International Journal of Luminescence and applications
Vol7 (1) April, 2017, **ISSN 2277 – 6362**

Effect of Tb on Photoluminescence Spectra of $Y_3Al_5O_{12}$ Phosphor

S. Kondala Rao[1] P.B.L Prasanna[1], P.Indira[2], B.Subbarao[3]
[1]Department of Physics, QIS College of Engineering and Technology, Ongole-523001, India
[2]Department of Physics, K.R.K Govt. Degree College, Addanki, AP, India
[3]Department of physics, VSR & NVR College, Tenali, A.P., India

Abstract:

The novel phosphor of $Y_3Al_5O_{12}$(YAG) activated with the trivalent rare-earth Tb^{3+} ions were synthesized by solid state method(SSR), characterization and luminescent properties were investigated. The photoluminescence (PL), X-ray diffractometry (XRD), scanning electron microscopy [SEM] and particle size were employed to study the luminescence properties. In the photoluminescence investigations there is a single and highly symmetric site for activators ions in the $Y_3Al_5O_{12}$ host lattice. The sharp emission properties show that the $Y_3Al_5O_{12}$ is a suitable host for rare-earth doped laser crystal and phosphor material. The results of the XRD show that obtained $Y_3Al_5O_{12}$:Tb^{3+} phosphor has a pure cubic with primitive structure.

Keywords:- Solid State Reaction [SSR], Photoluminescence [PL], Rare Earth ions [RE ions], X-ray diffraction [XRD].

1.0 INTRODUCTION

Inorganic compounds doped with rare earth ions form an important class of phosphors as they possess a few interesting characteristics such as excellent chemical stability, high luminescence the efficiency, and flexible emission colours. Recently they developed flat panel displays, such as field emission displays (FEDS), plasma display panels (PDPS) and thin film electro-luminescent devices (TFEL) or white light emitting diode (LED), have emerged as the principal motivation for research into rare-earth luminescence, and the present article therefore concentrates on the variety of different ways in which rare-earth luminescence has been exploited in this field. The rare-earth ions are characterized by a partially filled 4f shell that is well shielded by $^5s_2$ and $^5p_6$ orbitals. The emission transitions, therefore, yield sharp lines in the optical spectra.

2.0 EXPERIMENTAL PROCEDURE

2.1 Synthesis Process

$Y_3Al_5O_{12}$:Tb^{3+}(0.5, 1.0, 1.5, 2, 2.5, 3.0%) powders of various compositions were prepared by the conventional high temperature solid state reaction method. The starting materials are as follows. Y_2O_3, Al_2O_3, Tb_3O_7 (purity 99.99%) was used. The mixer of reagents was ground together to obtain a homogeneous mixer. After being ground thoroughly in stoichiometric ratios (1:1) by using an agatemortar by dry grounding for nearly 45 minutes, to ensure the best homogeneity and reactivity, powder was transferred to Alumina crucible, and then homogeneous powder was heated for 1200^0c for 3 hours and cooled in the same furnace for about 15 hours.

3.0 Characterization Techniques

The obtained powder was characterized by X-ray diffractometer (XRD) (Synchrotron Beam Indus -II) with Cu Kα radiation (λ = 0.15406 nm), Scanning Electron Microscope (SEM) (JEOL, JSM-6380), Spectrofluorophotometer (SHIMADZU, RF-5301 PC) using 150 Watt Xenon lamp as excitation source. The phase purity and surface morphology can be observed through these techniques. The PL excitation is recorded and monitoring at 545nm. Upon excitation at 254nm the Tb doped $Y_3Al_5O_{12}$ phosphor displays peaks at 365, 382, 437, 482 and 545nm. The peak at 365nm is normally attributed to crystal field of the phosphor.

4.0 Results and Discussion

4.1 Phase characterization

XRD Analysis results: Figure 1 shows the XRD patern of Tb^{3+} doped $Y_3Al_5O_{12}$ (YAG) phosphor. All the diffraction peaks are in agriment with these of the JCPDS card number(33-0040)(for pure $Y_3Al_5O_{12}$). the reflection peaks can be readily indexed to those of the pure cubic phase with primitive structure of YAG (PDF 33-0040) with space group Ia3d, No other impurity phases were detected at these doping levels. The results showed the expected chemical components in the phosphors. It is obvious that Tb3+ ions successfully substituted Y3+ ions and the small amount of Tb3+ ions in YAG host lattice did not change its crystalline structure.The particle size of $Y_3Al_5O_{12}$: Tb3+ calculated from the scherrer's formula isd=K.ƛ/ βcosϴ . Fig.3 is the SEM of Tb(3.0%) doped in $Y_3Al_5O_{12}$ phosphor. From the micrographs it is found that particles are mostly irregular shape and agglomated of various sizes from micron to 10 microns.

