Mechanoluminescence Properties of Pure and Ag^+(1-5%) doped $(Cd_{0.95}Zn_{0.05})S$ Phosphors

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Abstract- ***Pure and Ag^+ (1-5% molar concentration) doped $(Cd_{0.95}Zn_{0.05})S$ phosphors were prepared by high temperature solid state reaction method by using Sodium chloride (NaCl) as a flux under nitrogen atmosphere. The structural characterizations were studies here by using X-ray diffraction and scanning electron microscope analysis techniques. The mechanoluminescence (ML) spectra of pure and Ag^+ (1-5%) doped $(Cd_{0.95}Zn_{0.05})S$ Phosphors were investigated. Also the influences of Ag^+ ion concentration on mechanoluminescence spectra were studies.***

Keywords: ***$(Cd_{0.95}Zn_{0.05})S{:}Ag^+$, Phosphors, Mechanoluminescence, X-ray diffraction, Scanning electron microscope.***

I. INTRODUCTION:-

Developing environmentally clean sensors from abundant chalcogenide materials has attracted considerable attention these years. II–VI semiconductor material such as CdS and ZnS are chemically easily available, more stable and comparably better than other chalcogenides (such as ZnSe, CdSe etc). It is considered to be most promising host material for different kind of optical, pressure and thermal sensors [1-3].

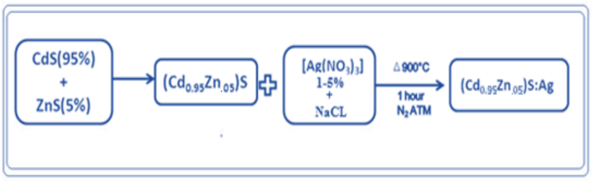
(Cd, Zn)S mixed phosphor, shows a direct wide band gap ≈3.5 eV in their bulk state. This property made it one of the most prominent materials in the field of optics, optoelectronics and photonics. Transitional elements ions such as Ag^+, Mn^{2+}, Ni^{+2} and Cu^{2+} have been doped into this phosphor to enhance its optical response, which is our requirement [4-5]. The Silver doped II–VI chalcogenide phosphor had been found to used as an enhancement ability for significant enhancement in optical properties, strong covalent bonding and lattice hardening in the materials[6-9]. This is done by using different synthesis method such as, chemical bath, evaporation, sol–gel processing, co precipitation, micro emulsion, and solid state reaction method etc. Out of the all synthesis process, the solid state reaction is adopt by us because it is quite simple and large production process[10-12].

The literature revels many authors have already studied various properties of (Cd, Zn)S. The Sao et al (2013) synthesized the Ag^+ doped $(Cd_{0.95}Zn_{0.5})S$ phosphors in air atmosphere with KCl as a flux, and studies the ML and TL properties. Ratnesh et al (2014) also studies the Ag^+ doped $(Cd_{0.95}Zn_{0.5})S$ with fixed molar percent of Ag^+. They have studied the effect of UV radiation on ML spectra. We previously investigated the Mechanoluminescence properties of $(Cd_{0.95}Zn_{0.05})S$ mixed nanoparticles doped with silver. The phosphor was synthesized at lower temperature using KCl as flux. The mechanoluminescence property was studied for fixed Ag^+ concentration with different UV exposure time [13-14].

In present investigation, pure and Ag^+ ion doped $(Cd_{0.95}Zn_{0.05})S$ phosphors were successfully synthesized by high temperature solid state reaction method under the N_2 environment. The optical and structural characterization were done. The structural analysis were done by X-ray diffraction technique and Scanning electron microscopy. In optical properties, Mechanoluminescence spectral response was studied for different Ag^+ concentration.

II. EXPERIMENTAL DETAILS

Solid state reaction method was used to prepare the pure and silver-doped $(Cd_{0.95}Zn_{0.05})S$ phosphor. The luminescent grade CdS and ZnS (Fluka, Switzerland), Silver nitrate $(Ag(NO_3)_3)$ and sodium chloride (NaCl) using as a flux. The contents of CdS and ZnS were fixed at 0.95 and 0.05 percent and different Ag^+ ion concentration (1-5 mol%) was added to it for the preparation of phosphors. The mixture was placed in an alumina boat. The heating was done in a silica tubular furnace maintained at 900°C in the inert atmosphere of flowing nitrogen gas. After completion of heating, the mixture was cooled upto room temperature in the same furnace followed by immediate crushing to convert in the fine powder form to have uniform particle size. (Scheme 1)[2,15-17].



