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Photoluminescence and Thermoluminescence Study of Europium Doped YAM Phosphor

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Abstract— *Paper reports the photoluminescence and thermoluminescence analysis of europium doped $Y_4Al_2O_9$ phosphor for variable concentration of Eu^{3+}. The sample was prepared by the conventional solid state reaction method, which is the most suitable for large-scale production. The prepared phosphor sample was characterized using X-Ray Diffraction (XRD), Photoluminescence (PL), Thermoluminescence (TL) and CIE techniques. The PL emission was observed in 613nm which is dominant peak gives the intense red emission for the $Y_4Al_2O_9$ phosphor doped with Eu^{3+} (0.2 mol% to 2 mol%). Excitation spectrum found at 254nm. The emission spectrum of Eu^{3+} ions consists mainly due to the transitions from the $^5D_0$ level to the levels ^7F_J (J=0, 1, 2, 3, 4) of Eu ions. The dependence of luminescence intensity on Eu concentration shows concentration quenching after 2mol% of europium. Thermoluminescence study was carried out for the phosphor with UV irradiation. Kinetic parameter was calculated by CGCD technique.*

Keywords— *Thermoluminescence; Photoluinescence; CGCD*

1. INTRODUCTION[1]

During the past decades, nanostructured materials have attracted considerable attention for their novel and enhanced properties, e.g., the Mn doped ZnS phosphor can yield both high luminescent efficiencies and short lifetime [1, 2]. Nanostructured materials may be developed to form a novel type of luminescent materials for display applications.

The Y_2O_3–Al_2O_3 system is a promising material for refractory coatings and for ceramic and semiconductor processing technology [3, 4]. Doped yttrium aluminium garnet (YAG) is widely used as a laser host material [5, 6], and yttrium aluminum perovskite (YAP) used as scintillation host material [7]. In addition, rare earth doped YAG is also employed as a phosphor [8, 9]. However, there are few reports on rare earth doped $Y_4Al_2O_9$ (YAM) [10-18].

1.1 Experimental

Phosphor $Y_4Al_2O_9$ with different concentrations of europium (0.2 mol % to 2.5 mol %), was synthesized by solid state reaction method with calcination temperature at 1000°C for 1 hour in a muffle furnace. Every heating is followed by intermediate grinding using agate mortar and pestle. The starting materials used for sample preparation are Y_2O_3, Al_2O_3 Eu_2O_3 and were used to prepare the phosphor. After being ground thoroughly in stoichiometric ratios by using an agate mortar by dry grinding for nearly 45 minutes, to ensure the best homogeneity and reactivity, powder was transferred to alumina crucible, and then heated in a muffle furnace at 1300 °C for 4 hour [19-27]. The phosphor materials were cooled to room temperature naturally.

The sample was characterized using XRD, photoluminescence (PL) emission and excitation spectra, and thermally stimulated luminescence glow curves were recorded at room temperature by using TLD reader I1009 supplied by Nucleonix Sys. Pvt. Ltd. Hyderabad [17-19]. The obtained phosphor under the TL examination is given UV radiation using 254nm UV source. Heating rate used for TL measurement is 5^0Cs^{-1}.

1.2 Results and Discussion

The XRD pattern of the sample is shown in figure 1. Structural parameters are described in table 1 which gives

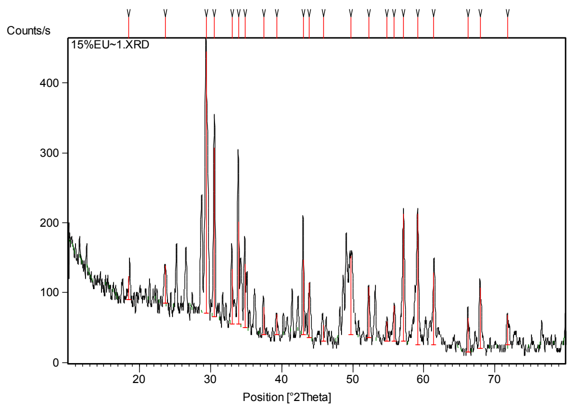

Fig. 1: XRD pattern of YAM:Eu^{3+} phosphor (1.5mol% Eu^{3+})

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the information about peak position, d-spacing, full width at half maximum etc. Sample show monoclinic structure.

