

Synthesis & PL, TL study of LaYPO₄: Eu Phosphor

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ABSTRACT

The present paper reports the Photoluminescence (PL) of the LaYPO₄ phosphor doped with, Eu with 0.5 mole percentage. The phosphors were synthesized using the standard solid state reaction technique and ground using mortar and pestle, fired at 1200°C for 3 hour in a muffle furnace at the rate of 5°C/min. The produced materials were analyzed by XRD, PL and TL. We have studied the effect of dopants on the Photoluminescence and Thermoluminescence properties of LaYPO₄ phosphor. Under the excitation of 254 nm wavelength, PL properties of the samples using Spectrofluorophotometer at room temperature. PL emission of doped LaPO₄ phosphor shows peaks at 589, 596, 614 and 622nm .

Keywords: *Photoluminescence; XRD; phosphor rare-earth ions; solid state reaction technique;*

INTRODUCTION

The useful applications of rare earth element compounds, especially lanthanide phosphate doped inorganic materials, have been touched upon broadly. Over the past a few years, they have been applied. Various solution-phase routes, including solid state reaction, sol-gel, precipitation, water oil microemulsion, polyol-mediated process, ultrasonification, hydrothermal, and mechanochemical method have been tried to lower the reaction temperature and obtain high-quality LaYPO₄ based nanoparticles. Phosphors are widely used in displays and lighting devices. The phosphor particles must have good characteristics such as their high brightness, fine size and narrow size distribution for application in PDP. We adopted the standard solid state reaction technique to prepare LaYPO₄ with good morphologies and fine crystal structures. However, the simple and mass fabrication of LaYPO₄ nano crystals with narrow grain size distribution and uniform morphology still remains a challenge.

TLD is one of the good techniques to measure absorbed dose. Many investigators are invented different TL dosimeter. But very few lamp phosphors are studied for TL dosimeter.(1-4). The thermo luminescence examination of phosphors brings out number of information and throw light on the use of materials as TL dosimeter^(1-5,7). The well known phosphors developed are $\text{LaPO}_4 : \text{Tb}$, $\text{Ca}\{\text{PO}_4\}\text{F Cl} : \text{Sb,M n}$ $\text{BaMgAl}_{10}\text{O}_{17}:\text{Eu,Nd}$, $\text{LiYF}_4:\text{U}^{4+}$, $\text{BaMgAl}_{10}\text{O}_{17}:\text{Mn}$, $\text{LaPO}_4 : \text{Ce}$ and aluminates in mono-,dia and tri-valent doped forms. In present paper, the TL spectra of synthesized phosphors have been recorded at room temperature.

MATERIALS AND METHOD

The base sample LaYPO_4 and LaYPO_4 phosphor doped with Eu rare-earth ions, were prepared using solid state synthesis method. Stoichiometric proportions of raw materials namely, Lanthanum Oxide (La_2O_3), Yttrium Oxide (Y_2O_3) Diammonium Hydrogen Phosphate [$(\text{NH}_4)_2\text{H PO}_4$], Europium Oxide (Eu_2O_3) were grinded in an agate motor and mixed and compressed into a crucible and heated at 1200°C for 3 hour in a muffle furnace. The prepared samples were again powdered for taking the measurements.

The excitation & emission spectra were recorded at room temperature using (SHIMADZU,make Spectrofluorophotometer RF – 5301 PC) using Xenon lamp as excitation source at display research Lab., Department of Applied Physics, M.S.U. Baroda.. The emission and excitation slit were kept at 1.5 nm.

Samples were irradiated by β -rays using Sr-90 as a natural source for β -rays. TL glow curve are recorded at room temperature by using TLD reader 11009 supplied by Nucleonix systems Pvt.Ltd,Hyderabad.