Scheme 1. Mechanism of solid state synthesis method of $(Cd_{0.95}Zn_{0.05})S: Ag^{+}$

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 Ka radiation. The X-rays were produced using a sealed tube and the wave length of X-ray was 0.154 nm. The X-rays were detected using a fast counting detector based on Silicon strip technology (Bruker Lynx Eye detector). The surface morphology of the prepared phosphor was determined by field emission scanning electron microscopy (FESEM) JSM-7600F. ML intensity was investigated by using the manual handmade setup developed by the applied physics department at Bhilai Institute of technology, Durg, Chhattisgarh(figure 1).

Fig.1 Experimental set up for studying ML.

III. RESULT AND DISCUSSION:-

3.1 X- Ray Diffraction (XRD) Results:-

The recorded diffraction pattern indicated the confirmation of formation of silver doped $(Cd_{0.95}Zn_{0.05})S$. The average particle size (D) of the as-formed $(Cd_{0.95}Zn_{0.05})S:Ag^{+}$ phosphor was estimated from the full width at half maximum (FWHM) of the diffraction peak of the powder, using Scherer's formula [17-18]. The average crystallite size is 165 nm(Figure 2).

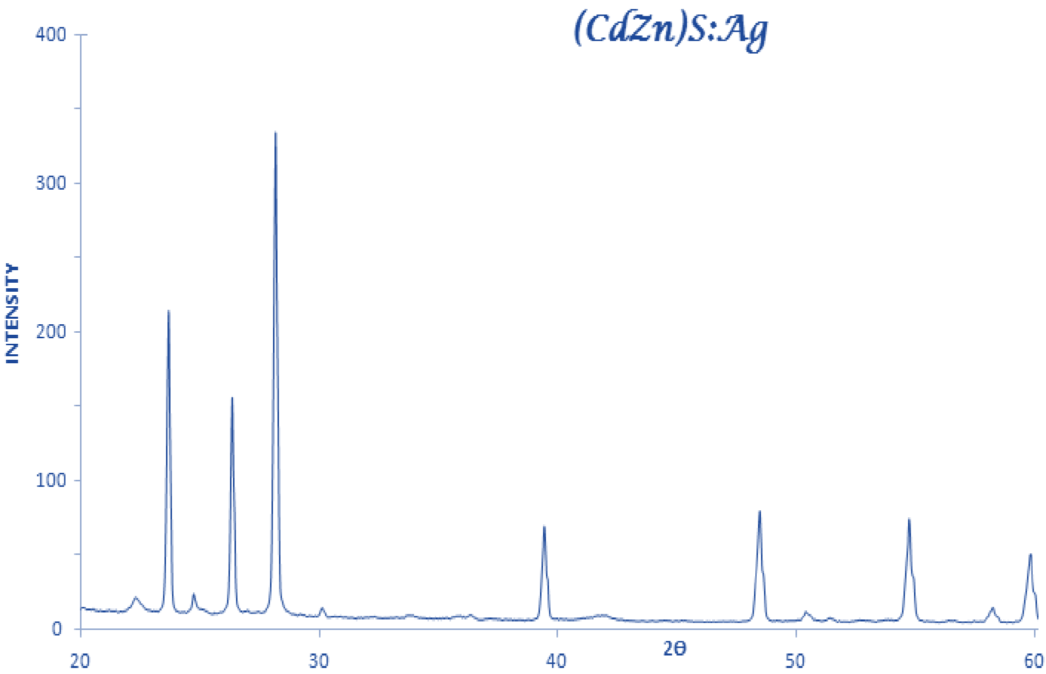


Figure 2. XRD image Ag^{+}(2%) doped $(Cd_{0.95}Zn_{0.05})S$

3.2 Scanning Electron Microscopy Results:-

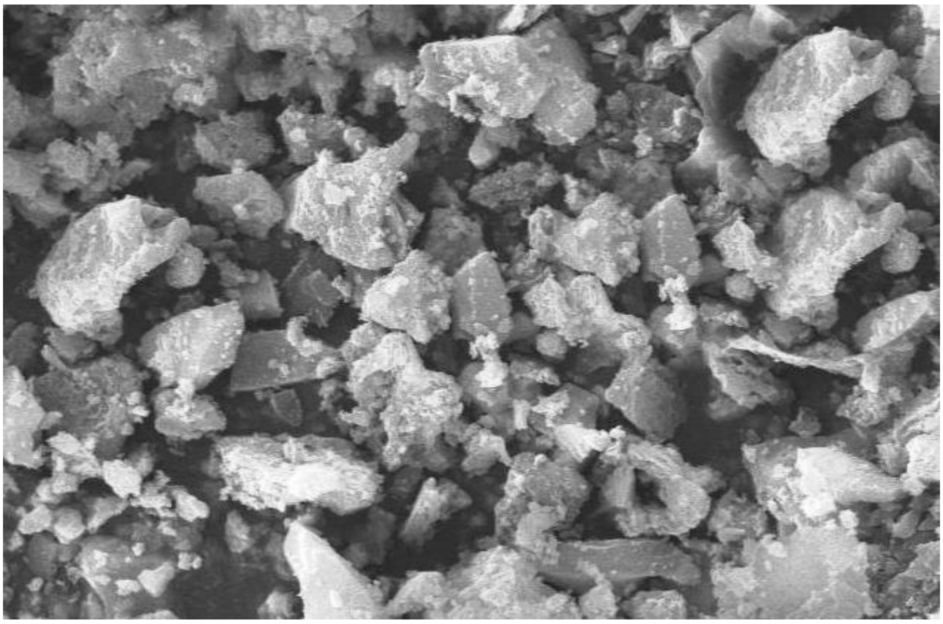
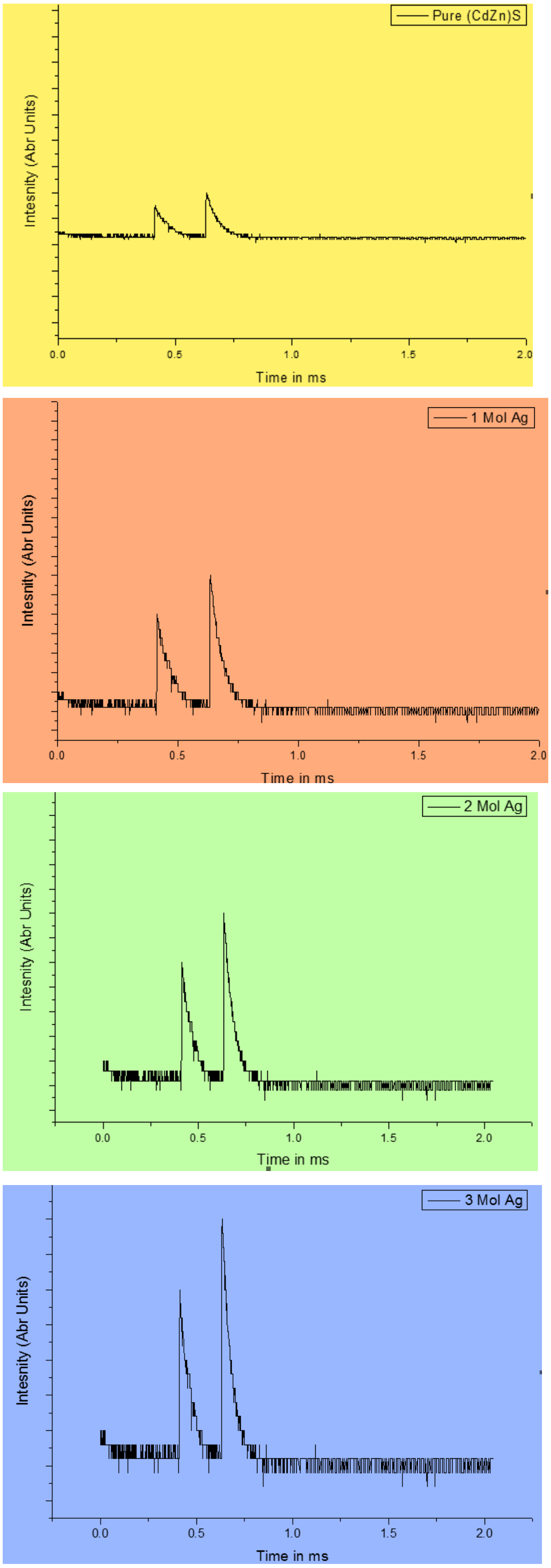


