

International Journal of Luminescence and Applications (ISSN: 2277-6362) Vol. 5, No. 1, February 2015. Article ID: 080. pp.157-160.

Effect of Photoluminescence Spectra for Variable Concentration of Eu³⁺ in YAIO₃ Phosphor

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Abstract— Behaviour displayed by effect of europium concentration on YAIO₃ (YAP) host shows good photoluminescence (PL) spectra in intense orange- red emission. Sample was synthesized by solid state reaction (SSR) synthesis which is suitable for large scale production of phosphors. The starting reagents used for sample preparation are Y_2O_3 , Al_2O_3 and Eu_2O_3 , boric acid used as a flux. Ratio of Y:Al was 1:1 which shows perovskite structure confirmed by the X-ray diffraction (XRD) study. The variable concentration of Eu^{3+} (0.1 to 2.5mol %) was used for synthesis of YAIO₃: Eu^{3+} . The entire prepared sample was studied by PL excitation and emission spectra. The excitation spectra found in the range of broad excitation 200-350 nm peak centred at 262 nm. For the corresponding excitation emission spectra was found in orange –red emission. The peaks centred at 592, 595, 606,609, 616 and 630nm. The intense peak found for 592 and 616nm emission. The 616nm emission is dominant all the emission spectra due to electric dipole transition (${}^{5}D_0 - {}^{7}F_1$). Spectrophotometric determinations of peaks are evaluated by Commission Internationale de I'Eclairage (CIE) technique. The prepared phosphor is useful for display devices applications for orange –red emission.

Keywords— Photoluminescence (PL), CIE.

1. INTRODUCTION

YAlO₃ (YAP) is an important inorganic compound in the Y_2O_3 -Al₂O₃ system, which has great application potentials in the field of luminescence devices for their excellent thermal conductivity, high mechanical strength, high temperature resistance and radiation resistance, etc. [1-5]. YAP has a perovskite structure. It is an excellent host matrixes for rare earth ions doped lasers and luminescence materials with wide applications in cathoderay tubes, displays, scintillation, vacuum fluorescent displays, electroluminescent, etc. [6-10]. Up to now, a number of soft-chemical processes, such as the coprecipitation method [11,12], the sol-gel method [13-15], the solution combustion process [16-18] and the decomposition method [19,20].The precursor conventional synthetic strategy for YAP phosphor is using the solid state reaction between Y_2O_3 and Al_2O_3 [21], which is a suitable method for large scale production.

The present investigation reports the synthesis, characterization and effect of variable concentration on luminescence study of YAP phosphor. The variable concentration of Eu^{3+} (0.1 mol% to 2.5 mol%) were

reported for PL studies. The sample shows well resolved spectra in visible region for variable concentration.

2. EXPERIMENTAL

To prepare YAP doped with europium (0.1 to 2.5 mol %) consists of heating stoichiometric amounts of reactant mixture which is taken in alumina crucible and is fired in air at 1000°C for 1 hour for calcination after that the sintering temperature 1300° C for three hour in a muffle furnace. Every heating is followed by intermediate grinding using agate mortar and pestle. The Eu³⁺ activated YAlO₃ phosphor was prepared via high temperature solid state method. The starting materials were as follows: Y₂O₃, Al₂O₃, Eu₂O₃ and H₃BO₃ (as a flux) in molar ratio were used to prepare the phosphor.

The XRD measurement was carried out using Bruker D8 Advance X-ray diffractometer. The X-rays were produced using a sealed tube and the wavelength of X-ray was 0.154 nm (Cu K-alpha). The X-rays were detected using a fast counting detector based on Silicon strip technology. The photoluminescence (PL) emission and excitation spectra were recorded at room temperature by use of a Shimadzu RF-5301 PC spectrofluorophotometer. The excitation source was a Xenon lamp [22-28]

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3. RESULTS AND DISCUSSION



Fig. 1: XRD pattern of YAP:Eu phosphor

Figure 2 shows the PL excitation spectra of YAP:Eu³⁺ phosphor monitored at 615 nm. The excitation spectrum ranges from 200 nm to 350 nm. The stronger broad band in the region from 225 nm to 300 nm with the center at 262 nm is attributed to the charge transfer band of Eu^{3+} – O^{2-} .

