International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 5, No. 2, June 2015. Article ID: 106. pp.268-270.

Photoluminescence Study of $LaPO_4$:Ce,Er,Tb Phosphor

B. Walter Ratna Kumar[1], B. Vinod Kumar[2], K.V.R. Murthy[3] and **Sk. Akram[1]**

[1] *Physics Department, P.B.N.College, Nidubrolu, AP, India.*
[2] *Chemistry Department, Krishna University, Machilipatnam, AP, India.,*
[3]*Display Materials Laboratory, Applied Physics Department,*
Faculty of Technology and Engineering, M. S. University of Baroda, Vadodara, India

Abstract— *$LaPO_4$:Ce,Tb is a well known green emitting phosphor, used commercially for display devices. Erbium at 1 mole percent acts as a sensitizer to $LaPO_4$:Ce,Tb Phosphor, and allowed the other emissions of Ce and Tb. It is interesting to note that on addition of Erbium the peak at 525nm due to Tb was missed and 545 nm was emitted with enhanced intensity by allowing other emissions of Tb and Ce. The present paper reports the synthesis and photoluminescence studies of $LaPO_4$: Ce 1%, Er 1% and Tb with various concentrations from 0.5 to 2.0% Phosphors, at 268nm excitation. The phosphors are prepared using Standard Solid State Reaction [SSR] method at a calcinating temperature of 1250 ^{o} C for 3 hours. Well indexed peaks at 488 and 545nm are observed with very good intensity and are due to transitions of Tb. The peaks at 381, 415 and 436nm, the blue region are due to the transitions of Ce along with 585 and 620 nm due to Tb are observed with less intensities.*

Keywords— *Solid State Reaction [SSR],Photoluminescence [PL] and Transitions*

1. INTRODUCTION

Inorganic compounds doped with rare earth ions play important role in making display Phosphors because of their excellent luminescence properties due to their transition capability and less cost. Almost, the commercial Phosphors are of RE doped inorganic Phosphors via Solid State Reaction method. The rare earth doped lanthanide ortho phosphates have many potential applications in the field of lighting and display devices. They are also used in the fields such as ceramics, proton conducters, sensors and thermal resistance materials. Rare earth ions (RE) are characterized by a partially filled ^{4}f shell, shielded by $^5s_2$ and $^5p_6$ orbitals in a host. Therefore, it gives sharp emission transition lines in the spectra. At present, the researcher want to examine the photoluminescence on the formation of Ce, Er doped and Tb co-doped $LaPO_4$ Phosphor.

2. EXPERIMENTAL

All the required starting material were taken in stoichiometric ratio and mixed thoroughly in an agate mortar, for 2hrs in acetone medium. Obtained powder mixture was grounded and annealed at 1250° C for 3 hrs to get $LaPO_4$:Ce,Er,Tb phosphor. Lanthanum Oxide (La_2O_3), Ammonium dihydrogen Orthophosphate ($NH_4H_2PO_4$) were taken as a base materials in a molecular stoichiometry of 2:1 to prepare $LaPO_4$ Phosphor. The Phosphors with 1% of Ce_2O_3, Er_2O_3 as dopant, and Tb_4O_7 as co-dopant with various concentrations from 0.5% to 2% is taken in molecular weight proportions and synthesized using Solid State Reaction (SSR) method. They were weighed and taken into a agate mortar and pestle mixed, grinded thoroughly for 45 minutes to get fine powder. Acetone is added intermediately in grinding procedure to get small and uniform particle size. The is heated in a muffle furnace at a heating rate of 6° C per minute, up to the temperature of 1250 ^{o} C and soaked for 3 hours and allowed to cool naturally to room temperature.

3. RESULTS AND DISCUSSIONS

3.1 PL Study

Fig (1) is the excitation spectrum of $LaPO_4$: Ce1%,Er1%,Tb1% Phosphor monitored at 400nm wavelength. A broad excitation band ranging from 220 to 320 nm with a peaks at 271nm is observed. Fig (2) is the emission spectrum of undoped $LaPO_4$ with 254nm excitation. Fig(3) is the PL emission of $LaPO_4$: Ce 1%, Er 1%, Tb(0.5 to 2%) at 268 nm excitation. Fig.3 represent the emission spectrum of $LaPO_4$: Ce 1%, Er 1%, Tb(0.5 to 2%) Phosphors. From the figure, well resolved PL emissions are found at 488 and 545nm with less good intensity. The peaks at 381, 415 and 436nm, the blue region due to transitions of Cerium along with the peaks at 585 and 620 nm due to Terbium are observed with less intensities.

