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The Effect of Different Temperatures on the Properties of Cadmium Selenide Films Prepared by Low-Cost Method

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Abstract

In this study, cadmium selenide (CdSe) thin films were grown on glass substrates by a low-cost method (chemical spry pyrolysis (CSP). Different temperatures (350,300,250 ºC) were used to prepare CdSe thin films. X-RD, energy band gap (Eg) and (SEM) scanning electron microscopy were used to study the effect of change in temperature on the films. X-RD analysis revealed that the minor shifting in diffraction angle, intensity, and full-width half-maximum caused variation in crystallite size. The relation between crystallite size and the temperature was directly proportional and found to be (43.2,41.7 and 38.8 nm) at temperatures (350,300 and 250 ˚C), respectively, with dislocation density and microstrain inversely proportional with depositing temperature. Increasing the temperature also affects the energy band gap, and the change was inversely between them(2.06, 1.97 and 1.95 eV). SEM results showed the effect of the prepared factor (temperature) on the surface morphology and best homogeneity in shape and size for samples prepared at temperatures (300 ˚C) .

Introduction

The II-VI binary semiconducting compounds such as (CdS, CdSe, and CdTe) are materials of interest for many applications in solid-state physics. CdSe is one of important materials for photovoltaic applications[1-3]. In recent years, there has been more interest in studying the physical properties of CdSe thin films to improve their physical properties of it. Many techniques were used to prepare it, such as physical vapor deposition [4]and spray pyrolysis, etc [5]. The CdSe films exhibited good transmittance [6]. The narrow optical band gap of compound CdSe has become more interesting because they have useful properties for photovoltaic applications [7–9].The CdSe nanostructures have physical and chemical properties, aside from the potential importance of being nonlinear optical materials [10-12]. The reason for studying CdSe nanostructures spaciously is because of their tunable emission on the visible scale, advances in their preparation techniques, and their different applications[13-19].It has both cubic and hexagonal characteristics compared with bulk materials [20].The synthesis parameters can be used to control the size and shape of nanoparticle strictures [21]. Controlling the sizes and the shapes of materials in the nano range allows for control of their bandgap over a wide range [22].

Experimental part

In the present research, CdSe films were deposited on the glass substrates by CSP method. Before depositing, the films must be cleaned by ultrasonically cleaned in acetone, then ethanol,. After that, cleaned with distilled water (DW), and finally, dried substrates. Using, C;OOPan aqueous solution (0.1 M) of cadmium acetate [2(CH3COO)Cd.H_2O] and selenium dioxide [SeO_2]. DW was used as solvent of precursor materials with continuous stirring by a magnetic stirrer. After preparing the solution, put it in a container to deposition on the clean substrates at different temperature degrees (250,300 and 350 ˚C); the distance between the nozzle and the substrates was fixed at 30 cm and sprayed at a rate of 3 mL/min. The crystallite size (D) was calculated by Debey- Scherer's equation [23-24].

$$D = k\lambda / \beta \cos\theta \qquad (1)$$

Where:

λ : wavelength, β : FWHM, *k* : shape factor and θ : diffraction angle.

Dislocation ,MB,,,,, [O86BYGTdensity (δ) has been calculated from the equation $\delta=1/D^2$ (lines/m^2). The micro strain (Ɛ) is calculated using the equation Ɛ=βcosθ/4[25].

Results and discussions

Structural analysis (X-RD)

Fig. 1 shows X-RD patterns of CdSe films. appear CdSe films is polycrystalline with hexagonal structure and the major peaks are in directions (100), (002) and (110) respectively, the high intensity refers to the dominate growth direction with another minor peaks. The higher peak in the direction of (002) at diffraction angles (2θº = 25.80º, 25.44º and 25.31º) for samples prepared at different depositing temperatures (350,300,250 ºC) respectively. The crystallite size has been calculated by the most preeminent (002) orientation and found to be (43.2,41.7 and 38.8 nm) respectively. Also shows when the temperature increases from (250 - 350 ºC) the crystallinity increases; that is perhaps because of the inverse relation between (D and T), the decrease in the crystallite size with increased temperature.

