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Mechanoluminescence Properties of $(Cd_{0.95}Zn_{0.5})S$ mixed nanoparticles doped with silver

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Abstract

Mechanoluminescence behavior of $(Cd_{0.95}Zn_{0.5})S$: Ag doped phosphor when load of 250 gm was dropped from 50 cm height for 2.5 Molar % concentrations of Ag ions has been studied. The particle size of $(Cd_{0.95}Zn_{0.5})S$:Ag were calculated by Debye scherrer's formula and it was found to be 185 nm. Miller indices has also been calculated. $(Cd_{0.95}Zn_{0.5})S$:Ag sample has been prepared by solid state method. The effects of UV-Exposure time on luminescence characteristics were investigated.

Key words: (Cd,Zn)S:Ag, Mechanoluminescence, XRD.

1. Introduction

Mechanoluminescence (ML) is the phenomenon of light emission from a light as a response reports to a mechanical stimulus gives to it. The light emissions induced by elastic deformation, plastic deformation and fracture of solids are called elastico mechanoluminescence (ML), plastico ML and fracto ML, respectively[1]. The development of materials with strong elastico ML intensity is an important goal in exploring applications of ML in stress indicators and other mechano-optical devices[2-3]. The ML can be produced by compressing, stretching, bending, loading, impulsively, deforming, cutting, cleaving, rubbing or grinding of solids. (Cd,Zn)S alloy have a direct and wide band gap energies ranging from 2.42 to 3.67 eV in their bulk state, are one of the most proficient material in the field of photonics and optoelectronics due to its dominance behavior of the composition over the size of the nanophosphors[4,5]. Because of their luminescence and nonlinear optical properties, and other excellent physical and chemical properties, semiconductors of group II-VI have potential applications in many

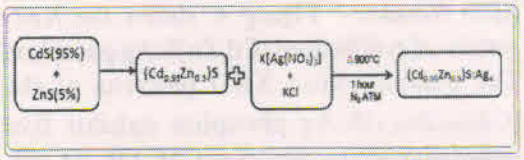
technical fields, including photo catalysts, gas sensors, imaging, solar cells, photo conductors, biological detection and UV sensors, short wavelength laser diodes and various luminescence devices[6-14,23].

In the recent past, systematic materials research has been done and it has resulted in producing a variety of materials that emit an intensive and repeatable ML during elastic deformation without any destruction. Binary chalcogenide nanocrystalline semiconductors such as PbS, ZnS, ZnSe, CdS and CdSe have attracted considerable attention in recent years due to their unique properties. Cadmium sulphide and Zinc sulphide are an n-type semiconductor that has been used extensively in many applications, including photo resistance sensors, low cost solar cells for energy conversion, light emitting diodes, laser materials, optical waveguides and nonlinear optical devices[15-16]. (Cd,Zn)S phosphor doped with Ag ion has been paid a great devotion by several researches because of its commercial application as a blue emitting phosphor. The optical band gap (E_g) tunability of the (Cd,Zn)S for various Zn^{2+} concentrations was successfully demonstrated[17]. Also the related ternary compounds $Cd_xZn_{1-x}S$ are promising materials for high density optical recording and for blue or even UV laser diodes. These applications are based on the structure of $Cd_xZn_{1-x}S$ which exhibit fundamental absorption edges that can varied from green to UV [18]. The control of the composition of $Cd_xZn_{1-x}S$ nano particles may lead to the development of ideal materials for short wavelength diode laser applications[19]. Among them, the wide band gap phosphors materials have opened avenue in fundamental studies and tremendous potential applications in diverse areas such as solarcell, photo-catalysis, sensors, photonic and other optoelectronic devices[20]. (Cd.Zn)S phosphor doped with Ag^+ ion has been paid a great devotion by several researches because of its commercial application as a blue emitting phosphor.

In this paper, highly luminescent Ag^+ ion doped $(Cd_{0.95}Zn_{0.5})S$ Phosphors were successfully synthesized by a solid state reaction method. It was observed that ML intensity corresponding to Ag impurity. Which are potentially important for white light generation. The development of materials with strong elastico ML intensity is an important goal in exploring applications of ML in stress indicators and other mechano-optical devices.

2. *Experimental Details :*

The silver-doped $(Cd_{0.95}Zn_{0.5})S:Ag$ mixed phosphor was prepared by solid state reaction method using mixture of luminescent grade CdS and ZnS (Fluka, Switzerland), Silver nitrate ($Ag(NO_3)_3$) and potassium chloride (flux) according to to stoichiometric ratio. The Ag^+ ion concentration was fixed X= 2.5 % Mole Percent and CdS and ZnS content are fixed at .95 and .5 percent respectively. The mixture was placed in a alumina crucible. The heating was done in a silica tubular furnace maintained at 900°C in the inert atmosphere of flowing nitrogen gas. After the heating was complete, the mixture was taken out of the furnace and immediately crushed and finely powdered to have a uniform particle size. Although defects are produced during grinding but better repetitive results are obtained in case of grind phosphors as compared to that in un-grind phosphors (Scheme 1)[2,23].



Scheme 1. Mechanism of solid state synthesis method of (Cd,Zn)S:Ag.

To determine the average particle size and the phase of the samples, X-ray powder diffraction (XRD) pattern was measured by using a D-8 Advance X-ray generator with Cu Kα radiation.

ML Measuring Device:- For recording the ML pattern, we were used handmade apparatus fitted with 931B photomultiplier tube (PMT) by taking 1 mg of sample each time as show in figure 1.

(1) Scale In Cms.
(2) Pulley,
(3) Metallic Wire,
(4) Load,
(5) Guiding Cylinder,
(6) Aluminum Foil,
(7) Sample,
(8) Transparent Lucite Plate,
(9) Wooden Block,
(10) Photomultiplier Tube,
(11) Iron Base Mounted On A Table

Arrangement Used For Measuring The Time Dependance Ml In Phosphor

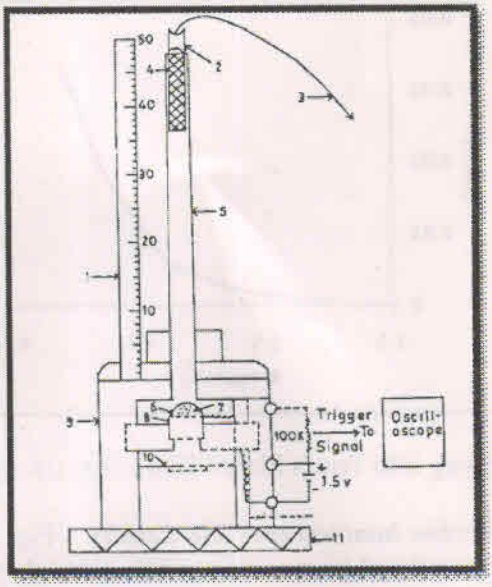


Fig. 1. schematic diagram of the experimental

3. Results & Discussion

Absorption Spectra:- Figure 2(a) & 2(b) Shows the optical absorption spectra and Plot between $(\alpha h\nu)^2$ verses energy (called Tauc Plot) of $(Cd_{0.95}\ Zn_{0.5})S$:Ag [Ag=2%M] Phosphor. The optical absorption spectra of $(Cd_{0.95}Zn_{0.5})S$:Ag phosphor recorded in the range of 250 to 650 nm. Optical absorption edge was obtained at 365 nm for $(Cd_{0.95}Zn_{0.5})S$:Ag. The band gap energy of the sample corresponding to the absorption edge is found 3.4 eV which agrees with the tauc's plot result[21].

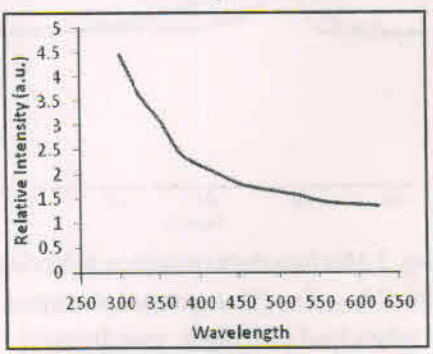


Figure 2(a) Absorption spectra of $(Cd_{0.95}\ Zn_{0.5})S$:Ag

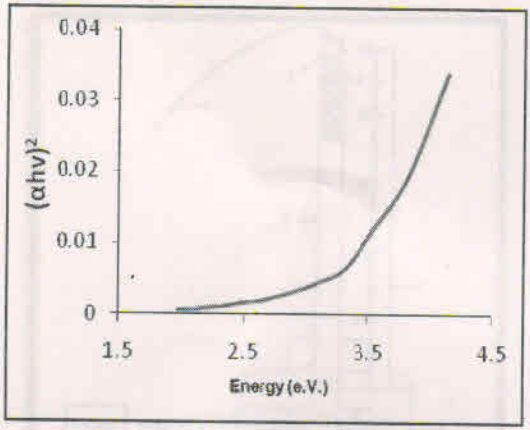


Figure 2(b) Tauc's Plot of $(Cd_{0.95}\ Zn_{0.5})S$:Ag

Mechno luminescence ML Results: - Fig. 3 shows the characteristics of ML induced by the impact of a moving piston onto the phosphor. The luminescence intensity depends upon the concentrations of silver. Maximum intensity of the phosphor is obtained for 2.5mole% of silver. It is seen that the luminescence intensity increases with increase iu UV Exposure Time

