Preparation of HgI_2 Films Using Solvent Evaporation

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Abstract

A deposited layer of HgI_2 has been prepared by using the solution technique. This technique takes a long time about (10 days) to get a film. The deposition time in this work reduced to (24 hours). The film consist of 2.25 mm thick layer of HgI_2.The band gap energy and type of optical transition were determined from transmission spectra, and an optical band gap of Eg =2.12 eV for direct transition was estimated. x-ray diffraction of HgI**2** to film shows a preferential orientation of peaks (101) and (102).

Keywords: HgI_2, Solution deposition, X-ray diffraction,Optical band gap

تحضير غشاء من يوديد الزئبق باستخدام تقانة تبخير المحلول

الخلاصة

تم ترسيب اغشية يوديد الزئبق باستخدام تقانة تبخر المحلول.هذه التقانة تتطلب زمن ترسيب طويل بحدود 10ايام,في بحثنا هذا تمكنا من الحصول على أغشية يوديد الزئبق بزمن ترسيب أقل بحدود 24ساعة وبسمك 2,25مايكرومتر.تم قياس النفاذية الطيفية ومن خلالها تم حساب قيم معامل الامتصاص وفجوة الطاقة وكانت بحدود2,12الكترون فولت.من خلال قياسات حيود الاشعة السينية اتضح لنا أن الاغشية هي متعددة البلورات وذات توجهية أفضل للمستويات البلورية (101) ,(102) .

1- Introduction

Red mercuric iodide (HgI_2) is a wide band gap semiconductor material (Eg=2.13 eV at 300K) with high atomic number (80.53). Due to the law dark current, high stopping power for photon, higher number of charge pair caused by irradiation, higher absorption coefficient for x-ray and gamma-ray detection. It was considered to be of the most promising semiconductor material for room temperature nuclear radiation detection [1-3]. The major advantages in using HgI_2 it does not require liquid nitrogen for cooling as opposed to most commercially available system [4]. In spite of the excellent properties of a single crystal of HgI_2, the technique used to produce single crystal is very expensive and more complicate in fabrication, the fabrication of single crystal HgI_2 in a form suitable for use for large area is not practical, therefore using near single crystal properties of poly crystalline HgI_2 films instead of a single crystal wafer will overcome this difficulty [5-7]. HgI_2 films were previously obtained by physicalvapor

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transport(PVT)[8],orby physical vapor deposition (PVD) (9,10) with much greater sensitivity can be obtained for x-ray imaging, or by screen print [11,12] with much lower dark current but reduced sensitivity, and by solvent evaporation technique which has already been used for crystal growth [13,14] .

The last technique is much cheaper and easier in fabrication HgI_2 films, since does not required any vacuum system. The requirement of this technique is the solution which is composed of HgI_2 powder and a volatile solvent either ethanol, ether, acetone [13] or tetrahydroforane (THF) [14]. The solution is placed inside a clean beaker and after a complete solvent evaporation from the beaker HgI_2 films will be deposited in the bottom of the beaker and the properties of the film depend on the evaporation rate .The disadvantage of this process is the long time taken to produce a film which is about 10 days. In this work we intend to reduce the deposition time of HgI_2 film by adding on amount of ionized water equal to the amount of solution, and

bythis approach we can reduce the deposition time to (24 hours).

2- Experimental

2-1 Substrate preparation

Substrate used for deposition HgI2 is borosilicate glass slides with dimensions (1.5*1.5cm),which were first cleaned in distilled water in order to remove the impurities and residuals from their surfaces, followed by rinsing in chromatic acid(for two days), to introduce functional groups called nucleation and/or epitaxial centers, which formed the basis for layer films growth. Then the samples were washed repeatedly in deionized water, and finally put in ultrasonic agitation with distilled water for 15 min then dried.

2-2 Deposition of the HgI_2 films

The sample studied here were polycrystalline film HgI_2 layers by solvent evaporation. HgI_2 powder (1.2 gm) from (DEHANE radial deform) was dissolved in (50ml) of volatile solvent (acetone) at 25^oc. The solutions placed inside a beaker with surface area of ($5cm^2$), After that we add an amount of ionized water to the solution equal to that of solvent (50ml), and after about 30 minutes a particles of HgI2 began to be deposited at the bottom of the beaker ,and after (24 hours) we pulled the residual solution (most of it is water) from the beaker and keep the sample for (1 hour) to become dry as shown in fig (1).The deposition of HgI2 happened because the density of acetone is less than that of water ,so the acetone atoms moved toward the surface of solution while the un-soluble HgI2 atoms in water will be separate from the solution and deposited at the bottom of the beaker, with a very little amount of HgI2 deposited on the wall of the beaker.