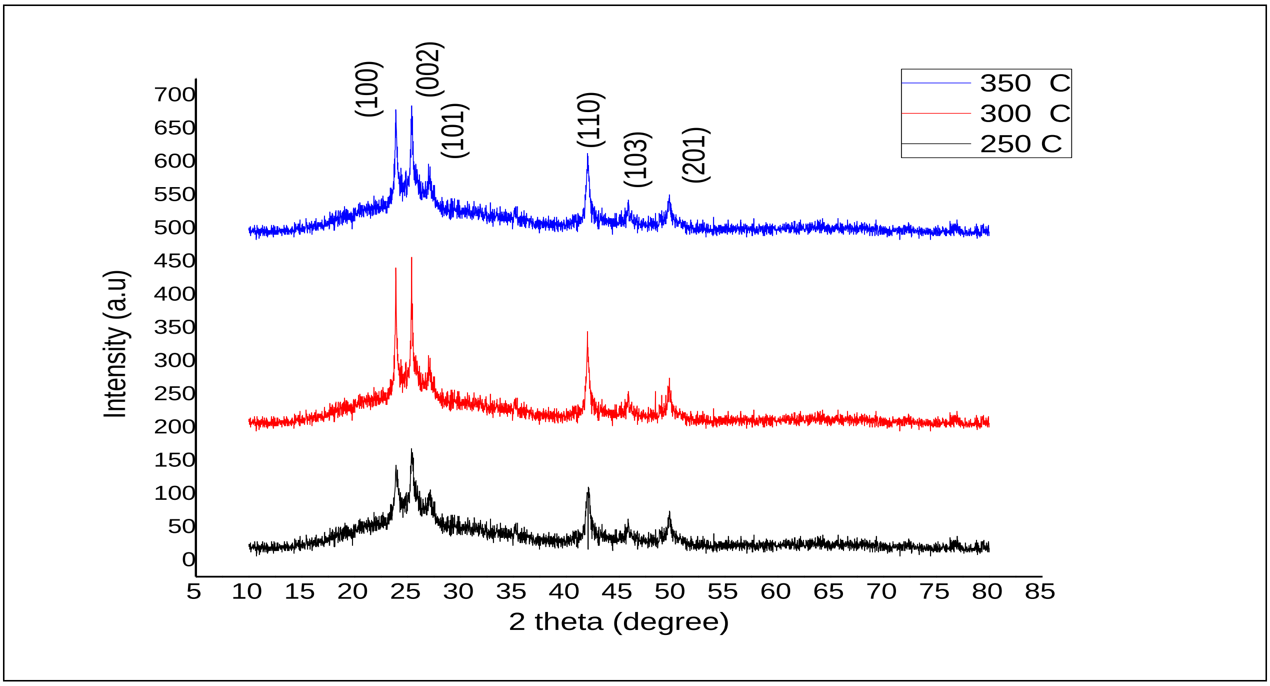

Fig. 1 X-ray diffraction spectrum at different temperatures.

Table 1 show the effect of temperature. When increase preparing temperature will decrease FWHM and also show the relationship between temperature and Crystallite size. dislocation density and micro strain proportional inversely with increase the prepare temperature.

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Table 1 shows some structural properties of prepared samples.

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Temperature (ºC)	2 theta (degree)	FWHM (degree)	D (nm)	(δ) (lines/m^2).	(Ɛ)
350	25.80	0.321	43.2	5.358 X10^{-6}	0.0801
300	25.44	0.332	41.7	5. 570 X10^{-6}	0.0829
250	25.31	0.360	38.8	6. 642 X10^{-6}	0.0899

From the optical properties calculated, the allowed direct band gap (Eg) for samples prepared at different temperatures was found to be (2.06, 1.97 and 1.95 eV) at temperatures (250, 300 and 350 ˚C) respectively. Figure 2 shows a decrease in the direct band gap energy with increases in temperature range because of realigning the atom's crystals level.