The emission spectra of the YAP:Eu³⁺ systems ($\lambda_{ex} = 254$ nm) are given in Fig.3. The emission spectra are all similar, no change on the peak position of emission spectra with increasing concentration of Eu³⁺. The distinct emission lines lying between 575 to 630 nm are observed due to transitions from ${}^{5}D_{0}$ to the ${}^{7}F_{I}$ (I = 0-2) level of Eu^{3+} . The origin of the transitions (electric dipole or magnetic dipole) from emitting levels to terminating levels depends upon the location of Eu^{3+} ion in YAlO₃ lattice, When Eu³⁺ ions are doping into the YAP crystal structure, Eu^{3+} ions occupy the sites of Y^{3+} ions which is responsible for emission spectra in host matrix and the type of transition is determined by selection rule [29, 30]. The peak at 592 nm and 595 nm arises from ${}^{5}D_{0}-{}^{7}F_{1}$ transition, the peaks at 606 nm, 609 nm, 616 nm and 630 nm are ascribed to the ${}^{5}D_{0}$ - ${}^{7}F_{2}$ transition. The weak peak at 364 nm, 420 nm and 430 nm (figure 3) are ascribed to the transition of ${}^{5}D_{3} - {}^{7}F_{0}$ levels, peak at 469nm is transition of ${}^{5}D_{2}$ - ${}^{7}F_{0}$. All possible transitions of Eu³⁺ ion in YAP host is shown in Table 2. The emission intensity of YAP: Eu^{3+} phosphors are strongly affected by Eu^{3+} doping concentration. Optimum intensity is obtained at a doping concentration of 1.5mol% of Eu³⁺. As shown in figure 3, the emission intensity of phosphor increases with the increase of Eu^{3+} concentration up to 1.5% and then intensity decreases due to concentration quenching. It is well known that the luminescent intensity is related to the average distance between luminescent centers. As the concentration of doping increases, the distance between active ions decreases. The interaction between active ions will occur and cause concentration quenching, when the distance is short enough. Therefore, the homogeneous distribution of active ions in host is essential in order to acquire highly doped phosphors without concentration quenching [31].



Fig. 2: PL excitation spectra of YAP:Eu³⁺ monitored at 615 nm



Fig. 3: PL emission spectra of YAP:Eu³⁺ with variable Eu³⁺ concentration

Table 2: Various transitions of Eu³⁺ ion in YAP

Transition	Emission wavelength (nm)
${}^{5}D_{3} - {}^{7}F_{0}$	364 nm, 420nm, 430nm
${}^{5}D_{2} - {}^{7}F_{0}$	469 nm
${}^{5}D_{0}-{}^{7}F_{1}$	592 nm, 595 nm
${}^{5}D_{0} - {}^{7}F_{2}$	606, 609 nm, 616 nm, 630 nm

4. CIE

The CIE coordinates were calculated by Spectrophotometric method using the spectral energy distribution of the YAP: Eu^{3+} sample (Fig 4). The color co-ordinates for the Eu doped sample are x=0.566 and y=0.393 (these coordinates are very near to the orange-red light emission). Hence this phosphor having excellent color tenability from orange-red light emission.



5. CONCLUSION

YAP:Eu³⁺ phosphor powder was successfully synthesized using a modified solid state method. XRD studies confirm the phosphors are in single phase and nano crystallites. YAP:Eu³⁺ (1.5%) phosphor shows an orange-red emission under 262nm excitation. The photoluminescence study shows that the emission intensity of magnetic dipole transition [592nm] (${}^{5}D_{0} \rightarrow {}^{7}F_{2}$) dominates over that of electric dipole transition (${}^{5}D_{0} \rightarrow {}^{7}F_{2}$) [616 and 630nm]. The optimum concentration of Eu³⁺ in YAP:Eu³⁺ was 1.5 mol%. The results indicated that present phosphor could find application for GaN-based UV-LED.

The PL studies, concluded that YAP:Eu³⁺ doped phosphor under 262nm excitation can acts as a single host for producing orange-red light with good intensity for all practical display devices in particular fluorescent lamps and CFLs.

ACKNOWLEDGEMENT

Authors are very thankful to CCOST for funding through mini research project.

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