

# Artikel 2\_1

*by* Ariswan Ariswan

---

**Submission date:** 29-Apr-2019 09:11PM (UTC+0700)

**Submission ID:** 1121336588

**File name:** Artikel\_2\_1.pdf (554.22K)

**Word count:** 2010

**Character count:** 10761

## Structural, Chemical Composition and Optical Properties of CdTe Fabricated by Vacuum Evaporation Technique

Ariswan

Physics Department, Faculty of Mathematics and Sciences, Yogyakarta State University

Corresponding author: ariswan@uny.ac.id

**Keywords:** Vacuum evaporation, polycrystalline, cadmium telluride, thin films

**Abstract.** CdTe polycrystalline thin films had been fabricated using vacuum evaporation technique. Their properties had been investigated using X-ray diffraction, energy dispersive spectroscopy (EDS), scanning electron microscope (SEM) and uv-vis spectroscopy. The results showed that the CdTe thin films crystallized at hexagonal structure with lattice parameters  $a = 6.45 \text{ \AA}$  and  $c = 7.66 \text{ \AA}$ . The EDS results showed that the chemical composition was non stoichiometry, slightly rich of Tellurium with Cd/Te of 0.9. It had a uniform shape with color homogeneity and an optical band gap at room temperature about 1.47eV.

### Introduction

Cadmium telluride (CdTe) is very important materials. It is one of the most promising photovoltaic devices applications. In general, it is a II-IV compound semiconductor which can also be applied to optoelectronic devices such as photodetectors, nuclear detectors, diode, transistor, etc. [1]. The CdTe polycrystalline films can be produced using several method such as closed space sublimation [2, 3], radio frequency (RF) sputtering [4], closed space vapor transport (CSVT) [5], molecular beam deposition [6], electrophoretic deposition (EPD) [7], and vacuum evaporation [8, 9].

The vacuum evaporation technique offers some advantages. It is a simple deposition apparatus applied under moderate vacuum conditions, it needs a high temperatures crucible but we can use a simple power supply. Previous attempts to fabricate the CdTe films by other researchers using this technique at ambient temperature resulted in a cubic structured thin films oriented to (111) plane [8, 9]. In this paper, we report our studies on the preparation of CdTe films using vacuum evaporation where the films were deposited onto a glass substrate at high temperature. The films then were characterized using X-ray diffraction (XRD) to determine the crystalline structure, energy dispersive spectroscopy (EDS) to measure the chemical composition, the scanning electron microscopy (SEM) to determine the morphology of the surface, and the UV-vis spectroscopy to determine the optical characteristics such as optical band gap energy  $E_g$ .

### Materials and Methods

The CdTe powder which was 250  $\mu\text{m}$  and 99.99% deposition grade Sigma-Aldrich product, was put in a vacuum evaporation system and placed at a boat shape molybdenum crucible with 4.1 cm length, 1.4 cm width and 1.2 cm thickness, and heated at 1400°C. The thin films were deposited on glass substrate heated at 370°C. The substrate were kept at this temperatur for 2 hours under a vacuum of  $3 \cdot 10^{-5}$  Torr. It was placed 10 cm above a source or a crucible for the first sample and 15 cm for the second sample.

To characterize the structure of the thin films, a Shimadzu XRD-6000 X-ray diffractometer using Cu  $K\alpha$  radiation with wavelength of  $\lambda = 1.54051 \text{ \AA}$  was employed. Fig. 1 shows the X-ray diffraction spectrum of CdTe with different spacer. The chemical composition of the films was determined by EDS using a JSM-6360 LA system attached to a JEOL brand scanning electron microscope. To determine the optical band gap energy, we used the transmission data of spectra made at room temperature at normal incidence in the energy range of 0.6 eV- 4.0 eV using UV

