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Optical and Electrical Properties of Sr-doped In_2S_3 Thin Films Prepared by Chemical Spray Pyrolysis Technique.

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ABSTRACT

Strontium doping indium sulfide thin films (In_2S_3:Sr) were deposited by spray pyrolysis technique on glass substrate at temperature 310C^0.The films were prepared by varying the(Sr) ratio from (0.1 , 0.5, 1.5)% .The effect of Strontium concentration on optical and electrical properties of In_2S_3:Sr thin films have been studied in detail visible (UV-Vis) transmittance spectroscopy measurements revealed that the optical transmittance of films exceeds 70% in the visible and near infrared region and also the direct band gap energy of the films it decreases with doping Strontium from (2.9ev) to (2.4ev).the mobility and conductivity is increases with doping Strontium and resistivity decreased from (8.5 to 1.74) Ώcm .

Introduction

In_2S_3 has a wide band gap, which can reduce the optical transmission loss at short wavelength [1] Indium sulfide is one of the potential materials for various device application due to its stability. This includes development of photovoltaic[2,3], potoelectrochemical solar cells, electronic and acoustic [4,5]. In_2S_3 is an n-type semiconductor that belongs to the III-VI group of compounds. [6] Depending upon synthesis temperature and pressure, it exists in three crystallographic phases such as β ,α and ϒ[,7]. Among These phases β - In_2S_3 is the most stable crystalline phase at room temperature with tetragonal structure [8]. Variety techniques were used to preparation In_2S_3 films such as chemical bath deposition CBD, spin coating[9], solvothermal, hydrothermal, [9] thermal evaporation[10], electrodeposition, pulsed laser deposition [11].

In the present work, we study the effect of doping Sr element at different volume ratio on properties of In_2S_3 films prepared by chemical spray pyrolysis tchniques.

Experimental work

Indium sulfide (In_2S_3) thin films doped by (Sr) at different percentage (0.1,0.5, and 1.5)% were deposited on to glass substrate from aqueous solution containing indium chloride ($InCl_3$) (98.99%), thioacetamide (NH_3CSNH_2) (98.99%), ($SrCl_3$. $6H_2O$).The concentration of In_2S_3 was fixed at 0.05M.The substrate temperature was kept at 310C^{0}for all films ,the air compressed pressure 3 bar and the distance between the glass substrate to nozzle was kept to 29cm.(it was noted after the experiments that it is the best distance if it decreases the material will agglomerate on the glass substrates)

The glass substrate (2.5cm*2.5cm*1mm) were washed with alcohol, acetone and distilled water for 30 minutes respectively and dried.

Results and discussion

0ptical properties

The optical transmittance spectra were recorded in the wavelength rang (300-1100) nm in order to investigate the effect of(Sr) content on the optical properties. Fig.1 shows the transmittance of In_2S_3 films doped with different ratio of (Sr). Transmittance of In_2S_3: Sr thin films varies from 70% to 60% explaining by good crystallinity of samples. we noted that when the amount of() Sr) increase above (o.1%) the transmittance of sample decrease .This is due to the fact that the Strontium atome are localized in the volum near the surface. Then excess of (Sr) increases

the absorption of our samples. The highest transmitted was obtained at low percentage of (Sr) doping element.

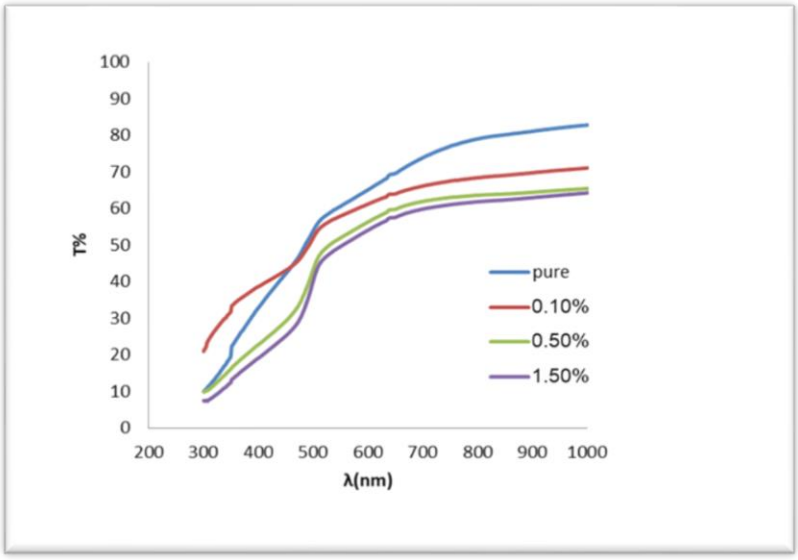

Fig. 1: Transmittance versus wavelength spectra of In_2S_3:Sr at different sr doping

The optical energy band gap of the as-deposited thin films was measured using the relation [13] $Ahv\vartheta=A(h\vartheta-Eg)^n$.

Were A is energy independent constant, n is an integer which is (1/2) for a direct allowed transition.

Optical band gap E_g of films was deduced from$(\alpha hv)^2$ versus hv extirpation straight line portion of the graph in the absorption regime. The value of energy gap befor deformation is (E_g=3.1)ev,the highest energy band gap was obtained with parentage of doping o.1% E_g=2.9ev.Fig.2 show the decrease of gap energy over 0.1% of Sr-doping. This is consistent with the research[12]. In this study both the improvement in the particle size and the stoichiometric deviations could contribute to the decrease of energy band gap of the films with the increase in the precursor concentration.

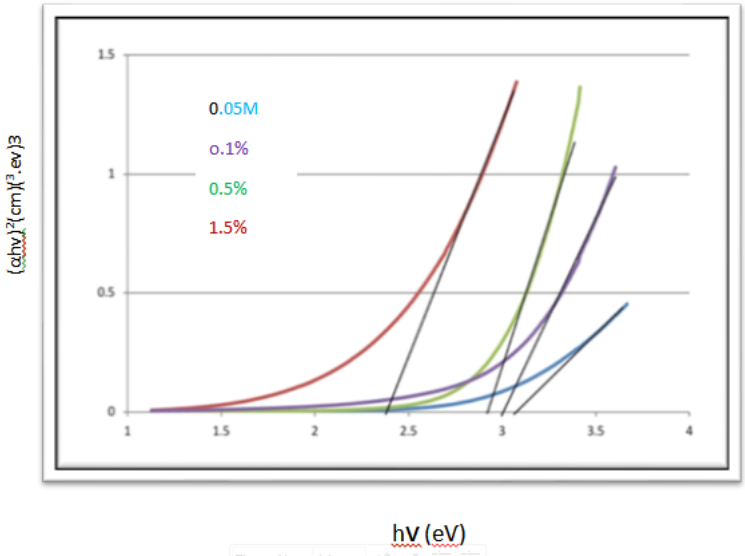

Fig. 2: plot of $(ahv)^2$ versus(hv) for In_2S_3 thin films for precursor concentration, (0.05M,0.1%.0.5%,1.5%)

Table 1: Energy gap of In_2S_3 thin films befor and after doping

Volume ratio	Eg(eV)
o.o5M	3.1
o.1%	2.9
0.5%	2.75
1.5%	2.4

Electrical properties

The electrical mobility, conductivity ,resistivity of In_2S_3 thin films deposited at different volume ratio(0,1,0.5,1.5)% were determined by Hall effect measuring instrument and the corresponding values were listed in table 2 The Hall coefficient values affirm that the films had an n –type characteristic.

The mobility value was 2.07 at 0.05 M and the mobility increases with increased volume ratio of (Sr)element. fig3 shows the mobility value changes with the volume ratios of In_2S_3 thin films. The mobility increases as result of reconstituting and the crystallinity prosperity of the material. This result is close to what the researcher fount [14].

Table 2: Electrical properties of In_2S_3:Sr thin films with different doping level

Concentration	Mobility (cm^2/v_s)	Conductivity $(\Omega cm)^{-1}$	Resistivity (Ωcm)
0.05M	2.07	1.17	8.55
0.1%	2.7	1.71	5.82
0.5%	3.2	5.72	2.41
1.5%	4.09	9.51	1.74

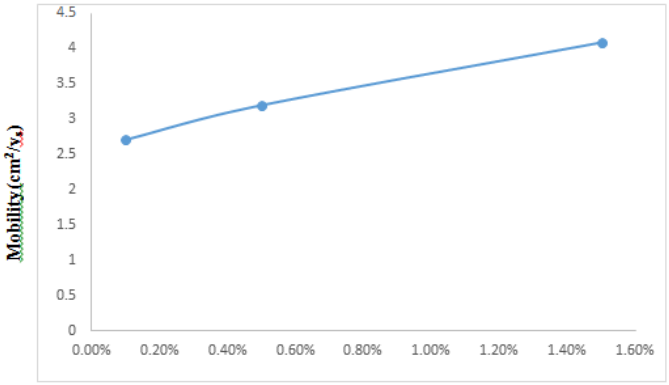

Fig. 3: mobility values of In_2S_3 thin films with different volume ratio of Sr element.