Table 1

Pos. [°2Th.]	*Height [cts]*	*FWHM [°2Th.]*	*d-spacing [Å]*	*Rel. Int. [%]*
18.5261	6.66	0.4723	4.78941	8.88
23.6387	10.75	0.3936	3.76385	14.33
29.3905	75.02	0.4723	3.03904	100.00
30.5203	48.49	0.4723	2.92907	64.64
33.0370	15.79	0.4723	2.71147	21.04
34.0041	29.33	0.4723	2.63653	39.10
34.9102	18.27	0.3149	2.57015	24.35
37.4953	7.87	0.4723	2.39868	10.49
39.2855	5.94	0.3936	2.29340	7.92
43.0716	21.49	0.4723	2.10017	28.65
43.9008	15.92	0.3149	2.06241	21.22
45.9340	4.82	0.9446	1.97574	6.43
49.7485	22.60	0.4723	1.83282	30.13
52.2609	14.65	0.3149	1.75047	19.53
54.7791	5.85	0.4723	1.67581	7.80
55.8243	10.37	0.3149	1.64689	13.82
57.1519	36.74	0.3149	1.61175	48.97
59.1195	37.63	0.3149	1.56272	50.16
61.3847	20.87	0.4723	1.51037	27.81
66.2353	9.85	0.3149	1.41104	13.13
67.9416	17.54	0.3149	1.37970	23.38
71.7793	8.77	0.5760	1.31400	11.69

Figure 2 is excitation spectra of $Y_4Al_2O_9:Eu^{3+}$ phosphor for variable concentration of europium (0.5-2mol%). The excitation spectra of $Y_4Al_2O_9:Eu^{3+}$ phosphor mainly consists of the charge transfer and (CTB) of Eu^{3+} located in 254 nm. The energy position of Eu^{3+} CTB is closely related to the covalency of Eu–O bond and the coordination number of Eu^{3+}. The covalency of $Eu^{3+}– O^{2-}$ bond is strongly influenced by the next nearest cation M^{3+} ($M=Y^{3+}$, Al^{3+}).

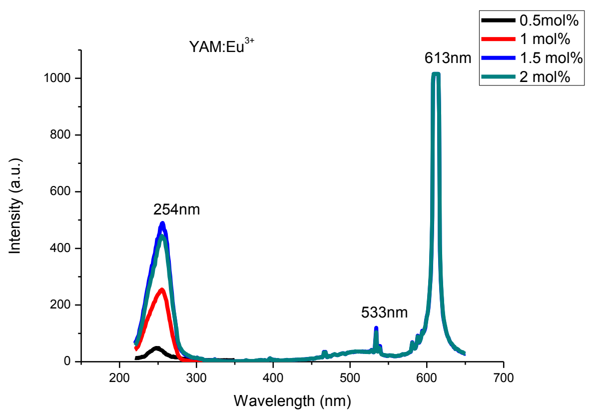

Fig. 2: Excitation spectra of $Y_4Al_2O_9:Eu^{3+}$ phosphor

Figure 3 shows the emission spectra of $Y_4Al_2O_9:Eu^{3+}$ phosphor with different concentration of Eu. The emission spectra are characteristic $^4f_6$ energy level transition emission. They are mainly due to two dipole transitions. One is $^5D_0$ to $^7F_1$ magnetic dipole transition, and another is $^5D_0$ to $^7F_2$ forced electric dipole transition. The intensity ratio of $^5D_0$ to $^7F_2$ to $^5D_0$ to $^7F_1$ can be viewed as a clue concerning the nature of the chemical surroundings of the luminescent center and its symmetry [25].

The strong emission peak of $Y_4Al_2O_9:Eu^{3+}$ phosphor is due to forced electric dipole transition of $^5D_0$ to $^7F_2$ centered at 613 nm.

