iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: IX Month of publication: September 2017

DOI:

Study of Mechanoluminescent ZnS: Cu, Cl Phosphor for Developing Sensors

T. R. Sanodiya[1], Pranav Singh[2], Piyush Jha[3*]
[1]YashodaBai Patel College, Kurai, Seoni, Madhya Pradesh, India
[2]Department of Postgraduate Studies and Research in Physics and Electronics, Rani Durgavati University, Jabalpur - 482 001, India
[3]Department of Applied Physics, Raipur Institute of Technology, Raipur, Chhattisgarh, India

Abstract: Luminescence due to fracture is known as fracto- Mechanoluminescence (FML). Recently, fracto-luminescence phenomenon has enabled us to explore various advanced sensor applications such as pressure sensors, damage sensors, etc. This article reports the FML of ZnS: Cu, Cl phosphor prepared by solid state reaction method using nitrogen atmosphere. When ZnS: Cu, Cl phosphor is deformed impulsively by the impact of a moving piston then, initially mechanoluminescence (ML) intensity increases with time, attains a peak value and then decreases with time. The semi-log plot of the ML intensity versus (t-t_m) gives the negative slope. The peak ML intensity increases linearly with increasing impact velocity. ML intensity is also increases linearly with increasing mass of the phosphor. The total ML intensity initially increases with increasing impact velocity and then it tends to attain a saturation value for higher values of the impact velocity of piston. The ML and photoluminescence (PL) spectra are lies at 532nm. The ZnS doped Cu; Cl is very cheap and suitable material for developing sensors.

Keywords: Mechanoluminescence, Triboluminescence, ZnS: CuClphosphor, Photoluminescence, Sensors.

I. INTRODUCTION

At present thezinc sulphide phosphor is very cheap mechanoluminescence (ML) material. Zinc sulphide (ZnS) exhibit Elastico-ML [1, 2], Plastico-ML [3, 4] and Fracto-ML [5] and zinc sulphide phosphor also reveal the ML during hyper velocity impact [6]. Pure zinc-sulfide is a noncentric [7] and exhibit ML [8]. Yet, when zinc sulfide doped with small percentage of strongly luminescent transition metal ions such as copper, manganese [9-13] and even silver [14], then it become strong mechanoluminescent under deformation. ZnS doped with Cu,Cl is found drastic enhance the mechanoluminescence (ML) properties [14].

ML or Triboluminescence (TL) has been known since almost 400 years. The first reference of this phenomenon was given by Francis Bacon's in his writing "Advancement of Learning" in the year 1605 [15]. ML is categorized into in three types: elastico-mechanoluminescence (EML), plastico-mechanoluminescence (PML) and Fracto-mechanoluminescence (FML) [16, 17]. EML is a non-destructive technique but PML and FML are destructive ML. Actually, before 1950 there were reports only on FML [15] in which the ML material was used for single time. Longchambon is the first person to record the ML spectra of sugar and other crystals in 1922 [15]. After discovery of photomultiplier tube (PMT) tremendous work was carried out in the investigation of ML. Scientist reported thousand of ML materials, their characteristics and mechanism [15] for fruitful applications.

FML is used to study of dynamics and mechanics of fracture, in fuse system for army warhead, design of damage and fracture sensors [18]. Recently, Chandra *et al.* reported that piezoelectric model is suitable for ML of ZnS:Mn phosphor [19]. The present paper report the different characteristics of ML of ZnS:Cu,Cl phosphor also the ML and photoluminescence (PL) spectra.

II. EXPERIMENTAL

The raw materials for the preparation of microcrystalline ZnS:Cu,Cl phosphor are luminescent grade ZnS, AR grade $CuSO_4.5H_2O$ and NaCl flux. The 4 mg of $CuSO_4.5H_2O$ is mixed in distilled water with the 1 gram quantity of ZnS. Then its water was evaporated by heating in an oven at 120°C and after cooling this mixture at room temperature, 20 mg ofNaCl was added and the mixture was thoroughly mixed using a pestle and a mortar. Thus, the prepared charge was transferred to a clean silica boat, which was covered with another boat. The hexagonal phosphor of ZnS:Mn was prepared by firing at 1200°C for 1 hour in a nitrogen atmosphere [19]. Then, the phosphor was taken out and cooled to room temperature. The cooled phosphor was cleaned two or three times with distilled water and dried again.

The photoluminescence (PL) spectrum was recorded using Carry Eclipse Fluorescence Spectrophotometer. In the present investigation the ML in ZnS:Cu,Cl phosphor was excited using impulsive technique and ML spectra is also recorded using technique has been reported previously [20].

III. RESULTS AND DISCUSSIONS

It is found that, when the piston strike on the ZnS:Cu,Cl phosphor, then initially the ML intensity increases with time and attains a peak value at a particular time (t_m), and later it decreases with time. Fig.1, shows the time dependence of the ML intensity of ZnS:Cu,Cl phosphor at 242 cm/sec impact velocity of piston.

