Analysis Of Structural And Optical Properties Of Ni-Co Co-Doped CdSe Thin Film Prepared By CBD

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Abstract:

The addition of Ni and Co in CdSe thin film have been carried out using chemical bath deposition technique on glass substrate at 80°c temperature in which selenium dioxide is the source of Se^{2-} ions and cadmium acetate is the source of Cd^{2+}ions, nickel chloride and cobalt chloride used for Ni^{+} and Co^{+} ions respectively. Samples were subjected to structural characterization using XRD, optical absorption and PL study also done, were XRD reveals the cubic structure, also the dislocation density (δ), strain (ε) and crystalline size (D) are discussed. The XRD data showed that the co-doping had a significant impact on the crystalline preferred orientation. FE-SEM images show some cabbage type structure particles having uniform distribution, PL intensity decreases with doping of Ni-Co and found direct band gap with at little high range. Co-doping of CdSe thin films with Ni and Co improved their solar cell efficiency.

Keywords: Nano-crystalline thin films, FE-SEM, XRD, Ni-Co Co-Doping

1. INTRODUCTION

In recent years, II-IV semiconductors in nano-crystalline forms have experienced an enormous development owing their interesting size dependent optical and electronic properties [1]. Cadmium Selenide is one from II–VI semiconductor compounds, is a promising photovoltaic material because of its high absorption coefficient near the band edge and its direct band gap which is 1.74eV [2]. There are many techniques to deposit thin films like vacuum evaporation, electrode deposition, chemical bath deposition, CBD method is the most suitable deposition among them due to its simplicity, affordability, and ability to deposit solid solutions without the need for complicated equipment [3-7]. We have produced uniform, very adherent, nearly stoichiometric CdSe films with fewer defects because to this Methode [8]. To increase qualities of CdSe Semiconductor, it has been doped with a variety of elements, including In, Fe, Ni, Co, Sm, and Ag [10]. It can form in cubic (zinc blende) and hexagonal (wurtzite). While the cubic is a metastable structural phase that frequently occurs at low temperatures, the hexagonal is the stable phase of CdSe [2]. In this study, pure Cadmium Selenide films were prepared by chemical bath deposition along with Ni and Co co-doping at same ratios.

2. EXPERIMENTAL DETAILS

Glass slides with dimensions (76mm 9×26mm 9×1mm) that had been chemically cleaned and dried in air for some hours, are used as substrates for the film-making process. Sodium selenosulphate (Na2SeSO3), serving as a precursor for selenide ions, was utilized in this process. 1 M solution of Na2SeSO3 was created by re-fluxing equal parts of 1 M sodium sulphite (Na2SO3) and 1 M selenium dioxide (SeO2) solutions in 250 ml beaker, while continuously stirring the mixture with a magnetic stirrer at 90°C for 4h.

Chemical deposition of CdSe film is carried out at room temperature. Deposition solution is prepared by taking 7 ml freshly prepared 1 M cadmium acetate $(CH_3COO)_2Cd_2H_2O$, 7 ml 1 M Na_2SeSO_3, 10 ml ammonia to adjust the pH value and 2ml of TEA in 50 ml beaker gently stirring the solution at room temperature for 5 min then glass substrates were vertically immersed. The substrates with CdSe coating were taken out of the bath after deposition period of 2h at 80°C temperature, washed with double distilled water and dried in air. For Ni and Co doping, to above solution 2ml of 1 M $NiCl_2.6H_2O$ and 2ml of 1M $CoCl_2.6H_2O$ solution was added [8]. The prepared pure CdSe thin film is orange red color and Ni-Co co-doped CdSe thin film is dark red in color.

3. RESULT AND DISSCUTION

3.1 XRD Analysis

The cubic phases of CdSe, Ni and Co exist, JCPDS card No (00-019-019) information for CdSe, Ni and Co selenide was used to determine the sample phase. The XRD pattern suggests a poly-crystalline structure, all the films demonstrate three dominant peaks at 25.55°, 42.17° and 50.67° belonging to (111), (220) and (311) planes for undoped CdSe and 25.51°, 42.39° and 50.22° are Ni-Co Co-doped CdSe respectively, with doping peaks increased slightly.

