P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2014,8 (2) :53-57

Growth Nanostructured CdO Thin Film via Solid-Vapor Deposition

Ahmed S. Obaid * **Khalil T.Hassan*** **Abdul-Muneam M.Ashij*** **Bashar M.Salih*** **M. Bououdina** **

* University of Anbar- College of Sciences
** University of Bahrain- Nanotechnology Centre.

ARTICLE INFO

Received: 19 / 5 /2022
Accepted: 28 / 5 /2022
Available online: 19/7/2022
DOI: 10.37652/juaps.2014.123916

Keywords:
Nanostructured CdO;
Solid-vapor deposition;
quantum size effect.

ABSTRACT

Cadmium Oxide (CdO) thin films have been prepared by vacuum evaporation method on Si (111) substrate at room temperature using CdCl2 as a source of Cd. Detailed structural properties of the films are presented using XRD and SEM. The films was pure polycrystalline CdO phase with high crystallinity. The lattice constant average crystallite size of the nanocrystalline CdO thin films were calculated. SEM image confirm the formation nanostructure. Energy dispersive X-ray analysis spectra of CdO thin films shows the presence of Cd and O peaks only, no additional peaks attributed to impurities or contamination are observed.

I. INTRODUCTION

Nanometer-sized semiconductors have attracted considerable attention over the past few years because of their unique physical properties. Moreover, their optical and electrical properties are different from that of the bulk counterpart, thereby offering new potential applications [1]. Cadmium oxide (CdO) has high electrical conductivity and high optical transmittance with a moderate refractive index in the visible region of the solar spectrum [2]. CdO thin films are wide, direct band-gap semiconductors with an optical energy gap of about 2.4 eV at room temperature. CdO, with its cubic structure, is also a II-VI n-type semiconductor with donor defects, such as Cd interstitials and oxygen vacancies. CdO is a degenerate, n-type transparent semiconductor with wide energy gap and high electrical conductivity.

* Corresponding author at: University of Anbar- College of Sciences
.E-mail address: ahmed.s.obaid.alqayssei@gmail.com

Its high conductivity is due to the increased crystallite size at high substrate, moderate mobility and high carrier concentration. These properties make it useful for a wide of rang applications in transparent electrodes[3], solar cells[4], photovoltaic device[5], photodiodes[6], gas sensors[7]. CdO thin films are prepared by many physical and chemical techniques such as activated reactive evaporation [8],dc-magnetron reactive sputtering [9], metal organic chemical vapor deposition [10,11], vacuum evaporation [12], electrochemical deposition [13], pulsed laser deposition [14], electron beam evaporation [15], spray pyrolysis [16], sol–gel [17], RF magnetron sputtering [18], and successive ionic layer adsorption and reaction [19]chemical bath deposition techniques[20], microwave-assisted chemical bath deposition [21].In this study, we present a very simple and low cost synthesis method is presented, in which the required temperature is attainable in a short time: thermal evaporator (VS). Nanostructures CdO was successfully obtained at definite distances away from the evaporation source without the use of any metal catalyst.

II. EXPERIMENT DETAILS

Nanosturctures CdO was deposited on n-Si (111) substrates via solid-vapor deposition method under argon gas flow using Cadmium chloride ($CdCl_2$) as a source of Cd. Si-substrate (1cm × 1cm) was cleaned to remove the oxide layer. Argon gas flow was used to purify the tube, and then the sample was placed inside the tube while argon gas was continuously injected into the system at a rate of 500 sccm (0.5 cm^3/min). After that, 1 g of $CdCl_2$ as source was placed in a small ceramic boat, and placed in quartz tube of 4 cm in diameter and 110 cm in length inside the tube furnace fixed at its center. The substrate was placed inside the quartz tube at 15 cm away from the center of the tube furnace. The source $CdCl_2$ and Si-substrate was heated at temperature of 580°C for a fixed period of time of 30 min under constant flow of Ar gas 500 sccm. The process ran for three hours then cooled down to room temperature.

III. CHARACTERISATIONS

The film thickness was measured using an optical reflectometer (Filmetrics F20). The structure of the prepared thin films were examined using high-resolution X-ray diffraction (HR-XRD) using X'Pert Pro MRD diffractometer (PANalytical Company) system equipped with Cu-Kα radiation wavelength (λ = 0.15418 nm) operating at 40 kV and 20 mA. Morphology and microstructure of the film was investigated by scanning electron microscopy (SEM) using Jeol JSM-6460 LV microscope operating at 10 kV and attached to energy dispersive X-ray spectrometer (EDX) for elemental chemical composition determination.

IIII. RESULTS AND DISCUSSION

STRUCTURAL CHARACTERIZATION

Figure 1 shows the evolution of X-ray diffraction patterns of CdO thin film deposited on Si (111) by VS method. It is clear that all the film is polycrystalline with good crystallinity. XRD pattern clearlyindicate the presence of five peaks located at 2θ = 33.0292, 38.3302, 55.3510, 66.0023, and 69.276° indexed as (111), (200), (220),(311),and (222) respectively. The observed diffraction peaks were indexed within a cubic rock salt (NaCl) type structure, as confirmed using a standard JCPDS card (ICCD-PDF4 No. 01-075-0591). The film was found to be well crystallized as indicated by sharp XRD peaks [22]. The main features of the diffraction patterns are similar but the relative intensity of the diffraction peaks varies without the appearance of new phases aside from cubic CdO. A preferred orientation of the deposited film along (111) directions was observed.The texture coefficient TC was used to determine the preferred orientation by the following equation[23]:

$$TC(hkl) = \frac{\frac{I(hkl)}{I_o(hkl)}}{\sum_n \frac{I(hkl)}{I_o(hkl)}} \times 100\% \qquad (1)$$

where *I(hkl)* is the measured relative intensity of plane *(hkl)*, $I_o(hkl)$ is the standard intensity of plane *(hkl)*, and n is the number of diffraction peaks. *TC(hkl)* = 1 represents films with randomly oriented crystallites, whereas higher values indicate the abundance of grains oriented in a given *(hkl)* direction. The highest *TC* value was obtained for (111) plane for the prepared nanostructures CdO thin films.

The lattice constant of the nanocrystalline CdO thin film was determined by fitting the more intense diffraction peak using a Gaussian function and is given by [24]:

$$a = d\,(h^2 + k^2 + l^2)^{1/2} \qquad (2)$$

where *h*, *k* and $\boldsymbol{l}$ are the Miller indices; and *d* is the interplanar space. The calculated lattice constant value was found to be 4.6948 A°, which os slightly than that for bluk, which clearly indicates that the crystallisation and stress occurring during the growth hence resulting in lattice expansion.

The average crystallite size (**Cs**) of nanostructured CdO can be calculated from the well-known Scherrer's formula [23]:

$$\boldsymbol{Cs = \frac{k\,\lambda}{\beta\,cos\theta}} \qquad (\mathbf{3})$$

where $\boldsymbol{K}$ is a constant (0.94), $\boldsymbol{\lambda}$ is the XRD wavelength (0.15418 nm), and $\boldsymbol{\beta}$ is the full width at half maximum (FWHM) of a defined diffraction peak. It is found that the crystallite (grains) size of the thin film is about 12 nm .

MICROSTRUCTURAL ANALYSIS

SEM image rveals that the surface morphology of the grown CdO on Si-substrate is at the nanoscale

regime, by the presence of cauliflower-like shaped microstructure formed by platelets oriented along (111) direction of Si-substrate and in agreement with XRD analysis.

Energy dispersive X-ray analysis spectra of CdO thin film is reported in Figure 3, with the corresponding quantitative chemical analysis is reported. It is very important to note that no additional peaks attributed to impurities or contamination are observed, thus confirming the purity of the prepared thin film as confirmed previously by XRD analysis.

V. CONCLUSION

In this study, we report on the synthesis of pure CdO nanostructures deposited on Si-substrates by thermal evaporation method without the use of any metal catalyst. It was confirmed that that he films has nanostructure by SEM observation. Nanostructures CdO thin films exhibit a cubic rock salt (NaCl) type structure as confirmed by XRD analysis. Both lattice constant and crystallite (grains) size were determined for the CdO nanostructures.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge support from ERGS grant and Universiti Sains Malaysia.

References

[1] A. S. Obaid, M. A. Mahdi, Asmiet Ramizy, Z. Hassan, Structural Properties of Nanocrystalline PbS Thin Films Prepared by Chemical Bath Deposition Method ,Advanced Materials Research 364 (2012) 60-64.

[2] R. Ferro and J. A. Rodriguez, Influence of F-doping on the transmittance and electron affinity of CdO thin films suitable for solar cells technology, Sol. Energy Mater. Sol. Cells 64 (2000) -270.

[3] Zhiyong Zhao DL, Morel CS Ferekides. Electrical and optical properties of tin-doped CdO films deposited by atmospheric metalorganic chemical vapor deposition. Thin Solid Films. 413(2002) 203–211.

[4] Baranov AM, Malov YA, Zaretsky DF, Tereshin SA. Solar cells based on the heterojunction a-C/p-Si. Solar Energy Materials & Solar Cells. 60(2000)11-17.

[5] Champness CH, Ghoneim K, Chen JK. Optimization of CdO layer in a Se-CdO Photovoltaic cell. Can. J. Phys. 63(1985)767.

[6] Kondo R. Okhimura H, Sakai Y. Electrical properties of Semiconductor Photodiodes
with Semitransparent films. Jpn. J. Appl. Phys. 10(1971)176.

[7] Mishra RL, Sharmaa AK, Prakash SG. Gas sensitivity and characterization of cadmium oxide (CdO) semi conducting thin filmdeposited by spray pyrolysistechnique.Digest Journal of Nanomaterials and Biostructures, 4 (2009)511–518.

[8] C Sravani, K T Ramakrishna Reddy and P Jayarama Reddy, Physical behaviour of CdO films prepared by activated reactive evaporation, Semiconductor Science and Technology, 6 (1991) 1036

[9] T. Subramanyam, B. Krishna, S. Uthanna, B. Naidu, P. Reddy, Influence of oxygen pressure on the physical properties of dc magnetron reactive sputtered cadmium oxide films, Vacuum 48 ,6(1997) 565-569.

[10] X. Li, T. Gessert, T. Coutts, The properties of cadmium tin oxide thin-film compounds prepared by linear combinatorial synthesis, Appl. Surf. Sci. 223,1-3 (2004) 138-143.

[11] D. Ellis, S. Irvine, J. Mater. Sci.: Mater. Electron. 15 (2004) 369.

[12] A.A. Dakhel, Transparent conducting properties of samarium-doped CdO J. Alloys Compd. 475 (2009) 51-54.

[13] J. Chang, R. Mane, D. Ham, W. Lee, B. Cho, J. Lee, S. Han, Electrochemical capacitive properties of cadmium oxide films, Electrochem. Acta, 53(2007) 695-699.

[14] R. Gupta, K. Ghosh, R. Patel, S. Mishra, P. Kahol, Influence of oxygen partial pressure on optoelectrical properties of aluminum-doped CdO thin films, Applied Surface Science ,254, 18, 15 (2008) 5868–58734103.

[15] H. Ali, H.A. Mohamed, M.M. Wakkad, and M. F.Hasaneen, Optical and Electrical Properties of Tin-Doped Cadmium Oxide FilmsPrepared by Electron

Beam Technique, Japanese Journal of Applied Physics 48 (2009) 041101.

[16] R.R. Salunkhe, D.S. Dhawale, D. P.Dubal, C.D. Lokhande, Sprayed CdO thin films for liquefied petroleum gas (LPG) detection, Sensors and Actuators B: Chemical 140 (2009) 86-91.

[17] S. Aksoy, Y. Caglar, S. Ilican, M. Caglar, Effect of heat treatment on physical properties of CdO films deposited by sol–gel method, Int. J. Hydrogen Energy 34 (2009) 5191–5195.

[18] B. Saha, R. Thapa, K. Chattopadhyay, Wide range tuning of electrical conductivity of RF sputtered CdO thin films through oxygen partial pressure variation,Sol. Energy Mater. Sol. Cells 92 (2008) 1077-1080.

[19] R.R. Salunkhe, D.S. Dhawale, T.P. Gujar, C.D. Lokhande, Structural, electrical and optical studies of SILAR deposited cadmium oxide thin films: Annealing effectMater. Res. Bull. 44 (2009) 364-368.

[20] C.H. Bhosale, A.V. Kambale, A.V. Kokate, K.Y. Rajpure, Structural, optical and electrical properties of chemically sprayed CdO thin films, Materials Science and Engineering: B
122 (2005) 67–71.

[21] A.S. Obaid, M.A. Mahdi, Z. Hassan , M. Bououdina, PbS nanocrystal solar cells fabricated using microwave-assisted chemical bath deposition, International Journal of Hydrogen Energy 38 (2013) 807-815.

[22] A.S. Obaid, M.A. Mahdi, Z. Hassan, and M. Bououdina, Characterization of
nanocrystalline PbS thin films prepared using microwave-assisted chemical bath deposition, Materials Science in Semiconductor Processing 15 (2012) 564-571.

[23] M.A. Rafa, and N.Rousdy, Study of optical properties of nanostructured PbS films ,Philosophical Magazine Lettersl 90(2010) 113-120.

[24] Li Fei, Li Zhen, Fu Jiang Jin, Structural and luminescent properties of ZnO nanorods prepared from aqueous solution, Materials Letters, 61(2007)1876–1880.

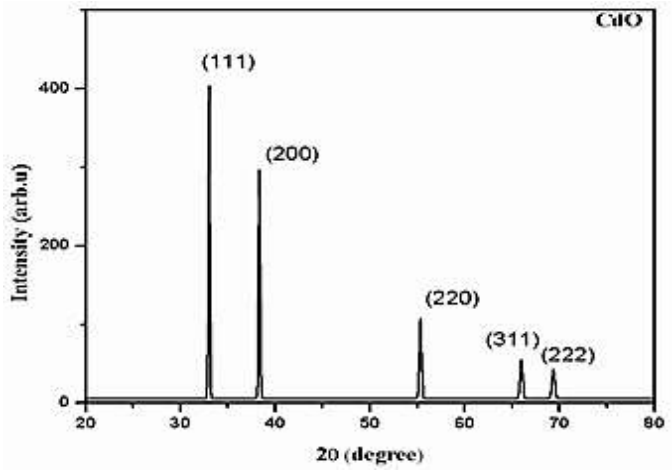

Figure 1. XRD of nanostructures CdO thin films deposited using thermal evaporator (VS)

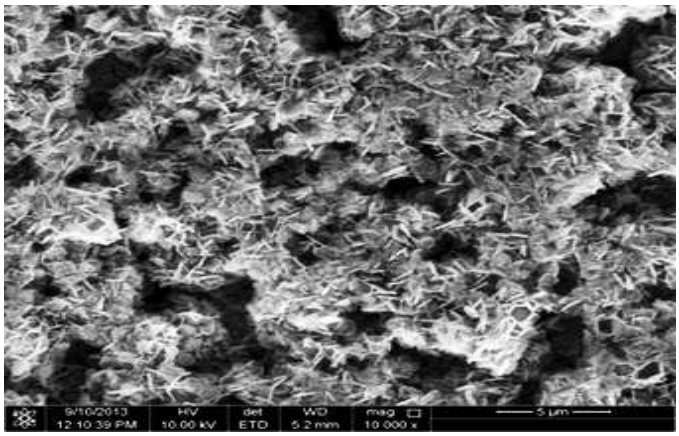

Figure 2. SEM images of nanostructures CdO thin films deposited using thermal evaporator (VS)

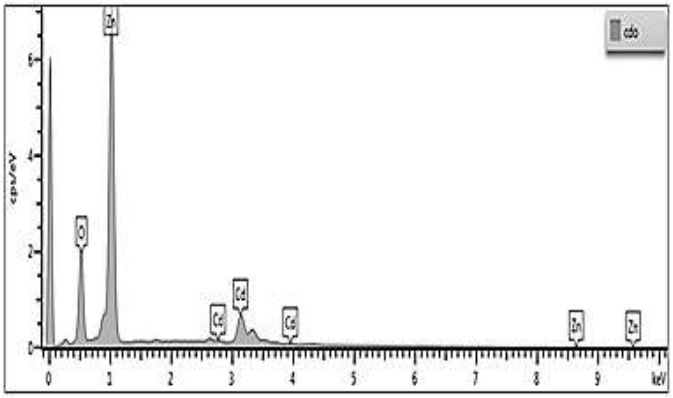

Figure 3. EDX spectrum of nanostructures CdO thin films deposited using thermal evaporator (VS)

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2014,8 (2) :53-57

تحضير اغشية الكادميوم اوكسايد النانويه باستخدام طريقة التبخير الحراري

احمد سلمان عبيد* خليل ثابت حسان* عبدالمعنم مصلح عاشج* بشار محمد صالح* محمد بودين**

E-mail: ahmed.s.obaid.alqayssei@gmail.com

الخلاصة

اغشية الكادميوم اوكسايد تم تحضيرها باستخدام طريقة التبخير الحراري على قواعد من السيلكون باستخدام كادميوم كلورايد كمصدر للكادميوم. دُرست الخصائص التركيبيه, طوبوغرافية السطح بواسطة حيود الاشعه السينيه (XRD), المجهر الالكتروني الماسح (SEM). اظهرت قياسيات حيود الاشعه السينيه ان غشاء الكادميوم اوكاسايد المرسب كان متعدد التبلور ومتبلور بصوره جيده. تم حساب ثابت الشبيكه والحجم الحبيبي النانوي. اكدت نتائج المجهر الالكتروني الماسح طبيعية التركيب النانوي للفلم. بينت نتائج تحليل الاطياف للطاقة والتشتت للاشعه السينه ان الفلم يحتوي على قمم الكادميوم والاوكسجين فقط من غير ظهور لاية قمم تعود للشوائب او التلوث.