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Structural, Optical and Magnetic properties of Co doped CdSe powders

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Abstract: Co doped CdSe powder samples were prepared via solid-state reaction route. In the present study the effect of Co doping on structural, optical and magnetic properties has been studied. X-ray diffraction studies showed the formation of hexagonal phase of wurtzite structure for all the samples. Optical studies showed an increase in the band gap with increasing Co concentration. Magnetization measurements showed a hysteresis loop and confirmed room temperature ferromagnetism in Co doped CdSe powders.
Keywords*:* Solid state reaction, X-ray diffraction, Optical studies, Room temperature ferromagnetism, Co doped CdSe.

Introduction

In recent years the scientific community has been attracted by the elite physical properties of dilute magnetic semiconductors (DMS) and their wide spread application in the spin based memory devices. These materials can be used efficiently as a source of injecting spin-polarized carriers into semiconductors and spin valves [1, 2]. DMSs are conventional non-magnetic semiconductors doped with magnetic transition metal ions such as Mn, Cr, Fe, Co, Ni etc [3]. These partly substitution of the transition metal atoms into the non-magnetic semiconductor results unique physical and magnetic properties [4]. Among II-VI semiconductors, CdSe is one of the predominant candidates, which shows an optical band gap of 1.75 eV and exhibits n-type conductivity. The present work aims at the synthesis of Co-doped CdSe powders and, investigations of their optical, structural and magnetic properties.

Experimental

Co doped CdSe powders with Co concentrations of 4 at.% and 8 at.% were synthesized by standard solid-state reaction method. Commercially available Co, Se and CdSe ((M/S Sigma-Aldrich 99.999% purity) were used as source materials. Appropriate quantities of freshly prepared CoSe and CdSe were mixed and ground thoroughly for 16-18 hours to ensure homogeneity. The ground powder samples were loaded in a closed quartz tube of diameter 10 mm and length of 20 cm, which was enclosed inside a outer protective quartz tube having a dimensions of 2.5×75 cm followed by sintering at 600°C for 6 hours under a pressure of 10^{-3} mbar using a

rotary pump. The complete set up was placed in horizontal tubular microprocessor controlled furnace. The sintered Co doped CdSe powders were subjected for different characterizations. Powder X-ray diffraction (XRD) patterns of all the samples were recorded using (Bruker, D8 Advance) diffractometer. The room temperature diffused reflectance spectra of the samples were recorded using double beam UV-Vis-NIR Spectrophotometer (Jasco V-670). Magnetic measurements were carried out with a Vibrating Sample magnetometer (Lakeshore VSM 7410).

Results and discussions

Structural properties

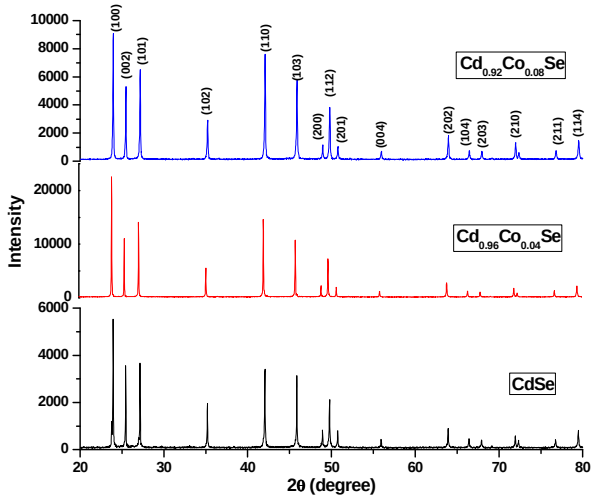


Fig. 1 X-ray diffraction pattern of pure and Co doped CdSe powders

XRD patterns of pure and Co doped CdSe powders are shown in Figure 1. All the diffraction peaks are indexed and found to be well matched to wurtzite structure of CdSe having hexagonal phase which is in good agreement with the (JCPDS card no. 77-2307). No traces of Co clusters or cobalt oxides are detected within the sensitivity limitation of XRD. The crystalline nature of the sample increases as the Co concentration increases. The shift in the peak position has been observed with increasing Co doping concentration which indicates the incorporation of Co in the CdSe host lattice. Figure 2 shows the variation of lattice parameter with increase of Co concentration. The lattice parameter of the pure and Co doped CdSe powders found to be decreased with the increase in Co concentration. This decrease of lattice parameter is due to the lower ionic radius of Co^{2+} (0.72 Å) ions as compared to Cd^{2+} (0.97 Å) ions.

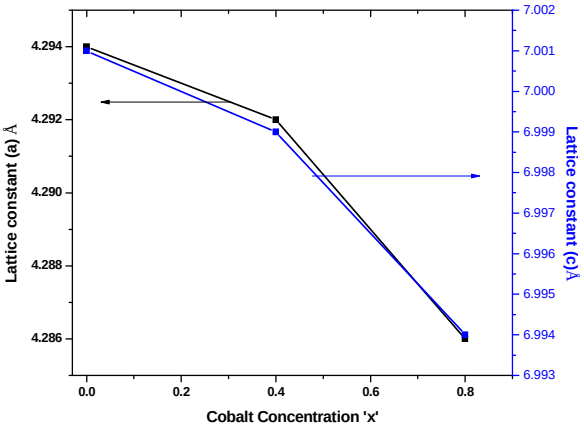
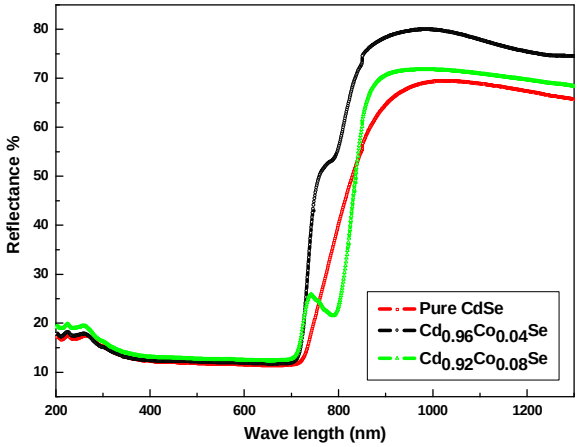


Fig. 2 Lattice constants of pure and Co doped CdSe powders as a function of Cobalt concentration ‘x’

Optical properties

Fig. 2 shows the diffuse reflectance spectra of pure and Co-doped CdSe powders. The bulk CdSe has a bang dap of 1.78 eV corresponding to absorption wavelength of 697 nm. However, with Co doping the blue shift has been observed. This can be explained by quantum confinement of electron-hole pairs (excitons), which

is dominant when the particle size is less than or comparable to the Bohr exciton radius of the bulk material. The Eg value has been found to be increase with Co doping concentration from 1.75 to 1.79 eV which can be attributed to decrease in particle size.



Magnetic Studies

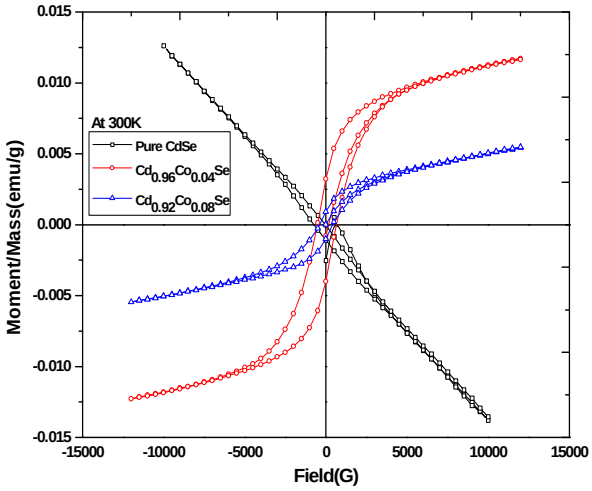


Fig. 3 M-H loops of pure CdSe and Co doped CdSe powders

Fig. 3 shows the moment versus applied magnetic field (M-H) hysteresis loops of pure and Co-doped CdSe for 4 at.% and 8 at.% alloy powders at room temperature. The pure CdSe showed diamagnetic behavior due to its intrinsic diamagnetic nature, whereas the Co doped CdSe samples exhibited a clear hysteresis loop. It was observed from the above Figure 3 that as the Co concentration increases a weak magnetic moment is achieved with magnetization (M_s) value of $12.00x10^{-3}$ emu/g and $5.46x10^{-3}$ emu/g at 4 at.% and 8 at.%, respectively. It can be inferred that the ferromagnetism in doped CdSe samples may be originated from the carrier mediated exchange interactions between delocalized carriers of the host and the localized d spins of the Co ions.

Conclusion

A systematic study of structural, optical and magnetic properties of Co 4% and 8% doped CdSe powders are carried out. Results of XRD, UV-Vis- NIR and VSM measurements reveal that particle size increases as the doping concentration of Co increases. The band gap of the Co doped CdSe samples increased with the increase in the dopant concentration. The magnetic measurements exhibited room temperature ferromagnetism in all the Co doped CdSe samples.

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