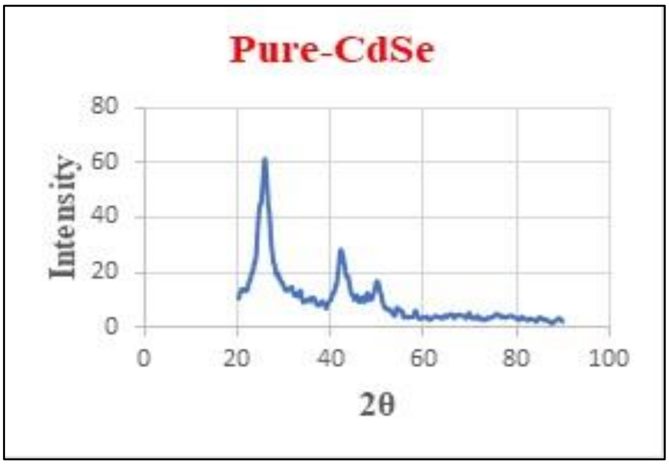


Fig: 1 (a) XRD graph of Pure CdSe

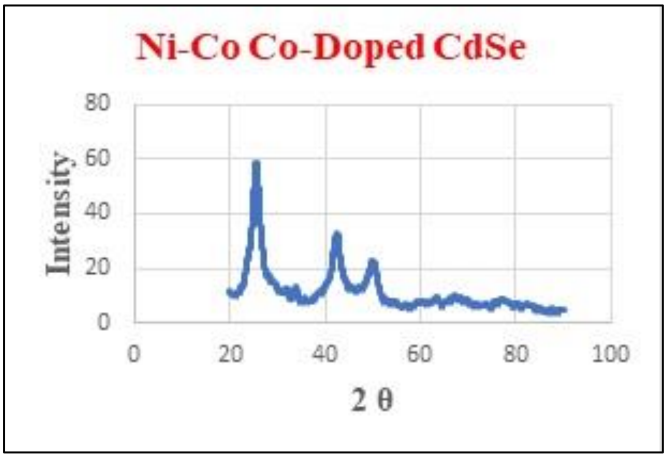


Fig. 1 (b) XRD graph of Ni-Co Co-doped CdSe

The FWHM from undoped CdSe is 3.84° and when doped with Ni-Co decreased to 2.58°. Crystallite size (D) was calculated using Debye-Scherrer formula [16]:

$$D = k\lambda / \beta \cos\theta \quad (1)$$

D of CdSe thin films was determined to be 1.65nm, while for CdSe:Ni+Co thin films it was determined to be 1.68nm. A device's outcomes are enhanced by good crystallization, confirmed by a large grain size, proving that CdSe is an excellent option for window layer [10].

The following equation was used to calculate micro strain (ε) [17]:

$$\varepsilon = \beta \cos\theta / 4 \quad (2)$$

The following equation was used to calculate dislocation density (δ) [18]:

$$\delta = 1 / D^2 \quad (3)$$

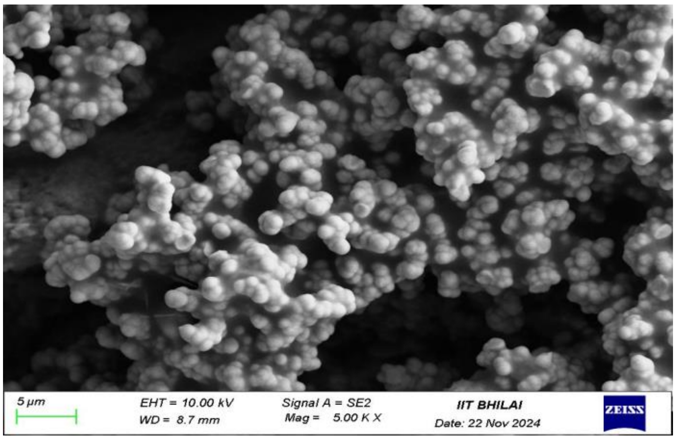
The property is nanocrystalline if the ε value is less. Polycrystalline films, on the other hand, are indicated by a greater ε. Films with lower values will have higher degrees of crystallinity and fewer flaws. Table 1 shows the structure parameter of all films.