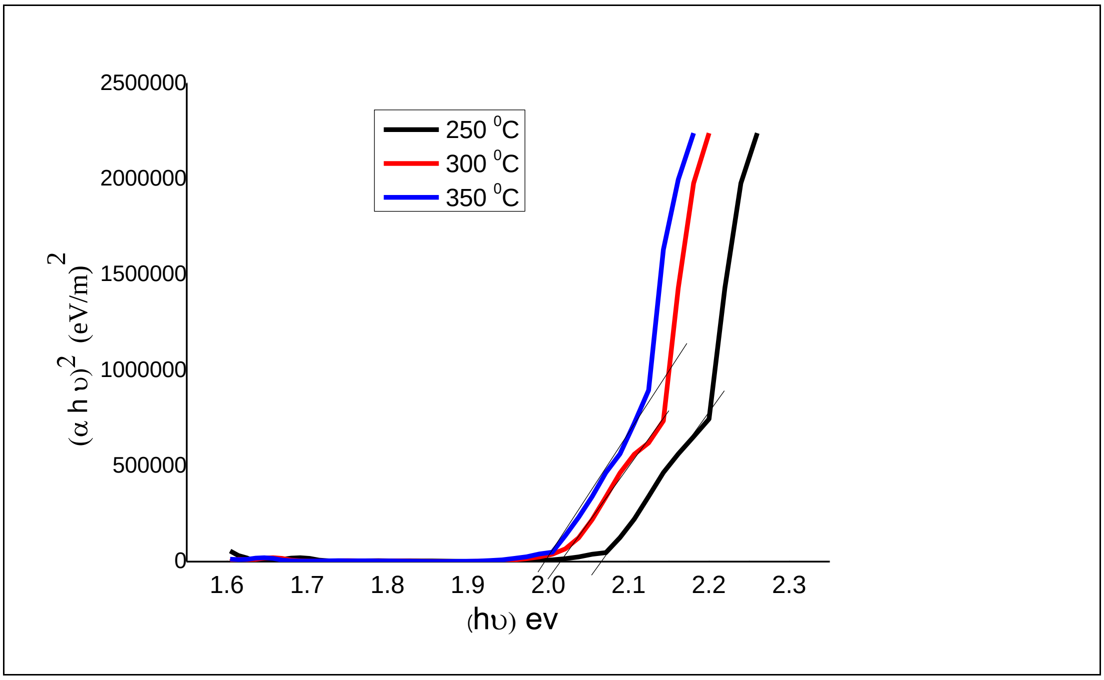
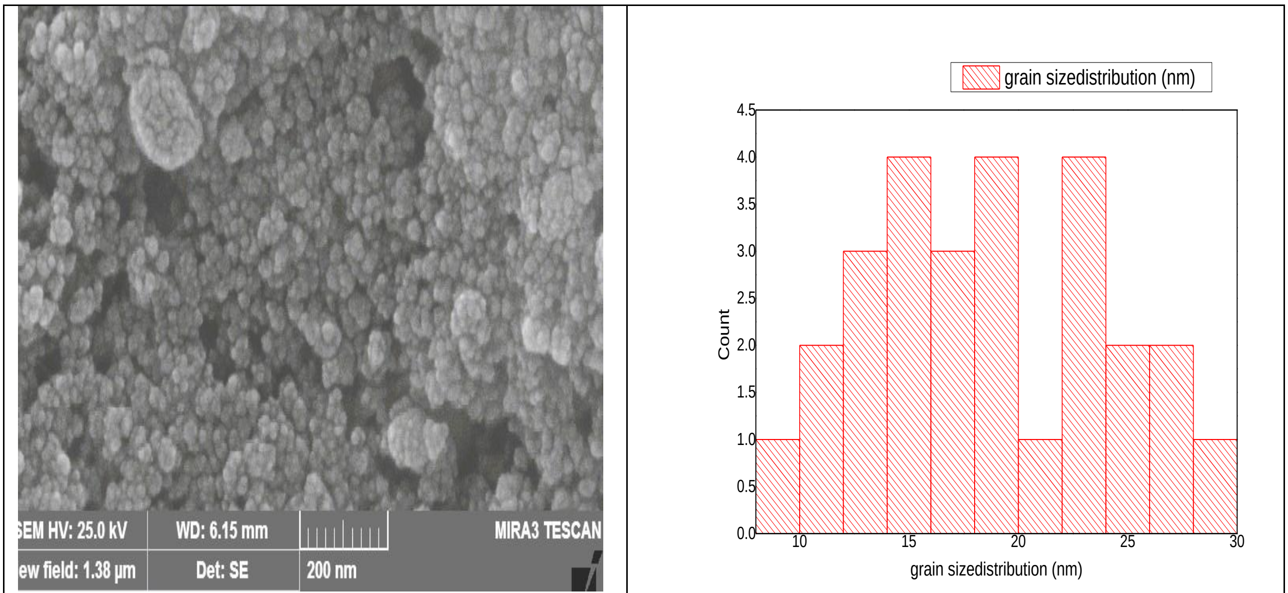


Fig. 2 explain the influence of changing temperature on the band gap energy (E_g) of CdSe.

