Preparation and Study The Optical Properties of $Cd_{1-x}Mn_xS$ Ternary Semiconducting Thin Films

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ABSTRACT:

Thin films of ternary $Cd_{1-x}Mn_xS$ (x=0.2, 0.4 ,0.6 , 0.8) were prepared on glass substrates by spray pyrolysis technique .X-ray diffraction (XRD)studies revealed that films are polycrystalline with an hexagonal structure .The effect of Mn concentration on Optical properties include Absorption, Transmission, Energy gap and Extinction Coefficient were studied. The energy band gaps of $Cd_{1-x}Mn_xS$ thin films were found to vary in the range (2.5 - 3.12)eV as Mn concentration increases. This study revealed that $CdMnS$ thin films can be used as anti-dazzling coating of eyeglasses since it classified as potential materials for solar cell absorber.

INTRODUCTION:

The most studied diluted magmatic semiconductors (DMSs) are $A^{II}_{1-x}Mn_xB^{VI}$ alloys which are direct-gap semiconductors(C. T. Tasi et al. 1996). DMSs have attracted much attention because they permit to tune the energy gap, by varying the concentration of the magnetic material (F. Iacomi et al. 2003).

Ternary chalcogenide thin films have a possible application in solar cells, light emitting diodes (LEDs) and nonlinear optical devices (E. Zema et al. 2004, F. Iacomi et al. 2006 and Ortega et al. 2003), some ternary compounds have been investigated for application as layers for photovoltaic application (Jiyon S. et al. 2005).

The Mn - based diluted magnetic semiconductors have a b-d exchange integral value considerably larger than other DMSs and an a symmetric splitting of Zeeman energy components (F. Iacomi et al. 2005). So $CdMnS$ this films have attracted considerable interest because of their novel magnetic and magneto-optical properties derived from this hybridization between the Mn 3d and SP-hexagonal CdS. The interaction of large mole fraction moves the intrinsic edge through the visible region and dominates the optical properties (F. Iacomi et al. 2006) .

Several preparative routes of synthesis of $CdMnS$ thin films were reported in literature: electro- deposition, vacuum evaporation, screen printing, photochemical deposition, chemical bath deposition, spray pyrolysis, sputtering (L. levey et al. 1990).

This paper present the influence of different concentration of Mn on the optical properties of $CdMnS$ thin films deposited on glass substrates by spray pyrolysis technique .

EXPERIMENTAL PROCESS:

$Cd_{1-x}Mn_xS$ thin films have been deposted by taking equimlor (0.05M)aqueous solution of $CdCl_2$, $MnSO_4.2H_2O$ and $(NH_2)_2SC$ in appropriate volume of water to obtain $[CdMn]:[S]$ ratio 1:1. The starting solution was mixed thoroughly and final solution was sprayed, the deposition time is 40 min, the nozzle was kept vertically above the substrate at distance of 25 cm ,the substrates temperature was maintained at 325±5 ^oC, after depositing films , it was allowed to cool to room temperature. The adhesion of the films on to the substrates was quite good. All $CdMnS$ films exhibited yellowish in color to deep yellow ,the thickness of the films in the range(2000-2500)A^0 measured by using weighing method.

The X-ray diffraction(XRD) patterns of the thin films were recorded at room temperature using a system type :**X Pert Pro MPD by PANalytical** company with, **Cuk_α** radiation, used to study the structure properties.

The optical properties of $Cd_{1-x}Mn_xS$ thin films for X=0.2, 0.4, 0.6 , 0.8 were studied by **UV-VIS** spectrophotometer type (**Thermospectronic)** in the range (300-800)nm at room temperature .

RESULTS AND DISCUSSIONS:

In the present work all of parameters which are temperature and deposition rate kept constant and films were prepared with various[Cd:Mn] concentration to maintain the ratio of the compound [CdMn:S][1:1].