1700 Pharmaspec uv-vis spectrophotometer which was a specular reflectance attachment from Shimadzu Corporation.

## Results and discussions

### Structural properties and chemical composition

Fig. 1 shows the XRD spectrum of a typical CdTe. For the first sample, the patterns show a preferential orientation in the (002) direction of the hexagonal structure with  $2\theta = 23.22^\circ$  [10]. The other small peaks,  $2\theta = 42.2^\circ$  and  $45.5^\circ$  could probably associated with (103) and (200) direction respectively. For the second sample,  $2\theta = 22.08^\circ$ ;  $24.12^\circ$  and  $39.98^\circ$  associated with (100), (002), and (110) directions. From these peaks, the lattice parameters  $a$  and  $c$  can be calculated using a relation of analytical method. This relation obtained by combining the Bragg's law and the distance between adjacent plane in the set of Miller plan indices ( $hkl$ ) at the hexagonal structure. The lattice parameters of a hexagonal system  $a$  and  $c$  is determined by [11]

$$\sin^2(\theta) = (\lambda^2/4a^2) [(4/3)(h^2 + hk + k^2) + l^2/(c/a)^2] \quad (1)$$

These parameters  $a$  and  $c$  are constant, so Eq.(1) can be written as

$$\sin^2\theta = A(h^2 + hk + k^2) + Cl^2 \quad (2)$$

where  $A = \lambda^2/(3a^2)$  and  $C = \lambda^2/(4c^2)$

The lattice parameters were calculated using the analytical method above and the results were  $a = 6.50 \text{ \AA}$ , and  $c = 7.66 \text{ \AA}$  for the first sample,  $a = 6.45 \text{ \AA}$ ,  $c = 7.37 \text{ \AA}$  for the second sample. These values are in a good agreement with the lattice parameter reported by others [12].

XRD spectrum shows that  $2\theta = 20.9^\circ$  peak (marked as \*) is the most probable  $\text{CdTeO}_3$ . In fact, in the presence of  $\text{O}_2$  at the CdTe films growth, it generally contains a very small amount of  $\text{CdTeO}_3$  [10].

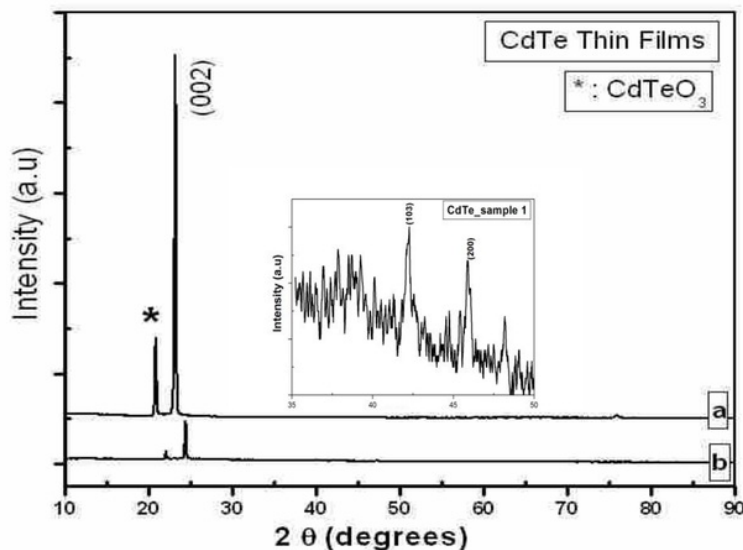


Fig.1 XRD pattern of CdTe by vacuum evaporation (a) the first sample and (b) the second sample.

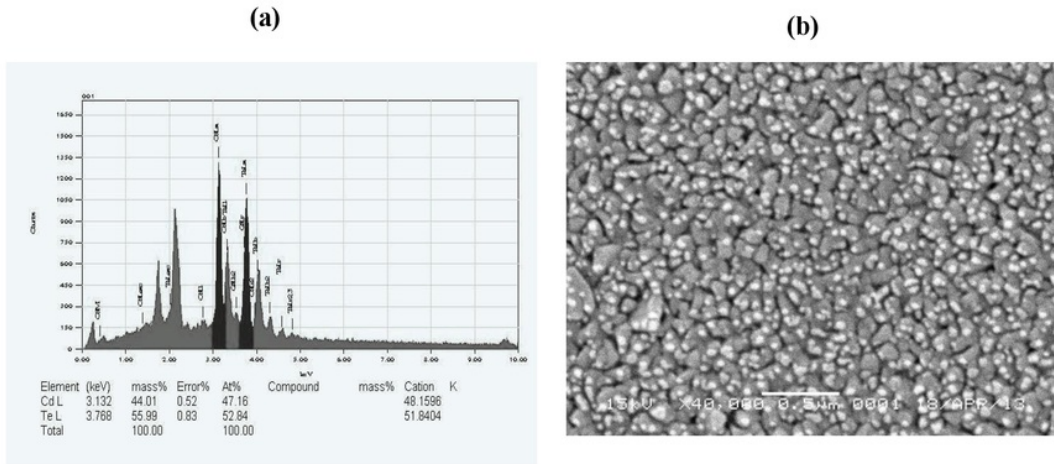


Fig.2 (a). Chemical composition by EDS and (b). SEM image of CdTe.