Table -1: Structural parameter of intended films

Specimen	2θ (°)	hkl plane	FWHM (°)	Optical band gap (eV)	Crystalline size (nm)	Dislocation Density ($\times 10^{14}$) E
Pure CdSe	25.55 42.17 50.67	111 220 311	3.84	1.8	22.06	0.0023
Ni+Co doped CdSe	25.51 42.39 50.22	111 220 311	2.58	1.94	32.77	0.00093

3.2 FE-SEM Morphology

The CdSe thin films in used chemical bath deposition technique the structures illustrate the first homogeneous characteristics or uniformly sized the grains on the surface,



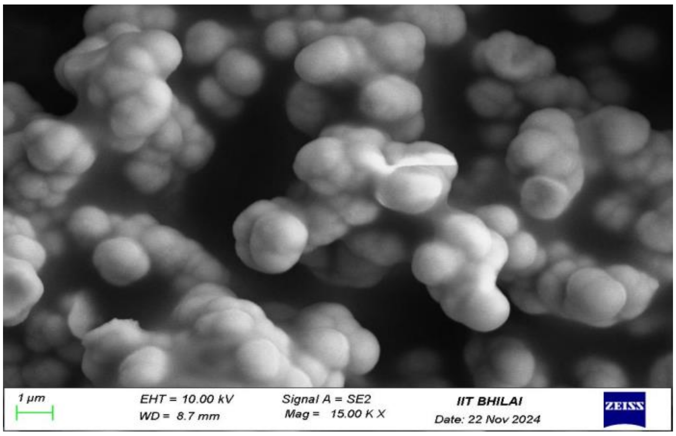


Fig: 2 (a) and (b) FE-SEM image of Pure-CdSe

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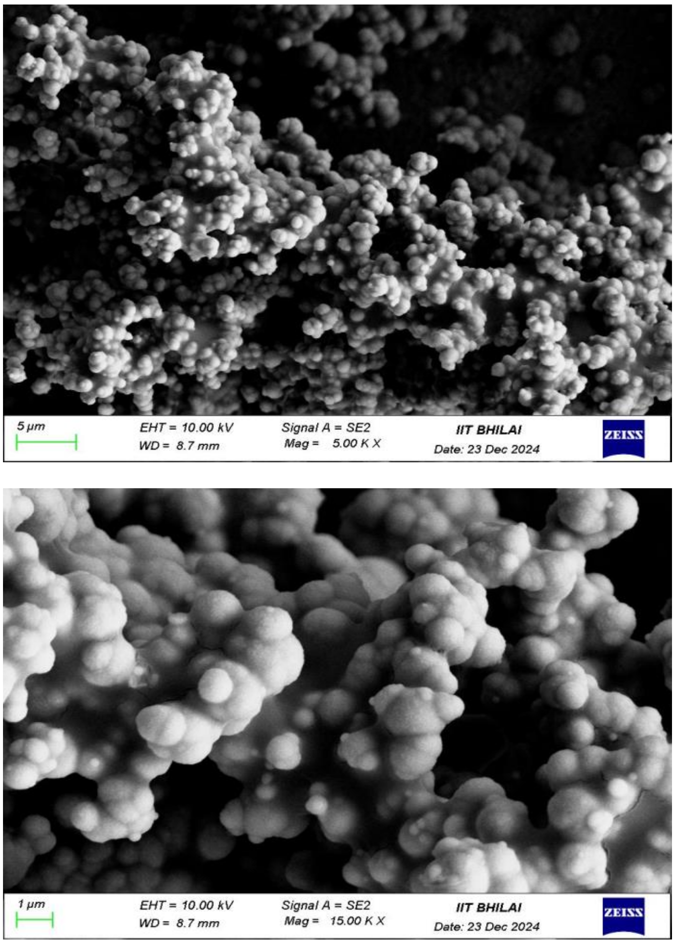

Fig: 3 (a) and (b) FE-SEM image of Ni-Co doped CdSe

in present study fig: 2 (a) and (b) shows Pure CdSe mano-crystalline thin film surface structure and Fig: 3 (a) and (b) shows Ni-Co Co-doped nano-crystalline CdSe thin films with 5000 and 1500 magnifications. From FE-SEM images it is clearly visible that with Ni and Co-doping the particle size is decreases.