2-3 Thickness measurements

Film thickness is measured by weight method because the thickness of the layer is greater than 1µm. Sensitive electrical balance of Metler AE-160 was used ,with preciseness reaches 10^{-4} gm.The following mathematical relationship is adopted

Thickness=$\Delta m/p_f$ x A_f

Δm: represents the deposited thin film weight, which is equal to the difference between weight of the glass slide after and before the deposition process.

p_f: density of film

A_f: the film area

2-4 Structural measurements

The diffraction spectra of HgI_2 films were obtained by scanning (2Θ) in the range (20-60) using cu-kα (Philips-PW 1840) which has the following characteristics: the CuKα with (1.54^0A) wavelength and scanning speed: (3 degree/min).

2-5 Optical measurements

The optical transmission measurement was performed at room temperature between (400-700) nm using phenix-2000 uv-vis spectrophotometer. Optical band gap value was deduced from the extrapolated intercept of $(\alpha\ h\nu)^2$ versus ($h\nu$). Absorption coefficient (α) was calculated from the transmission spectra using Beer-lamberts law [15].

$\alpha = 1/d \ln 1/T$

Where α: the absorption coefficient

d: film thickness

T: transmission of the film

2-6 The contacts

In order to study the electrical properties, we used ohmic contacts respectively. They were obtained by using the graphite spray material manufactured by (Rc Industries, France)through mask made from (AL)foil designed to give two metals contacts of dimensions($0.2*0.65cm^2$)and (0.8cm)inter electrode distance.

2-7 Electrical measurements

Electrical measurements were carried out by using the planar structure to measure the electrical Current-Voltage curves were measured with the use of a dc power supplied(0-350 V), and (0-100mA), and the output current was measured by Keithly Electrometer type 602. The illumination source used was a white light lamp with power of 100 W located about 15 cm from the sample.

3- Results of Discussion

3-1:crystallographic structure

The diffraction spectra of HgI_2 films which were obtained reflected the presence of sharp peaks ,and by comparison between the x-ray diffraction of HgI_2 film with ASTM chart we get all the peaks of (101), (102), (103), (112), (114), (006), (211), (106) as shown in fig (2), with two small peaks does not belong to HgI_2,probably it's a metallic impurities .The x-ray diffraction shows the preferential orientation of the peaks (101) and (102) direction ,and this is because these two planes are probably the more stable. These results are in good agreement with data obtained by others[13].

3-2 Band gap

Fig. (3) shows transmission spectra for wavelength less than 700 nm. From the transmission spectra, HgI_2 seams oblique for the wavelength less than the absorption edge, a sharp increase takes place near the absorption edge and for higher wavelength.

Fig (4) shows the absorption coefficient, where the sharp decrease in (α) with increasing (λ). From the observed absorption data ,it is found that the plot of $(\alpha hv)^2$ versus (hv) fig(5) give fairly near straight line indicating that the transition were direct and allowed. Band gap (Eg) is obtained by extrapolation to zero absorption, the values of Eg films are around 2.12 eV and are equal to HgI_2 single crystal band gap, which is accepted to be 2.13 eV.

3-3 Electrical properties

Figure (6&7) shows the I-V curves for both dark and light conditions . From the curves It is clear that the increasing in photocurrent with applied voltage is much greater than that of dark current , this could be due to the increasing in quantum collection efficiency of photo –generated charge carriers .Figure (16) shows the variation of the (Iph/Id) ratio with the applied voltage . It is clear that at applied voltage less than 25V the ratio is fairly constant and shows no variation with the biasing , and for higher applied voltage the ratio increase sharply .This behavior could be attributed to the increasing of the Schubweg distant which is equal to the product of ($\mu \tau E$) [23] .Hence , at V<25v the Inter electrode distant equal to ($\mu \tau E$), and for higher voltage the Schubweg distant increases casing increasing in quantum collection efficiency of photo – generated charge carriers.

