Preparation and characterization of PLD deposited Indium Selenide thin film

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Received on: 10 /6/2013 & Accepted on: 3/10/2013

ABSTRACT

Indium Selenide films were deposited by pulsed laser deposition (PLD) with a Nd-YAG laser under vacuum condition. During the deposition, the substrates were kept at room temperature. The typical thicknesses of films were 200nm, 800 nm. The films were analyzed by X-ray diffraction for the crystallographic, the surface morphology of the film were investigated by AFM. It has been observed that grain growth depend on film thickness. The optical properties were characterized in the ultraviolet–visible region employing optical transmission, absorption, band gap. The direct optical band gap value for the films was found to be of the order of (2.2, 2.1) eV for thickness (200,800) nm respectively at room temperature.

Keywords: Indium Selenide Pulsed Laser Deposition, Optical Properties, Band Gap.

تحضير ودراسة خواص غشاء من انديوم سيلنيد بطريقة الترسيب بالليزر النبضي

الخلاصة

تم تحضير اغشية من انديوم سيلنيد بطريقة الترسيب بالليزر النبضي بليزر نيديموم-ياك تحت الضغط الجوي تم الحفاظ على حرارة القاعدة المرسبة عليها في درجة حرارة الغرفة. كان سمك الغشية المحضرة 200نانومتر و 800 نانومتر تم دراسة خاصية التبلور باستخدام حيود الاشعة السينية . تم دراسة تضاريس السطح بواسطة مجهر القوى الذرية وتم ملاحظة الحجم الحبيبي يعتمد على سمك الغشاء المحضر اما الخواص البصرية النفاذية والامتصاصية وفجوة الطاقة تم دراستها بالمنطقة المرئية والفوق البنفسجية ووجد ان فجوة الطاقة تساوي 2.2,2.1 لسمك الاغشية 200 نانومتر و800 نانومتر على التوالي بدرجة حرارة الغرفة .

INTRODUCTION

Indium Selenide is an important material of III–VI group compounds. The energy gap of indium selenide at room temperature is 1.1-2.5 eV, which makes it an attractive material for solar energy conversion [1–3], infrared devices [2], lasers [2] and diodes [4]. It is also used as a promising material for optoelectronic devices [5].

https://doi.org/10.30684/etj.32.2B.9
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Indium Selenide thin film prepared by electrochemical atomic layer epitaxy, chemically deposited, , thermal evaporation[8] , pulsed laser deposition[9], this technique has main advantages in short process time involving the target preparation and in the possibility to prepare multicomponent chalcogenide amorphous thin films of sufficient quality and required chemical composition, producing nanocrystalline powders without chemical treatment.The disadvantages of PLD method are the difficulty of preparing films with homogeneous thickness on large area substrates and the presence of particulates (droplets) in the deposited films [10]. In the present study, we have deposition InSe thin film by PLD Technique to calculate the optical properties, structure and morphology of the growth product.

EXPERIMENTAL

$In_{0.8}Se_{0.2}$ thin films (99.99% purity prepared by Bridgman method) were deposited by PLD technique onto cleaned glass substrates held at room temperature .The pressure inside the chamber was lower than 10^{-5} Torr. The thickness of films 200nm,800nm were measured by using optical interferometer method, the crystalline structure of the films is analyzed using X-ray diffractometer (XRD-6000 Shimadzu). For the present AFM (model AA3000 angstrom advanced.inc) investigation were employed to study the roughness and the grain size. Optical measurements were recorded using (metertech sp8001) spectrophotometer in the wavelength range 400-900 nm.

RESULTS AND DISCUSSION

Structure characteristics

XRD Analysis

Figure (1) shows the XRD patterns of Indium Selenide film grown on substrate at room temperature. The film exhibit a diffraction pattern typical for a polycrystalline structure [11]. The strong diffraction peak at 2θ=32.94° corresponds to diffraction from the (101) planes while the other peaks at 2θ=27.90° , 36.34° and 38.5 are the result of diffraction from the (201) (002) and (110) planes, respectively. According to XRD results, the In0.8Se0.2 film is polycrystalline (hexagonal system) [11, 12] (ASTM Diff. File No. 71-0250).