3.3 Optical properties

Absorbance

Optical absorbance spectra were captured between 450 and 750 nm in wavelength. It is evident from Fig. 4 (a) and (b) that co-doping raised the absorbance values as the optical absorbance rose with wavelength.

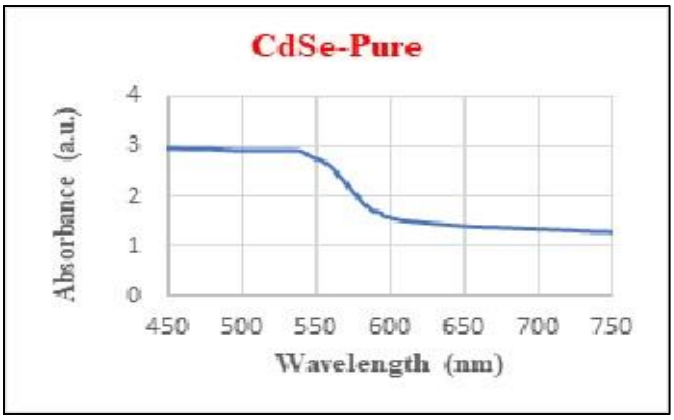

Fig: 4 (a) Absorbance spectra of pure-CdSe

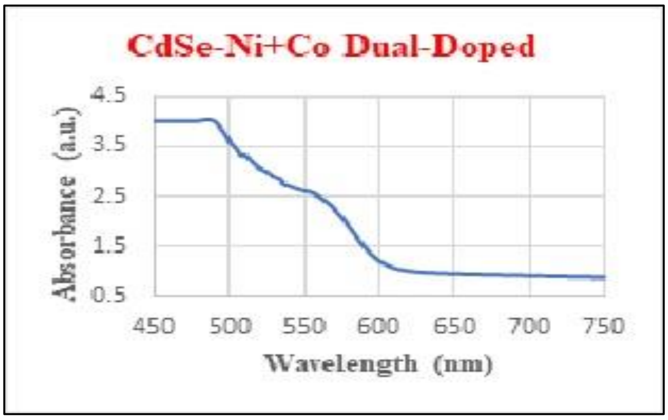

Fig. 4 (b) Absorbance spectra of Ni-Co Co-doped CdSe

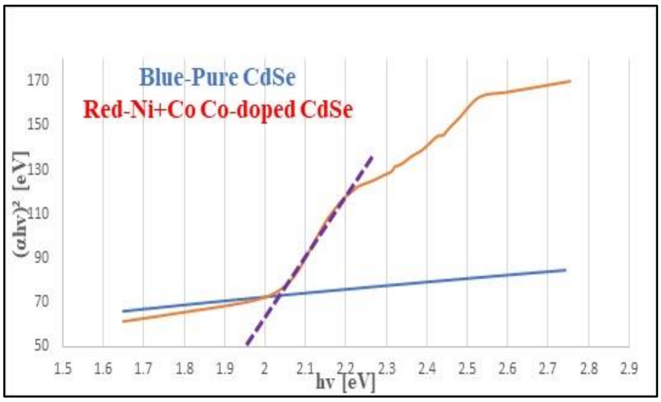

Fig: 5 Plot of $(\alpha h\nu)^2$ vs. hν (derived from fig. 4 (a) and (b)

This could be explained by the fact that Ni and Co-doped CdSe thin films are thicker than pure CdSe films. This indicates that Ni and Co have a greater capacity to absorb light. Fig. 5 shows the Tauc plots for pure CdSe and Ni-Co Co-doped CdSe nanocrystalline thin films shows direct transition and it is direct band gap nature at 1.94 eV.

4. CONCLUSION

Pure and Ni-Co dual doped CdSe thin films were examined for their structural and optical characteristics. The structural investigation verified that the cubic system is present in both pure and Ni-Co Co-doped CdSe thin films. The crystallite size and lattice properties of CdSe thin films were altered by co-doping with Ni and Co, by doping the crystallite size shrank. The absorbance of the CdSe thin film was altered by Ni-Co co-doping; since the optical absorbance increased with wavelength, co-doping increased the absorbance values and observed that band gap is also increases to 1.94eV from 1.74eV. The characteristics of the CdSe thin film were enhanced for usage as a solar cell by Ni-Co co-doping.

5. REFERENCES

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