23

The grain size of CdTe films is also an important cell parameter. Fig. 2(b) shows the surface morphology of CdTe films prepared by vacuum evaporation technique with crucible to substrate distance of 10 cm. Its deposit consisted of grains 0.1 μm in size uniformly distributed throughout the films and it was polycrystalline in nature. Fig. 2(a) shows the results of EDS in which the element ratio of Cd and Te is 0.9.

2

**Optical properties**

Fig. 3 shows the results of the optical transmittance spectra for the first and the second samples. Transmittance ( $T$ ) is the ratio of the transmission intensity ( $I_T$ ) and the incidence intensity ( $I_o$ ). So using Lambert's law  $I_T = I_o \exp(-\alpha d)$ , the absorption coefficient  $\alpha$  can be estimated from the optical transmittance spectra using [13]

$$\alpha = (2.303/d) \log (1/T) \tag{3}$$

Where  $d$  is the thickness of the thin films.

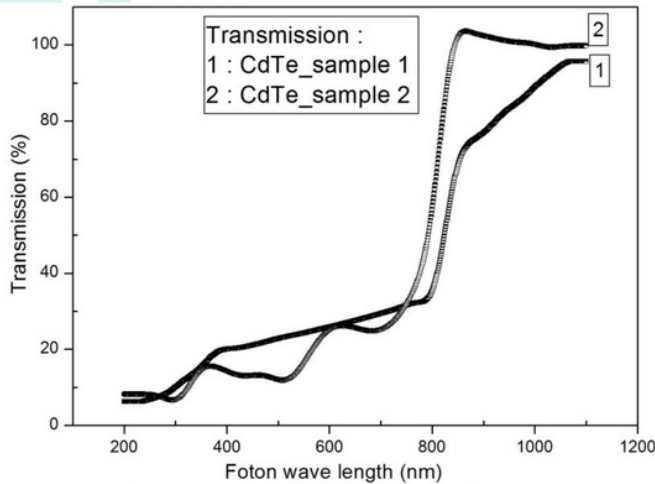


Fig.3 Transmission spectra of polycrystalline CdTe for the first (1) and the second (2) samples.

CdTe has a direct band gap structure, so this band gap energy  $E_g$  can be determined from the extrapolated intercept on the photon energy  $h\nu$  axis using

$$(\alpha \cdot h\nu)^2 = B^2 (h\nu - E_g) \quad (4)$$

where  $B$  is constant with a value ranging from  $10^5$  to  $10^6 \text{ cm}^{-1} \text{ eV}^{1/2}$  [14]. This result is shown in Fig.4 and the band gap energy of the two samples are 1.47 eV and 1.43 eV respectively. These values agree well with the reported values in the previous studies [15].

