To study the induced-annealing effects in structural and optical properties of Ag doped CdS composite semiconducting thin films.

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Abstract: -

In this paper analysed annealing effect in CdS adding Ag metals. Films fabricated by cost effective and simple rote Spin Coating Method. Ultra sonicated used for Ag doping in CdS with different concentration like 1and 5%.Prepared film annealed in vacuum oven presence of Argon gas atmosphere at high temperature 100, 200, 400^{0}C for 20 minutes. Characterize structure and optical parameter of thin film by X-ray Diffractometer (XRD) and UV-Visible spectrometer. The micro strain, dislocation density, average crystallite sizes of the samples calculated from WH plots, Debye Scherrer and Modified Debye Scherrer formula. An obtained result remains same and near standard value 9.603nm but effectively changes with increasing temperature due to lattice compression. Optical band gap values of different samples calculated by approximate Tauc-plot method. Absorption wavelength also investigates of the sample. FTIR spectrometer uses for finding bond formation and stretching of functional groups. Photoluminescence spectrometer used for observes material imperfections and impurities. The grain size and optical band gap of Ag/CdS composite thin film change with increasing temperatures and obtained suitable range. It used for window material of solar cell.

Keywords: - CdS powder, Silver powder, Ultra-sonication, Spin Coating, Magnetic Stirrer, Vacuum Oven.

1. Introduction

The II-VI group compound semiconductors have wide band gap because used in numerous applications. Compound semiconductors are the technologically important materials. Cadmium Sulphide (CdS) is one of the important compound semiconductors of II-VI group. It has band gap of 2.40 eV for cubic structure and proposed as great potential application such as photovoltaic solar cells, optoelectronic devices, bio sensing, and nano-medicines. The effect of Cu-doping on CdS thin films deposited by the spray pyrolysis technique. CdS is used to enhance the efficiency of solar cell and devices. It has large absorption coefficient and used for photo catalytic activity. The band gap shifts from 2.43 to 2.4 eV. The conductivity is measured by direct record of the variation of resistance with temperature [1]. Copper doped cadmium sulphide (CdS: Cu) quantum particle: topological, morphological and photolimincence studies [2]. Structural and optical studies on Ag- CdS quantum dots [3].Thin films of CdS: Cu, morphological, optical, structural and electrical properties [4]. Ag-doped PbS thin films by nebulizer spray pyrolysis for solar cells [5]. Annealing effects on structural, morphological, and optical behaviours of CBD-CdS nanostructure films for solar cells [6]. Annealing-Induced modifications in physicochemical and optoelectronic properties of Ag-doped nano structured CdS thin films [7]. Effect annealing temperature on the physical properties of cadmium sulphide thin films deposited by using thermal evaporation technique [8]. Effect of annealing temperature on the optical spectra of CdS thin films deposited at low solution concentrations by chemical bath deposition (CBD) technique [9]. Electrical and optical properties dependence on annealing temperature for CdS thin films [10]. Influence of single and dual doping (Ag and Co) on the optical properties of CdS quantum dot thin films for solar application [11]. Mechanism and principle of doping: realizing of silver incorporation in CdS thin film via doping concentration effect [12]. Quantitative measurement of transport properties Ag-doped nano-crystalline CdS thin films [13]. Simple synthesis of Ag-doped CdS nanostructure material with excellent properties [14]. Structural and solar cell properties of a Ag-containing Cu_2ZnSnS_4 thin film derived from spray pyrolysis [15]. Structural, morphological, optical and electrical properties of spray deposited ternary CdAgS thin films towards optoelectronic applications [20]. Study of annealing-induced changes in CdS thin films using X-ray diffraction and Raman spectroscopy [21].The role of annealing temperature on optical properties of ZnO thin films prepared by spray pyrolysis techniques [22]. Ultrasound-assisted green synthesis of silver nanoparticles and their incorporation in antibacterial cellulose packaging [23]. Green ultrasound-assisted microwave preparation of Ag-doped CdS nanoparticles [24]. Therefore, our present studies aimed on the accommodation of Annealing effect in Ag /CdS composite thin film and to characterize their structural, optical, PL properties under different concentration and variational temperatures. In my previous we have studied concentration effect of Ag in CdS thin film at room temperature. Ag doped CdS NPs semiconductor possess wide band gap which makes them very special in the field of electronics and are used to enhance the efficiency of solar cell and devices, besides they also have high photosensitivity due to this ability they are capable to detect visible radiation, which helps in enhancement of efficiency of solar cells in LED and effectively work as photoconductor. The UV characteristic, X- ray diffraction, Photoluminescence and FTIR data of CdS predicts as Ag doping concentrations and temperature have been increased then seen some change, Particle Size, Crystal Structure, Band Gap Radiation Absorption. This is interesting result for solar cell and photo catalytic activities.

2. Experimental Details:-

2.1 Materials:-

Cadmium sulphide (CdS) yellow powder of molecular weight 144.47g mol^{-1} with purity more than 99.9% purchased from Sigmachemie specialty Pvt. Ltd. (Amaranth West, Maharashtra). Silver (metal) powder (Ag) molecular weight 107.87 g mol^{-1} with purity 99.9 purchased Alpha chemika pvt. Ltd. (Andheri, Mumbai). Propane -2-ol $(CH_3)_2CHOH$, Triton X-100 Dichloromethane (CH_2Cl_2) Qualikemes Fine chem. Pvt. Ltd.

2.2 Synthesis of sample:-

CdS and Ag powder used for preparation Ag: CdS composition thin film. To synthesis undoped and silver doped CdS thin film by Spin coating method. Silver powder mixed in CdS powder with different wt% percent by sol gel method. Insert table have composition of representation of Ag doped CdS film.