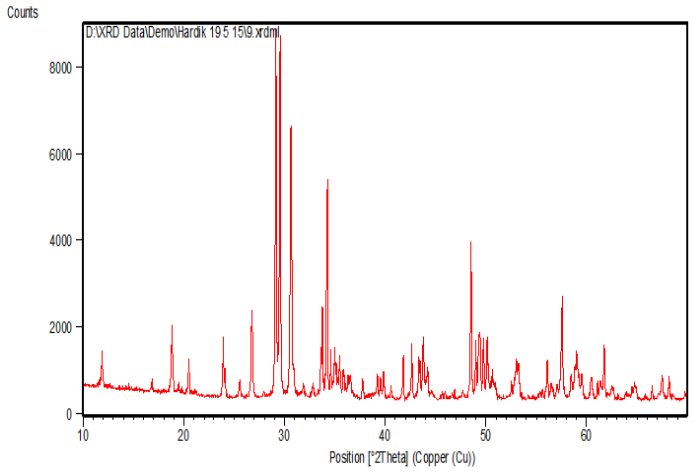

Fig.1 XRD pattern of Tb (2.5 mol%) doped $Y_3Al_5O_{12}$ phosphor

4.1 Photoluminescence (PL) studies:

The fig shows PL emissions and excitations of the Tb doped phosphor $Y_3Al_5O_{12}$:Tb(0.5, 1.0, 1.5, 2.0, 2.5, 3.0%). The PL excitation is recorded and monitoring at 545nm. Upon excitation at 254nm the Tb doped $Y_3Al_5O_{12}$ phosphor displays peaks at 365, 382, 437, 482 and 545nm. The peak at 365nm is normally attributed to crystal field of the phosphor. Apart from the mentioned peak above other small peaks observed in violet – blue – yellow and red in small intensities. The peaks observed at 382, 437, 485 and 545nm all are the standard Tb3+ transitions. All the peaks

observed are attributed the following transitions and energy of electrons released in ev.From fig. it is found as Tb concentration is increased in $Y_3Al_5O_{12}$ phosphor the intensity of Tb 545nm peak continuously increases.

395	$^5D_3 \rightarrow {}^7F_4$	3.139 eV
440	$^5D_1 \rightarrow {}^7F_1$	2.818 eV
483	$^5D_2 \rightarrow {}^7F_2$	2.567 eV
545	$^5D_1 \rightarrow {}^7F_1$	2.281 eV

