International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 5, No. 2, June 2015. Article ID: 091. pp.208-210.

Synthesis and Thermoluminescence Study of $Y_2Zr_2O_7$: Eu^{3+} Phosphor

Jagjeet Kaur[1], **Yogita Parganiha**[1], **Arun Kumar Sahu**[1], **Vikas Dubey**[2], **Ravi Shrivastava**[3], **Deepika Chandrakar**[1] and **Deepti Singh**[1]

[1]*Department of Physics, Govt. VishwanathYadavTamaskar Post Graduate Autonomous College, Durg (C.G.) India*
[2]*Department of Physics, Bhilai Institute of Technology, Raipur, (C.G.), India*
[3]*Department of Physics, ICFAI University, Kumhari, Raipur (C. G.), India*

Abstract— *This paper reports the Thermoluminescence properties of Eu^{3+} doped yttrium zirconate phosphor. The phosphor is synthesized by solid state reaction method. This method is suitable for large scale production. Starting materials used for sample preparation are Y_2O_3, ZrO_2, Eu_2O_3 and fixed concentration of boric acid using as a flux. The prepared phosphors for different concentration of Eu^{3+} were examined by Thermoluminescence (TL) glow curve for fix UV irradiation. For UV irradiation UV 254 nm source was used. The kinetic parameters such as activation energy, order of kinetics and frequency factor were calculated by peak shape method. Most of the peak shows general order kinetics. The effect of UV exposure on TL studies was examined and it shows linear response with dose that indicates the sample may be useful for TL dosimeter.*

Keywords— *Solid state reaction; Thermoluminescence; yttrium zirconate.*

1. INTRODUCTION

Rare earth (RE) ions doped metal oxide crystalline powders are potential phosphors with several advantages such as heat-resistance, chemical stability and long working life. Eu^{3+} is well known as activator dopants for many different inorganic lattices [1, 2].Crystalline powders are good host materials for luminescent rare earth ions, for their better heat-resistance and luminescence variety than glasses. It has been confirmed that $Y_2Zr_2O_7$ is a good base material [3]. $Y_2Zr_2O_7$ has been researched for its electrical behavior, considering the probability of replacing YSZ (yttrium stabilized zirconia) [4,5] $Re_2Zr_2O_7$ oxides have been synthesized by many methods, including co-precipitation [5], sol–gel [6], hydrothermal [7], and hydrazine methods [8]..In the present paper Europium doped yttrium zirconate was prepared by solid state reaction method and thermoluminescence kinetic parameter were calculated by using peak shape method.

1.1 Experimental

Eu^{3+} doped $Y_2Zr_2O_7$ ($Y_2Zr_2O_7$: Eu^{3+}) luminescent powders have been synthesized by solid state reaction method.For synthesis of samples by this method, Y_2O_3, Zr_2O_3 and Eu_2O_3 were mixed in stoichiometric ratio by dry grinding in mortar & pestle for nearly 45minutes. The mixture is taken in alumina crucible and is fired in air at 1000°C for 1 hour followed by dry grinding and further heated at 1160°C for 3 hours in muffle furnace in presence of boric acid (H_3BO_3) as a flux. The concentration of Eu^{3+} ions were 0.1 mol% - 2.0mol%.

The samples were characterized by using thermoluminescence (TL), and SEM. The obtained phosphor under the TL examination is given UV radiation using 254 nm UV source Thermoluminescence glow curves were recorded at room temperature by using TLD reader I1009 supplied by Nucleonix Sys. Pvt. Ltd. Hyderabad [9-13].

1.2 Results and Discussion

Figure 1 shows SEM image of prepared phosphors for different resolutions. As this figures shows,the grain size of $Y_2Zr_2O_7$:Eu^{3+}seems in the range of few microns. The surface morphology is uniform andfew particles are agglomerated.

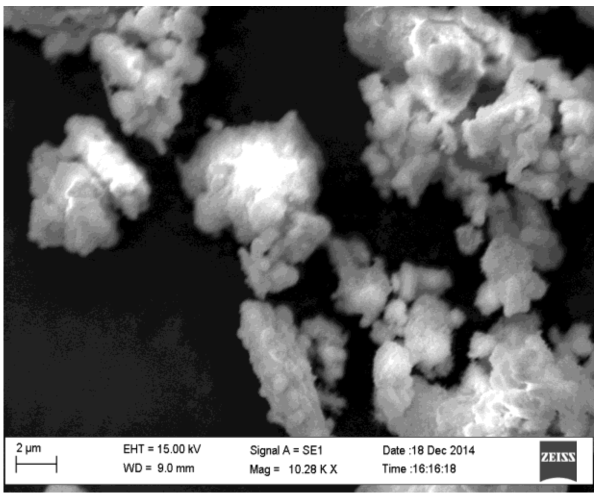

Fig. 1: SEM image of prepared phosphor

** Corresponding Author Email: parganiha.yogita@rediffmail.com*

Figure 2 shows the TL glow curve of $Y_2Zr_2O_7$ doped with variable concentration of Eu^{3+}(0.1%- 2.0%) for fixed UV exposure time i.e. 5 minute at constant heating rate i.e. 6.7^0Cs^{-1}. The sample shows general order kinetics. The TL intensity increases up to 0.5% Eu^{3+}concentration than it decreases.