S. N.	Material	Molecular weight(gm)	Weight (gm)	1% of total weight(gm)	Doping Material	Molecular weight (gm)	Weight (gm)	1% of total weight(gm)
1.	CdS	144.47	144.47 x 100%=144.47	1.4447	Ag	107.86	107.86 x 0%=0	0
2.	CdS	144.47	144.47 x 99% =143.02	1.4302	Ag	107.86	107.86 x 1%=1.0786	0.01078
3.	CdS	144.47	144.47 x 97%=140.13	1.4013	Ag	107.86	107.86 x 3%=3.2358	0.03235
4.	CdS	144.47	144.47 x 95%=137.24	1.3724	Ag	107.86	107.86 x 5%=5.3930	0.05393

Table:-1. Composition of representation of Ag doped CdS film

CdS and Ag powder mixed in grinder (Mortar pestle) at 30 minutes. Di-chloromethane, propan-2-ol were mixed at volume ratio of 10:1 and then pure CdS and silver doped CdS mixed powder were dissolved in the mixed co-solvents. Ag doped CdS mixed powder sonicated at 200V, 20min for doping mechanism. The colour of the solution was yellow. Then the solution was stirred for 1.30h at 50^0 C temperatures in a magnetic stirrer to completely dissolve the powder. After stirring, the solution was optically transparent and very faint yellow with light black. After that a small amount of Triton X-100 was add in the solution to make uniform and high quality Ag: CdS thin film.

2.3 Experimental Details:-

The CdS thin film was deposited using simple, cost effective spin coating method on the glass substrate 2x2cm^2. The glass substrates were cleaned by acetone and double distilled water before thin film fabrication. Fig 1 show schematic representation of coating process

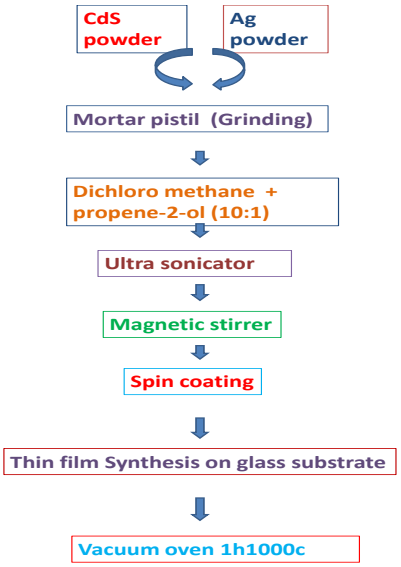

Fig:1 Schematic representation of coating process

The Ag**:** CdS composite precursor solution was spin coated one time on cleaned substrates at speed 2000 rpm, 60s. This process was completed with pure CdS and different concentration 0.1, 0.5wt% Ag doped CdS. Then the deposited CdS films were dried 24 hour at room temperature in vacuum oven. These films are annealed at 100, 200, and 400^0 C in two zone furnace (0-1372^0 C) in presence of inert gas.

3. Characterization:-

The X-ray Diffraction (XRD) have been collected spectra of undoped and Ag doped CdS sample by using copper (Cu) Kα Bruker AXS Single Crystal X-ray Diffractometer (modal Apex II) in the range (2θ) 20^0-60^0 with step size 1/100 ^{0}. UV-visible spectra have been collected uses shimadzu (UV-2600) wave length range 200-900nm. FTIR spectra calculated by ALPHA Bruker FTIR spectroscopy (ECO-ATR) in the transmittance mode at room temperature in the wave number range 4000-200 cm^{-1}. Horiba FluoroMax-4 spectrometer used for Photoluminescence (PL).

4. Result and discussion

The focus of this article is the annealing dependency of Ag doped CdS thin film properties because the temperatures and concentration play the important role change to structural and optical parameter of thin film. The structural properties of crystal were studied by XRD utilizing the Cu-Kα radiation.

4.1XRD Data Analysis: -

The XRD is considered as a non-destructive technique for studying the crystallographic and structural properties of materials. The XRD spectra of nine Ag doped CdS thin film having 100,200,400 temperatures. The XRD pattern of annealed CdS samples exhibits prominent broad peaks at 2θ values of 26.7^0, 44^0 and 52^0 which could be indicated scattering from the (111), (220) and (311) cubic CdS planes, respectively, suggesting that the particles are in cubic (zinc bland phase) form and are in good agreement with the reported data on CdS [14]. No peak attributable to other phases defined Ag completely dissolves in CdS. The broadening of the diffraction peak provides information about crystalline size. As the width increases, the particle size decreases and vice-versa [15].

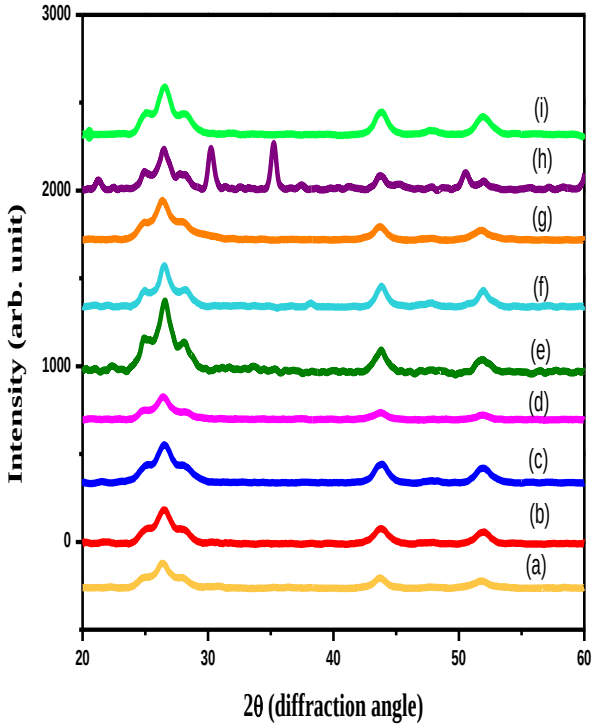

Fig 2 : Diffractogram graph (a, b, c) undoped CdS , (d, e, f) CdS + 1% Ag, (g, h, i) CdS + 5% Ag annealed at 100°C, 200°C, 400°C respectively.

The Debye Scherer equation, which is based on the full width at half maximum (FWHM) of the diffraction peaks has been used to calculate the average crystallite size [19], is given by

$$t_{DS} = 0.94\lambda / \beta_{hkl} \cos(\theta)$$

Where t_{DS} is the average crystallite size, λ is the wavelength of the Cu k_λ radiation which has the value 0.15406 nm, β_{hkl} is the FWHM of the diffraction peaks corresponding to the crystal face (h k l) and θ is the angle of diffraction or Bragg angle.