The x-ray diffraction patterns of the $Cd_{1-x}Mn_xS$ thin films are shown in figure(1).Although the general form has the same features, the peak positions shift slightly with increasing Mn concentration .All the patterns can be distinctly assigned to the hexagonal CdS phase the preferred peak correspond to the (002) at (2Θ=26.40) and the broadening of the diffraction peaks indicate the nanostructure nature of the samples which agree well with work done by (Wang Q.S. et al. 2004 and M.Boshta et al. 2008).The grain size **(D)** was calculated from the formula: **($D=0.9 \lambda/\beta\cos\Theta$)** where Cuk_α **(λ=1.54 A^0)** is the wavelength of x-ray source , **Θ** angle of Bragg diffraction , **β** is a half band width (B.D.Cullity 1967) ,we can deduce from the result that all $Cd_{1-x}Mn_xS$ thin films have the nearly same grain size which is about (17.32)nm .

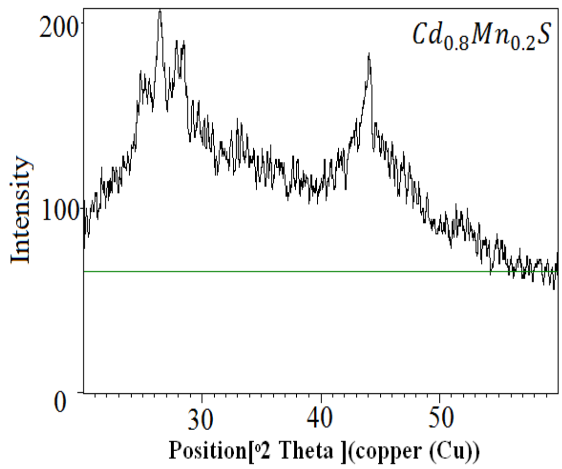


Fig (1-a)

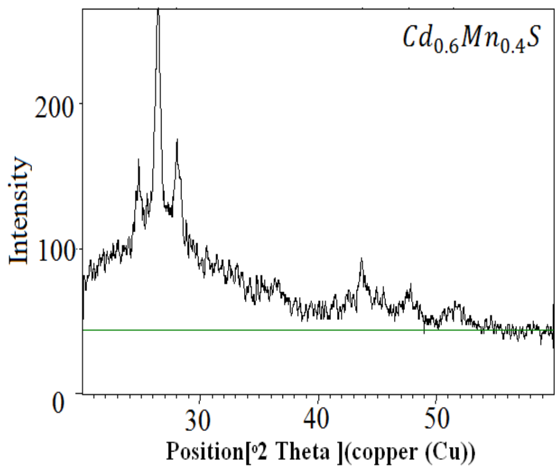


Fig (1-b)

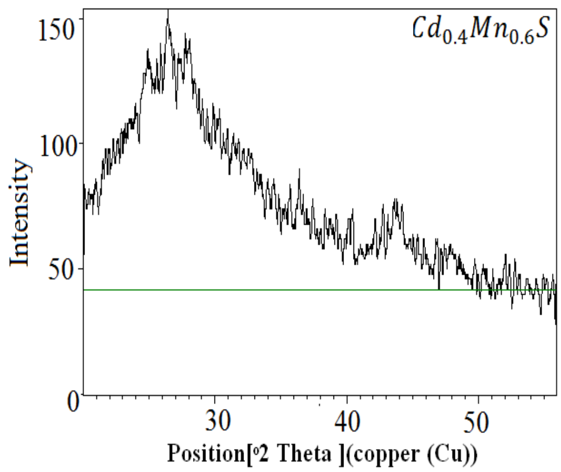


Fig (1-c)

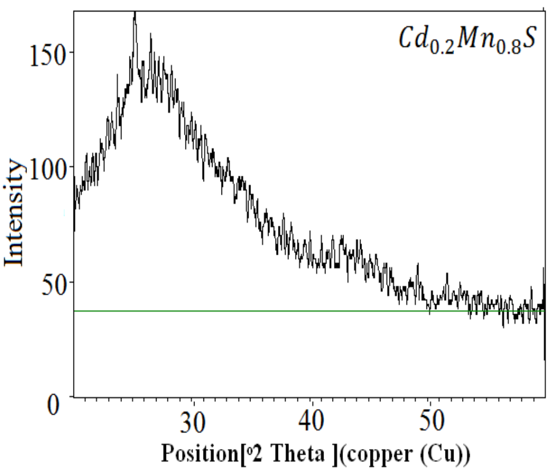


Fig (1-d)

Fig.(1): XRD patterns for $Cd_{1-x}Mn_xS$ thin films prepared with different X-values.