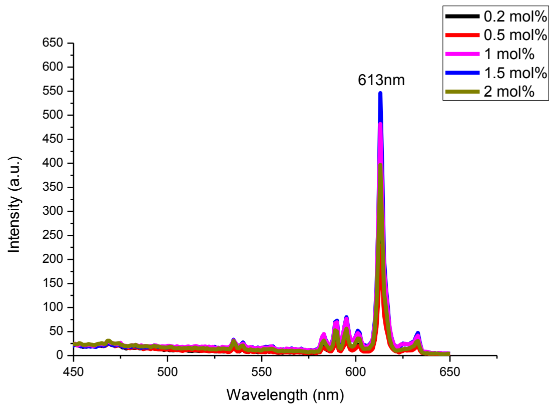

Fig. 3: Emission spectra of $Y_4Al_2O_9:Eu^{3+}$ phosphor

Fig. 4 shows a typical TL glow curves for the Eu^{3+} doped $Y_4Al_2O_9$ phosphor exposed to dose of UV rays from a 254UV source. Comparison of theoretical and experimental glow curve analysed by CGCD technique and three distinct peaks found at 381, 406 and 548K. Based on these findings, 548K looks very attractive for TL dosimetry application. The studied samples demonstrate good repeatability of TL signal, less fading, even after repeated irradiations.

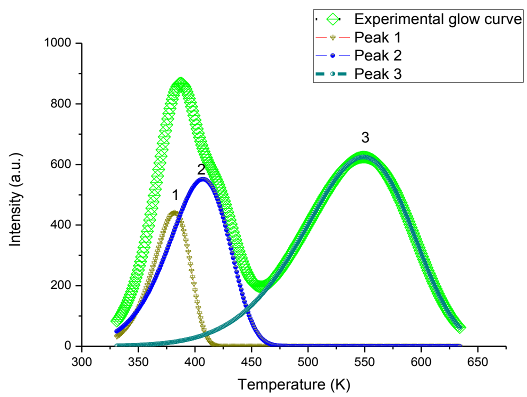

Fig. 4: CGCD pattern of $Y_4Al_2O_9:Eu^{3+}$ phosphor (1.5mol% Eu^{3+}) with 20 min UV exposure time

Thermoluminescence (TL) phosphors generally exhibit glow curves with one or more peaks when the charge carriers are released. The glow curve is characteristic of the different trap levels that lie in the band gap of the material. The traps are characterized by certain physical parameters that include trap depth (E) and frequency factor(s). For many TL applications, a clear knowledge of these physical parameters is essential. In the study of relatively deep trapping effect-states in various solid state materials as well as TL dating, a detailed analysis of TL glow curves is indispensable [19-28].

2. CONCLUSION

$Y_4Al_2O_9:Eu^{3+}$ (1.5%) phosphor shows an intense red emission under 254nm excitation. The photoluminescence study shows that the emission intensity of electric dipole transition [613nm] ($^5D_0 \rightarrow {}^7F_2$) dominates over that of magnetic dipole transition ($^5D_0 \rightarrow {}^7F_1$) [594 nm]. The optimum concentration of Eu^{3+} in $Y_4Al_2O_9:Eu^{3+}$ was 1.5 mol%. The results indicated that present phosphor could find application for GaN-based UV-LED.

The $Y_4Al_2O_9$ phase was quenched in favor of the red emission of Eu^{3+} ions indicating that europium must be close to yttrium aluminate monoclinic host for better host to Eu energy transfer. However, under 254nm excitation Eu (1.5%) doped $Y_4Al_2O_9$ phosphor shows high intensity.