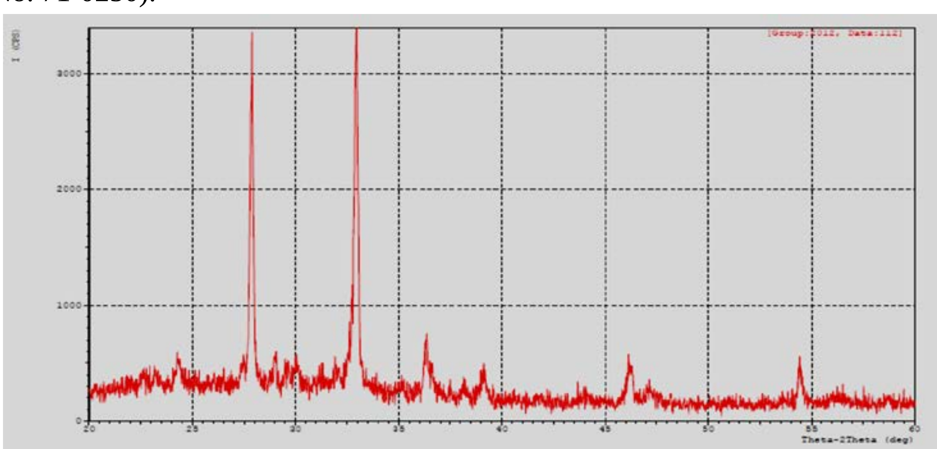
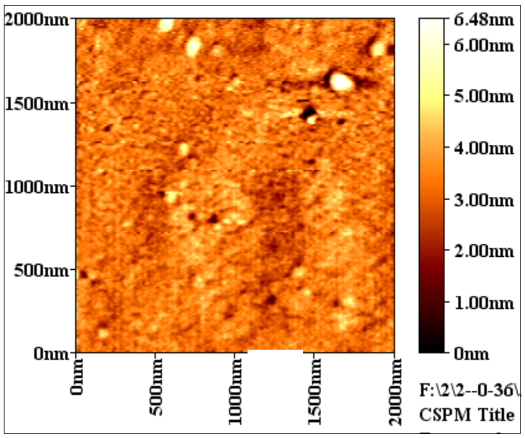


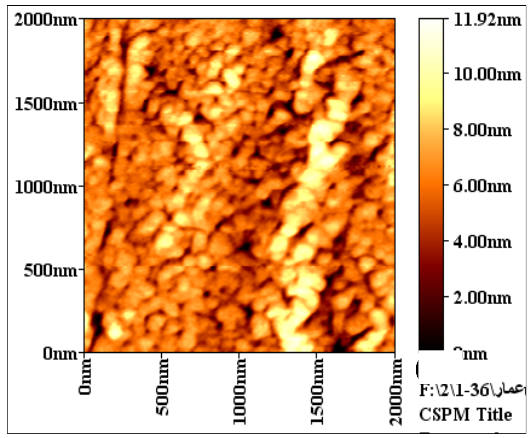
Figure (1) show X-ray diffraction patterns for $In_{0.8}Se_{0.2}$thin films.

Surface morphology analysis

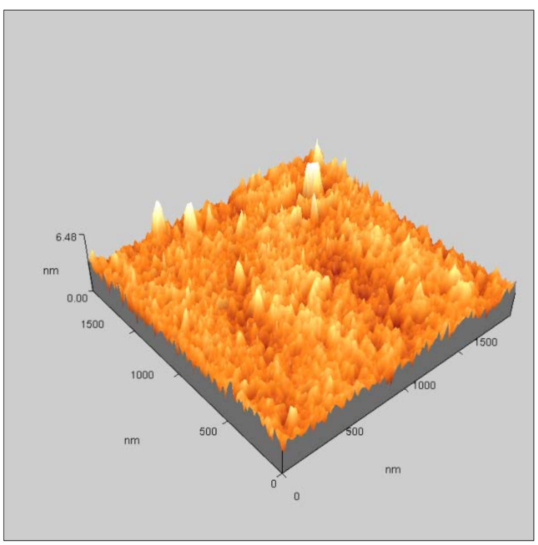
Indium Selenide thin films of thickness 200nm, 800nm studied by AFM images of indium selenide films shown in Figure (2). It is observed that the thin film is homogenous, very smooth, without cracks or pinholes and it well covers the glass substrate for both thicknesses. The average grain size and roughness of indium selenide sample is reported in Table (1).the grain size indicated that



(A)



(B)