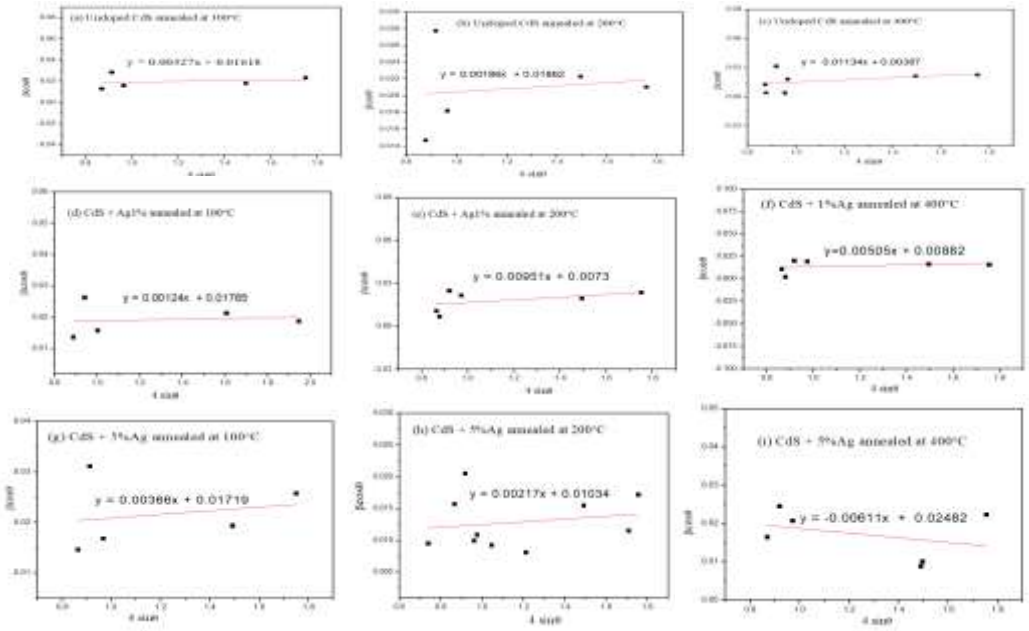

Fig 3: WH Plot corresponds to the samples: First row represents undoped CdS, Second row represents CdS + 1% Ag, third row represents CdS + 5% Ag, annealed sample at 100^0C, 200°C, and 400°C respectively.

Modified sheerer formula also used for calculate crystalline size

$$ln\beta = ln\frac{1}{cos\theta} + ln\frac{k\lambda}{D}$$

The strain in the samples and the average crystallite size are calculated from Williamson-Hall (WH) analysis. To incorporate the impact of both the crystallite size as well as micro strain, WH analysis is ideal [16, 17, 18]. The WH relation is based on the uniform distortion model (UDM) which assumes uniform distribution of crystalline strain in all directions and can be represented by the following equation:

$$\beta \cos\theta = \frac{k\lambda}{tWH} + 4\varepsilon \sin\theta$$

Here β_{hkl} is the FWHM of the XRD peak corresponding to the (h k l) plane [19, 20]. k is a fitting constant and is considered to be 0.9 in the particular case. The micro strain (ε) in the crystal is calculated from slopes of the trend lines obtained after fitting the measured data points with WH relation while the average crystallite size (t_{WH}) is estimated from y-intercept of the trend line. The negative slope of the trend line indicates a lattice compression whereas the positive one refers to tensile micro strain. The measured XRD data obtained from the cadmium sulphide samples are fitted with the WH relation. The WH plots for the annealed samples are shown in the figures: 3. the micro strain and the average crystallite sizes of the samples calculated from WH plots are listed in the Table 4. The dislocation density of undoped and doped cadmium sulphide samples which is a measure of the number of dislocations in a unit volume of a crystalline material is determined by the formula $\delta = 1/(t)^2$ where t is average crystallite size determined from the Debye Scherer formula. Calculated crystalline size above three methods tabulated in below table: 2. The crystallite size of undoped CdS decreases at moderate temperature but high temperature and concentration size increases due to compressibility and ion exchange. In this investigation it is possible to conclude that the CdS films having good crystalline and structural parameter can be synthesized using a simple spin-coating technique and the crystallinity of the spin-coated CdS film can be tuned by the annealing effect [21].

Sr. No.	Annealed Sample	Strain (ε)	Dislocation Density (lines/m^2)	Crystallite size (t_{DS}) (in nm)	Crystallite size (t_{MS}) (in nm)	Crystallite size (t_{WH}) (in nm)
1.	Undoped CdS at 100°C	0.00327	0.022551	7.40732	8.173329	8.569468
2.	Undoped CdS at 200°C	0.00186	0.023597	6.952499	7.312874	7.446509
3.	Undoped CdS at 400°C	0.01134	0.018817	14.35825	17.41856	35.82791
4.	CdS + Ag1% at 100°C	0.00124	0.020262	7.588841	7.923447	7.855751
5.	CdS + Ag1% at 200°C	0.00951	0.019544	9.409317	11.6995	18.9937
6.	CdS + Ag1% at 400°C	15.72041	0.013063	16.13231	16.12364	15.72041
7.	CdS + Ag5% at 100°C	0.00366	0.026139	6.931807	7.675829	8.065969
8.	CdS + Ag5% at 200°C	0.00217	0.009407	11.7437859	12.68419008	13.40948

9.	CdS + Ag5% at 400°C	-0.00611	0.017218	9.36698	6.926512	5.586382

Table 2: The estimated values of strain (ε), crystallite size calculated from WH plot (t_{WH}), from Debye – Scherer formula (t_{DS}), from Modified Scherer formula (t_{MS}), dislocation density (δ) from the W-H analysis.

4.2. Optical Characteristics.

Annealing treatment to CdS films affect the electronic transitions in the material which is deduced by studying the optical properties of these thin films. Figure: 4 (a),(b), (c), represents the band gaps of annealed Ag-doped CdS thin films and pure CdS films at different temperature 100 °C, 200°C, 400°C respectively. Since annealing treatment can improve the structure and quality of the films, it should also affect the transmittance of the films and therefore change its optical band gap [35].