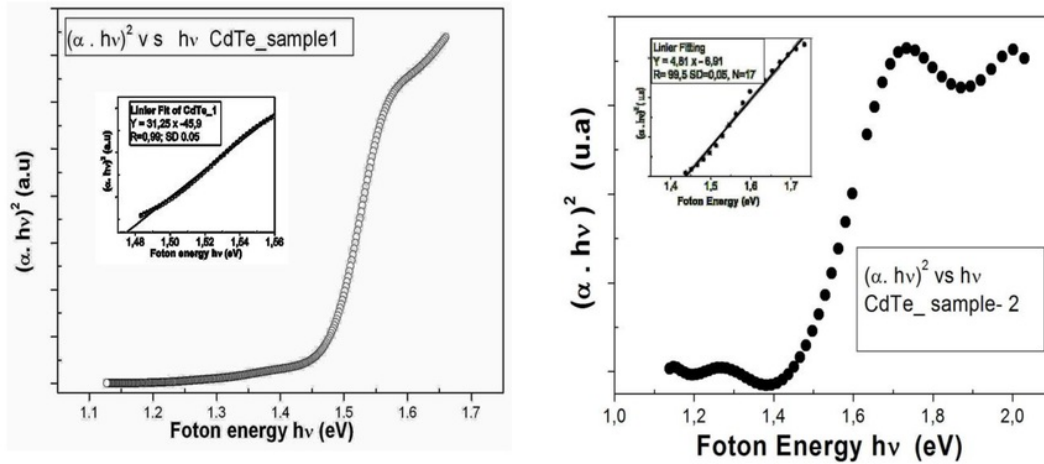


Fig. 4 Plot of  $(\alpha \cdot h\nu)^2$  versus photon energy  $h\nu$  for CdTe thin films.

## Conclusion

CdTe polycrystalline thin films had been fabricated using vacuum evaporation technique and their properties had been characterized. The film composition was determined from a good 10 cm distance of crucible and substrate. The results of XRD showed that the CdTe had an hexagonal structure and a characteristic diffraction peak related to preferential orientation of (002). We calculated the band gap energy using the transmittance experiment data and the band gap energy of CdTe was found to be 1.47 eV.

## References

- [1]. S. Lalitha, S.Zh. Karazhanov, P. Ravindran, S. Senthilarasu, R. Sathyamoorthy, J. Janabergenov, Electronic structure, structural and optical properties of thermally evaporated CdTe thin films, *Physica B* 387 (2007) 227-238
- [2]. N. Abbas Shah, A. Ali, Z. Ali, A. Maqsood, A.K.S. Aqili, Properties of Te-rich cadmium telluride thin films fabricated by closed space sublimation technique, *Journal of Crystal Growth*, 284 (2005), 477-485
- [3]. C. S. Ferekides, D. Mariniskiy, V. Viswanathan, B. Tetali, V. Palekis, P. Selvaraj, D.L. Morel, High efficiency CSS CdTe solar cells, *Thin Solid Films* 361-362 (2000) 520-526
- [4]. M. Zapata Torres, R.Castro Rodriguez, M.Melendez Lira, S.Jimenez Sandoval, A.Zapatra Navaro, J.L.Pena, Structural transition from CdTe to CdIn<sub>2</sub>Te<sub>4</sub> in films grown by close spaced vapor transport with free evaporation, *Thin Solid Films* 358 (2000) 12-15

- 
- [5]. A. V. Sukach, V.V. Tetoyorkin and N.M. Krolevec, Mechanisms of carrier transport in CdTe polycrystalline films, *Semiconductor Physics, Quantum Electronic & Optoelectronics V 12 N 2* (2010) 221-225
- [6]. J. Huerta, M. Lopez, O.Zelaya, MBE growth of CdTe Epilayer on InSe(111) substrates, *Superficies vacio* 8, (1999) 125-129
- [7]. Mohd Norizam, Azmi Zakaria, Atefeh Jafari, Mohd Sabri, Mohd Ghazali, Wan Ravizah, Wan Abdullah and Zulkarnain Zainal, Characterization of CdTe films deposited at various bath temperature and concentration using Electrophoretic Deposition, *Int. J. Mol.Sci*, 13 (2012) 5706- 5714
- [8]. S.J. Ikhmayies, R.N. Ahmad-Bitar, Characterization of vacuum evaporated CdTe thin films prepared at ambient temperature, *Materials Science in Semiconductor Processing* 16 (2013) 118-125.
- [9]. Z.R. Khan, M. Zulfeqar and M.S. Khan, Structural, optical, photoluminescence, dielectric and electrical studies of vacuum-evaporated CdTe thin films, *Bull. Mater. Sci.* 35 (2012) 169-174
- [10]. Lifei Xi, Chrys Boothroyd, and Yeng Ming Lam, Controlled Synthesis of CdTe and CdSe Multiblock Heteronanostructures, *Chem Mater* 27 (2009) 1465-1470
- [11]. C. Suryanarayana and M. Grant Norton, *X- Ray Diffraction A Practical Approach*, (1998), Plenum Press New York and London, p.125-153.
- [12]. Alessio Bosio, Nicola Romeo, Samanta Mazzamutto, Vittorio Canevari, Polycrystalline CdTe thin films for photovoltaic application, *Progress in Crystal Growth and Characterization of materials*, 52 (2006) 247-279
- [13]. K. Sakthivel, S. Velumani, T. Venkatachalam and S. Ganesan, Structural and optical studies of hot wall vacuum evaporated CdTeSn thin films, *Advance Materials Research Vol.68* (2009) 77- 83
- [14]. H. Sakata, H. Ogawa, , *Sol. Energy Mater. Solar Cells* 63 (2000) 259
- [15]. U. Aler, E. Bacaksiz, E. Yanmaz, Structural, magnetic and Optical Properties of Co-diffused CdTe thin films, *Journal of Alloy and Compounds* 456 (2008) 6-9