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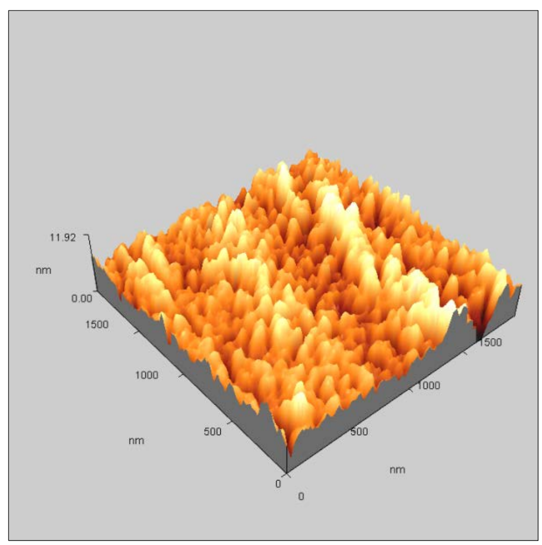
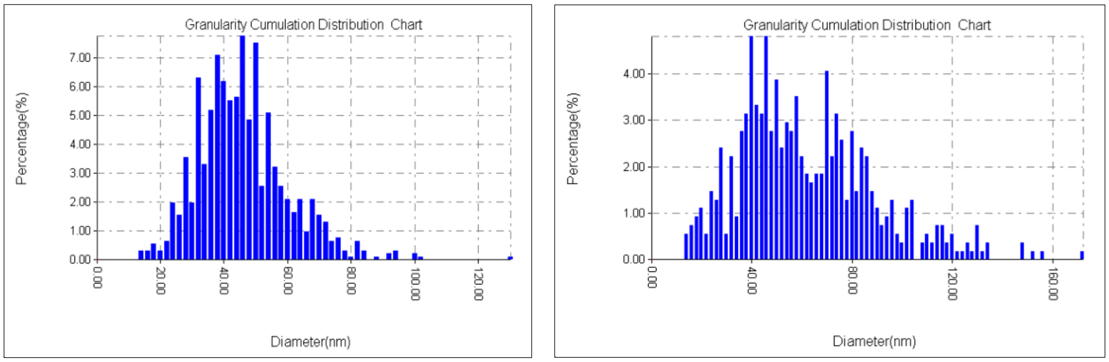


(D)



(E) (F)

Figure (3) show images of $In_{0.8}Se_{0.}$ thin films deposited on glass substrate in different thickness (A,B) AFM image(C,D) 3D AFM image (E,F) grain size distribution,images A,C,E represent thickness 200nm and images B,D,F represent thickness 800nm ,area size 2um*2um.

of the thickness 800nm larger grain size than thickness 200nm and Average roughness , Root mean square show that the roughness of the thickness 200nm more smooth than thickness 800nm .

Table (1) provides information about grain size and roughness for thickness (200,800)nm.

Thickness (nm)	Average grain size (nm)	50% diameter(nm)	Average roughness(nm)	Root mean square(nm)
200	45	42	0.42	0.58
800	60	56	1.3	1.8

Optical studies

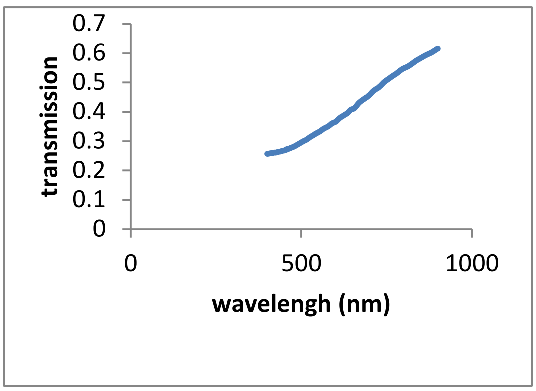
The optical properties of indium selenide film deposited onto glass substrate

Table (2) provides information about band gap for thickness (200,800) nm.

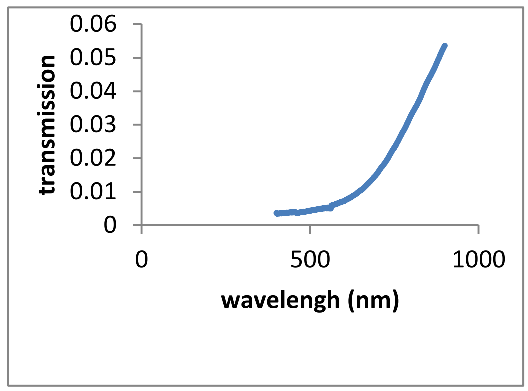
	Band gap (eV)	Ref.
1	1.1,1.23	[8]
2	1.7,2	[13]
3	1.2,1.58	[9]
4	2.5	[14]
5	2.2,2.1	Present

Were taken in the wavelength range of 400–800 nm.Figure (3) A, B shows the transmittance vs wavelength spectra of InSe thin films of thickness 200nm, 800nm respectively. From Figure (3C, D) it can be observed that the transmittance decreases rapidly with the increases in the film thickness. It can be observed that the absorption coefficient increases with increases of photon energy.