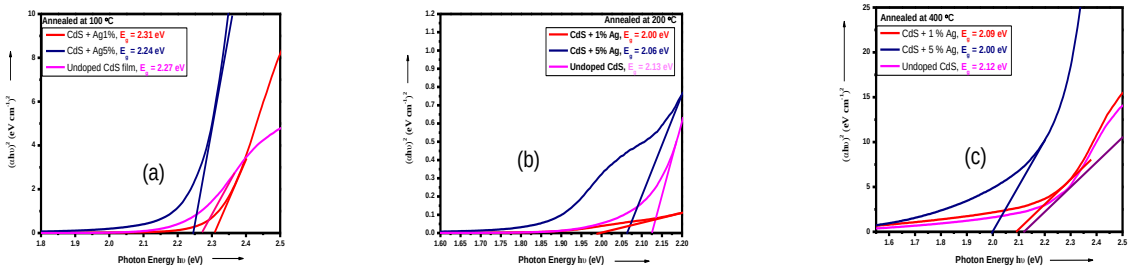

Fig 4: (a) (b) (c) shows optical Energy Band Gap (Eg) of undoped CdS, 1% Ag doped CdS, 5% Ag doped CdS thin film with 100^0C, 200^0C 400^0C temperature**.**

Regarding the extrapolation of the linear region of the curves to the horizontal axis intercept, the recorded values of energy gap shows below table:

Sample name	Annealing at °100 C	Annealing at °200 C	Annealing at °400 C
Undoped CdS film	2.27 eV	2.13 eV	2.12 Ev
CdS + 1%Ag	2.31 eV	2.00 eV	2.09 Ev
CdS + 5%Ag	2.24 eV	2.06 eV	2.00 eV

Table 3: Energy Band Gap of undoped CdS film, CdS + 1%Ag and CdS + 5%Ag annealed at different temperatures

The net effect of this absorbance spectra can be well understand by the classical relation connecting the absorption coefficient α and optical band gap E_g by Tauc Relation [38].

$$(\alpha h\nu)^2 = A\,(h\nu - E_g)^n \qquad \ldots \quad (1)$$

Where, α is probability parameter for transition, hν incident photon energy, n is transition coefficient and E_g is energy band gap value which can be estimated from plot between $(\alpha h\nu)^2$ verses (hν). Here n= 2, which indicates that CdS is a direct allowed band gap material and the characteristic electronic transition between the valence and conduction bands in CdS semiconductor is direct transition. From the 4(a), 4(b), it can be seen that the band gap decreases as the annealing temperature is increased from 100 °C to 200 °C, may be due to variation in physicochemical properties such as crystallite size, defect-induced band tailing, creation of impurity states, donor level degeneracy, surface morphology, and compositional modifications up to certain extent [7, 26, 27, 32, 33]. Annealing provides possibility for ionic displacement in materials which can create large number of lattice defect like ionic vacancies, and so forth, these defect (such as voids, interstitials, dislocations, strains, etc) can act as trap centers and affect the optical absorbance. Therefore, decrease in optical band gap (as mentioned in Table:2) can be primarily associated with defect-induced band tailing and donor level degeneracy due to creation of localized energy states near the band edge [7, 28]. This is because when annealing temperature is provided to the thin films it is gained by almost all the atoms of the material thereby due to thermal vibrations the atoms may have been displaced from their original positions and hence by colliding among themselves they create vacancies, interstitials, and so forth [29]. These defects can act as trapping centers and affect energy band gap [30].The results confirm that Ag substitutes Cd sites more as compared to interstitially at lower doping and Ag enters interstitially more as compared to substitutionally at higher Ag doping in the substitutionally position. Essentially, it acts as an accepter and at the interstitial position, it acts as a donor. Consequently, it produces donor and accepter levels below and above the conduction and valence band, respectively. Thus, the decrease in energy gap of the film after Ag doping is attributed to the creation of additional energy levels in the CdS film's energy gap, which results in the broadening of the band of the film and hence decreases its energy gap [34]. Doping involves adding

impurity atoms to semiconductor crystals, which creates an extra energy level near the conduction or valence band edges. However, when annealing temperature is increased from 200 °C to 400 °C, the energy band gap increases as opposed to the previous trend. This is attributed to the fact that grain size increases and Eg is closer to the bulk material, indicating that annealing at a higher temperature is beneficial to the agglomeration of the film grains.

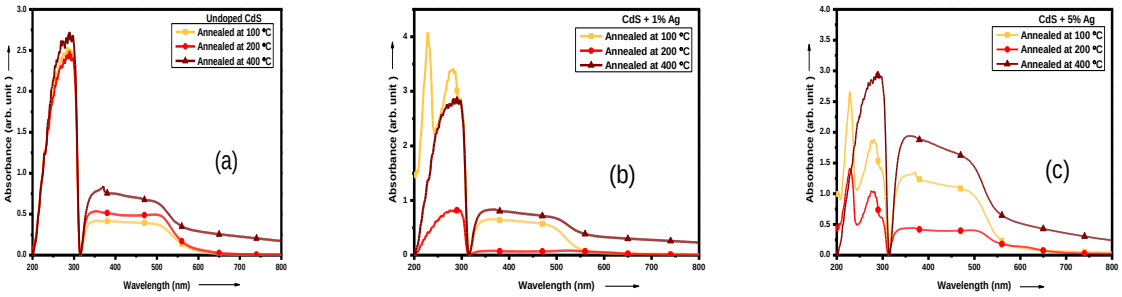

Fig.5: Absorbance spectra of (a) undoped CdS at different annealed temperatures. Fig.(b): Absorbance spectra of 1% Ag doped CdS at different annealed temperatures. Fig.(c) : Absorbance spectra of 5% Ag doped CdS at different annealed temperatures.