The emissions at 488 and 545 are allowed transitions of Terbium. It is interesting to note that the peak suppose to be at 525nm is of Er however the Terbium peak at 545 nm peak was emitted with enhanced intensity and also the other emissions of Tb and Ce are seen. The main peaks at 488 and 545nm with very good intensity are due to transitions of Tb. The peaks with less intensity at 381,

* *Corresponding Author Email: walter_rkb@yahoo.com*

415 and 436nm are due to the transitions of Ce along with 585 and 620 nm due to Tb. The peak at 365nm is attributed to the crystal field. The intensity of $LaPO_4$: Ce1%, Er1%, Tb1.5% Phosphor is high with 692 units, and is followed by 2%, 1% and 0.5% of Tb concentrations in $LaPO_4$: Ce1%,Er1% system. The intensities of different concentrations of Tb in $LaPO_4$: Ce1%, Er1% Phosphor is given in the Table:1 for better understanding.

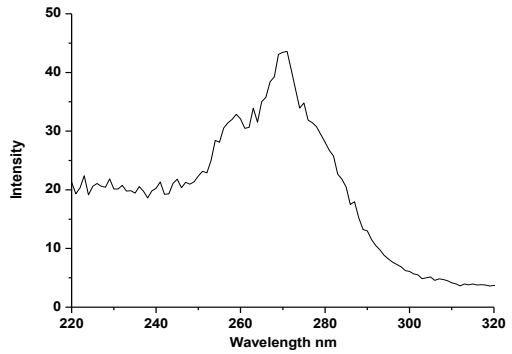

Fig. 1: Excitation spectrum of $LaPO_4$: Ce 1%, Er1%, Tb(..) monitored at 400 nm

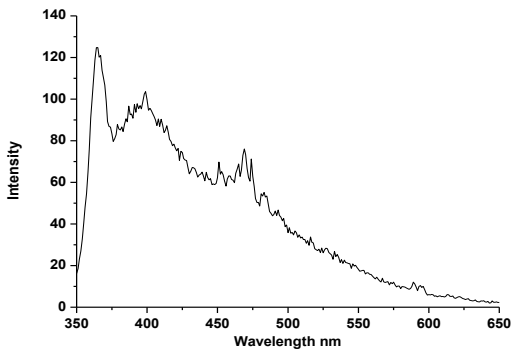

Fig. 2: Emission Spectrum of $LaPO_4$

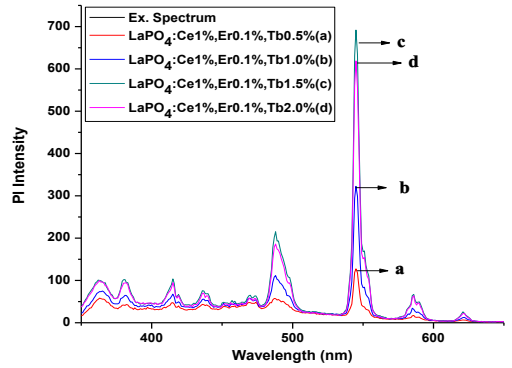

Fig. 3: Emmision spectra of $LaPO_4$: Cel %, Er0.1%, Tb(..) at 1250°C with 268nm Ex.

The peaks at 382, 415 and 436nm are due to $^5d_3 \rightarrow {}^7f_0$ transition and is due to magnetic dipole of the crystal. The peak at 488nm is due to $^5d_2 \rightarrow {}^7f_0$ transition and is due to magnetic dipole of the crystal. The peak at 545nm is due to $^5d_1 \rightarrow {}^7f_0$ transition and is due to magnetic dipole of the crystal. The peak at 586 nm is due to $^5d_0 \rightarrow {}^7f_1$ transition and is due to magnetic dipole of the crystal. The peak at 621nm is due to $^5d_0 \rightarrow {}^7f_2$ transition and is due to highly sensitive electric dipole of the crystal.