Figure (3) E, F shows the band gap energy diagram of as grown InSe films of thicknesses 200nm, 800nm The plot of $(\alpha h\nu)^2$ against hν is linear which indicates that the direct transition is Extrapolating the straight line portion of the $(\alpha h\nu)^2$–hν energy axis for zero absorption gives an optical band gap energy value of 2.2 eV for thickness 200nm and 2.1eV for 800nm, the Figure (4). the thickness increases, the band gap energy decreases, which may be attributed due to grain growth and increase of localized grain boundary, which in turn increases the point defects. The estimated band gap values are tabulated in Table (2).



(A)



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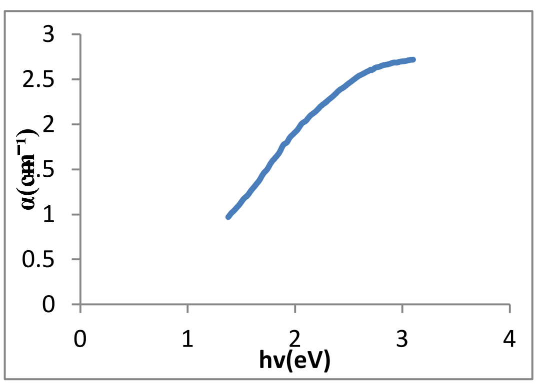
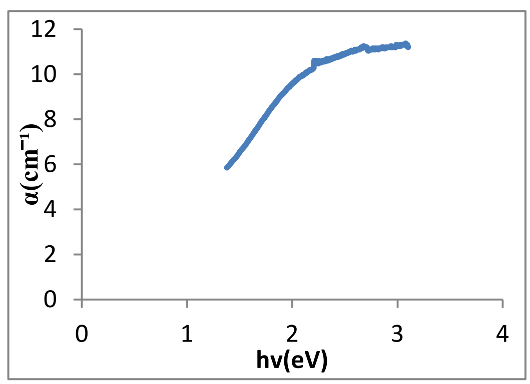
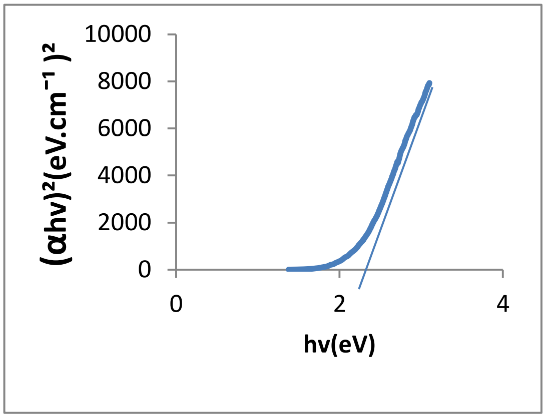


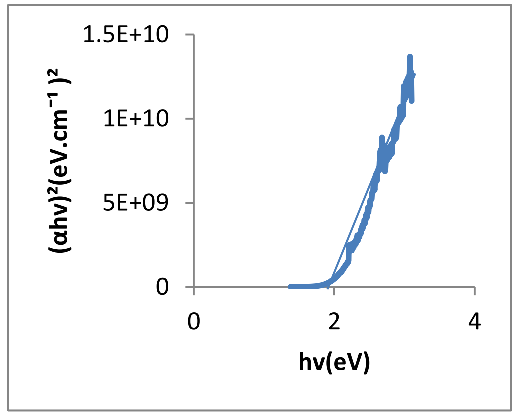
(C)



(D)



(E)



(F)

Figure (3) shows the optical properties of $In_{0.8}Se_{0.}$ thin films deposited on glass substrate in different thicknessA and B transmittance against wavelength C and D absorption coefficient against hν E and F Plot of $(\alpha h\nu)^2$ against hν,A,D,E represent thickness of 200nm and images B,C,F represent thickness of 800nm .

CONCLUSIONS

Homogenous, a uniform and smooth films of Indium Selenide have been successfully deposited using pulse laser deposition method. The film exhibit a diffraction pattern typical for a polycrystalline structure. Surface morphology analyze by AFM. Optical studies show that, Indium Selenide films have high optical absorption coefficient and direct band-to band type optical transition, optical band gap energy value of 2.2 eV for thickness 200nm and 2.1eV for 800nm.

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