Absorption spectra of the CdS thin films, 1% Ag doped CdS film , 5% Ag doped CdS film are measured in the UV-visible regions as a function of the substrate temperature in the figures (a), (b), (c) respectively. Figure shows typical absorption spectra for the investigation of CdS thin films. It can be observed that the absorption edge shifts continuously to longer wavelength with increase in the substrate temperature. The highest values of the optical absorption are achieved for film deposited at room temperature. Interference maxima and minima due to multiple reflections on the film surfaces can be observed in the transmission spectra. The appearance of interference fringes in these spectra indicates the excellent surface quality and films are free from any in homogeneity [43].The sharp decrease in the optical absorption at the longer wavelength (λ: 540 nm – 620 nm) is resulted from the excitation of charge carriers across the optical band gap (Eg : 2 eV – 2.3 eV).

4.3. Photoluminescence (PL) spectroscopy:-

The effect on energies and dynamics of photo-generated charge carriers as well as nature of the emitting states were studied using photoluminescence (PL) property of undoped and Ag doped CdS.

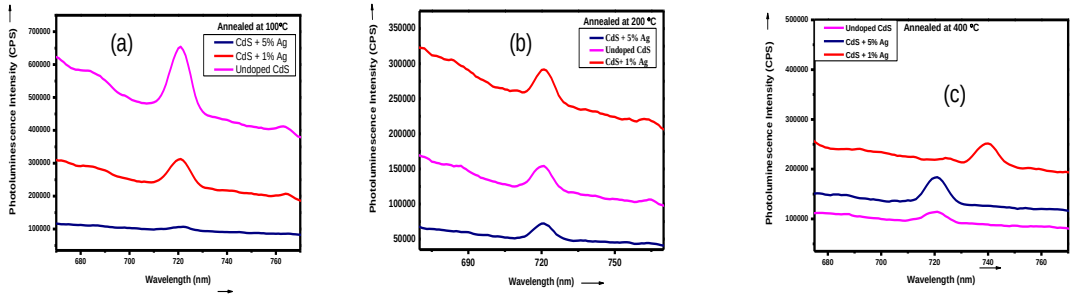

Fig. 6: Photoluminescence spectra of (a) undoped CdS thin film, (b) 1% Ag doped CdS thin film, (c) 5% Ag doped CdS thin film annealed at 100 °C, 200 °C, 400 °C.

Fig.6 shows PL spectra of undoped, 1% Ag and 5% Ag doped CdS thin film at different annealing temperatures100^0, 200^0, 400^0c respectively. The peak centred at 721 nm with excitation wavelength kept at 480 nm, All the undoped and doped CdS films are also known to show a broad PL band in the range ∼700–800 nm , particularly at 721 nm (1.72 eV), which is in good agreement with the literature [11]. This band is attributed to the complex defects including the cadmium vacancy [12]. It is also observed that the defect PL decreases on annealing [35, 41]. Here in all the figures 6 (a), (b), (c) PL a common spectra band is observed at 1.72 eV (~ 721 nm), 2.36 eV (~ 525 nm), 1.90 eV (~ 653 nm) with the first one is prominent one and the rest two are lower in peak intensity. However, In Figure (a), (b), (c) the peak intensity at the band 2.36 eV and 1.90 eV are not shown here. The PL intensity at 1.72 eV is attributed to the neutral complex concentration [39, 40]. The width of the emission bands of doped CdS also becomes more broaden than that of pure CdS. The effect on emission band of metal Ag doped CdS may attribute to the metal Ag content. Thus PL data also support the understanding from XRD that there is a significant improvement in the crystalline quality on annealing.

4.4. FTIR Analysis:-

Molecular structure of the undoped and Ag doped (1% and 5%) CdS were investigated in the near IR, mid IR, far IR region nanoparticles over the range of 500-4000 cm^{-1}. The IR spectra suggest that interaction between pure CdS and metals are confirmed and, formed the nano composites. The IR spectra of composite samples were recorded using ATR method [41]. Bond formation between the elements tabulated in table: 5, 6, and 7 for corresponding undoped, 1% Ag and 5% Ag doped CdS thin films.

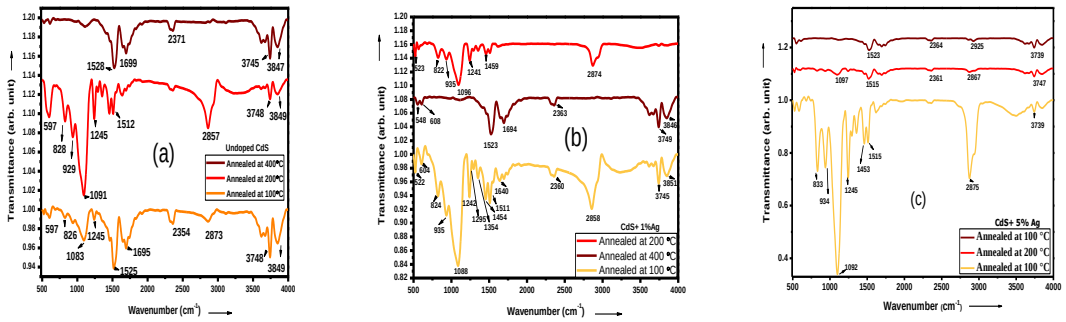

Fig. 7(a): FTIR spectrum of undoped CdS film. Fig 7(b) 1% Ag doped CdS thin film Fig 7(c) 5%Ag doped CdS thin film

For the annealed temperature 100 °C		For the annealed temperature 200 °C		For the annealed temperature 400 °C	
Position of Bands (in cm^{-1})	Assignment of bands	Position of Bands (in cm^{-1})	Assignment of bands	Position of Bands (in cm^{-1})	Assignment of bands
597	-C=O Stretching	597	-C=O Stretching	1528	-NH Bending
1083	-S=O Stretching	828	-PO Asymmetry C stretching	1699	-C=O Stretching
1245	-C=O Stretching	929	-C-OH Out of plane bending	2371	-BH Stretching
1525	-C=S Stretching	1245	-CO Stretching		
1695	-C=O Stretching	1512	-N=O Stretching		
2873	-C-H Stretching	2857	-C=H Symmetry stretching		

Table 5: The wave number and chemical bond related to transmittance peak in the IR spectrum for undoped CdS.