Results and Discussion

Phase purity and structure:--

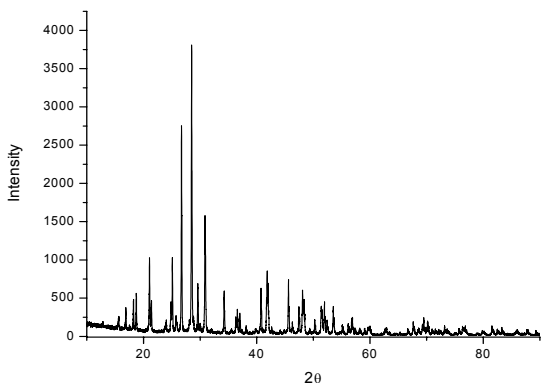


Fig.1. XRD pattern of LaYPO_4

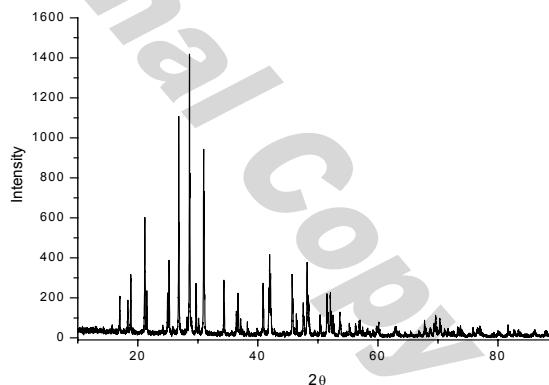


Fig.2. XRD pattern of $\text{LaYPO}_4:\text{Eu}$

The crystallinity and phase purity of the product were firstly examined by XRD analysis. Fig 1 and 2 shows the typical X-ray diffraction (XRD) patterns of synthesized samples of pure LaYPO_4 and LaYPO_4 doped with Eu. The XRD pattern of $\text{LaYPO}_4:\text{Eu}$ is similar to that of bulk

powder except for the much broader peaks of [14]. The peaks in the diffraction pattern seems to match with those of LaYPO₄ (JCPD no.- 32-0493) indicating monoclinic phase of monazite structure. The main peak was found around 28.7° corresponding to a d- value of about 3.10Å⁰, followed by other less intense peaks corresponds to the monoclinic system of crystal structure of Lanthanum Yttrium Phosphate[5-7]. All diffraction patterns were obtained using CuKα radiation ($\lambda = 1.540598 \text{ \AA}$) at 40 kv and 30 mA, and divergence slit fixed at 1.52 mm. Measurements were made from $2\theta = 10^\circ$ to 80° with steps of 0.008356° .

The crystallite size of particles of powder sample were calculated by using Scherer equation $D = 0.9 \lambda / \beta \cos\theta$

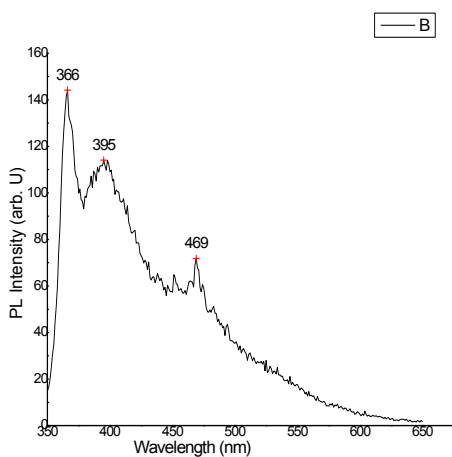
Where β represents full width at half maximum (FWHM) of XRD lines

λ = Wavelength of the X-rays.(0.154 nm in the present case)

θ = Bragg's angle of the XRD peak.