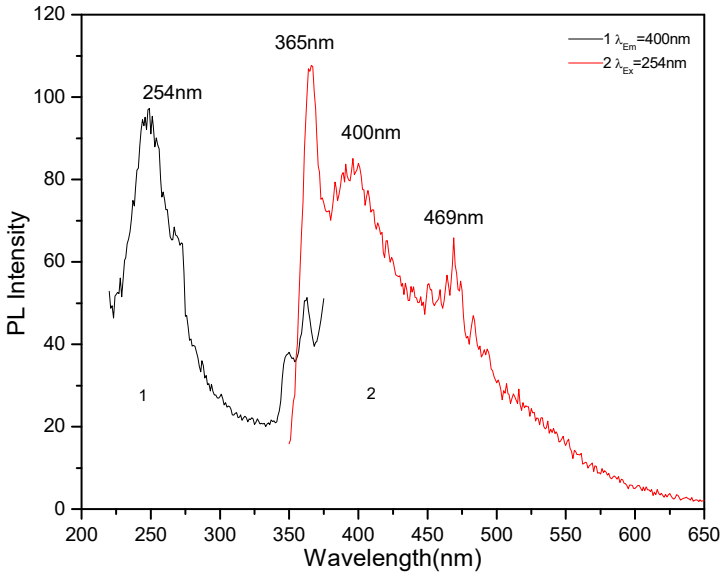

Fig.2 PLE and PL spectra of $Y_3Al_5O_{12}$ phosphor

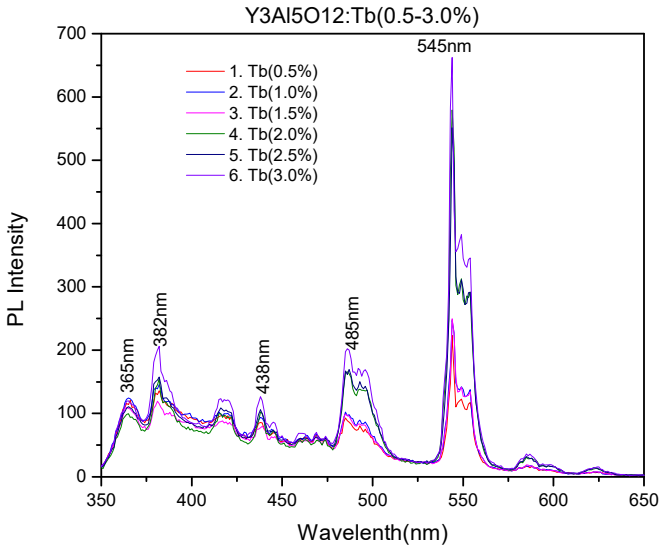

Fig.3. PL spectra of Tb (0.5 - 3.0 mol%) doped $Y_3Al_5O_{12}$ phosphor

Table-1

S.No	Sample	Dopant concentration	Emission peak intensities under 254nm Ex.				
			365nm	382nm	437nm	485nm	545nm
1	$Y_3Al_5O_{12}$	Tb(0.5%)	121	136	86	93	223
2		Tb(1.0%)	123	146	94	102	239
3		Tb(1.5%)	109	120	79	99	250
4		Tb(2.0%)	100	154	102	166	579
5		Tb(2.5%)	111	155	105	170	552
6		Tb(3.0%)	120	207	125	202	661

4.2 SEM analysis

The typical SEM micrographs of the phosphor powders are depicted in Figure. 4. The morphology of resulting sample which reveals the formation of polycrystalline material with grain size shape distribution is irregular and average grain size is in sub-micrometer range due to agglomeration of smaller grains which forms due to thorough crushing and high temperature processing of the samples. This proves the solid state synthesis method is favorable for synthesis

macro structured samples of reported phosphor. The particle sizes are in the size range of 2–5 μm. From SEM images, it has been noted that the agglomeration of synthesized powder phosphors has been increased with the change in Tb content, owing to the density variation

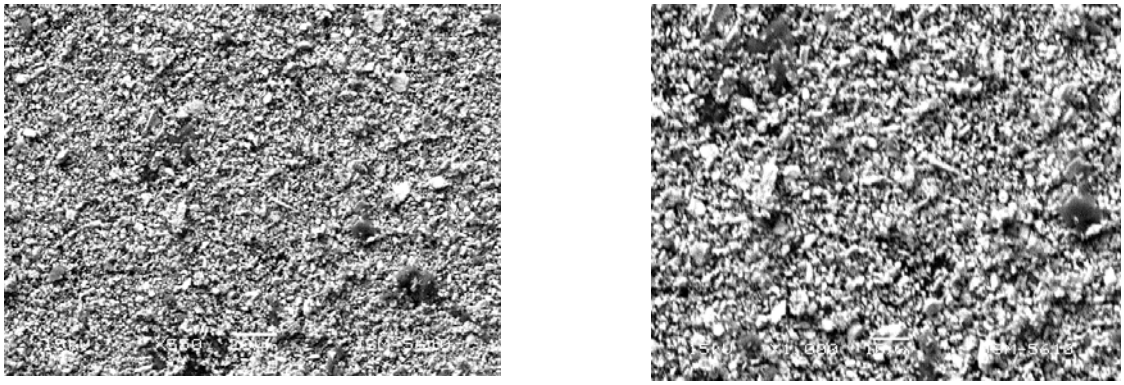

Fig.4. SEM image of Tb (2.5%) doped $Y_3Al_5O_{12}$ phosphor

4.3 Conclusions

In the present work pure YAG and Tb^{3+} doped YAG phosphors were successfully synthesized by conventional solid state reaction method and its photoluminescence studies were investigated in detail. The YAG based orange red emitting phosphor, characterized by X-ray diffraction pattern and SEM micrographs show the formation of microcrystalline sample. The photoluminescence studies of synthesized Tb^{3+} doped YAG phosphor material shows excitation at 254nm the phosphor displays peaks at 365, 382, 437, 482 and 545nm. The peaks observed at 382, 437, 485 and 545nm all are the standard Tb^{3+} transitions. These phosphors with tunable emissions may find potential applications in the fields of miniature color displays in the near future. The luminescence enhancement observed in the nano phosphors is of practical importance for this system to be applied to field emission devices.

References

1. Shinoya S,. Yen WM. Phosphor Handbook, Laser and Optical Science and Technology Series, CRC Press, Boca Raton, 1999.
2. Kondala Rao. Sayan, Murthy KVR. et.al,. International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 02 , P.672-676,(2015).
3. Feldmann C, Jüstel T, Ronda C R, Schmidt P J. *Adv. Funct. Mater* 2003, 13: 511.
4. S.Kondala Rao, P.Indira, K. V. R. Murthy, International Journal of Luminescence and its applications(IJLA),Vol.5,No.2,pp.287-290.(2015)
5. Danielson E, et al X-ray powder structure of Sr_2CeO_4: *J. Mol. Struct.*, 1998, 470: 229.
6. K.V.R. Murthy et al, Journal of Lumin., Vol.124, Issue 2, (2007), Pages 217-220.
7. Murthy, K.V.R. et al, MRB, Vol.41, 10, (2006), 1854-1860.