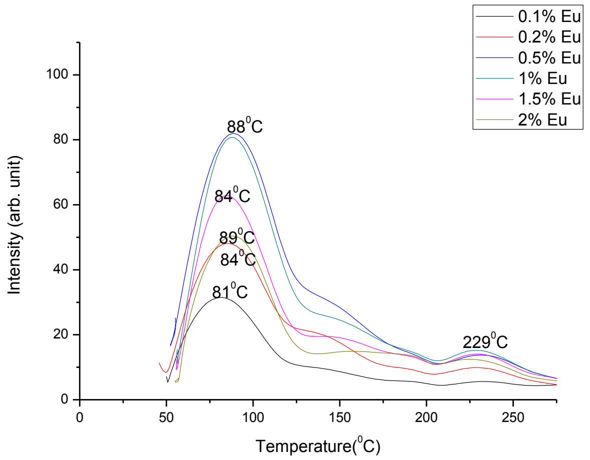

Fig. 2: TL glow curve for $Y_2Zr_2O_7$ doped with Variable concentration of Eu^{3+} (0.1%- 2.0%) for 5minute UV exposure time

Table 1 shows the effect of different Eu^{3+} concentration on peak temperature of TL glow curve of the phosphor. For $Y_2Zr_2O_7$ doped with variable Eu^{3+} concentration frequency factor is in the range$3X10^6$and $2X10^{10}$. Trap depth was also calculated which was found to be in the range 0.68 – 0.86eV.

Figure 3 shows the TL glow curve of $Y_2Zr_2O_7$ doped with 0.5 mol% Eu^{3+} with different UV exposure time at constant heating rate i.e. $6.7^0C\ s^{-1}$. The sample shows general order kinetics. The TL intensity increases up to 15 minute of UV dose than it decreases. Table 2 shows the effect of different UV exposure on peak temperature of TL glow curve of the phosphor. For $Y_2Zr_2O_7$ doped with 0.5 mol% Eu^{3+} frequency factor is in the range $6X10^5$and $1X10^9$. Trap depth was also calculated which was found to be in the range 0.48– 0.69eV.

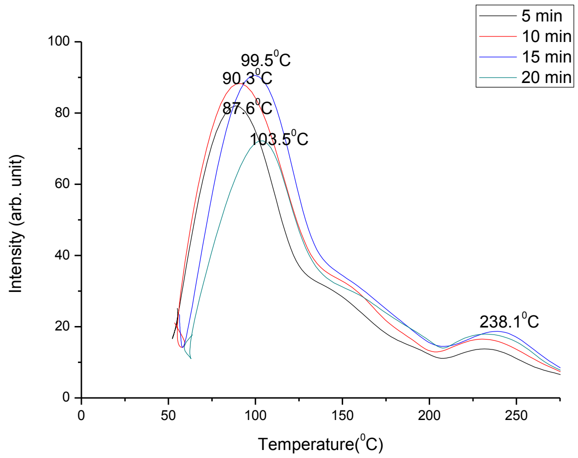

Fig. 3: TL glow curve of $Y_2Zr_2O_7$ doped for 0.5 mol% Eu^{3+}

2. CONCLUSION

Eu^{3+} doped $Y_2Zr_2O_7$ phosphors were successfully synthesized by solid state reaction method. This method is suitable for large scale production and eco-friendly method. The sample was characterized by SEM and TL studies. In thermoluminescence study maximum peak shows general order kinetics. The general order kinetic shows the formation of both trapping, deep and shallow traps for the UV irradiated phosphor. Activation energy for prepared sample which ranges in between 0.48 to 0.86eV.

Table 1: Kinetic parameters for UV irradiated $Y_2Zr_2O_7$: Eu^{3+}(0.1-2%)phosphor

Mol%	T_1	T_m	T_2	τ	δ	ω	μ	*Activation energy (E)*	*Frequency factor (s)*
0.1	57.10	81.00	111.40	23.90	30.40	54.30	0.56	0.72	7×10^9
0.2	58.40	84.00	120.10	25.60	36.10	61.70	0.59	0.69	2×10^9
0.5	61.70	88.00	121.40	26.30	33.40	59.70	0.56	0.68	1×10^9
1	64.40	88.00	118.80	23.60	30.80	54.40	0.57	0.77	2×10^{10}
1.5	63.10	84.00	115.40	20.90	31.40	52.30	0.60	0.86	9×10^7
2	63.70	89.00	115.40	25.30	26.40	51.70	0.51	0.68	3×10^6

Table 2: Kinetic parameters for UV irradiated $Y_2Zr_2O_7$: Eu^{3+} phosphor

UV exposure (min)	T_1	T_m	T_2	τ	δ	ω	μ	*Activation energy (E)*	*Frequency factor (s)*
5	61.70	87.60	121.40	25.90	33.80	59.70	0.57	0.69	1×10^9
10	61.70	90.30	128.00	28.60	37.70	66.30	0.57	0.63	1×10^8
15	71.00	99.50	131.30	28.50	31.80	60.30	0.53	0.65	2×10^8
20	72.30	103.50	136.60	31.20	33.10	64.30	0.51	0.48	6×10^5

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