Photoluminescence study on YAP:Eu^{3+} phosphor

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Abstract: Behaviour displayed by europium doping level at fixed concentration (2.5mol%) on YAlO$_3$ 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$_2$O$_3$, Al$_2$O$_3$ and Eu$_2$O$_3$, 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 fixed concentration of Eu^{3+} (2.5mol %) was used for synthesis of YAP:Eu^{3+}.. The excitation spectra found in the range of broad excitation 200-300nm peak centred at 254nm. For the corresponding excitation emission spectra was found in orange –red emission. The peaks centred at 590, 596, 600, 608, 614, 618 and 628nm. The intense peak found for 590 and 614nm emission. The 614nm emission is dominant all the emission spectra due to electric dipole transition ($^5D_0 – {}^7F_2$) and weak emission found at 590nm are due to magnetic dipole transition ($^5D_0 – {}^7F_1$). Spectrophotometric determinations of peaks are evaluated by Commission Internationale de l'Eclairage (CIE) technique. The prepared phosphor is useful for display devices applications for orange –red emission.

Keywords: YAP; PL spectra; display devices application.

I. INTRODUCTION:

The Y$_2$O$_3$–Al$_2$O$_3$ 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 aluminumperovskite (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$_4$Al$_2$O$_9$ (YAM). It has been reported that the space group for the crystal structure of Y$_4$Al$_2$O$_9$ is P2$_1$/c of monoclinic system [10,11]. The Al atoms are coordinated to four oxygen atoms, the Y atoms are coordinated to either six or seven oxygen atoms [11], and its site symmetry is C1 [12-16].

In this paper, a new modified solid state reaction method was used to synthesize YAP:Eu^{3+}phosphor. This synthesis has the advantages of inexpensive precursors, convenient process control and large mass production. The YAP:Eu^{3+} phosphor was synthesized at a high temperature of 1300^{0}C. The structure, morphology, and photoluminescenceand of YAP:Eu^{3+}phosphor is investigated in detail.

II. EXPERIMENTAL:

To prepare YAP:Eu^{3+}withfixed concentrations of europium (2.5 mol %), consists of heating stoichiometric amounts of reactant mixture is taken in alumina crucible and is fired in air at 1100°C for 1 hour in a muffle furnace. The starting materials were as follows: Y$_2$O$_3$, Al$_2$O$_3$ Eu$_2$O$_3$ and H$_3$BO$_3$(as a flux).Powder was transferred to alumina crucible, and then heated in a muffle furnace at 1300 °C for 4 hour [16]. The phosphor materials were cooled to room temperature naturally.

The sample was characterized using XRD for structural analysis and crystallite size calculation. The XRD measurements were 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 (BrukerLynxEye detector). 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 [13-17].

III. RESULTS AND DISCUSSION:

The XRD pattern of the sample is shown in figure 1. The width of the peak increases as the crystallite sizedecreases. The size of the crystals has been computed from the full width half maximum (FWHM) of the intense peak using Scherer's formula. Crystallites size of sample in the range 65nm - few microns is found. Formula used for calculation is

$$D = \frac{0.9\lambda}{\beta \cos \theta}$$

Here D is particle size

β is FWHM (full width half maximum)

λis the wavelength of X ray source

θis angle of diffraction

D = 0.9*1.54/0.252*Cos (28.33) =65nm

. Sample show perovskite structure.

Table 1 shows the peak parameters for corresponding XRD patterns and the area of the peak, height of the peak, FWHM and 2θ values.
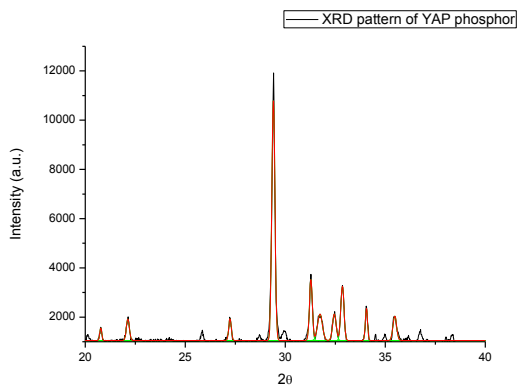

Figure 2 XRD pattern of YAP:Eu^{3+} phosphor

Table 1 peak parameters corresponding to XRD pattern

	Area	Center	Width	Height
1	62.88537	20.77467	0.09849	509.43294
2	163.61435	22.1292	0.15026	868.8131
3	143.39051	27.23636	0.1294	884.18032
4	1895.75869	29.40452	0.15459	9784.42495
5	450.83286	31.28087	0.14516	2478.03003
6	323.86708	31.73573	0.24078	1073.20368
7	242.99376	32.45316	0.18044	1074.47319
8	439.47145	32.8551	0.15924	2201.94373
9	183.14627	34.05784	0.11264	1297.32411
10	225.69692	35.47532	0.1817	991.10877

3.1 Photoluminescence study:

Figure 2shows the excitation spectra of YAP:Eu^{3+} phosphor. The excitation spectra of YAP:Eu^{3+} phosphor mainly consists of the charge transfer and (CTB) of Eu^{3+} located in 254nm. 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 covalencyof Eu^{3+}–O^{2-} bond is strongly influenced by the next nearest cation M^{3+} (M=Y^{3+}, Al^{3+}). Strongerchemical bond between Eu–O bond and M^{3+}ions forms for the crystalline phosphor, compared with amorphous one [15].