Fig.4 shows the resistivity of the as-deposited films decreases with increases in volume ration of Sr. The resistivity of In_2S_3 thin films is (8.55Ωcm) when focusing (0.05) M and when deformed, its value decreased to (5.82,2.41,1.74) at volume ratio (0.1,0.5,1.5)% straight. There reason for this is the increase in the granular size and the thickening of the films. The electrical resistivity decreased exponentially with increasing film thickness[15].

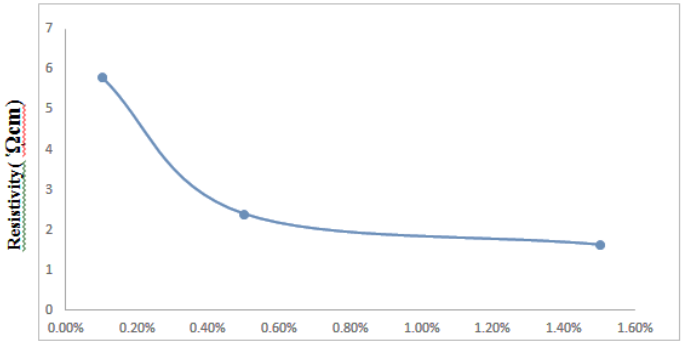

Fig. 4: Resistivity values of In_2S_3 thin films with different volume ratio of Sr element

Fig5. explained the conductivity of In_2S_3:Sr thin films is improves as concentration increases of ratio. It is well known that the n-type conductivity in In_2S_3 is owing to Sulphur vacancy and intertie tail indium atoms. The enhancement in conductivity with increasing precursor concentration may be ascribed to the increase in crystallite size. This is agreeing with the researcher [15].

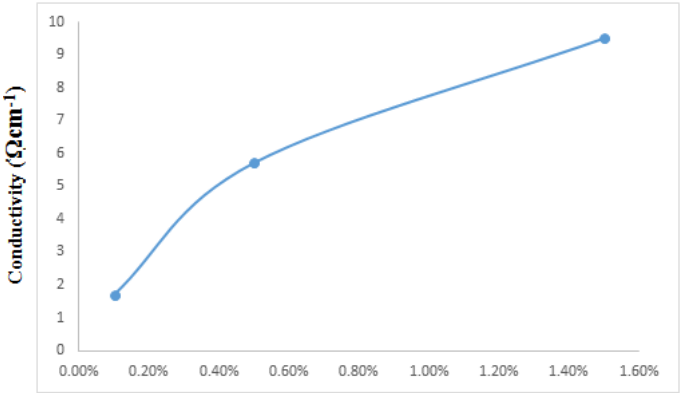

Fig. 5: conductivity values of In_2S_3 thin films with different volume ratio of Sr element.

Conclusion

The obtained thin films In_2S_3:Sr were uniform with good adherence. A high transmittance in the visible region is a good indication of In_2S_3:Sr thin films as a window in some applications such as solar cell and others. Also, the direct energy gap and the deformation of Sr activator decreased its value with increasing proportion. Studied optical propertied showed this films have a direct band gap in the rang (2.9,2.4)ev acceding to the different ratio. The electric properties (mobility, conductivity, resistivity) showed In_2S_3:Sr semiconductor n-type and both mobility and conductivity will be increases offset a decreases in values of resistivity with increases the volume ratio the doping Sr.

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الخواص البصرية والكهربائيةلاغشية In_2S_3:Sr المخدرة ب Sr المحضرة بتقنية الانحلال الحراري بالرش الكيميائي

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الملخص

تم ترسيب الاغشية الرقيقة المنشطة لكبريتيد الانديوم In_2S_3:Sr بتقنية الانحلال الحراري بالرش الكيميائي على ركائز زجاجية عند درجة حرارة 310 درجة مئوية. درس تاثير تغير النسب الحجمية للمادة المخدرة على الخصائص البصرية والكهربائية وبنسب حجمية %(0.1,0.5,1,5).

اظهرت قياسات مطياف (UV-VIS) ان النفاذية الضوئية للاغشية تتجاوز 70% ضمن المنطقة المرئية والقريبة من الاشعة تحت الحمراء, كما وجد ان قيم نطاق فجوة الطاقة المباشرة للافلام تنخفض قيمتها مع تعاطي المنشطات بحدود ev(2.4----2.9) ومن خلال نتائج قياسات تاثير هول.

تبين ان مادة In_2S_3:Sr شبه موصل من النوع السالب n-type وقيم كل من التحركية والتوصلية تزداد بزيادة النسب الحجمية للمادة المخدرة ويقابلها انخفاض حاد بقيم المقا ومية بحدود Ωcm (1.74−8.5) .