4. CONCLUSIONS

1. $LaPO_4$: Ce, Er,Tb phosphor successfully synthesized using SSR method.
2. Erbium acts as a sensitizer to $LaPO_4$:Ce,Tb Phosphor, and also allowed the other emissions of Ce and Tb.
3. It is interesting to note that, on the addition of Erbium, the peak at 525nm due to Erbium was missed and 545 nm peak was emitted with enhanced intensity and also allowed the other emissions of Tb and Ce.
4. The main peaks at 488 and 545nm with very good intensity are due to transitions of Tb. The peaks with less intensity at 381, 415 and 436nm are due to the transitions of Ce along with 585 and 620 nm due to Tb.
5. The intensity of $LaPO_4$: Ce1%, Er1%, Tb1.5% Phosphor is high with 692 units, and is followed by 2%, 1% and 0.5% of Tb concentrations in $LaPO_4$: Ce1%,Er1% system.
6. The phosphor may be useful in the potential application of ornamental or decorative lamps and display devices.

Table 1: Emission intensities of $LaPO_4$: Ce1%, Er1%,Tb(...) Phosphor with 268nm Excitation.

Emission wavelength nm	*Emission Intensities of $LaPO_4$: Ce1%, Er1%,Tb(x) Phosphor under 268 nm Excitation*			
	Tb 0.5%	*Tb 1%*	*Tb 1.5%*	*Tb 2%*
365	56	75	97	96
382	43	64	95	95
415	48	68	104	95
436	44	55	76	70
488	57	112	215	186
545	128	322	692	618
586	17	32	67	64
621	07	12	22	22

B. Walter Ratna Kumar thank UGC-SERO, for their selection and provision of grant to my Minor Research Project entitled " Synthesis and characterization of Phosphors for display applications.''

I thank Secretary & correspondent, Principal and members of Dept. of Physics for their constant support towards the implementation of the Project.

REFERENCES

[1] S. Shionoya, W. Yen, Phosphor Handbook, CRC Press, Boca Raton, (1999).

[2] B. W Ratna Kumar et al., Proce. Applied Physics and Material Science, Ed. By K V R Murthy et al. Pub.Hikey Media ISBN: 978-93-82570-37-0, 2014 (35-27).

[3] B. Vinod Kumar et al., Proce. Applied Physics and Material Science, Ed. By K V R Murthy et al. Pub.Hikey Media ISBN: 978-93-82570-37-0, 2014 (139-140).

[4] Y.S.Patil, et.al. Effect of Er doping on Structural and Photoluminescence Properties of $LaPO_4$:Eu Phosphor. Advances in Applied Science Research, 2011,2(5):303-309.

[5] G.L.Sudharani, R.KrishnaRao and K.V.R.Murthy, Proceedings of the National Conference on Applied Physics and Material science, ISBN: 978-93-82570-10-3 (2013).

[6] PZ Zambare, AP Zambare, KVR Murthy, OH Mahajan, Archives of Physics Research 2 (2), 74-79.

[7] P Page, KVR Murthy, Philosophical Magazine Letters 90 (9), 653-662.

[8] MR Rao, BS Rao, NP Rao, K Somaiah, KVR Murthy, Indian Journal of Pure & Applied Physics 47 (6), 456.

[9] Gao Pu-xian, Ding Yong, Mai Wen-jie, Hughes W L, lao Chang-shi, WANG Zhong-lin. Science, 2005, 309(5741): 1700−1704.

[10] Rajesh K, Shajesh P, Seidel O, Mukundan P, Warrier K G K. Advanced Functional Materials, 2007, 17(10): 1682 −1690.

[11] Chunxia Li.;Zewei Quan.; Jun Yang.;Yang, P.;Lin,J.; Inorg. Chem. 2007,46,16,6329-6337. 12 DOI: 10. 1021/ic070335i.

[12] Fang,Y.P.;Xu,A.W.;Song,R.Q.;Zhang,H.X.;You,L.P.;Yu,J.C.;Liu,H.Q.;J.Am.Chem.Soc.2003,125,51,16025-16034.

[13] Rao,R.P.;Devine,D.J.; Journal of Luminescence, 2000, 87-89, 1260-1263

[14] Mounir Ferhi; Horchani-Naifer,K; Mokhtar Ferid,; J.of Rare earths,2009,27,2,182-186.

[15] Meyssamy,H; Riwotzki,K; Kornowski,A; Naused, S; Haase; Adv.Mater.1999,11,10,840-844.

[16] Niinisto,L; Leskela,M; GschneidnerJr.K.A; Eyring,L; (Eds.), Handbook on the Physics and Chemistry of Rare Earths, Elsevier, Amsterdam,1987.