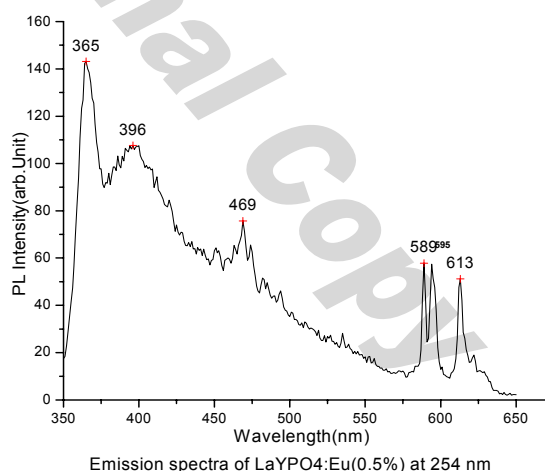
Photoluminescence Study:-

Fig.3. and fig. 4. Represents the emission spectra of LaYPO₄.The PL emission of undoped LaYPO₄ phosphor was observed at 470 nm under the excitation of 254 nm wavelength a perfect blue region with very good intensity.The emission spectra of LaYPO₄: Eu (0.5%) is shown in fig.4 reveals the modification of the emission wavelength of pure phosphor. The peaks at 589 nm and 594 nm corresponding to orange red colour are derived from the allowed magnetic dipole moment transition [$5D_0 \rightarrow 7F_1$], whose intensity is affected by the crystal environment surrounding Eu.(8,9)The peak at 614 nm corresponding to red colour are generated from the forced electric transition [$5D_0 \rightarrow 7F_2$].The Eu ions allow to occupy a site without inversion center. The intensities $5D_0 \rightarrow 7F_3$ and $5D_0 \rightarrow 7F_4$ are highly suppressed as compared to the intensified $5D_0 \rightarrow 7F_1 \rightarrow 5D_0 \rightarrow 7F_2$.(12,13)



Emission spectra of LaYPO₄ at 244 nm

Fig. 3. Emission spectrum of LaYPO₄



Emission spectra of LaYPO₄:Eu(0.5%) at 254 nm

Fig. 4. Emission spectrum of LaYPO₄:Eu

Thermoluminescence Study:-

The all TL glow curves are recorded at room temperature. Figure 5 represents TL glow curve of LaYPO_4 sample with 20 Gy beta irradiation. The glow curve exhibit one peak at 257.98°C temperature. But same phosphor doped with 0.5% Eu synthesized exhibit one emission peaks at 117°C & 235°C temperatures as shown in figure 6.. Figure represents TL glow curve of LaYPO_4 phosphor. Fig. 6 also exhibits two peaks at 117 and 235°C temperature.

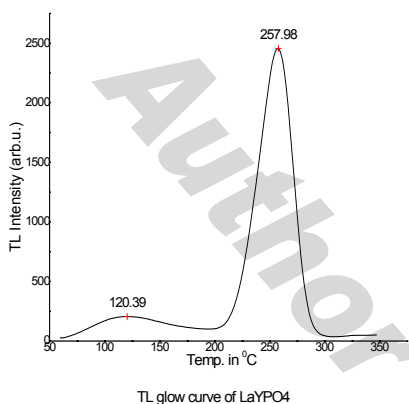


Fig.5.TL curve of LaYPO_4

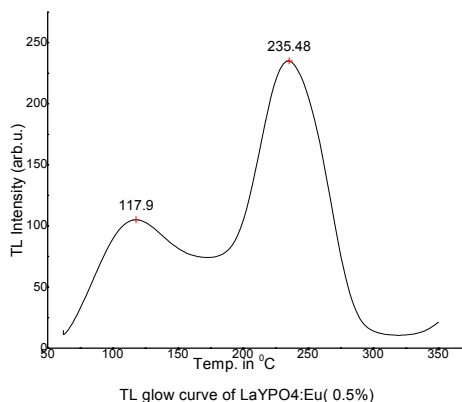


Fig.6. TL curve of $\text{LaYPO}_4:\text{Eu}$

CONCLUSION

LaYPO_4 phosphor doped with Eu rare-earth ions, were prepared using solid state synthesis method are successfully synthesized. The main peak in XRD pattern was found around 28.7° corresponding to a d- value of about 3.10Å , followed by other less intense peaks corresponds to the monoclinic system of crystal structure of Lanthanum Yttrium Phosphate. The photoluminescence and thermoluminescence properties of the material are studied.

Acknowledgement:

The authors are thankful to Dr. U.V. Bhosle, Principal, MCT's Rajiv Gandhi Institute of Technology, Andheri, Mumbai, for continuous encouragement

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Synthesis and Effect of Eu Dopant on PL and Crystallites size of Lanthanum Phosphate:
LaPO₄:Eu³⁺ **Archives of Applied Science Research, 2012, 4 (2):757-76**
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