Photoluminescence Study of LaPO₄:Ce,Er,Tb Phosphor

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Abstract—LaPO₄ :Ce,Tb is a well known green emitting phosphor, used commercially for display devices. Erbium at 1 mole percent acts as a sensitizer to LaPO₄ :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 LaPO₄ : 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 °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 385 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 ⁴f shell, shielded by ⁵s² and ⁷p⁶ 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 LaPO₄ 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 LaPO₄:Ce,Er,Tb phosphor. Lanthanum Oxide (La₂O₃), Ammonium dihydrogen Orthophosphate (NH₄H₂PO₄) were taken as a base materials in a molecular stoichiometry of 2:1 to prepare LaPO₄ Phosphor. The Phosphors with 1% of Ce₂O₃, Er₂O₃ as dopant, and Tb₂O₃ 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 an agate mortar and pestle mixed, ground thoroughly for 45 minutes to get fine powder. Acetone is added intermittently 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 °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 LaPO₄: 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 LaPO₄ with 254nm excitation. Fig(3) is the PL emission of LaPO₄: Ce 1%, Er 1%, Tb(0.5 to 2%) at 268 nm excitation. Fig.3 represent the emission spectrum of LaPO₄: 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,
415 and 436 nm are due to the transitions of Ce along with 585 and 620 nm due to Tb. The peak at 365 nm is attributed to the crystal field. The intensity of LaPO₄: Ce1%, Er1%, Tb1.5% Phosphor is high with 692 units, and is followed by 2%, 1% and 0.5% of Tb concentrations in LaPO₄: Ce1%, Er1% system. The intensities of different concentrations of Tb in LaPO₄: Ce1%, Er1% Phosphor is given in the Table:1 for better understanding.

4. CONCLUSIONS

1. LaPO₄: Ce, Er, Tb phosphor successfully synthesized using SSR method.
2. Erbium acts as a sensitizer to LaPO₄: 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 525 nm 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 545 nm with very good intensity are due to transitions of Tb. The peaks with less intensity at 381, 415 and 436 nm are due to the transitions of Ce along with 585 and 620 nm due to Tb.
5. The intensity of LaPO₄: Ce1%, Er1%, Tb1.5% Phosphor is high with 692 units, and is followed by 2%, 1% and 0.5% of Tb concentrations in LaPO₄: 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 LaPO₄: Ce1%, Er1%, Tb(...) Phosphor with 268nm Excitation.

<table>
<thead>
<tr>
<th>Emission wavelength nm</th>
<th>Emission Intensities of LaPO₄: Ce1%, Er1%, Tb(...) Phosphor under 268 nm Excitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tb 0.5%</td>
</tr>
<tr>
<td>365</td>
<td>56</td>
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<td>382</td>
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<td>415</td>
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<td>621</td>
<td>07</td>
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REFERENCES