Figure 3.SEM image of 2% silver-doped $(Cd_{0.95}Zn_{0.05})S$

Figure 3 shows the SEM image of 2% silver-doped $(Cd_{0.95}Zn_{0.05})S$. This results is in good agreement with XRD results. By the surface morphology it was found that, some agglomerate and defects produced during the synthesis and uniform distribution of silver throughout the sample.

3.3 Mechanoluminescence Results: Fig. 4 shows ML characteristics of $(Cd_{0.95}Zn_{0.05})S:Ag^{+}$ phosphor. It was found by that the luminescence intensity is increasing as increasing the concentrations of silver. This results is similar as Sao at al. 2013. The effect of nitrogen atmosphere just enhances the ML spectra intensity of prepared phosphor. Maximum intensity of the phosphor is obtained for 5 mol % of silver [13,14,16].



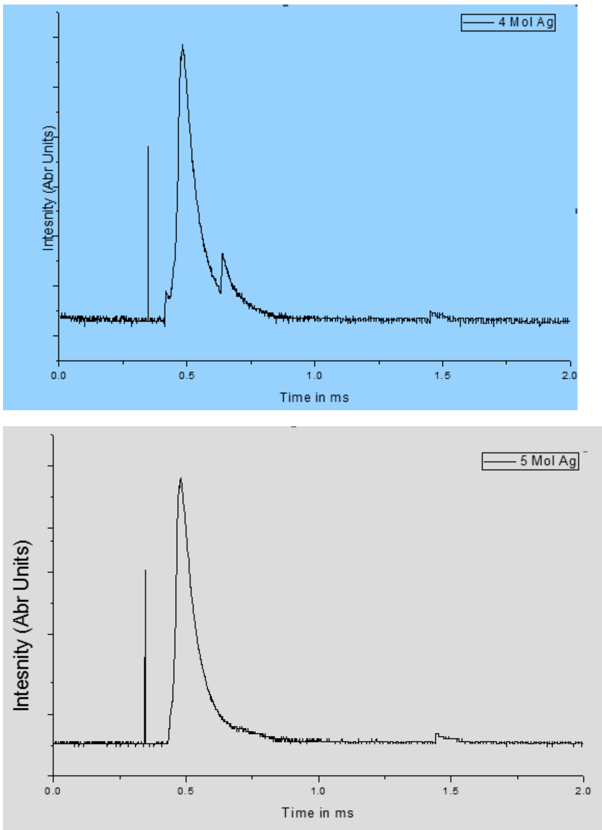


Figure 4. Mchanoluminescence Properties of pure and 1-5% silver-doped $(Cd_{0.95}Zn_{0.05})S$ Phosphor

IV. CONCLUSION:-

Solid state reaction method successfully produced highly efficient optical and eco-friendly $(Cd_{0.95}Zn_{0.05})S$ phosphor doped with different concentration of Ag^+ ion. The average crystallite size for 2% Ag^+ doped$(Cd_{0.95}Zn_{0.05})S$ phosphor was found to be 165 nm by Scherrer formula. The Mchanoluminescence spectra of $(Cd_{0.95}\ Zn_{0.05})S{:}Ag^+$ phosphor shows that the ML intensity strongly depends upon the Ag^+ concentration.