Conclusions

In this investigation, HgI2 thick film were grown on glass substrates by using solution technique. The structural and optical properties were studied, the x-ray diffraction has a preferential orientation at (101),(102). The optical band gap is equal to 2.12eV. From the I-V characteristic we get an increasing in photocurrent with applied voltage much greater than that of dark current. Which make it very attractive for x-ray detector devices.

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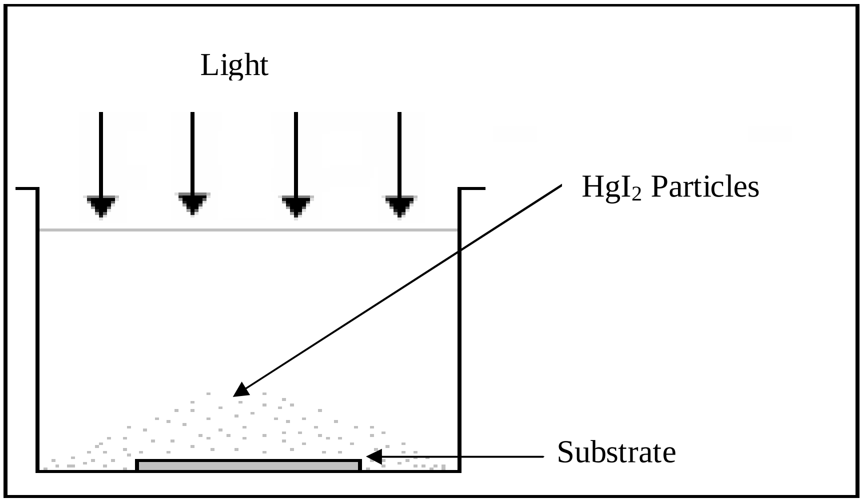