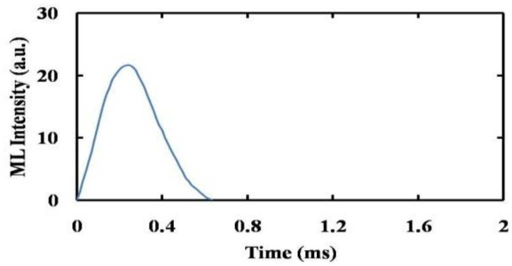


Fig.1 Time dependence of ML intensity of ZnS:Cu,Cl phosphor (at 242 cm/sec).

Fig.2 shows the semilog plot ofML intensity (I) versus (t-t_m) for ZnS:Cu,Cl phosphor. It is seen that the plot is a straight line with negative slope.

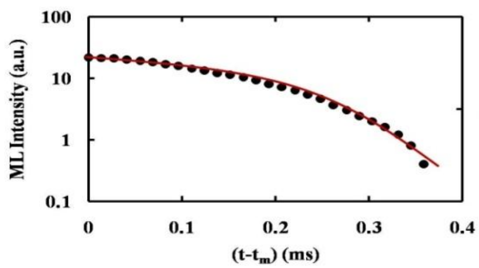


Fig.2 Semi-log plot of the ML intensity versus (t-t_m) for ZnS:Cu,Cl phosphor (at 242 cm/sec).

Fig.3 shows that the peak ML intensity increases linearly with increasing impact velocity. This result revealed that some part of the mechanical energy or piezoelectric energy is converted into the light energy [19]. At small value of initial velocity the ML intensity increases linearly with impact velocity. Hence, the ML of ZnS:Cu,Cl phosphor may be useful in designing the impact stress sensors, damage sensors and impact velocity sensors.

As the mass of the phosphor is increases luminescence centers are also increases. Due to increase of luminescence centers ML intensity is increases with mass of the phosphor. Fig.4 shows that the total ML intensity increases linearly with increasing mass of the phosphor.

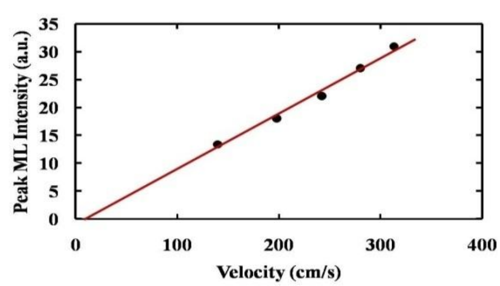


Fig.3 Dependence of the peak ML intensity on impact velocity for ZnS:Cu,Cl phosphor.

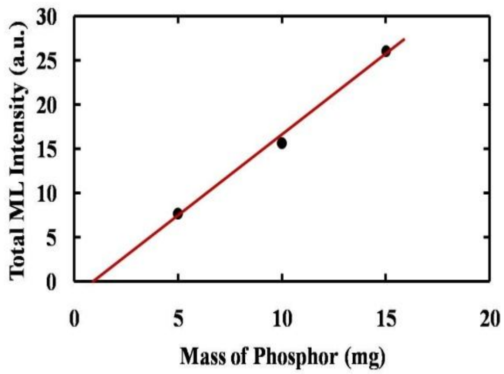


Fig.4 Dependence of ML intensity on mass of the ZnS:Cu,Clphosphor.

It is clearly reveal from the Fig.5 that total ML intensity I_T initially increases with increasing impact velocity and then it tends to attain a saturation value for higher values of the impact velocity of piston.Fig.5 shows the dependence of the total ML intensity I_T (i.e. the area below the ML intensity versus time curve) on the impact velocity for ZnS:Cu,Cl phosphor.

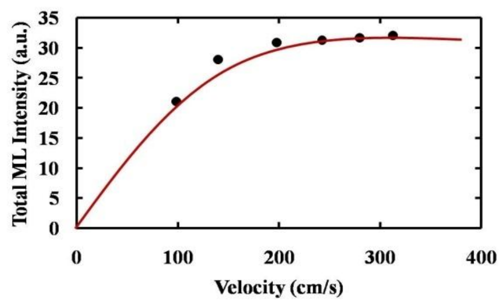


Fig.5 Dependence of the total ML intensity on impact velocity for ZnS:Cu,Cl phosphor.

In Fig.6 demonstrate the mechanoluminescence spectra and the photoluminescence spectra of ZnS:Cu,Cl phosphor excited at 365 nm by light waves. The emission spectra is found at 532nm. It is seen that the ML spectra are similar to the PL spectra. Hence it can be said that same luminescence center is responsible for ML and PL.

