperature over the range (R.T – 453K) by using the electrical circuit (sensitive digital electrometer type keithley (616) and electrical oven), electrical resistivity, electrical conductivity and activation energy has been calculated from t he equations respectively [11]:

$R_{film} = V / I$

$\rho = R_{film} .A / L$ electrical resistivity

$\sigma = 1 / \rho$ electrical conductivity

$$\sigma = \sigma_o \ \exp\left[-\frac{Ea}{K_B T}\right]$$

Where: E_a: energy activation

Results and Discussion

Figure (1, 2) show the Current as a function of the voltage with changing of electrode materials (aluminum and copper) with temperature range (293-373)K and thickness ($1000A^0$), this is attributed to increase charge mobility then increasing of removal charge from valence to conductive band, also the figures showed two region first kind Hopping Conduction at low voltage value and non linear relation (current–voltage), another kind free band conduction with linear relation voltage-current, with increasing temperature.

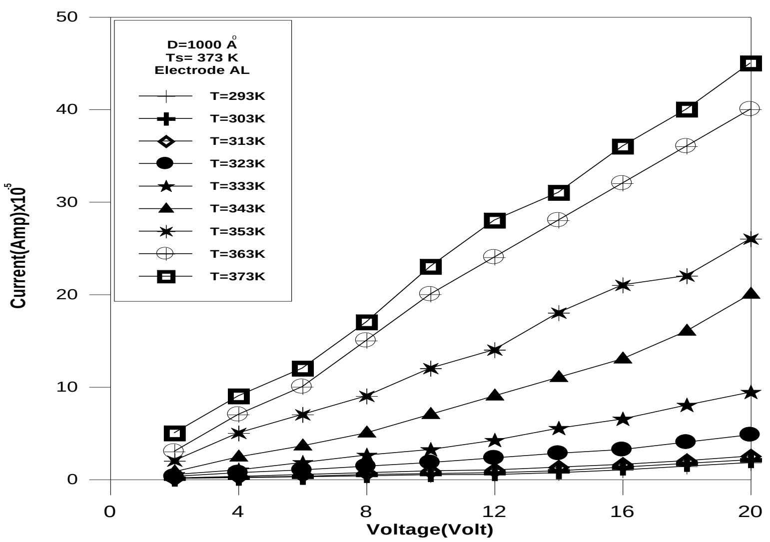

Fig-1- Show The plot current versus voltage of the ZnSe thin film at different temperature

With aluminum electrode mater

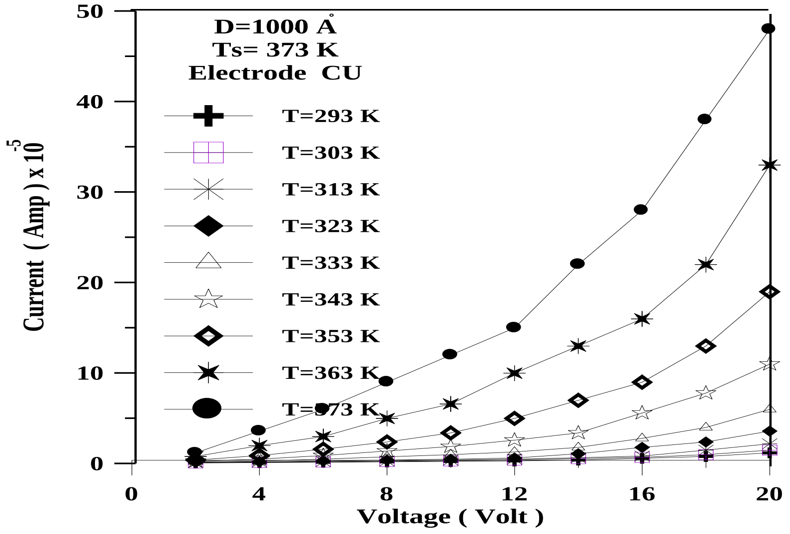

Fig-2- Show The plot current versus voltage of the ZnSe thin film at different temperature

With copper electrode mater

Figure (3) showed high value of current when used Copper electrode then Aluminum electrode [12] with thickness ($1000A^0$) and temperature (T=323K), because work function for Copper less than Aluminum , so the carrier charge need energy less to removal from valence to conductive band due to increase current than electrical conductivity, from figure (4) observe two values for activation energy (Ea) so have two conductive mechanism.

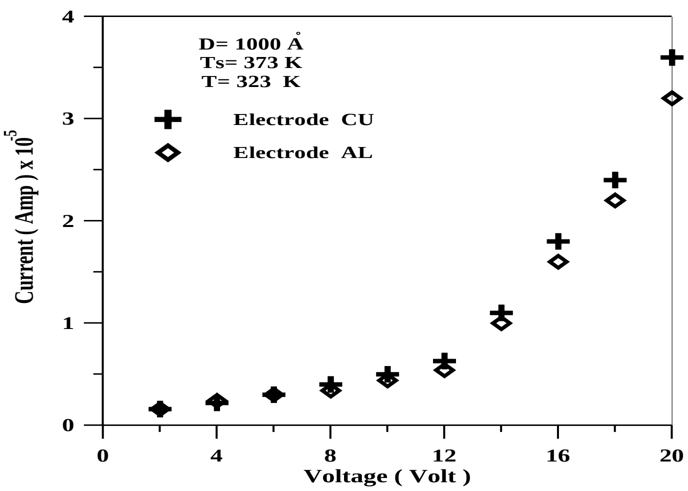

Fig-3- Show The plot current versus voltage of the ZnSe thin film at (323K)

With different electrode mater

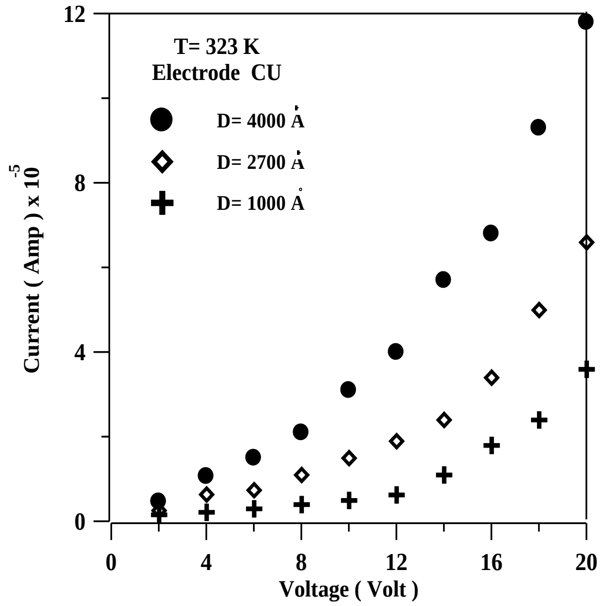

Fig-4- Show The plot Ln conductivity versus (1000/T) of the ZnSe thin film

With different electrode mater

Figure (5, 6) showed the variation of the Current as a function of voltage with increased thickness and different electrode with temperature (T=323K), figure (7,8) explained increased electrical conductivity with increased thickness and different electrode, because increase charge carrier due to increase current and electrical conductivity.

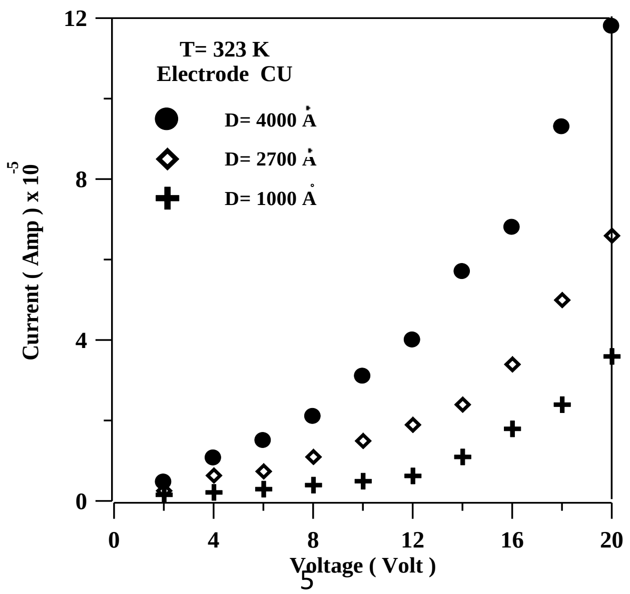

Fig-5- Show The plot current versus voltage of the ZnSe thin film at different thickness

With copper electrode mater

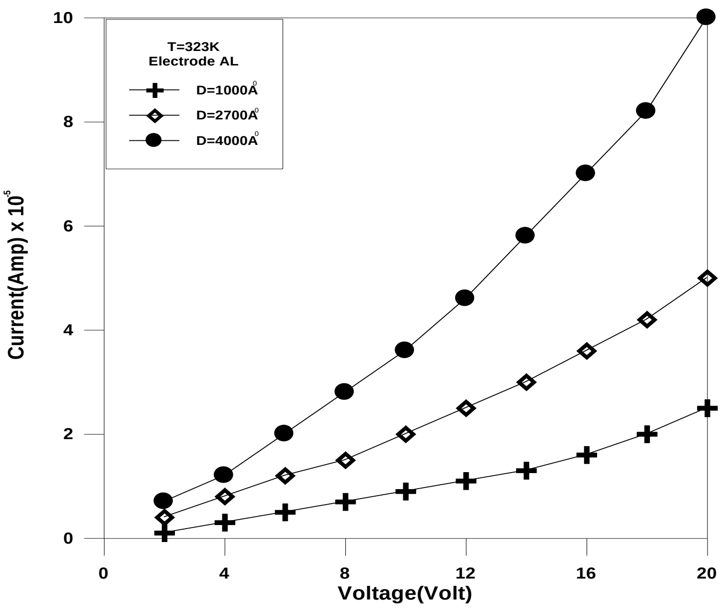

Fig-6- Show The plot current versus voltage of the ZnSe thin film at different thickness

With aluminum electrode mater

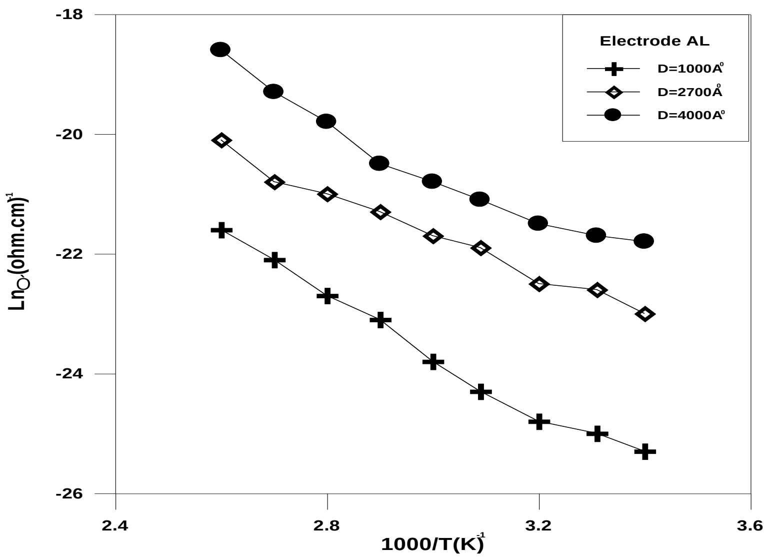

Fig-7- Show The plot Ln electrical conductivity versus (1000/T) of the ZnSe thin film