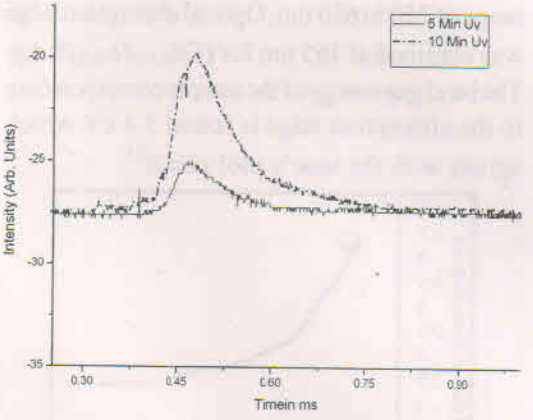


Fig. 3 Mechanoluminescence behavior of $(Cd_{0.95}\ Zn_{0.5})S$:Ag doped phosphor when load of 250gm was dropped from 50 cm height for 2.5 Molar concentrations of Ag.

XRD Results:- Figure 4. shows the XRD pattern of synthesized (Cd,Zn)S:Ag phosphor. The characteristic XRD patterns of the $(Cd_{0.95}Zn_{0.5})S$:Ag phosphor exhibit five prominent peaks are about 28.32^0, 31.67^0, 47.57^0, 56.52^0, and 58.50^0 which are originated from (1 1 1), (2 0 0), (2 2 0), (3 1 1) and (2 2 2) planes and other peaks are observed due to the impurity of Ag^- ions. These diffraction patterns are in good agreement with JCPDS card number 65-7887. It's show cubic structure.

The average particle size (D) of the as-formed $(Cd_{0.95}Zn_{0.5})S$:Ag phosphor was estimated from the full width at half maximum (FWHM) of the diffraction peak of the powder, using Scherrer's formula[22].

$$D = .09\lambda/\beta Cos\theta$$

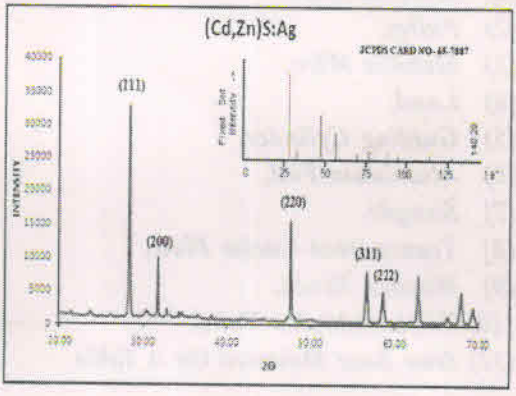


Figure 4. XRD results of $(Cd_{0.95}Zn_{0.5})S$:Ag, Ag concentration is 2.5 mole%.

Where λ is the wavelength of X-ray used, θ the Bragg angle and ß is FWHM of corresponding peaks. The average crystallite size is 185 nm. Table 1 shows the calculation for miller indices.

Table 1 Miller indices of Cubic $(Cd_{0.95}Zn_{0.5})S$:Ag phosphor.

Peak #	2Θ	Θ	$\sin^2\Theta$	$\sin^2\Theta/\sin^2\Theta_{min}$	$(\sin^2\Theta/\sin^2\Theta_{min})*3$	$h^2+k^2+l^2$	hkl
1	28.32	14.16	0.059	1	3	3	111
2	31.67	15.835	0.074	1.244	3.732	4	200
3	47.57	23.785	0.162	2.71	8.153	8	220
4	56.52	28.26	0.224	3.74	11.23	11	311
5	58.5	29.25	0.238	3.98	11.96	12	222
6	62.78	31.39	0.271	4.53	13.600	14	321

Discussion

Synthesis of high quality luminescent and free standing $(Cd_{0.95}Zn_{0.5})S$ phosphor doped with Ag^+ ion is prepared by solid state reaction method. The phenomenon of ML in the silver doped $(Cd_{0.95}Zn_{0.5})S$ phosphor are related to the movement of dislocations and the recombination of activated electrons and holes. We have investigated the Mechanoluminescence phenomenon in the $(Cd_{0.95}\ Zn_{0.5})S$:Ag. The phosphor was prepared by solid state reaction method. It was found that ML intensity strongly depends upon the UV exposure time.

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