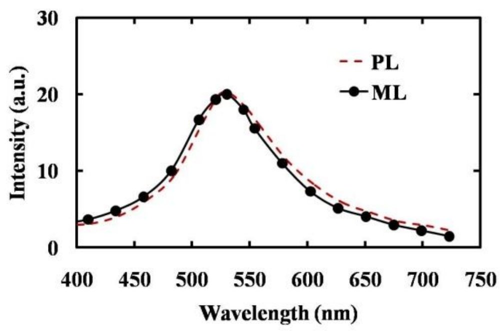


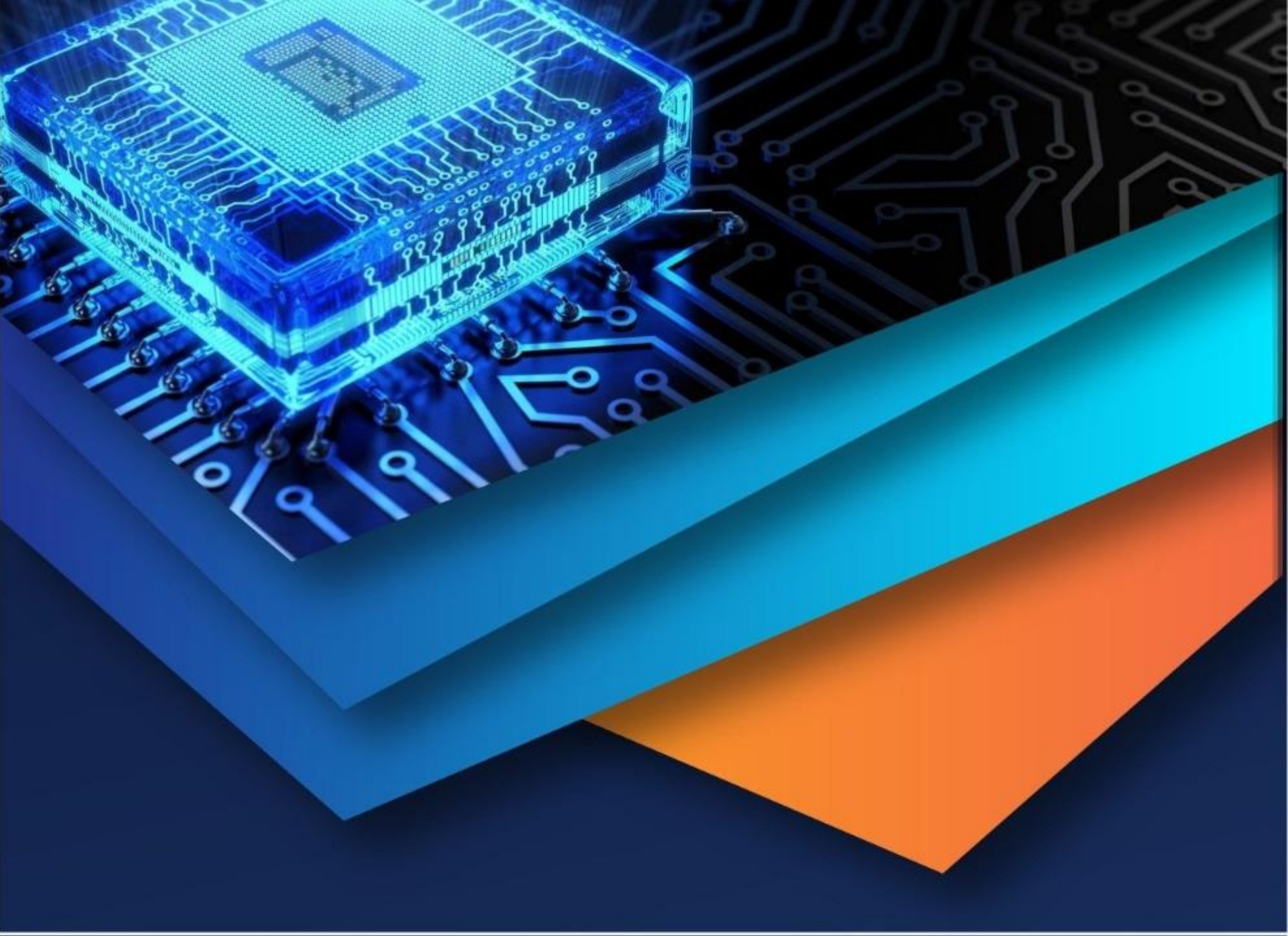
Fig.6 ML and PL spectra of ZnS:Cu,Cl phosphor.