Morphological characterizations

Appear from SEM image effect the substrate temperature on the roughness surface homogeneity shapes and size. Figure (3A, B and C) represent CdSe NPs deposited on glass substrates at deferent temperature temperatures (250, 300 and 350 ˚C) respectively and the grain size distribution of this samples. SEM images showed spherical shapes of CdSe NPs on all films but appear more homogeneity in shape and size for samples prepared at temperatures (300 ˚C).



A

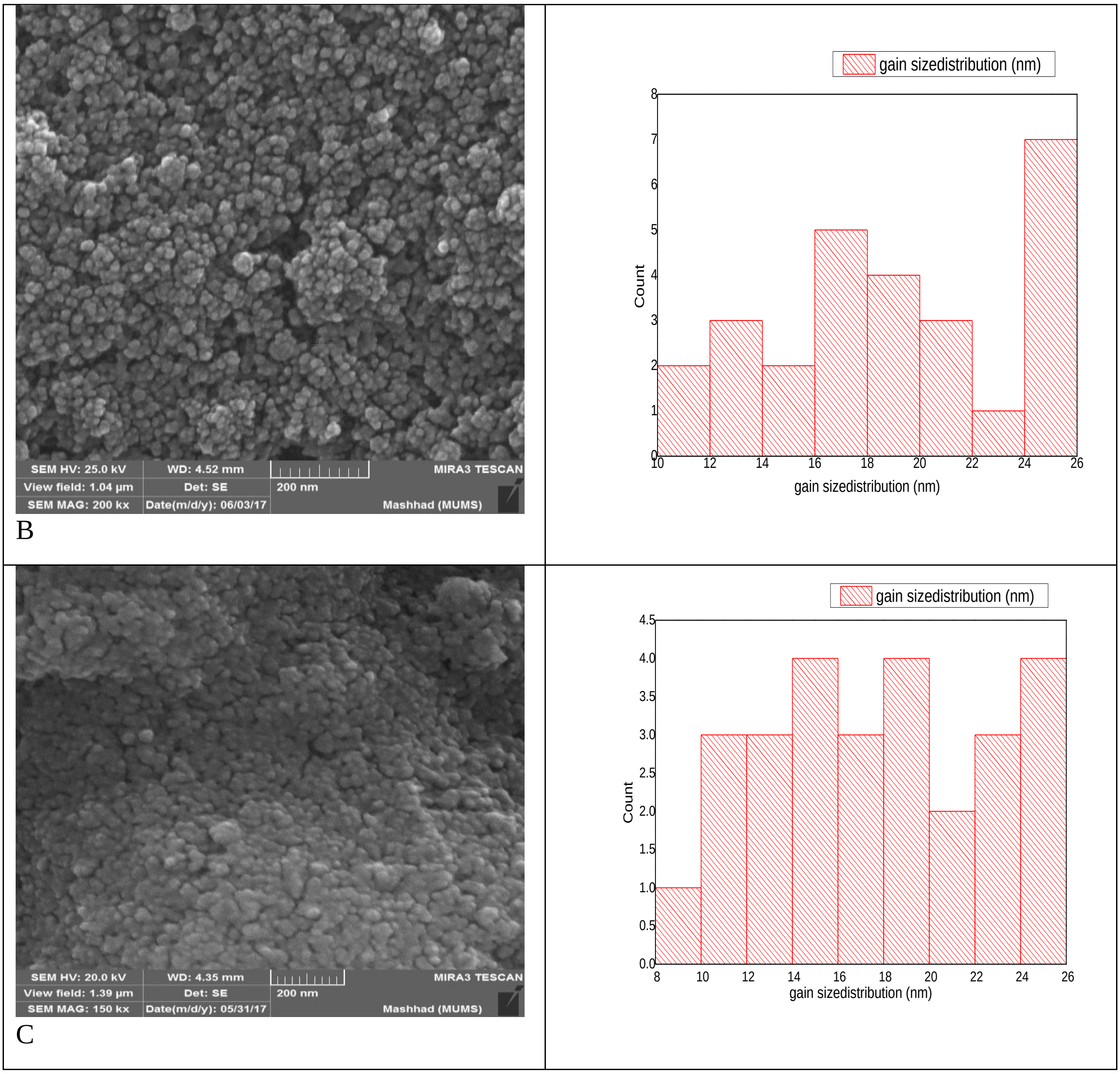


Fig. 3 SEM image and grain size distribution for samples at different temperatures.