Figure(1)The experimental set-up

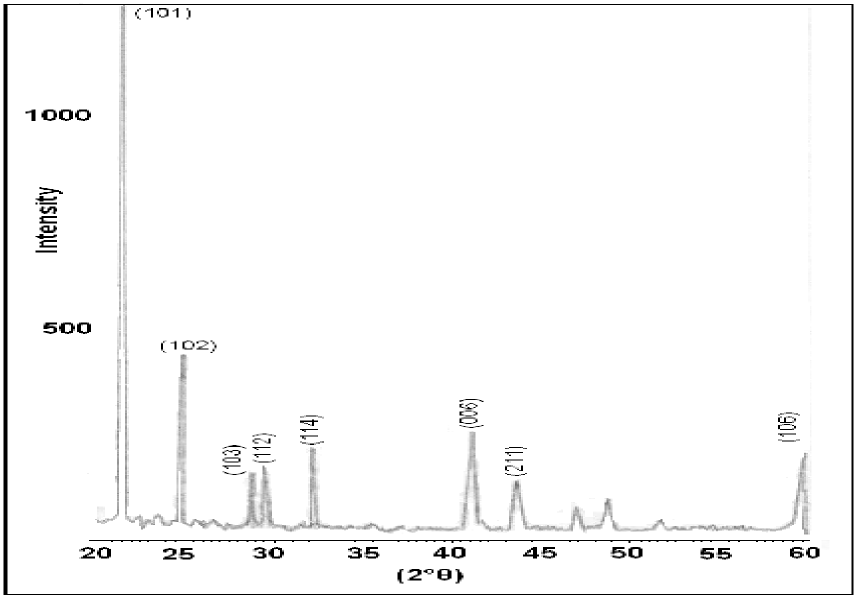

Figure (2) The x-ray diffraction of prepared HgI_2 film

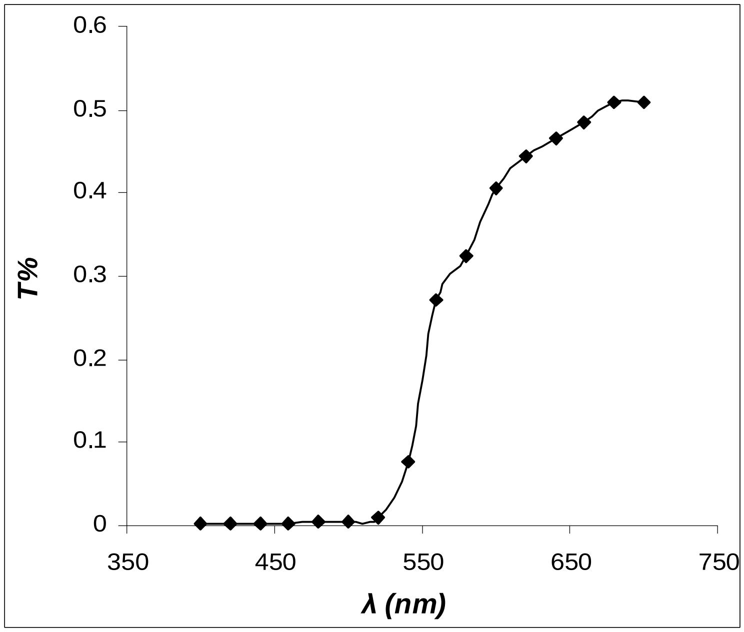

Figure (3) The transmutation spectra of the deposited layer

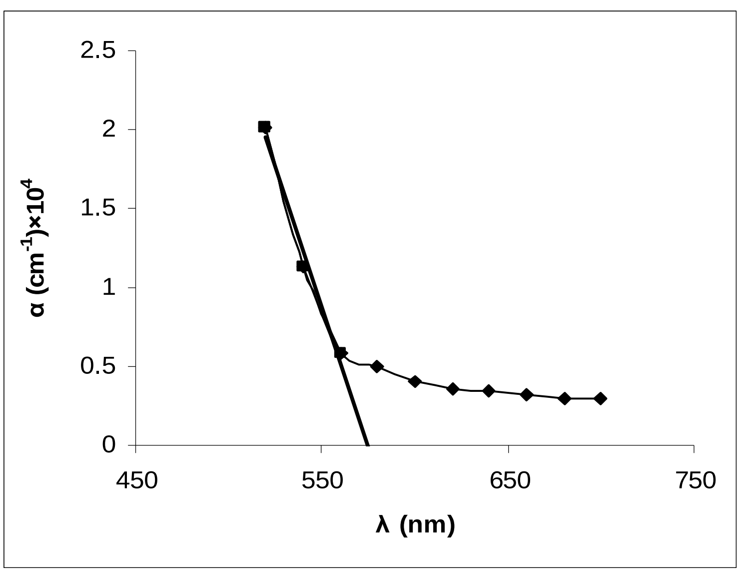

Figure (4) Absorption coefficient of the HgI_2 film layer

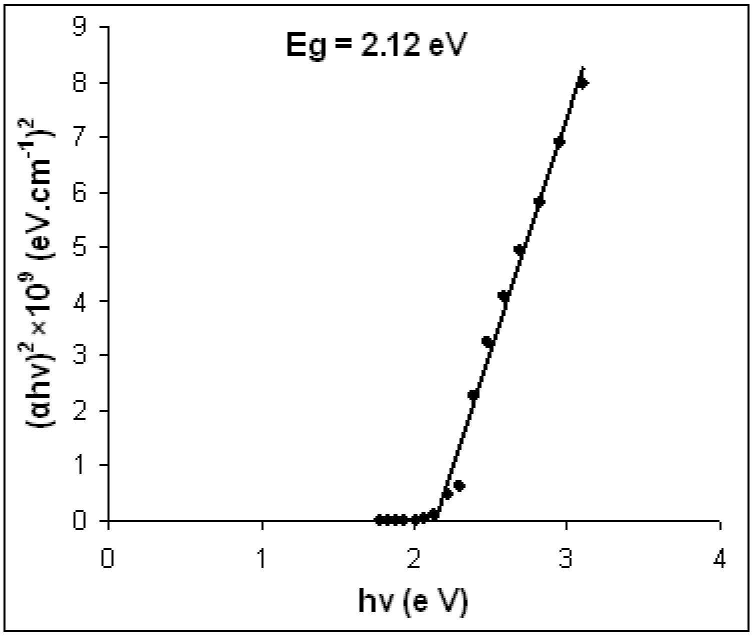

Figure (5) variation of $(\alpha\ hv)^2$ versus (hv) of the deposited layer