## **Advanced Materials Science and Technology**

10.4028/www.scientific.net/AMR.896

### **Structural, Chemical Composition and Optical Properties of CdTe Fabricated by Vacuum Evaporation Technique**

10.4028/www.scientific.net/AMR.896.497

#### **DOI References**

- [1] S. Lalitha, S. Zh. Karazhanov, P. Ravindran, S. Senthilarasu, R. Sathyamoorthy, J. Janabergenov, Electronic structure, structural and optical properties of thermally evaporated CdTe thin films, *Physica B* 387 (2007) 227-238.  
<http://dx.doi.org/10.1016/j.physb.2006.04.008>
- [2] N. Abbas Shah, A. Ali, Z. Ali, A. Maqsood, A.K.S. Aqili, Properties of Te-rich cadmium telluride thin films fabricated by closed space sublimation technique, *Journal of Crystal Growth*, 284 (2005), 477-485.  
<http://dx.doi.org/10.1016/j.jcrysgro.2005.08.005>
- [8] S.J. Ikhmayies, R.N. Ahmad-Bitar, Characterization of vacuum evaporated CdTe thin films prepared at ambient temperature, *Materials Science in Semiconductor Processing* 16 (2013) 118-125.  
<http://dx.doi.org/10.1016/j.mssp.2012.06.003>
- [9] Z.R. Khan, M. Zulfequar and M.S. Khan, Structural, optical, photoluminescence, dielectric and electrical studies of vacuum-evaporated CdTe thin films, *Bull. Mater. Sci.* 35 (2012) 169-174.  
<http://dx.doi.org/10.1007/s12034-012-0274-x>
- [10] Lifei Xi, Chrys Boothroyd, and Yeng Ming Lam, Controlled Synthesis of CdTe and CdSe Multiblock Heteronanostructures, *Chem Mater* 27 (2009) 1465-1470.  
<http://dx.doi.org/10.1021/cm802350p>
- [13] K. Sakthivel, S. Velumani, T. Venkatachalam and S. Ganesan, Structural and optical studies of hot wall vacuum evaporated CdTeSn thin films, *Advance Materials Research* Vol. 68 (2009) 77- 83.  
<http://dx.doi.org/10.4028/www.scientific.net/AMR.68.77>
- [14] H. Sakata, H. Ogawa, , *Sol. Energy Mater. Solar Cells* 63 (2000) 259.  
[http://dx.doi.org/10.1016/S0927-0248\(00\)00032-5](http://dx.doi.org/10.1016/S0927-0248(00)00032-5)
- [15] U. Aler, E. Bacaksiz, E. Yanmaz, Structural, magnetic and Optical Properties of Co-diffused CdTe thin films, *Journal of Alloy and Compounds* 456 (2008) 6-9.  
<http://dx.doi.org/10.1016/j.jallcom.2007.02.028>