The spectral absorbance of the $Cd_{1-x}Mn_xS$ thin films shown in figure(2) it indicate that all films absorbed strongly in the UV-VIS region ,it seemed that the absorbance decreases with increasing Mn concentration ,figure(3) showed the spectral dependence of transmittance which increases steadily with wavelength(λ) and with Mn concentration to maximum values in the VIS region of the solar spectrum ,these high transmission properties make the films good materials for antireflection coating and for solar thermal application as $CdMnS$ is direct band gap materials (F.Iacomi et al. 2006).

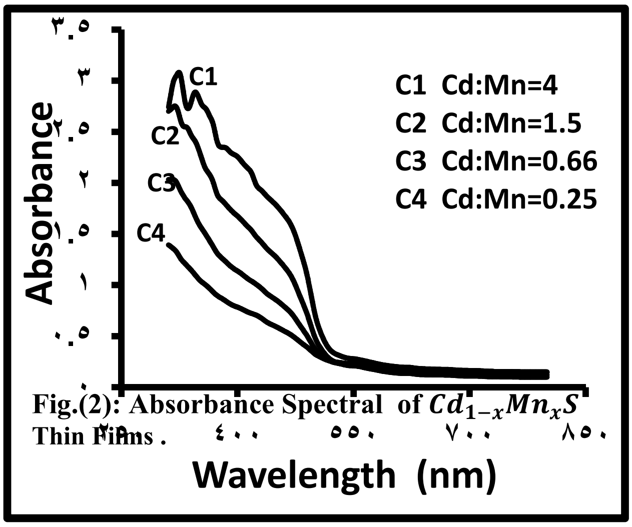


Fig.(2): Absorbance Spectral of $Cd_{1-x}Mn_xS$ Thin Films .

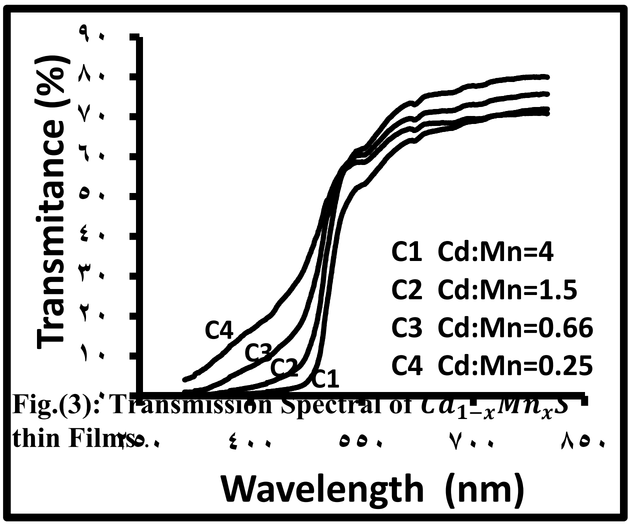


Fig.(3): Transmission Spectral of $Cd_{1-x}Mn_xS$ thin Films .

Figure (4) shows the variation of typical absorption coefficient (α) of $Cd_{1-x}Mn_xS$ thin films with incident photon energy (hν) ,it is seemed that the absorption coefficient increases with the increasing beam energy for all samples , this may be due to the large absorption coefficient for different thin films composition. Plot of $(\alpha\ h\nu)^2$ against shown in figure(5) ,the energy band gaps were obtained by extrapolating the linear portion of the curves at $(\alpha\ h\nu)^2=0$, the band gaps values were (2.5 ,2.65 , 3 and 3.12)eV ,this values lies between energy gap of (2.42- 3.2) eV for (CdS, MnS) respectively (Robert C.WEAST 1978 and M.R.I. Chowdhury et al. 2011).

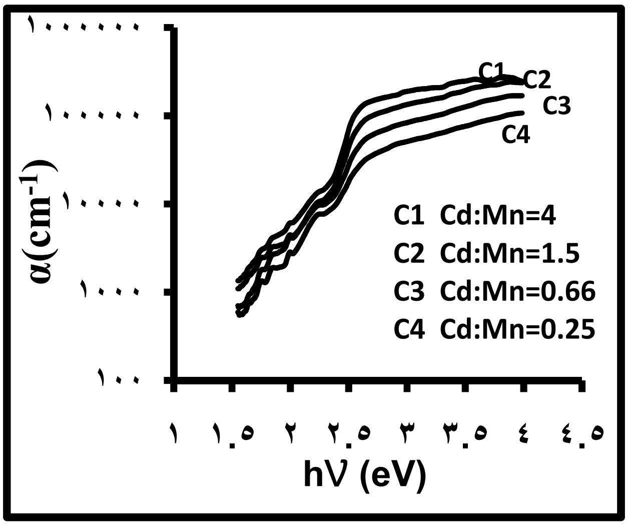


Fig.(4): Absorption Coefficient (α) as a Function of Photon Energy (hν) for $Cd_{1-x}Mn_xS$ Thin Films .

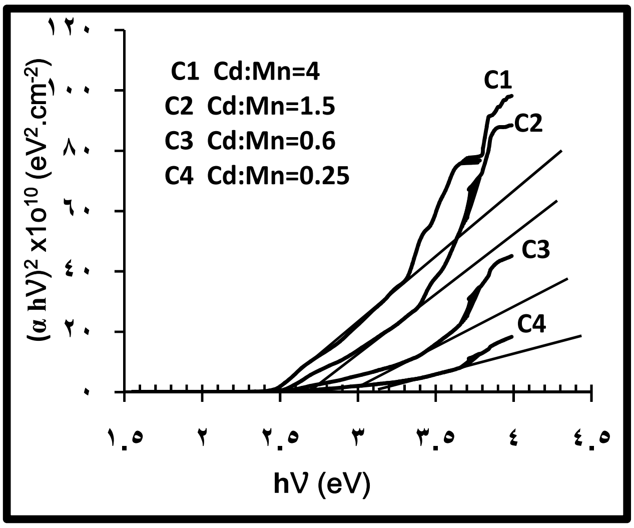
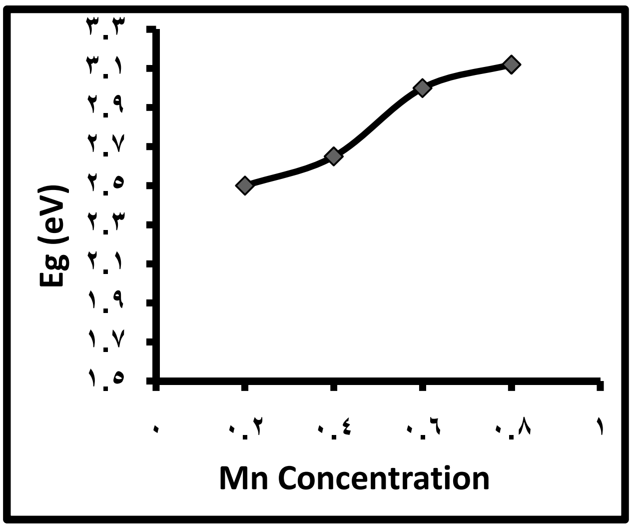


Fig.(5): Plots of $(\alpha h\nu)^2$ as a Function of Photon Energy (hν) for $Cd_{1-x}Mn_xS$ Thin Films .

Figure(6) obtains the nature of variation of Energy gap (Eg) with Mn concentration it observed nonlinear increase in the band edge of $Cd_{1-x}Mn_xS$ thin films with increasing the concentration of Mn,this behaviour is in a good agreement with the published work of (L.Levy et al. 1997).The dependence of the band gap on the Mn concentration can be ascribed to the fact that Cd was substituted by Mn in the CdS structure ,and to the exchange interaction of the conduction and valance band electrons of Mn^{2+} d electrons(F.Iacomi et al. 2003) the difference in the band gap energy values are clearly indicated by the thin films colors (F.Iacomi et al. 2006),the yellow color turned to yellowish-deep as the value of band gap energy diminishes.



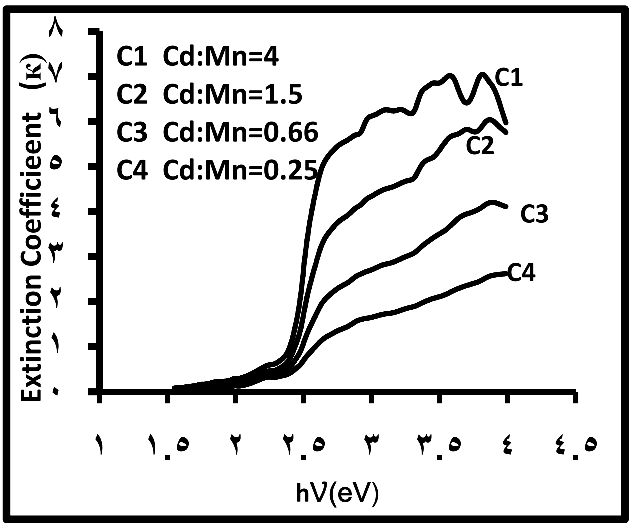


Fig.(6): Energy gaps of $Cd_{1-x}Mn_xS$ Thin Films as a Function of Mn Concentration.

Figure(7): Extinction Coefficient (κ) as a Function of Photon Energy (hν) for $Cd_{1-x}Mn_xS$ Thin Films .

The relationship between extinction coefficient (**κ**) and wavelength (λ) can be expressed as **κ =αλ/4π** (N.A Subrahamanyam 1977). The variation of extinction coefficient (κ) with photon energy(hν) for $Cd_{1-x}Mn_xS$ thin films were shown in figure(7) it is observed that all samples have their minimum value of extinction coefficient at the VIS region and start to increase in the VIS-UV region .The maximum value for sample C1 ($Cd_{0.8}Mn_{0.2}S$) is (7.04) at photon energy (3.81)eV while the sample C4 ($Cd_{0.2}Mn_{0.8}S$) has it maximum value (2.62)at photon energy (3.98)eV .

CONCLUSION:

Ternary semiconductor $Cd_{1-x}Mn_xS$ thin films with energy gaps ranging between (2.5)eV for $Cd_{0.8}Mn_{0.2}S$ and (3.12)eV for $Cd_{0.2}Mn_{0.8}S$ have been deposited on glass substrates using spray pyrolysis technique .The X-ray diffraction patterns showed that CdMnS thin films are polycrystalline with an hexagonal structure. The influence of Mn concentration on absorption, transmission ,energy gap and extinction coefficient were investigated ,we can conclude from this investigation that at low concentration of manganese acts as crystalline center and as a scattering center when the concentration becomes higher . The change in the band gap correlate well with this explanation .

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تحضير ودراسة الخواص الضوئية للأغشية شبه الموصلة للمركب الثلاثي $Cd_{1-x}Mn_xS$

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<u>الخلاصة:</u>

حضرت أغشية المركب الثلاثي $Cd_{1-x}Mn_xS$ (x=0.2 ,0.4 ,0.6 , 0.8) على قواعد زجاجية بطريقة الترسيب الكيميائي الحراري.أظهرت دراسة حيود الأشعة السينية(XRY) أن أغشية المركب هي متعددة التبلور بتركيب سداسي . درس تأثير تركيز Mn على الخواص الضوئية التي تتضمن الامتصاصية، النفاذية ، فجوة الطاقة ومعامل الخمود .وقد وجد أن فجوة الطاقة لأغشية المركب $Cd_{1-x}Mn_xS$ تتغير ضمن المدى(2.5-3.12)eV بزيادة تركيز Mn .أظهرت هذه الدراسة بان الأغشية الرقيقة للمركب $CdMnS$ تصلح لاستخدامها في طلاء زجاج النظارات لكونها من المواد الماصة للإشعاع الشمسي.