REFERENCE:-

[1] S. K. Kulkarnia, U. Winkler, N. Deshmukh, P. H. Borse, R. Fink, E. Umbach, Appl Surf. Sci. 169–170 (2001) 438.

[2] Senthil, K., Mangalarj, D., Narayandass, S.K. "Structural and optical properties of CdS thin film", Applied Surface Science, 169-170, pp 476-479 (2001).

[3] Jagjeet Kaur , N. S. Suryanarayana and Vikas Dubey Chinese Chemical Letters 22 (2011) 709–712.

[4] T. Prem Kumar, K. Sankaranarayanan, Chalcogenide Letters Vol. 6, No. 11, November 2009, p. 617 – 622.

[5] T.Y. Lui et al., Nanotechnology 17 (2006) 5935.

[6] S.K. Kulkarnia, U. Winkler, N. Deshmukh, P.H. Borse, R. Fink, E.Umbach, Appl Surf. Sci. 169–170 (2001) 438.

[7] R. K. Tamrakar, Studies on Absorption Spectra of Mn Doped CdS Nanoparticles, (LAP Lambert Academic Publishing, Verlag, 2012). ISBN 978-3-659-26222-7.

[8] R. Tiwari, P. B. Taunk, R. K. Tamrakar, N. K. Swamy, V. Dubey " Synthesis, Characterization and Thermoluminescence Behavior of (Cd, Zn)S Mixed Phosphor Doped With Silver, Chalcogenide Letters Vol. 11, No. 3, March 2014, P. 141 - 158.

[9] D. P. Bisen, Ravi Sharmab*, N. Brahme, Rounak Tamrakar. Effect Of Temperature On The Synthesis Of Cds:Mn Doped Nanoparticles, Chalcogenide Letters Vol. 6, No. 9, September 2009, p. 427 – 431.

[10] R. K. Tamrakar " UV-Irradiated thermoluminescence studies of bulk CdS with trap parameter, Research on chemical intermediates, DOI10.1007/s11164-013-1166-4.

[11] Ratnesh Tiwari, Vikas Dubey & Raunak Kumar Tamrakar, copper doped cadmium sulphide (CdS: Cu) quantum particles: topological, morphology and photoluminescence studies, International Journal of Industrial Engineering & Technology (IJIET) ISSN 2277-4769 Vol.3, Issue 3, Aug 2013, 67-74.

[12] Raunak Kumar Tamrakar and D. P. Bisen, Optical and kinetic studies of CdS:Cu nanoparticles Res Chem Intermed (2013) 39:3043–3048.

[13] S. K. Sao, N. Brahme , D. P. Bisen , R. Sharma, G. Tiwari , S. Tigga , P. Chandrakar and R. Tamrakar, Recent Research in Science and Technology 2012, 4(8): 117-118, ISSN: 2076-5061.

[14] Ratnesh Tiwari; Raunak Kumar Tamrakar; N. Kumar Swamy;Vikas Dubey. Ultra Scientist Vol. 26(1)B,1-6 (2014).

[15] Raunak Kumar Tamrakar, Durga Prasad Bisen, Chandra Shekher Robinson, Ishwar Prasad Sahu, and Nameeta Brahme, Ytterbium Doped Gadolinium Oxide (Gd_2O_3:Yb^{3+}) Phosphor: Topology, Morphology, and Luminescence Behaviour in Hindawi Publishing Corporation Indian Journal of Materials Science Volume 2014, Article ID 396147, 7.

[16] Tamrakar R. K., Bisen D. P., Upadhyay K. and Sahu I. P., UV-irradiated thermoluminescence studies of (Cd,Zn)S:Ag phosphors with trap parameter, “Shaping The Future With Green Chemistry (SFGC-14)” Page -109-112 ISBN:-978-93-82570-34-9.

[17] Tamrakar R. K., Bisen D. P., Upadhyay K. and Bramhe N., Effect of Fuel on Structural and Optical Characterization of Gd_2O_3:Er^{3+} Phosphor, Journal of Luminescence and Applications (2014) Vol. 1 No. 1 pp. 23-29.

[18] P. Klug, L.E Alexander, X-ray Diffraction Procedure, Wiley, New York, 1954.

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