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Structural, Optical and Magnetic properties of Cu doped ZnSe powders

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Abstract: Cu doped ZnSe powder samples were prepared via solid-state reaction route. In the present study the effect of Cu doping on structural, optical and magnetic properties has been explored. X-ray diffraction studies confirmed the formation of cubic phase in all the samples. Optical studies showed that with the increase of Cu concentration, the band gap of the samples also increased. The Cu doped ZnSe samples exhibited ferromagnetism at room temperature and proved Cu doped ZnSe samples are diluted magnetic semiconductors.
Keywords*:* Solid state reaction, X-ray diffraction, Optical studies, Room temperature ferromagnetism, Cu doped ZnSe.

Introduction

Spintronic devices are those which avail both the intrinsic spin and charge of an electron to transport and process the data in an enhanced non volatile memory medium by consuming low power. DMS are the materials which have the amalgamated characteristics of semiconductors and magnetic materials. They are synthesized by substitution of a fraction of host cations in traditional semiconductor by magnetic ions like Fe, Co, Ni or appropriate rare earth metals [1]. Zinc Selenide (ZnSe) being one of the best II-VI diluted magnetic semiconductors has proven itself to have a wide spectrum of applications in the fields of optoelectronics and electroluminescence. It has a direct band gap of 2.70 eV [2]. The present work is intended to study the structural, optical and magnetic studies of Cu doped ZnSe powders.

Experimental

Cu-doped ZnSe powders with Cu concentrations of 5 and 10 at. % were prepared through a solid -state reaction technique. 5N purity ZnSe, Cu and Se (99.99%, M/S Sigma–Aldrich) were used as source materials. Stoichiometric compositions of freshly prepared CuSe and ZnSe were mixed under persistent mechanical grinding for 15-17 hours using an Agate mortar and pestle to ensure homogeneity and then fired at 600°C for 6 hours under a pressure of 10^{-3} Torr. The fired Cu doped ZnSe powders were subjected for different characterizations. Structural studies was performed using (Bruker, D8 Advance) diffractometer. Optical studies of the samples were recorded using double beam UV-Vis-NIR Spectrophotometer (Jasco V-670). Magnetic studies were carried out with a Vibrating Sample magnetometer (Lakeshore VSM 7410).

Results and Discussion

Structural analysis

Figure.1 Shows the XRD patterns of the as prepared pure ZnSe and Cu doped ZnSe samples. All the samples showed intense diffraction peaks oriented along (1 1 1), (2 0 0), (2 2 0), (3 1 1), (2 2 2) and (4 0 0) planes which are in accordance with JCPDS card no 88-2345. These intense peak positions in the samples clearly showed the formation of cubic zinc blende structure of ZnSe. The preferential orientation was found to be (111) plane for all the samples. It was also observed that as the Cu concentration increased from 5 at.% to 10 at.%, the intensity of the ZnSe peaks decreased. No other peaks related impurity or secondary phases were detected within the detection limit of XRD. Also there is no change in the crystalline structure except shift in peak positions suggesting the incorporation of Cu ion into the Zn lattice rather than the interstitial sites. This shift in the peak positions is due of the lower ionic radii of Cu^{+2} ions (0.057 nm) relative to the ionic radii of Zn^{+2} ions (0.074 nm).

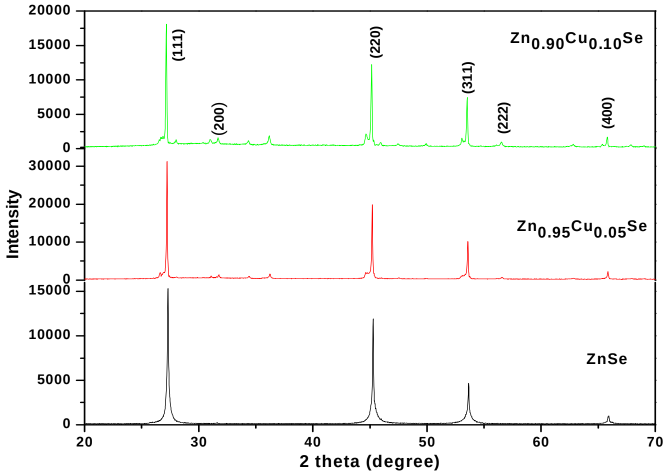

Fig.1 X-Ray diffraction patterns of Pure and Cu doped ZnSe powders

Optical studies

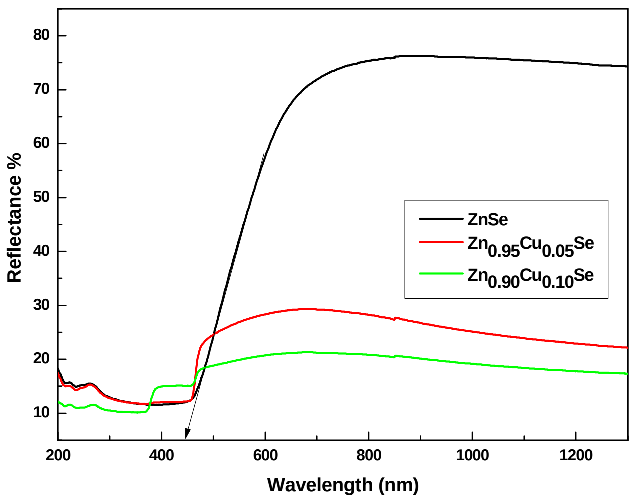

Fig.2 Diffuse reflectance spectra of pure and Cu doped ZnSe powders.

Figure .2 shows the diffused reflectance spectra of pure and Cu doped ZnSe powders. With increase of Cu doping concentrations, optical band gap increased from 2.70 eV (pure ZnSe) to 2.80eV. The position of the absorption edge shifted towards the lower wavelength region with increasing Cu concentration. This increase in the band gap may be due to lower wavelength shift or blue shift can be well explained by the Burstein-Moss effect [3]. The Burstein–Moss effect is a phenomenon in which the apparent band gap of a semiconductor is increased as the absorption edge is pushed to higher energies. Due to this consequence, the Fermi level merges into the conduction band with increasing of the carrier concentration. Thus, the low energy transitions are blocked thereby widening of the band gap. As the Cu doping level increases it leads to the supply of excess carriers which results the increased band gap or blue shift. Hence, in Burstein-Moss effect the Fermi level merges into the conduction band with increase of doping concentration.

Magnetic studies

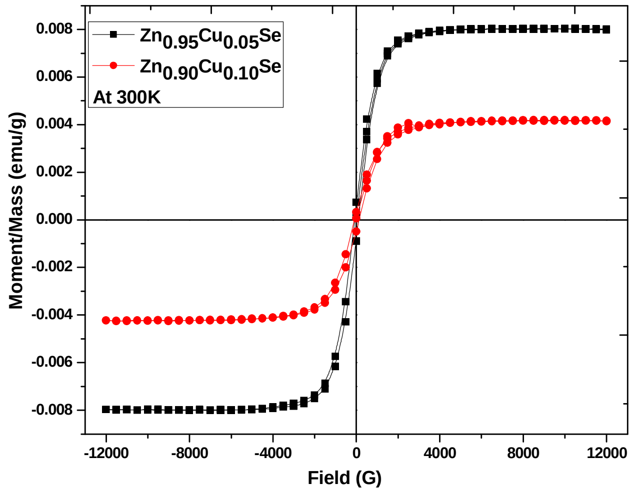

Fig.3 M-H loops of Cu doped ZnSe powders

Figure.3 depicts the room temperature M-H loops for Cu doped ZnSe powders. All the Cu doped ZnSe powders exhibits ferromagnetism at room temperature. The observed value of saturation magnetization [M_s] for 5 at.% and 10 at.% are 8.03x10^{-3} emu/g and 4.2x10^{-3} emu/g with a coercive field of approximately 96.53 G and 112.96 G respectively. The magnetisation [M_s] values of the samples decreased with increasing Cu doping concentration. But the coercivity of the samples increased with increasing copper doping concentration. Hence, from the above plot that the hysteresis behaviour observed in 5 at.% Cu doped ZnSe supports the existence of ferromagnetism with strong magnetic moment and as the Cu concentration is increased to 10 at.%, ferromagnetic behaviour with feeble magnetic moment is observed. The reason for the decrease in magnetic moment with increasing copper concentration could be due to an increased number of copper atoms occupying adjacent cation positions resulting in anti- ferromagnetic alignment. The ferromagnetism observed in Cu doped ZnSe may be accounted to the interactions between localized 'd' spins of Cu ions and the delocalized carriers of the Zn ions in the ZnSe host lattice.

Conclusion

Cu-doped ZnSe (Cu: 5 at.% and 10 at.%) powders were synthesized by single step solid-state reaction method. From X-ray diffraction, the crystal structure was confirmed as cubic. The Cu ions replaced the Zn ions without changing the ZnSe crystal structure. The reflectance measurement reflects the increase in optical band gap energy with increase in Cu concentration and then decreased with further increase in Cu concentration. The magnetization measurements clearly showed room temperature ferromagnetism in 5 at.% and 10 at.% Cu doped ZnSe powders.

References

1. Ohno H., Making nonmagnetic semiconductors ferromagnetic, Science, 1998, 281, 951-956.
2. Wang H., Du F., Hydrothermal synthesis of ZnSe hollow microspheres, Crys Res Technol, 2006, 41,323–327.
3. Suwanboon S., Ratana T., Ratana W., Fabrication and properties of nanocrystalline zinc oxide thin film prepared by sol-gel method, J Sci Technol, 2008, 30, 65-69.

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