Conclusions

The chemical spry technique is a simple, low-cost technique. CdSe were successfully deposited on substrates at temperature. The deposited temperature directly affected the structural properties of CdSe. The crystallite size change depended on the deposited temperature and decreased from (43.2 nm to 38.8 nm)with increase the prepared temperature. The energy band gap decreases with increases in temperature from (2.06, 1.97 and 1.95 eV). SEM images showed spherical shapes CdSe with homogeneity in shape and size. The results show that the prepared films can be applied in many fields, such as photovoltaic and sensing.

References

1. Xavier Mathew , J. Pantoja Enriquez a , Alessandro Romeo , Ayodhya N. Tiwari b. (2004). CdTe/CdS solar cells on flexible substrates . Solar Energy, 77 , 831–838

2. E. Benamar, M. Rami, M. Fahoume, F. Ccraibii, A. Ennaoui .(1998). Electrodeposited cadmium selenide films for solar cells Ann. Chim. Sci. Mater., 23 p.p 369-372.

3. C. Baban and G. I. Rusu. (2003). On the structural and optical characteristics of CdSe thin films Appl. Surface Scie. 211, 6.

4. A. A. Yadav, M. A. Barote, and E. U. Masumdar. (2010). Studies on cadmium selenide (CdSe) thin films deposited by spray pyrolysis Mater. Chem. Phys. 121, 53.

5. Zhao J, Bardecker JA, Munro AM, Liu MS, Niu Y, Ding I-K, Luo J, Chen B, Jen AKY, Ginger DS.(2006). Efficient CdSe/CdS quantum dot light-emitting diodes using a thermally polymerized hole transport layer. Nano Lett.6:463–7.

6. Pengjie Wang, Rengang Zhang, Tuantuan Wang , Xuemei Li , Rui Cui, Hongyu Liu, Peng Zha ng, Xingzhong Cao, Runsheng Yu, Baoyi Wang.(2024). The effect of annealing temperature on the properties of CdSe thin films prepared by annealing the SES deposited precursors. Optic materials.157, 116284.

7. Schreuder MA, Xiao K, Ivanov IN, Weiss SM, Rosenthal SJ.(2010). White light-emitting diodes based on ultrasmall CdSe nanocrystal electroluminescence. Nano Lett;10:573–6.

8. Wang X, Liu H, Shen W.(2016). Controllable in situ photo-assisted chemical deposition of CdSe quantum dots on ZnO/CdS nanorod arrays and its photovoltaic application. Nanotechnology;27:085605.

9. X.G. Peng, L. Manna, W. Yang, J. Wickham, E. Scher. (2000). Shape control of CdSe nanocrystals. Nature 404 , 59–61.

10. L. Brus. (1998). Chemical approaches to semiconductor nanocrystals. J. Phys. Chem. Solids 59 , 459–465.

11. Y. Wang, N. Herron. (1991) . Nanometer-sized semiconductor clusters: materials synthesis, quantum size effects, and photophysical properties. J. Phys. Chem. 95, 525–532.

12. M. Bruchez, M. Moronne, P. Gin, S. Weiss, A.P. Alivisatos.(1998). Semiconductor nanocrystals as fluorescent biological labels. Science 281, 2013– 2016. DOI: 10.1126/science.281.5385.2013

13. M.C. Schlamp, X.G. Peng, A.P. Alivisatos. (1997). Improved efficiencies in light emitting diodes made with CdSe(CdS) core/shell type nanocrystals and a semiconducting polymer . J. Appl. Phys. 82 , 5837–5842.

14. V.I. Klimov, A.A. Mikhailovsky, S. Xu, A. Malko, J.A. Hollingsworth, C.A. Leatherdale, H.J. Eisler, M.G. Bawendi. (2000). Optical gain and stimulated emission in nanocrystal quantum dots. Science 290, 314–317.

15. H. Weller. (1998).Transistors and Light Emitters from Single Nanoclusters. Angew Chem Int Ed Engl. 37,1658–1659.

16. M.T. Harrison, S.V. Kershaw, M.G. Burt, A.L. Rogach, A. Kornowski, A. Eychmuller, H. Weller.(2000). Colloidal nanocrystals for telecommunications. Complete coverage of the low-loss fiber windows by mercury telluride quantum dot. Pure Appl. Chem. 72, 295–307.

17. W.C.W. Chan, S.M. Nie.(1998). Quantum Dot Bioconjugates for Ultrasensitive Nonisotopic Detection. Science 281, 2016–2018.

18. X.D. Liu, P. Peng, J.M. Ma, W.J. Zheng.(2009). Preparation of novel CdSe microstructure by modified hydrothermal method. Mater. Lett. 63, 673–675.

19. H.N. Wang, Z.Y. Guo, F.L. Du.(2006). Solvothermal synthesis of CdSe nanorods via DEA solution. Mater. Chem. Phys. 98, 422–424.

20. N. Shukla, M.M. Nigra. (2010). Synthesis of CdSe quantum dots with luminescence in the violet region of the solar spectrum. Luminescence 25 (2010) 14.

21. Wisam J. Aziz, Raad S. Sabry, Abbas K. Jarallah.(2018). Production of TiO2 Nanoparticles in Different Phases and Shapes by using PLA and Hydrothermal Method. Al-Mustansiriyah Journal of Science, Volume 29, Issue 2.

22. 1Karan Surana, Pramod K Singh, Hee-Woo Rhee, B. Bhattacharya.(2014). Synthesis, characterization and application of CdSe quantum dots. Journal of Industrial and Engineering Chemistry. http://dx.doi.org/10.1016/j.jiec.2014.01.019

23. N , Lovergine, P .Prete, L . Tapfer, F . Marzo, A. Mancin. (2005).Thick CdTe Epilayers for RT X-ray Detector Applications. Cryst Res Tech. 40, 1018.

24. M. Jawad Lahwd, A. Kasoob Jarallah. (2023). Effect of thickness and annealing temperature on the structural, morphological and optical properties of CdTe nano thin films. AIP Conf. Proc. 2591, 040024.

25. K. Girija, S. Thirumalairajan, S.M. Mohan, J. Chandrasekaran. (2009) Structural and Optical Characteristics of CdSe Thin Films Prepared by Chemical Bath Deposition Technique. Iraqi Journal of Applied Physics Letters, IJAPLett vol. (2) no. (4).

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تحضير اغشية سيلينيد الكادميوم بطريقة واطئة الكلفة و تقييم تأثير درجات الحرارة المختلفة على الأغشية

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الكلمات المفتاحية:
CdSe ، الاغشية الرقيقة، الرش الكيميائي الحراري

معلومات المؤلف

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الخلاصة:

في هذه الدراسة تم إنّما اغشية رقيقة من سيلينيد الكادميوم (CdSe) على ركائز زجاجية باستخدام تقنية واطئة الكلفة (التحلل الكيميائي الحراري). تم استخدام درجات حرارة مختلفة ((250،300،350 درجة مئوية) لتحضير أغشية رقيقة من CdSe. كما تم استخدام المجهر الالكتروني الماسح SEM وفجوة الطاقة و حيود الأشعة السينية ((X-RD (Eg) لدراسة تأثير التغير في درجة الحرارة على الأغشية. يظهر من خلال فحص X-RD تحول طفيف في زاوية الحيود والشدة والعرض عند منتصف الشدة العظمى مما يسبب تغير في حجم البلورة. وكانت العلاقة بين حجم البلورة ودرجة الحرارة متناسبة بشكل مباشر، ووجد أنّها (41.7،43.2 و38.8 نانومتر) عند درجة الحرارة (300،350 و250 درجة مئوية) على التوالي، وكثافة الانخلاع والاجهاد تتناسب عكسيًا مع درجة حرارة الترسيب. كما أنّ زيادة درجة الحرارة تؤثر أيضًا على نطاق فجوة الطاقة وكان التغير عكسيًا بينهما (2.06، 1.97 و1.95 إلكترون فولت). ويظهر من صورة SEM تأثير العامل المحضر (درجة الحرارة) على مورفولوجيا السطح، وأفضل تجانس في الشكل والحجم للعينات المحضرة عند درجات حرارة (300 درجة مئوية).