IV. CONCLUSIONS

The solid state reaction method is useful for the preparation of ZnS:Cu,Cl phosphor using nitrogen atmosphere. It is found in the present investigation that: When the sample is excited by the piston then ML intensity initially increases with time, attains a peak value and then, decreases with time; The peak ML intensity increases linearly with increasing impact velocity of the piston. The semi-log plot of the ML intensity versus (t-t_m) gives the negative slope.The peak ML intensity increases linearly with increasing impact velocity of the piston. ML intensity is also increases linearly with increasing mass of the phosphor. The total ML initially increases with increasing impact velocity and then it tends to attain a saturation value for higher values of the impact velocity of the piston. The ML and photoluminescence (PL) spectra are lies at 532nm. These measurements show that ZnS:Cu,Cl phosphor is suitable for the development of stress and damage sensors.

REFERENCES

[1] C. N. Xu, T. Watanabe, M. Akiyama, and X. G. Zheng, "Artificial skin to sense mechanical stress by visible light emission", Appl. Phys. Lett. 75(1999) 1236-1238.
[2] V.K. Chandra, B.P. Chandra, and P. Jha, "Strong luminescence induced by elastic deformation of piezoelectric crystals", Appl. Phys. Lett. 102(2013)241105-1-8.
[3] S.I.Bredikhin, Y. A.Ossipyan, and S.Z.Shmurak, "Effect of light on strain-stimulated light emission in ZnS crystals", Sov. Phys. JETP 41 (1975)373-375.
[4] S.I. BredikhinandS.Z. Shmurak,"Interaction between charged dislocations and luminescence centres in ZnS crystal", SovPhys JETP 49 (1979)520–524.
[5] B.P. Chandra, "Squeezing light out of crystals triboluminescence",Nucl. Tracks10(1985) 225-241.
[6] NP Bergeron, WA Hollerman, SM Goedeke, M Hovater, W Hubbs, A Finchum, R.J. Moore, S. W. Allison, and D. L. Edwards, "Experimental evidence of triboluminescence induced by hypervelocity impact",Int. J. Impact Engg.33(2006) 91-99.\
[7] R. Scarmozzino, "On the excitation mechanism of light emission in triboluminescent materials", Lett. NuovoCim. 4 (1970) 825-827.
[8] S. I. Bredhikhin and S.Z. Shmurak, "Deformation stimulated emission of ZnS crystals", JETP Lett. 19 (1974) 367-368.
[9] B. P. Chandra, P. K. Dubey, and S.C. Datt, "Mechano and electroluminescence of heavily doped Zn: Mn phosphors", Phys. Stat. Sol. (a) 97 (1986) K59-K61.
[10] K. Mayer, D. Orbikat, and M. Rossberg, "Progress in triboluminescence of alkali halides and doped zinc sulphides (I)",Krist. Tech. 5 (1970) 5-49.
[11] R. Scarmozzino, "Effects of hydrostatic pressure on triboluminescent materials", Sol. St. Commun. 9 (1971) 1159-1162.
[12] G. Alzetta, I. Chudacek, and R. Scarmozzino, "Excitation of triboluminescence by deformation of single crystals", Phys. Stat. Sol. (a) 1 (1970)775-785.
[13] R. A. Vardanyan, S. G. Veselko, and G. G. Kirakosyan, "Luminescence of deep centres in plastically deformed semiconductors", Sov. Phys. Sol. State 31 (1989) 24-29.
[14] C.N.Xu, T Watanabe, M. Akiyama and X.G.Zheng, "Preparation and characteristics of highly triboluminescentZnS film",Mater. Res. Bull.34(1999) 1491-1500.
[15] P. Jha and B.P. Chandra, "Survey of the literature on mechanoluminescence from 1605 to 2013", Lumin. 29 (2014) 977-993.
[16] B. P. Chandra, Mechanoluminescence in Luminescence of Solids, D. R. Vij (Ed.), (Plenum Press, New York) p. 36 (1998).\
[17]]B. P. Chandra, Mechanoluminescent Smart Materials and their Applications, in Electronic and Catalytic Properties of Advanced Materials, edited by A. Stashans, S. Gonzalez and H. P. Pinto, (Transworld Research Network, Trivandrum, Kerala, India) p.1 (2011).
[18] B.P. Chandra, V.K. Chandra, P. Jha, R. Patel, S. K. Shende, S. Thaker, and R.N. Baghel, "Fracto-mechanoluminescence and mechanics of fracture of solids", J. Lumin. 132 (2012) 2012–2022.
[19] B. P. Chandra, V. K. Chandra, PiyushJha, DeeptiPateria, and R. N. Baghel, "Is the fracto-mechanoluminescence of ZnS:Mn phosphor dominated by charged dislocation mechanism or piezoelectrification mechanism ?", Lumin. 32 (2016) 67-75.
[20] P. Jha and B. P. Chandra, "Impulsive excitation of mechanoluminescence in $SrAl_2O_4$:Eu,Dy phosphors prepared by solid state reaction technique in reduction atmosphere", J. Lumin. 143 (2013) 280-287.



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY