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Preparation of CdTe thin films using seed method

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Thin films of cadmium telluride were deposited on glass substrates with different deposition periods (20, 30 and 40 min), the deposition process was carried out using the seed method. The energy gap of the films was calculated, and its value changed inversely with the deposition period from 2.5eV to 1.9eV. The deposition period also influenced on the grain size; the minimum average grain size was about 93.24 nm.
Keywords : CdTe thin films, optical properties of semiconductors, structural properties of CdTe, chemical bath deposition of CdTe

Отримання тонких плівок CdTe методом затравки. *Rana zeyad abdulfattah Al-fulayih, Mohammad M. Uonis, Edrees E. Khadeer, Anwar M. Alfaidhi*
Тонкі плівки телуриду кадмію осаджувалися на скляні підкладки з різним періодом осадження (20, 30 і 40 хв), процес осадження проводився методом затравки. Було розраховано енергетичну щілину плівок, і її значення змінювалося обернено пропорційно періоду осадження від 2,5 еВ до 1,9 еВ. Період осадження також впливав на розмір зерна, мінімальний середній розмір зерна був приблизно 93,24 нм.

1. Introduction

Cadmium telluride is among the most important II-VI binary semiconductors due to its optical and electrical conductivity [1]. Cadmium telluride has a direct and fairly low energy gap from 1.42 eV for the polycrystalline state to 1.5eV for single crystal state [2, 3, 4]; it also has a high absorption coefficient of about 10^{-5} cm^{-1} [5], which make it suitable for many applications including imaging detectors [6], photo chemical cells [7] and gamma-ray detection [8]. CdTe can be prepared as an *n*-type or *p*-type semiconductors depending on the preparation method [9], including sublimation in confined spaces [10, 11], magnetron sputtering [12], thermal evaporation [13], chemical bath deposition [14] and the bilayer coating method [15]. The seed deposition method involves a rapid deposition process over a short period of time to obtain small grains or seeds of the material attached to the surface of the sample and left to dry; the deposition is then repeated on the same substrate, where these seeds will serve as the basis for building the thin film. It is worth noting that both deposition processes may be performed using the same technique or using two different techniques, and some processes may be carried out on the first layer before depositing the second layer, such as annealing at certain temperatures [16, 17, 18]. In our research, the seed deposition method was used to prepare CdTe thin films for different deposi-

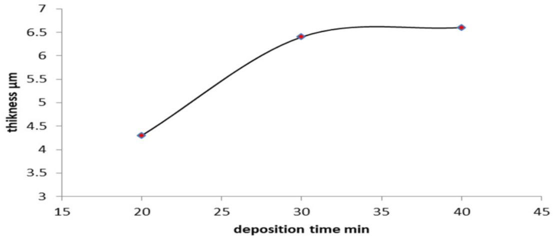

Fig. 1 Thin films thickness versus deposition periods

tion periods; the samples then were tested using UV-spectrometer, scanning electron microscope SEM and X-ray spectroscopy.

2. Experimental

Thin films of CdTe were deposited on glass substrates for different deposition periods (20, 30, and 40 min) using the seed method. The solution used in the depositing process was prepared by mixing two solutions; the first solution was prepared from dissolving 0.4g TeO_2 in 50 ml of distilled water and then adding 20 drops of HCl to complete the dissolution. The second solution was prepared by dissolving 0.3 g $CdCl_2$ also in 50ml of distilled water; then both solutions were mixed using a magnetic stirrer for 3hrs at 90°C. The glass substrates were immersed vertically in the latter solution for 1 min, then allowed to dry to form a very thin layer on which thin films were formed; finally the samples were again immersed in the solution for different deposition periods (20, 30 and 40 min) at 90°C.

The extinction coefficient and refractive index had been obtained from the following equations [19].

$$K_0 = \frac{\alpha\lambda}{4\pi} \tag{1}$$

α is the absorption coeffecient, λ is the wavelength.

$$n = \frac{(1+\sqrt{R})}{(1-\sqrt{R})} \tag{2}$$

R is the reflectance.

3. Results and discussion

Thin CdTe films were deposited on glass substrates for different deposition periods. The thickness of the films increases with the deposition time as a result of the continuous adhesion of the compound particles over time (Fig.1).

The optical properties of the films were investigated; the transmittance, absorbance and reflectance depended on the deposition times.

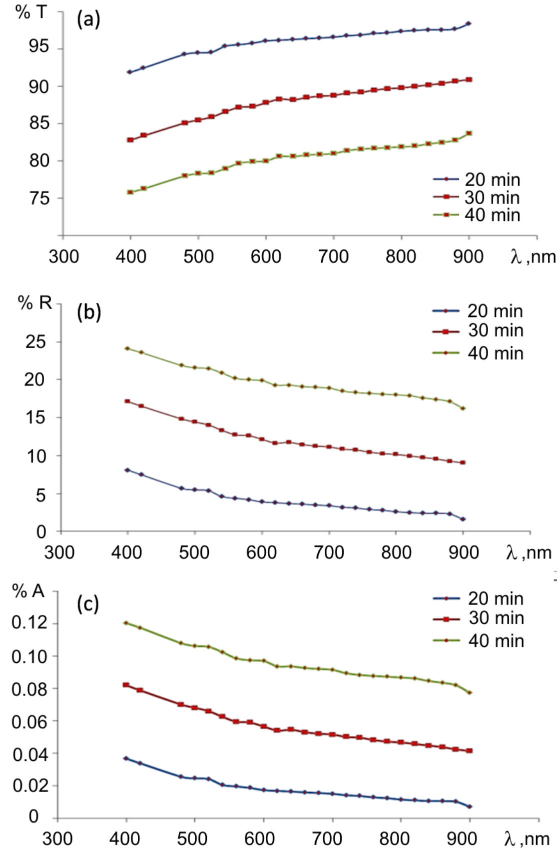

Fig. 2 Optical properties of films obtained with different deposition times: (a) transmittance, (b) reflectance and (c) absorbance

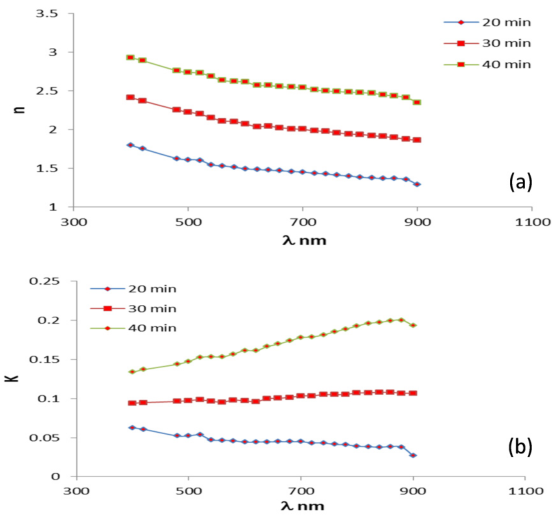

Fig.3 The optical constants of films obtained for different deposition times (a) refractive index (b) extinction coefficient

The highest transmittance was recorded for the films prepared after 20 min, then it decreased over deposition with increasing film thickness (Fig. 2-b). The change in the film thickness also led to a change in the absorbance and reflectance values in the UV-spectrum (Figs. 2-b and 2-c).

The optical constants show a clear dependence on the deposition time (Fig. 4). The refractive index **n** increases with deposition time, as the film thickness increases resulting in an increase in film density. The extinction coefficient **K** increases also with deposition time and this is the expected result due to the increase in absorption.

The calculated energy gap of the films decreased with deposition time; it was 2.5eV for films prepared for 20 min, decreased to 2.07eV for films prepared for 30 min and became about 1.9eV for films prepared for 40 min (Fig.4). The decrease in the energy gap values with deposition time is a result of the increase in the grain size of the compound.

The samples were examined using a scanning electron microscope (Fig. 5); the images show that the grain size increases directly with deposition time as a result of growth and aggregation. The images also show that the films are amorphous with presence of a crystalline phase and the crystallinity is inversely proportional to deposition periods.

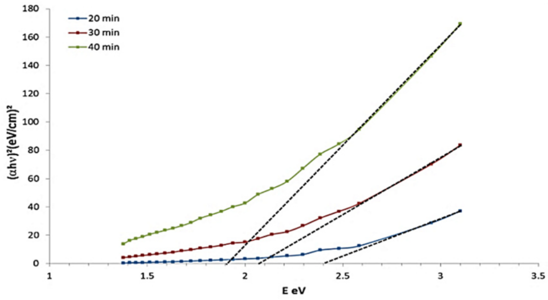

Fig. 4 Energy gaps of CdTe films prepared for different deposition times

Fig. 6 shows the XRD spectra of CdTe thin films, indicating that the films are amorphous with a crystalline phase present, the amount of

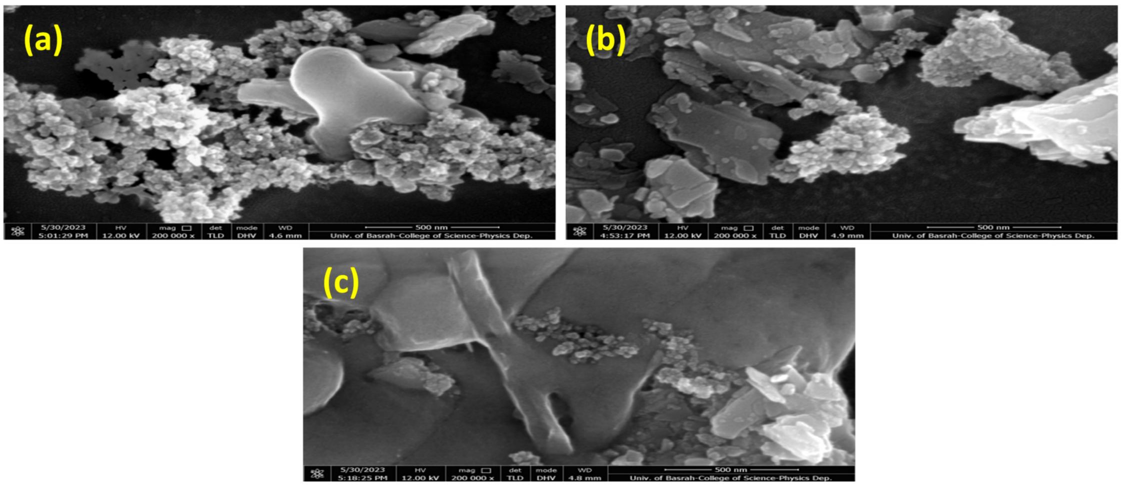

Fig. 5 SEM images of CdTe thin films deposited for different times: (a) 20 min (b) 30 min and (c) 40 min

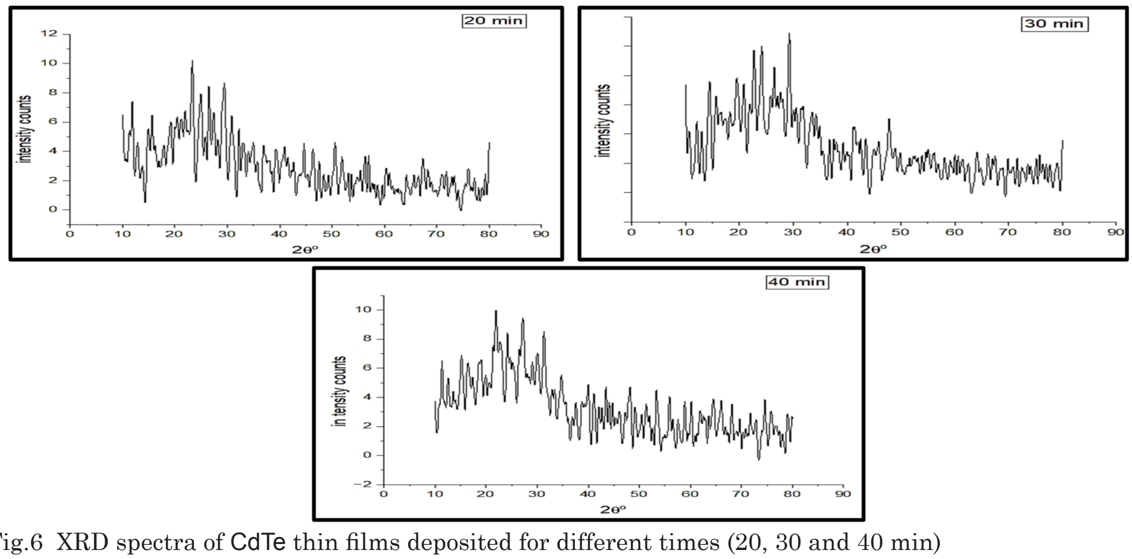

Fig.6 XRD spectra of CdTe thin films deposited for different times (20, 30 and 40 min)

Table 1 Average grain size of CdTe thin films deposited for different times (20, 30 and 40 min)

Deposition period	2θo	FWHM	D nm	Average grain size nm
20 min	23.34	0.88688	91.47521	93.24228
	39.3	0.90859	92.84722552	
	46.34	0.90578	95.40440118	
30 min	24.14	1.20031	67.68796744	98.6644
	39.3	0.61996	136.0733929	
	45.86	0.93527	92.23184505	
40 min	24.18	0.6913	117.535958	150.8316
	39.3	0.4	210.9001516	
	46.14	0.69605	124.0587568	

which decreases with deposition time, which is consistent with the SEM images in Fig. 5.

The gran size increased with deposition time; the average grain size was about 93.24 nm for films deposited for 20 min and increased to 150.8316 nm for films deposited for 40 min (Table1).

4. Conclusions

The chemical bath deposition method CBD has been used to prepare CdTe thin films for different deposition periods. All the films were amorphous with presence of crystalline phase but the degree of crystallinity decreased with deposition time. The thickness of the film increases directly with deposition time. The energy gap decreased from 2.5eV to 1.9eV with deposition time while the grain size increased with deposition time from 93.24nm to 150.83 nm.

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