## Artikel 2\_1

---

### ORIGINALITY REPORT

---

**24%**

SIMILARITY INDEX

**17%**

INTERNET SOURCES

**18%**

PUBLICATIONS

**7%**

STUDENT PAPERS

---

### PRIMARY SOURCES

---

<b>1</b>	<b><a href="https://citeseerx.ist.psu.edu">citeseerx.ist.psu.edu</a></b> Internet Source	<b>3%</b>
<b>2</b>	<b><a href="https://es.scribd.com">es.scribd.com</a></b> Internet Source	<b>3%</b>
<b>3</b>	<b>Submitted to Prince of Songkla University</b> Student Paper	<b>2%</b>
<b>4</b>	<b>A. GuruSampath Kumar, Li Xuejin, Xueming Hong, Youfu Geng, Yu Du, T. Subba Rao. "Investigation of structural, electrical and optical properties of oxygen (O<sup>7+</sup>) ion irradiated CdZnO thin films for solar cell applications", Radiation Physics and Chemistry, 2019</b> Publication	<b>1%</b>
<b>5</b>	<b><a href="https://dspace.lboro.ac.uk">dspace.lboro.ac.uk</a></b> Internet Source	<b>1%</b>
<b>6</b>	<b>Submitted to Higher Education Commission Pakistan</b> Student Paper	<b>1%</b>

---



- 7 Submitted to CSU, San Jose State University 1%  
Student Paper
- 
- 8 N. Abbas Shah, A. Ali, Z. Ali, A. Maqsood, 1%  
A.K.S. Aqili. "Properties of Te-rich cadmium  
telluride thin films fabricated by closed space  
sublimation technique", Journal of Crystal  
Growth, 2005  
Publication
- 
- 9 Razmjoo, O., M.E. Bahrololoom, and P. 1%  
Najafisayar. "The effect of current density on  
the composition, structure, morphology and  
optical properties of galvanostatically  
electrodeposited nanostructured cadmium  
telluride films", Ceramics International, 2016.  
Publication
- 
- 10 Suyitno, Ishak. "The Influence of Sandblasting 1%  
and Electropolishing on the Surface Hardness  
of AISI 316L Stainless Steel", Advanced  
Materials Research, 2014  
Publication
- 
- 11 [www.aqr.ee](http://www.aqr.ee) 1%  
Internet Source
- 
- 12 Shah, N.M.. "Growth, structural and optical 1%  
properties of copper indium diselenide thin  
films deposited by thermal evaporation  
method", Solar Energy, 200905  
Publication

---

13	<a href="http://connection.ebscohost.com">connection.ebscohost.com</a> Internet Source	1%
14	Kyung Sik Kim, S. Thanikaikarasan, T. Mahalingam, Subramaniam Velumani, Tae Kyu Kim, Yong Deak Kim, Rene Asomoza. "Preparation and Microstructural Studies of Electrodeposited FeSe Thin Films", Advanced Materials Research, 2009 Publication	1%
15	<a href="http://epdf.tips">epdf.tips</a> Internet Source	1%
16	<a href="http://tel.archives-ouvertes.fr">tel.archives-ouvertes.fr</a> Internet Source	1%
17	<a href="http://eprints.kfupm.edu.sa">eprints.kfupm.edu.sa</a> Internet Source	1%
18	SALEEM, M., L. FANG, Q. L. HUANG, D. C. LI, F. WU, H. B. RUAN, and C. Y. KONG. "ANNEALING TREATMENT OF ZnO THIN FILMS DEPOSITED BY SOL-GEL METHOD", Surface Review and Letters, 2012. Publication	1%
19	<a href="http://staff.uny.ac.id">staff.uny.ac.id</a> Internet Source	1%
20	<a href="http://dspace.nbu.gov.ua">dspace.nbu.gov.ua</a> Internet Source	1%

---

---

22 Nazar Abbas Shah. "Preparation and Characterization of CdTe for Solar Cells, Detectors, and Related Thin-Film Materials", *Journal of Electronic Materials*, 02/2008  
Publication

1%

---

23 Falcão, Vivienne Denise, Wagner Anacleto Pinheiro, Carlos Luiz Ferreira, and Leila Rosa de Oliveira Cruz. "Influence of deposition parameters on the properties of CdTe films deposited by close spaced sublimation", *Materials Research*, 2006.  
Publication

<1%

---

Exclude quotes  On

Exclude matches  < 2 words

Exclude bibliography  On

# Artikel 2\_1

---

GRADEMARK REPORT

---

FINAL GRADE

**/100**

GENERAL COMMENTS

**Instructor**

---

PAGE 1

---

PAGE 2

---

PAGE 3

---

PAGE 4

---

PAGE 5

---

PAGE 6

---