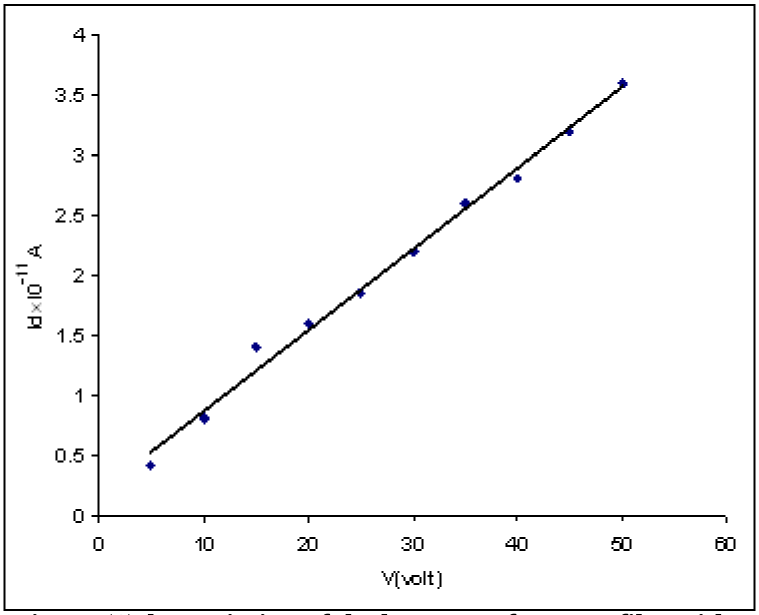

Figure (6)the variation of dark current for HgI_2 film with potential difference across the film

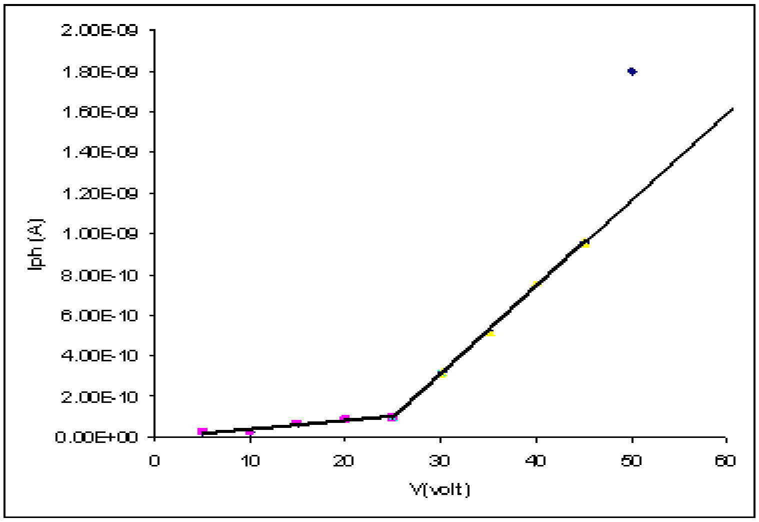

Figure (7)the variation of photo current for HgI_2 film with potential difference across the film

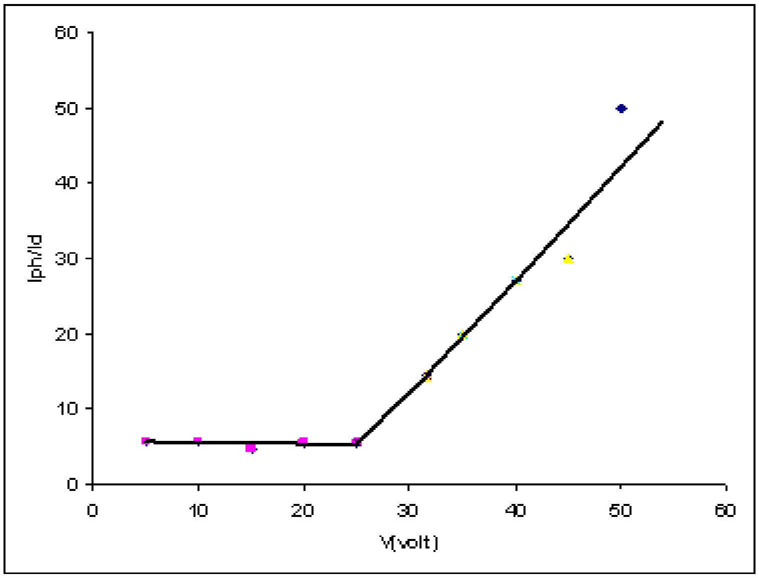

Figure (8)the variation of the photo current/dark current for HgI_2 film with potential difference across the film