REFERENCES

[1] R.N. Bhargava, D. Gallagher, X. Hong, A. Nurmikko, Phys. Rev. Lett. 72 (1994) 416

[2] W.P. Zhang, P.B. Xie, C.K. Duan, K. Yan, M. Yin, L.R. Lou, S.D. Xia, J.C. Krupa, Chem. Phys. Lett. 292 (1998) 133

[3] J.R. Lo, T.Y. Tseng, Mater. Chem. Phys. 56 (1998) 56

[4] E.A. Aguilar, R.A.L. Drew, J. Eur. Ceram. Soc. 8 (2000) 1091

[5] V. Lupei, N. Pavel, T. Taira, Appl. Phys. Lett. 81 (2002) 2677

[6] K.L. Vodopyanov, R. Shori, O.M. Stafsudd, Appl. Phys. Lett. 72 (1998) 2211

[7] J. Glodo, A.J. Wojtowicz, J. Alloys. Compd. 300&301 (2000) 289

[8] C.H. Lu, R. Jagannathan, Appl. Phys. Lett. 80 (2002) 3608

[9] J.Y. Choe, D. Ravichandran, S.M. Blomquist, D.C. Morton, K.W. Kirchner, M.H. Ervin, U. Lee, Appl. Phys. Lett. 78 (2001) 3800

[10] V. Dubey, J. Kaur, S. Agrawal, Research on Chemical Intermediates, 5 (39), 2013

[11] Sadhana Agrawal, Vikas Dubey, Jour. Rad. Res. Appl. Sci. 7(4), 2014, 601-606.

[12] Vikas Dubey; Jagjeet Kaur; Sadhana Agrawal; Res. Chem. Intermed. (2014), DOI 10.1007/s11164-014-1563-3

[13] Vikas Dubey, Jagjeet Kaur, Sadhana Agrawal; N.S. Suryanarayana, K.V.R.Murthy, Superlat. Microstruc. 67 (2014) 156–171.

[14] J. Kaur, Y. Parganiha, V. Dubey, D. Singh, D. Chandrakar, Superlattices and Microstructures 73 (2014) 38–53.

[15] V.Dubey, J.Kaur, S. Agrawal, N.S.Suryanarayana, KVR Murthy, Optik – Int. J.Light Electron Opt. (2013), doi 10.1016/j.ijleo.2013.03.153.

[16] V. Dubey, N. S. Suryanarayana, J. Kaur, Jour. Miner. Mater. Charac. Engin., 9 (12), (2010) 1101-1111.

[17] V. Dubey, J. Kaur, N.S. Suryanarayana, K.V.R.Murthy, Res. Chem. Intermed. (2012) DOI: 10.1007/s11164-012-0872-7.

[18] V.Dubey, J.Kaur, S. Agrawal, Res. Chem. Intermed. (2013) DOI 10.1007/s11164-013 1201-5

[19] Vikas Dubey, JagjeetKaur, SadhanaAgrawal, Materials Science in Semiconductor Processing 31 (2015) 27–37

[20] Vikas Dubey, Sadhana Agrawal, Jagjeet Kaur, Optik 126 (2015) 1–5.

[21] C. Hu, H. Liu, W. Dong, Y. Zhang, G. Bao, C. Lao, Z.L. Wang, Adv. Mater. 19 (2007) 470–474.

[22] Vikas Dubey, V.P. Dubey, Raunak Kumar Tamrakar, Kanchan Upadhyay, Neha Tiwari, Journal of Radiation Research and Applied Sciences, Volume 8, Issue 1, January 2015, Pages 126-135.

[23] R Shrivastava, J Kaur, V Dubey, B Jaykumar, S Loreti, Spectroscopy Letters 48 (3) 2014, 179-183.

[24] V Dubey, J Kaur, S Agrawal, Research on Chemical Intermediates 41 (1) 2014, 401-408.

[25] V Dubey, R Tiwari, RK Tamrakar, GS Rathore, C Sharma, N Tiwari, Infrared Physics & Technology 2014 67, 537-541.

[26] S Agrawal, V Dubey, 3rd international conference on fundamental and applied sciences (icfas 2014): Innovative Research in Applied Sciences for a Sustainable Future, 1621, 560-564, http://dx.doi.org/10.1063/1.4898522.

[27] J Kaur, Y Parganiha, V Dubey, D Singh, Research on Chemical Intermediates 40 (8) 2014, 2837-2858.

[28] Vikas Dubey, Sadhana Agrawal, and Jagjeet Kaur, Indian Journal of Materials Science Volume 2014, Article ID 367378, 8 pages http://dx.doi.org/10.1155/2014/367378.