Thermoelectric power for thermally deposited cadmium telluride films

M. F.A. Alias[1], R. A. Abdullah[2], N. F. Abd Al Jabbar[2], A.A.J.Al-Douri

[1]Department of Physics, College of Science, University of Baghdad, Baghdad, Iraq

[2]Department of Physics, College of Education, University of Tikrit, Iraq

E-mail: may20131313@yahoo.com

Abstract

Thermal evaporation method has used for depositing CdTe films on corning glass slides under vacuum of about 10^{-5}mbar. The thicknesses of the prepared films are400 and 1000 nm. The prepared films annealed at 573 K. The structural of CdTe powder and prepared films investigated. The hopping and thermal energies of as deposited and annealed CdTe films studied as a function of thickness. A polycrystalline structure observed for CdTe powder and prepared films. All prepared films are p-type semiconductor. The hopping energy decreased as thickness increased, while thermal energy increased.

Key words

CdTe Film,
Thermal Evaporation,
Structure, See beck effect.

Article info.

Received: Jun. 2014
Accepted: Nov. 2014
Published: Apr. 2015

القدرة الكهروحرارية لاغشية CdTe المرسبة حراريا

ميسون فيصل احمد الياس[1]، رشا عباس عبدالله[2]، نيران فاضل عبد الجبار[2]، علاء احمد جمعة الدوري

[1]قسم الفيزياء، كلية العلوم، جامعة بغداد، بغداد، العراق

[2]قسم الفيزياء، كلية التربية، جامعة تكريت، العراق

الخلاصة

تم استخدام تقنية التبخير الحراري لترسيب اغشية CdTe على ارضية زجاجية تحت الفراغ وبضغط 10^{-5}ملي بار. كانت سمك الاغشية المحضرة 400 و1000 نانومتر. لدنت الاغشية المحضرة بدرجة حرارة573 كلفن. تم دراسة التركيب لمسحوق واغشيته CdTe. درست الطاقات الحرارية والتنطط للاغشية الغير ملدنة والملدنة كدالة للسمك. لوحظ ان تركيب مسحوق CdTe والاغشية المحضرة هو متعدد التبلور. جميع النماذج المحضرة من النوع الموجب. طاقة التنطط تقل مع زيادة السمك بينما تزداد الطاقة الحرارية.

Introduction

Since the 1950s, the semiconductor material in various technical fields has been widely applied to develop rapidly. Semiconductor materials thermoelectric properties are greatly improved the efficiency of thermoelectric effect. As a green environmentally friendly energy conversion technology, a thermoelectric power generation technology is used in candles lamps, heat fans, thermoelectric generators, field generators, and boiler heat generator system. Thermoelectric power measurement provides some important information about the type of carriers, position of the Fermi level inside the forbidden band, and the nature of scattering mechanism [1,2].

Cadimum Tellurid (CdTe) is the most candidate materials for photovoltaic and optoelectronic devices. CdTe is a II-VI compound with wurtzite crystal structure that has lattice parameters a=4.7 ^{o}A and

$c=7.47\ ^{o}A$. It is either n-type or p-type semiconductor [3].

The studies about thermoelectric behavior are not abundant in the scientific literature, so this paper was investigated thermoelectric power as a function of heat treatment for prepared CdTe film prepared by thermal evaporation method at both thickness 400 and 100 nm.

Experimental Steps

Cadmium telluride powder 99.999% purity manufacturer by Balzers Switzerland have deposited by Edward E306A coating system under 2×10^{-5}mbar vacuum, molybdenum boat has used as a source. The prepared films deposited on 7059 corning glass slides, which cleaned ultrasonically with acetone, demonized water, and finally dried by air blower. The thickness measured by crystal monitor built in vacuum coating system. The substrate temperature maintained at 373K, which obtained by a tungsten heater and measured by thermometer with thermocouple type K. The prepared films have annealed at30 mbar vacuum oven at 573K. Aluminum used as electrodes. The structural analyses have done by Phillips PW3710 X-ray diffractometer (XRD) with CuK_{α} with wavelength target 1.5405 Å. The thermoelectric power measurement has measured with temperature within the range 393- 513 K. It applies using digital electrometers type Keithley 616.

Results and Discussion

Fig. 1 shows the XRD patterns obtained for CdTe powder, as deposited and annealed films. All patterns for CdTe were a cubic polycrystalline structure with varies crystal orientation as comparing to ASTM cards. The four peaks observed in the XRD pattern for CdTe powder at around 23.8°, 31.7°, 39.5°, and 46.3°. These peaks could be readily assigned to the planes (111), (102), (220), and (311) respectively of the cubic phase. The XRD pattern of as deposited CdTe film had narrow sharp peaks at (111) and less reflection at (102), (220) planes, while the peak at (311) plane disappear. The XRD pattern for annealed CdTe film illustrated two peaks only oriented at (111) and (220). This means that annealing temperature caused to improve the structure of film by increasing crystallite size. The preferential orientation for all patterns was at (111) plane.

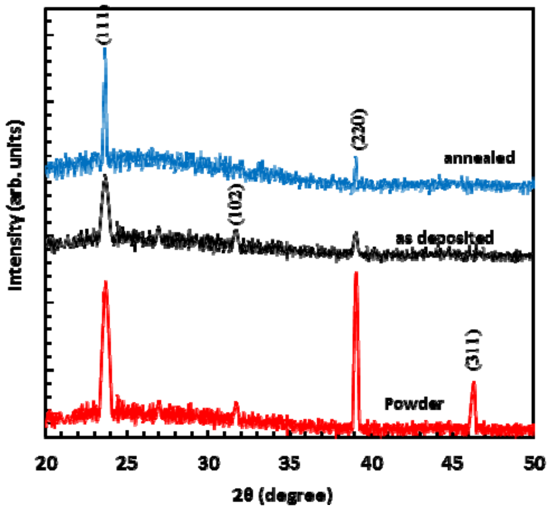

Fig. 1: The XRD pattern for CdTe powder and films as deposited and annealed.

See beck effect represents the temperature deference (ΔT) that causes carriers transportation from the hot end to the cold end that, in turn, creates an electric field that causes a thermal voltage. This thermally generated voltage is called See beck voltage (V_{emf}), which is preoperational to the temperature that is created across films. See beck coefficient (S_{emf}), on other words, thermoelectric power (P_{emf}) is defined by [4, 5]:

$$P_{emf} = V_{emf}/\Delta T$$

Fig. 2 illustrates See beck voltage which was proportional to the temperature, which created across the CdTe films. The increase in thickness and heat treatment cause increased in Seebeck voltage. Another noticeable remark is that V_{emf} increased with increasing temperature.

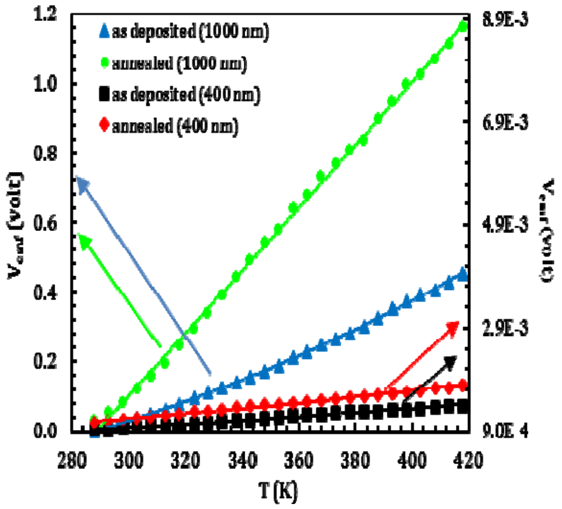

Fig. 2: Electromotive voltage as a function of temperature of as deposited and annealed CdTe films.

Fig. 3 illustrated the thermoelectric power (P_{emf}) as a function of reciprocal temperature in the temperature range (317–417)K. It increased with increasing temperature and thickness. This is due to improvement in structure as shown in Fig. 1. In general P_{emf} increased with heat treatment for both film thicknesses.

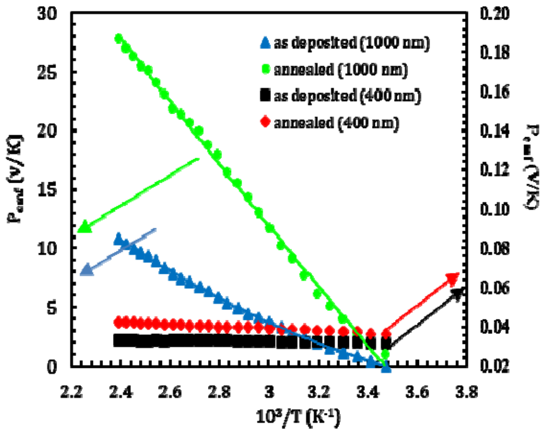

Fig. 3: Thermoelectric powervs $10^3/T$ for as deposited and annealed CdTe films.

The thermal energies (E_{th}) obtained from the slope of curvatures in Fig. 3 using the following relation [6]:

$$P_{emf} = -\frac{k_B}{q}\left[A + \frac{E_{th}}{k_B T}\right]$$

where E_{th} represents the electron energy of the thermoelectric power and $A\ k_B$is the average energy of transported electrons measured with respect to conduction band energy. The A value depends on the nature of scattering [9]. The thermal activation energy decreased when the film annealed, as given in Table 1. Also positive values of See beck coefficient mean that all prepared films are p-type. Dhawale et al [4] and Abdullah[5] gave credence to these results.

Table 1: Values of E_{th}, S_{emf} and ΔW for as deposited CdTe film and annealed at 573K with 400and 100nm thickness.

Th(nm)	T_a(K)	E_{th}(meV)	S_{emf}(V/K)	ΔW(meV)
400	300	51.7536	3.9×10^{-6}	0.3985
	573	51.7555	5.0×10^{-6}	0.4110
1000	300	54.4121	1.1	0.3420
	573	52.8324	2.7	0.3740

Hopping energy (ΔW) that calculated from the difference between E_a^{dc} and E_{th} was decreased with increasing thickness, where as E_a^{dc} and E_{th} increase with heat treatment, as illustrated Table 1. This behavior may due to increase in crystallite size and decreasing the density of defect levels [7, 8].

Conclusions

The outcome of this investigation can be summarized as:

- The structure of CdTe powder and films are cubic polycrystalline with preferential orientation at (111) plane.
- The activation energy decreased as thickness increased.
- All prepared films are p-type semiconductor.

- The hopping and thermal energies decreased with heat treatment.
- Thermal energy for prepared films increased as thickness increased, while hopping energy decreased.

References

[1] J. H. Lee, H. Y. Lee, Y.K. Park, S. H. Shinand, K. J. Park, Jpn. J. Appl. Phys., 37 (1998) 3357.

[2] S. R. Das, J. G. Cook, Thin Solid Films, 163 (1988) 409.

[3] S. J. Fonash, Solar Cell Devices Physics Academic Press Inc., 1981.

[4] D. S. Dhawale, D. P. Dubal, M. R. Phadatare, J. S. Patil, C. D. Lokhande, JMater. Sci., 46 (2011) 5009.

[5] R. A. Abdullah, F. S. Atallah, N. A. Dahham, M. A. Razooqia, E. M. Nasir N. M. Saeed, AIP Conf. Proc. 1476, 351 (2012).

[6]M. H. Brodsky, Amorphous Semiconductors, Berlin, Springer- Verlag press, 1979.

[7] D. J. Desale, S. Shaikh, F. Siddiqui, A. Ghosh, R. Birajdar, A. Ghule, R. Sharma, Pelagia Research Library, Advances in Applied Science Research 2, 417 (2011).

[8] M. Singh, Y. K. Vijay, B. K. Sharma, Pramana Journal of Physics, 69 (2007) 631.