With aluminum electrode at different thickness

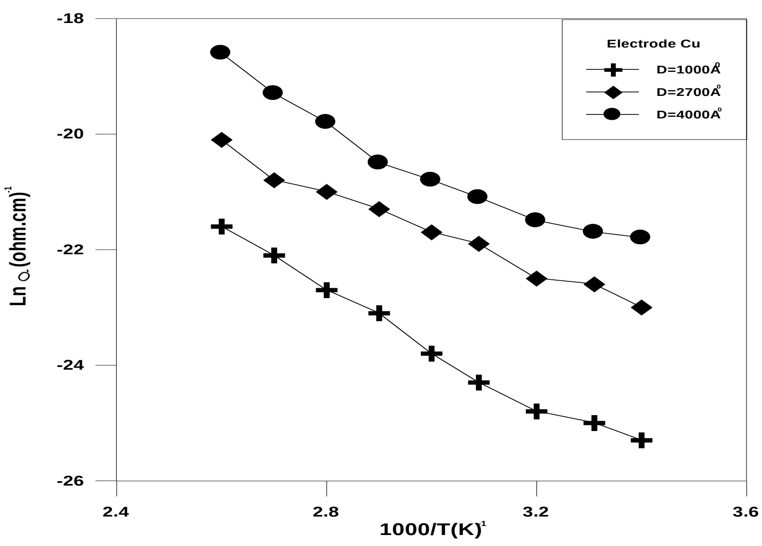

Fig-8- Show The plot Ln electrical conductivity versus (1000/T) of the ZnSe thin film With copper electrode at different thickness

Thickness A°	Electrode AL Ea_1	Electrode AL Ea_2	Electrode Cu Ea_1	Electrode Cu Ea_2
١٠٠٠	0.21	1.03	0.14	1
٢٧٠٠	0.25	0.93	0.156	0.74
٤٠٠٠	0.264	0.845	0.163	0.72

Table-1- Show the activation of energy value for ZnSe thin films With different thickness and electrode mater

Conclusions

The Current increase with increase temperature and changing of electrode material.

It was observed that conductivity increased with increase in temperature and thickness.

Also it was observed that electrical conductivity have two activation energy value , this is attributed to mechanical moving first between localize state inner energy gab by hopping conductivity at low temperature another inner energy gab by thermal excitations mechanism

The value of (Ea_2) decreased with increased thickness.

The value of (Ea_1) increased with increased thickness.

Second activation energy (Ea_2) value higher than (Ea_1).

References

1- Yan L., Woollam J. A. And Franke E., J. Vac. Sci. Technol.A 20.693(2002).
2- Ghosh S., Mukherjee A., Kim H. and Lie C., Mater.Chem. phys. 78.26 (2003).
3- Shriver D. F., Atkins P.and Langford C. H., Inorganicry, 2nd ed (Freeman W.H. and Company, New York, 1994).
4- Akira O., Noriyoshi S. and Zembutsu S., Appl J. Phys.64, 694 (1998).
5- Noda Y., Ishikawa T., Yamabe M. and Hara Y., Appl. Surf. Sci. 28, 113 (1997).
6- Kumerasan R., Ichimura M. and Arai E., Thin Solid Films 414, 25 (2002).
7- Kim T. W., Jung M., Lee D. V., Oh E., Lee S. D., Jung H. D., Kim M. D., Kim J. R., Park H. S. and Lee J. Y., Thin Solid Films 298, 187 (1997).
8- Liu Q., Lakner H., Taudt W., Heuken M., Mendorf C., Heime K., E. and Kubalek, J. Cryst. Growth 197, 507 (1999).

9- Venkatachalam S., Mangalara D. and Narayandass Sa. K., Physica B 393, 47 (2007).

10- Chaliha S., Borah M.N., Srmah P.C. &Rahman, 2008, Effect of substrate temperature on structural properties of thermally evaporation ZnSe thin films of different thickness, J.phys, V.114, No1.

11- Mankarious R.G., 1964, "Solid state electron, P. 702.

12- AL-Deen N.S, 1980, inorganic chemical, science college, Baghdad University.

13- Overhof H. and Thomas P., Electronic Transport in Hyelrogeante Amorphous Semiconductors, Springier-Verlage, Vol.114, 1989.