Figure 3shows the emission spectra of YAP:Eu^{3+}phosphor with different concentration of Eu. The emission spectra are characteristic $^4f_6$energy level transition emission. They are mainly dueto two dipole transitions. One is $^5D_0$to$^7F_1$magnetic dipole transition (590nm), and another is $^5D_0$ to$^7F_2$forced electric dipole transition (614nm). The intensity ratio of $^5D_0$to$^7F_2$to $^5D_0$to$^7F_1$ can be viewed as a clue concerning the nature

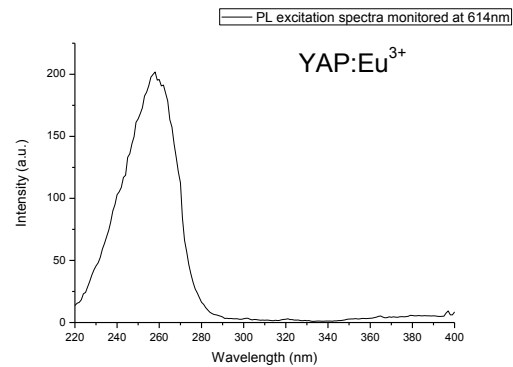of the chemical surroundings of the luminescent centerand its symmetry [15].
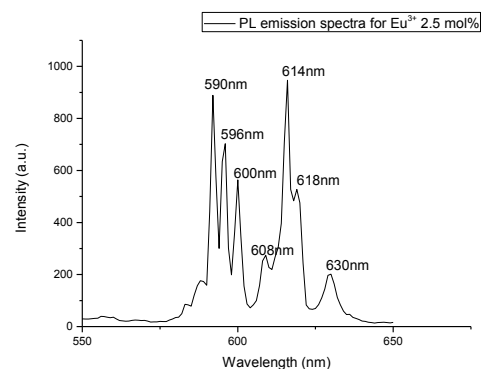

Figure 2 PL excitation spectra of YAP:Eu^{3+} phosphor

Figure 3 PL emission spectra of YAP:Eu^{3+} phosphor

The strong emission peak of YAP:Eu^{3+} phosphor is due to forced electric dipole transition of $^5D_0$to$^7F_2$centered at 614 nm. It is characteristic red emission. The phosphor should mainly exhibit the orange $^5D_0$–$^7F_1$ emission (for 590nm). However, the strong emission peak of YAP:Eu^{3+} crystalline phosphor is $^5D_0$–$^7F_1$transition (centered at 591, 596 nm) and $^5D_0$–$^7F_2$ transition (centered at 614, 618 and 630 nm). It is possible that some Eu^{3+}ions deviate from the inversion center of the crystal lattice. The 600nm and 608 nm is due to forbidden transition of europium.

3.2 CIE coordinates:

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=0.565 and y=0.361 (these coordinates are very near to the orange light emission) and x=.650 and y = .313 (these coordinates are very near to the red light emission). Hence this phosphor having excellent color tenability from orange-red light emission.

CIE 1931 Chromaticity Diagram
Dell Gamut

1931 2-degree Observer
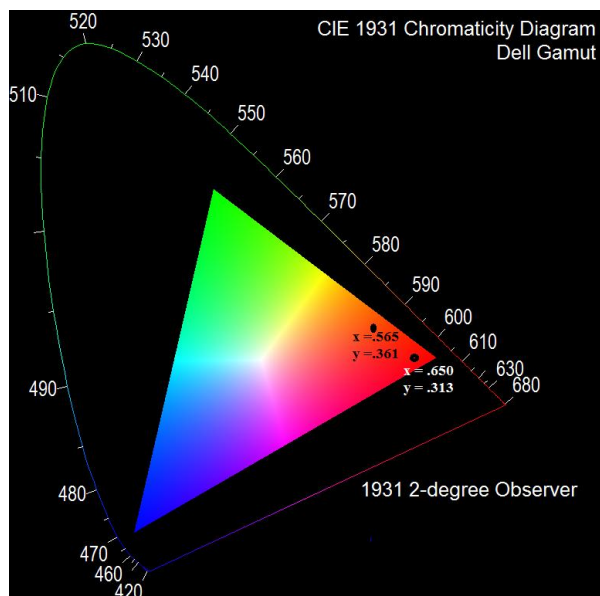
IV. CONCLUSION:

1. XRD pattern shows well resolved peak related to perovskite structure.

2. Crystallite size distribution over the range 65nm – few microns ranges.

3. From the PL spectra the peaks cantered at 590nm and 614nm intense peak so the prepared phosphor useful for red emitting device applications.

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