For the annealed temperature 100 °C		For the annealed temperature 200 °C		For the annealed temperature 400 °C	
Position of bands(in cm^{-1})	Assignment of bands	Position of Bands (in cm^{-1})	Assignment of bands	Position of bands(in cm^{-1})	Assignment of bands
604	-CS Stretching	548	S-S Stretching	822	-NCS Bending
824	POC Stretching	608	C=O Bending	935	-C-O-H Bending
1088	--PH_2 Bending	1523	CN Stretching	1096	-C-O-C Stretching
1242	Aliphatic P=O Stretching	1694	Aromatic ketone C=O Stretching	1241	-C-O Stretching
1295	SO_2 Asymmetric bending			1459	-CH3 Asymmetric bending
1454	CH3Asymmetric bending			2874	C-H Stretching
1640	C=O Stretching				
2858	-CH Stretching				

Table 6: The wave number and chemical bond related to transmittance peak in the IR spectrum for 1% Ag doped CdS film.

For the annealed temperature 100 °C		For the annealed temperature 200 °C		For the annealed temperature 400 °C	
Position of bands(in cm^{-1})	Assignment of bands	Position of bands(in cm^{-1})	Assignment of bands	Position of bands(in cm^{-1})	Assignment of bands
934	Out of plane –OH stretching	1097	-C-O-C Stretching	1523	-C-N Stretching

1245	-C-O stretching	2361	Antisymmetric mode of CO2	2925	-CH2 Asymmetric Stretching
1453	-CH3 Asymmetric Bending	2867	Methyl –CH Stretching	3739	Terminal silanol group (SiOH)
2875	Methyl Asymmetric –C-H Stretching				

Table 7: The wave number and chemical bond related to transmittance peak in the IR spectrum for C 5% Ag doped CdS film.

The FTIR spectrum of thin film samples shows different transmittance peaks related to different chemical bonds for the 5% Ag doped nanostructure CdS films. The variation of Cd-S bond formation with annealing temperature was investigated by studying the wave number 617.22 cm-1. The FTIR interpretation is majorly done with the help of "Infrared Spectroscopy: Fundamentals and Applications "Book, written by Barbara Stuart. Over all, the relative intensity of all metals doped CdS increases as compared to the intensity of pure CdS QDs which is suggesting the improvement of crystallinity in CdS due to involvement of metals [39]. The authors have observed from Fig. 7(a), (b), (c) that as the annealing temperature increases from 100 °C to 400 °C, the transmittance peaks becomes lesser, this indicates that stretching and bending or the vibration decreases. This Study indicates that the Cd-S and Ag-S bond formation also increases with the annealing temperature.

5. Conclusions:-

Ag doping in CdS thin films can be achieved by cost-effective chemical route. In the present work investigate structural and optical properties of pure CdS; Ag doped CdS thin films by spin coating method. In structural investigation represent crystalline size decreased with high temperature no more peaks shows completely dissolve Ag metal in CdS. The analysis of optical absorption spectra revealed an allowed direct transition for undoped as well as silver doped CdS films. The Energy band gaps lies in the range 2.00 eV to 2.3 eV. The significant observation is that as annealing temperature is increased, the band gap gets decreased; also as the doping is increased, the band gap gets decreased. Decrease in band gap shows defect-induced charge transportations. The PL intensity at 1.72 eV is attributed to the neutral complex concentration. In the FTIR spectrum, as the increasing temperature as well as concentration revealed strong bond formation and less vibration.

Declaration of Competing Interest:-

The authors declare that they have no known competing financial interest or personal relationship that could have appeared to influence the work reported in this paper.

Data availability: - The data that has been used is confidential.

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References:-

1. Ahmed A.Aboud , AyanMukherjee , Neerish Revaprasadu ,Ahmed Nagaty Mohamed , The effect of Cu-doping on CdS thin films deposited by the spray pyrolysis technique,(2019) Pages 2021-2030.doi: https://doi.org /10.1016/j.jmrt.2018.10.017.
2. Ratnesh Tiwari, Vikas Dubey, Raunak kumara, Tamrakar, Copper doped cadmium sulphide (CdS:Cu) quantum particle :topological ,morphological and photolimincence studies,(2013), International Journal of Industrial Engineering & Technology (IJIET) ISSN 2277-4769 Vol.3, 67-74.
3. Ibrahim Mohammed S., M. Gubari, Ghamdan M. M., Huse, Nanasaheb P., Dive, Avinash S. , Sharma, Ramphal, Structural and optoelectronic studies on Ag-CdS quantum dots. (2017), Condensed Matter and Applied Physics. doi: 10.1063/1.5032974.
4. Rodriguez, F.J. S.; Angulo-Rocha, J.; Ramos-Brito, F.; Yee-Rendón, C.M.; GarcíaHipólito, M.; Aguilar-Frutis, M.; Castillo, S.J, Thin films of CdS:Cu, morphological, optical, structural and electrical properties, (2016) Superficies y vacío, vol. 29, núm. pp. 62-69 Sociedad Mexicana de Ciencia y Tecnología de Superficies y Materiales A.C. Distrito Federal, México, ISSN: 1665-3521.
5. S. Rex RosarioI. Kulandaisamy, K. Deva, Arun Kumar, K. Ramesh, Hala A. Ibrahium, Nasser S. Awwad, Ag-doped PbS thin films by nebulizer spray pyrolysis for solar cells, (2020) Pages 4505-4515. doi: https://doi. org/10. 1002/ er. 52 27.
6. D. Quinonez-Urias, A. Vera-Marquina, D. Berman-Mendoza, A. L. Leal-Cruz, L. A. Garc´ıa-Delgado, I. E. Zald´ıvar-Huerta, A. Garc´ıa-Juarez, A. G. Rojas-Hernandez, R. Gomez Fuentes, Annealing effect on structural, morphological, and optical behaviors of CBD-CdS nanostructured films for solar cells, (2014), Vol. 4, No. 11 Optical Materials Express 2280. doi: 10.1364/OME.4.002280.
7. Vidya S. Taur, Rajesh A. Joshi, and Ramphal Sharma, Annealing-Induced Modifications in Physicochemical and Optoelectronic Properties of Ag-Doped Nanostructured CdS Thin Films, (2012), International Journal of Photo energy Article ID 264027, 7 pages doi:10.1155/2012/264027.
8. Jumaa Mohammed, Jasim M., Abbas, Falah I., Mustafa, Effect Annealing Temperature on the Physical Properties of Cadmium Sulphide thin Films Deposited by using Thermal Evaporation Technique, (2020) Series: Materials Science and Engineering 757 012077 IOP Publishing. doi :10.1088/1757-899X/757/1/012077.

9. Zahid Rizwan, Azmi Zakaria, Mohd Sabri Mohd Ghazali, Atefeh Jafari, Fasih Ud Din, Reza Zamiri , Effect of Annealing Temperature on the Optical Spectra of CdS Thin Films Deposited at Low Solution Concentrations by Chemical Bath Deposition (CBD) Technique, (2011), Int J Mol Sci. ; 12(2): 1293–1305. Published online 2011 Feb 22. doi: 10.3390/ijms12021293.
10. F.Y. A-Shaikley, Electrical and Optical Properties Dependence on Annealing Temperature for CdS Thin Films. ,(2013),Indian Journal of Applied Research Volume: 3| ISSN - 2249-555X.
11. Ahmed, Abdullah Ahmed Ali ,Al-Hesni, Nasim M. ,Al-Osta, Ahmed H., Al-Salmi, Mohammed L. ,Manssor, Khlood A. ,Ja'adan, Saleh M. ,Al-Asbahi, Bandar Ali ,Qaid, Saif M. H. , Ghaithan, Hamid M., Farooq, W. A., Influence of single and dual doping (Ag and Co) on the optical properties of CdS quantum dot thin films for solar application, (2021), Optik, vol. 246, p.167824. doi: 10.1016/j.ijleo.2021.167824.
12. Vladimir Popov, Ivaylo Hinkov, Svetlomir Diankov, Maria Karsheva and Yordan Handzhiyski, Ultrasound-assisted green synthesis of silver nanoparticles and their incorporation in antibacterial cellulose packaging, (2015), Green Process Synth; 4: 125–131.
13. JunMa, Guo'anTai, WanlinGuo, Ultrasound-assisted microwave preparation of Ag-doped CdS nanoparticles, (2010),Ultrasonics Sonochemistry, Pages 534-540. doi: https://doi.org/10.1016/-j.ultsonch. 2009. 11.008.
14. P. Rodrı´guez, N. Mun˜oz-Aguirre, E. San-Martin Martı´nez, G. Gonzalez, O. Zelaya, J. Mendoza, Formation of CdS nanoparticles using starch as capping agent, Applied Surface Science 255 (2008) 740–742. doi: 10. 1016/j.apsusc.2008.07.032.
15. Sadegh Yousefi, Behrooz Ghasemi, MohammadTajally, AlirezaAsghari ,Optical properties of MgO and $Mg(OH)_2$ nanostructures synthesized by a chemical precipitation method using impure brine, (2017), Volume 711, Pages 521-529. doi: https://doi.org/10.1016/j.jallcom.2017.04.036.
16. G. Rajender, P. Giri, Strain induced phase formation, microstructural evolution and band gap narrowing in strained TiO2 nanocrystals grown by ball milling, Journal of Alloys and Compounds(2015), S0925-8388(16)30737-X.doi:10.1016/J.JALLCOM.2016.03.154.
17. Abdullah M.A. Al-Hussam, Salah Abdul-Jabbar Jassim, Synthesis, structure, and optical properties of CdS thin films nanoparticles prepared by chemical bath technique, Journal of the Association of Arab Universities for Basic and Applied Sciences, (2012), Volume11. doi: https://doi.org/10.1016/j.jaubas.2011.10.001.
18. A. S Najm, Abdulwahab Aljuhani, Hasanain Salah Naeem, K. Sopian, Raid A. Ismail, Araa Mebdir Holi, Laith S. Sabri, Asla Abdullah AL-Zahrani, Rashed Taleb Rasheed, Hazim Moria , Mechanism and principle of doping: realizing of silver incorporation in CdS thin film via doping concentration effect, (2022), Issue 46, RSC Advances. doi: https://doi.org/10.1039/D2RA04790J.
19. Baljinder Janpreet, Singh, Ramneek Kaur, R. K. Moudgil, S. K. Tripathi, Quantitative measurement of transport properties: Ag-doped nanocrystalline CdS thin films, (2017),RSC Advances, RSC Adv., 7, 53951-53962. doi: https ://doi.org/10.1039/C7RA02904G.
20. Md. Ferdous, Rahman, Jaker Hossain, Abu Bakar Md. Ismail, Structural, surface morphological and optical properties and their correlation with the thickness of spin coated superior quality CdS thin film synthesized using a novel chemical route.(2020) SN Applied Sciences volume 2, Article number: 1956. doi: https://doi. org/10.1007/s42452-020-03836-2.
21. Tahir Iqbal, Gulshan Ara, N. R. Khalid, Mohsin Ijaz, Simple synthesis of Ag-doped CdS nanostructure material with excellent properties, Applied Nanoscience, (2019), doi: https://doi.org/10.1007/s13204-019-01044-y.
22. Thi Hiep Nguyen Takato Kawaguchi Jakapan Chantana Takashi Minemoto Takashi Harada ,Shuji Nakanishi ,Shigeru Ikeda, Structural and Solar Cell Properties of a Ag-Containing Cu_2ZnSnS_4 Thin Film Derived from Spray Pyrolysis, (2018), CS Appl. Mater. Interfaces, 10, 6, 5455–5463.doi: https://doi._org/10.1021/_acsami._7b14929.
23. V. Narasimman, V. S. Nagarethinam, K. Usharan A. R. Balu, Structural, morphological, optical and electrical properties of spray deposited ternary CdAgS thin films towards optoelectronic applications, (2018). Materials Research Innovations , Volume 22, doi: https://doi.org/10.1080/14328917.2016.1264857.
24. Shramana Mishra, Alka Ingale a, U.N. Roy, Ajay Gupta, Study of annealing-induced changes in CdS thin films using X-ray diffraction and Raman spectroscopy, (2007), Thin Solid Films 516,91–98. doi:10.10 16/j.tsf. 2007.04.160.
25. A.U. Moreh, M. Momoh S. Abdullahi, J. S. Shehu, M. O. Mustapha, N. C. Martha, The Role Of Annealing Temperature On Optical Properties Of ZnO Thin Films Prepared By Spray Pyrolysis Techniques, (2015), Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 3159-0040 Vol. 2.
26. M. G. Faraj, M. H. Eisa, M. Z. Pakhuruddin, Physical Properties of Spray Pyrolysed Cadmium Sulfide Thin Films Deposited on Different Polymer Substrates, (2019), Int. J. Electrochem. Sci., 14 10633 – 10641.doi: 10.20964/2019.11.11.
27. M. Thambidurai, N. Muthukumarasamy, S. Agilan, N. Murugan , N. Sabari Arul , S. Vasantha, R. Balasun daraprabhu, Studies on optical absorption and structural properties of Fe doped CdS quantum dots, (2010), Solid State Sciences, Volume 12 Pages 1554-1559. doi: https://doi. org/10. 1016/j. solid states cienc es.2010.06.020.
28. M.H. Yükselici, C. Allahverdi, H. Athalin, Zinc incorporation into CdTe quantum dots in glass, Materials Chemistry and Physics, (2010), 119 218–22. doi: https://doi.org/10.1016/j.matchemphys.2009.08.057.
29. Hani Khallaf, Guangyu Chai, Oleg Lupan, Lee Chow, S. Park, Alfons Schulte, Characterization of gallium-doped CdS thin films grown by chemical bath deposition, (2009), Applied Surface Science 255 4129–4134. doi: doi:10.1016/j.apsusc.2008.10.115.
30. S. Chandramohan, T. Strache, S. N. Sarangi, R. Sathyamoorthy, and T. Som, Influence of implantation induced Ni-doping on structural, optical, and morphological properties of nanocrystalline CdS thin films, (2010), Materials Science and Engineering B, vol. 171, no. 1–3, pp. 16–19. doi: http://dx. doi.org/10. 1016/j.m seb.2010.03.047.
31. Jumaa Mohammed, Jasim M Abbas, Falah I. Mustafa, Effect Annealing Temperature on the Physical Properties of Cadmium Sulphide thin Films Deposited by using Thermal Evaporation Technique Paper, Open Access to cite this article, (2020), IOP Conf. Ser.: Mater. Sci. Eng. 757 012077. doi:10.1088/1757-899X/757/1/012077.
32. S. Chandramohan, A. Kanjilal, S. Sarangi, S. Majumder, R. Sathyamoorthy, T. Som, Implantation-assisted Co-doped CdS thin films: Structural, optical, and vibrational properties, (2009), J. Appl. Phys. doi 106 063506. https://doi.org/10.1063/1.3224867.

33. L. Saravanan, A. Pandurangan, R. Jayavel, J. Nanopart, Synthesis of cobalt-doped cadmiumsulphide nanocrystals and their optical and magnetic properties, (2011). doi:13 1621–1628. 10.1007/s11051-010-99154
34. A. S Najm, ag Abdulwahab Aljuhani, b Hasanain Salah Naeem,c K. Sopian,d Raid A. Ismail,e Araa Mebdir Holi,f Laith S. Sabri,g Asla Abdullah AL-Zahrani,h Rashed Taleb Rasheede and Hazim Moria, Mechanism and principle of doping: realizing of silver incorporation in CdS thin film via doping concentration effect, (2022), RSC Adv., 12, 29613-29626. doi: https://doi.org/10.1039/D2RA04790J.
35. M. Ichimura, F. Goto, E. Arai, Structural and optical characterization of CdS films grown by photochemical deposition, (1999), Journal of Applied Physics 85, 7411. doi:: https://doi.org/10.1063/1.369371.
36. Anke E. Abken, D. P. Halliday, and Ken Durose, Photoluminescence study of polycrystalline photovoltaic CdS thin film layers grown by close-spaced sublimation and chemical bath deposition, (2009), Journal of Applied Physics, 105, 064515.https://doi.org/10.1063/1.3074504.
37. Shramana Mishra a, Alka Ingale a, U.N. Roy, Ajay Gupta, Raja Ramanna, Study of annealing-induced changes in CdS thin films using X-ray diffraction and Raman spectroscopy, (2007), Thin Solid Films 516, 91–98, doi:10.1016/J.TSF.2007.04.160.
38. O. Stenzel, The Physics of Thin Films Optical Spectra, Springer-Verlag, Berlin, (2005).
39. Maticiuc N, Hiie J, Raadik T, Graf A, Gavrilov A. The role of Cl in the chemical bath on the properties of CdS thin films. Thin Solid Films, (2013), 535:184–187. doi: 10.1016/j.tsf.2012.11.107.
40. Natalia Maticiuca , Mart Kukka , Nicolae Spalatub, Tamara Potlogb , Malle Krunksa ,Vello Valdnaa , Jaan Hiie, Comparative study of CdS films annealed in neutral, oxidizing and reducing atmospheres,(2014), Energy Procedia 44, 77 – 84. doi: 10.1016/j.egypro.2013.12.012.
41. M Naziruddin Khan, Abdullah Almohammedi, MA Majeed Khan, Muhammad Ali Shar, Metals Doped CdS Quantum Dots: Structural, Optical and Photocatalytic Properties under Visible Light Irradiation, (2020), International Journal of Metallurgy and Metal Physics ISSN: 2631-5076, Volume 5. doi: 10.35840/2631-5076/9246.
42. A Sabah, S A Siddiqi, S Ali, Fabrication and characterization of CdS nanoparticles annealed by using different radiations, (2010), International Scholarly and Scientific Research & Innovation 4: 532-539. doihttps:// zenodo. org/ badge/ doi/10.5281/zenodo.1330301.svg
43. Mohd. Arif, Siddhartha, Ziaul Raza Khan, Effect of substrates temperature on structural and optical properties of thermally evaporated CdS nanocrystalline thin films,(2014) Indian Journal of Pure and Applied Physics 52(10):699-703, ISSN 0019-5596.