SYNTHESIS AND OPTICAL ANALYSIS OF EU^{3+} AND DY^{3+} ACTIVATED MGPBAL$_{10}$O$_{17}$ PHOSPHOR FOR SOLID STATE LIGHTING

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Abstract
Here synthesis and photoluminescence (PL) investigation of $MgPbAl_{10}O_{17}:Eu^{3+}$ and Dy^{3+} carried out using combustion synthesis method. The structural and morphological studies and confirmation of phase and purity were done using XRD and SEM. PL spectra of Eu^{3+}doped sample showed peaks corresponding to the $5D_0$-$7F_j$ (j =1,2,3&4) transitions showing emission at 592nm (yellow) with another at 618 nm(red) for excitation at 396 nm, while in case of Dy^{3+} showing emission at 484nm (blue) and 574 nm (yellow) for 350 nm excitation showing strong and prominent emission for the generation of white light.
Keywords:- Photoluminescence , XRD, SEM,CIE

Introduction

In industry purpose the improvement of advanced illumination and display technologies accelerates the employment of phosphor.[1] As we compaire the incandescent and fluorescent lamp, which are the conventioanl energy source, observed that white light emitting diodes paying more and more attention for various significance, for example economical, ecofriendly, energy consuming and excellent electrochemical performance. [2,3] Luminescence analysis i.e.emission and excitation properties of the trivalent rare earth dopand based compounds acknowledged vast relevance in the region of solid state lighting in addition to w-LED [4,5]. With the combination of near ultraviolet (near-UV) chip w-LED can be fabricated various light such as red/green/ red emitted from the prepared phorphor material, which provides better-quality color consistency with a high chroamticity indexed [6,7]. While development of w-LED for the solid state lighting, the research on the novel optical a material becomes a burning topic. In this paper, we studied intense red and blue emitting of Eu^{3+} and Dy^{3+} activated $MgPbAl_{10}O_{17}$ phosphor for solid state lighting. At present the , conventional illuminating sources still dominate the illumination market, because of high price, unsatisfactory CRI index and more color temperature of the existing white LEDs products[1] While considering the luminescent resources material, hexa-aluminate is the most significant matrix element. Eu, Ce, Tb, Mn activated hexa-aluminate viz., $BaMgAl_{10}O_{17}$:Eu, $Ce_{0.67}Tb_{0.33}Al_{11}O_{19}$ and $BaAl_{12}O_{19}$:Mn have been extensively useful in fluorescent lamps with also plasma display device system.[8]

Experimental procedure

Here prepared phosphor $MgPbAl_{10}O_{17}:Eu^{3+}$ and Dy^{3+} prepared by using combustion synthesis method. The raw materials used and the detailed synthesis procedure is same as we had already reported earlier. [9] with Eu_2O_3 and Dy_2O_3 of A.R. grade (99.99%), converting them into nitrate form by using nitric acid.All the measurements are performed at room temperature [10].

3. Result and discussion

3.1. X-ray diffraction

Conformation of phase with purity about the formation of compound with crystal structure of the phosphor prepared by combustion synthesis method with extra heat treatment of the prepared phosphor was finalized by powder x-ray diffraction analysis method. XRD blueprint of the phosphor preapred $MgPbAl_{10}O_{17}$ be excellent in matched with the reported XRD pattern in our previous work [9].

SEM Analysis

SEM morphology of the prepared phosphor studied with the help of morphological analytical studies reported earlier [9], SEM study explain the morphological analysis of the prepared phosphor prepared by using combustion synthesis method suitable for the purpose of solid state lighting ranging from few micrometers to submicrometers.[11]

Luminescent property of $MgPbAl_{10}O_{17}$:Eu^{3+} Phosphor

Excitation spectrum of $MgPbAl_{10}O_{17}$: Eu^{3+} sample (Eu^{3+} was 5 mol.%) prepared using combustion synthesis method using urea as a flux shown in fig1 while emission spectrum showing in fig 2 showing sharp red emission used for the purpose of solid state lighting.While preparing the material all the corrosponding reagent taken as per the stoichiometric ratio of the prepared composition calculated due to the total oxidizing with reducing fuel valancy which behaves as a statastical and numrical coefficient for the stoichiometric equilibrium position . Exictation spectra appears at 396 nm for the 618 nm emission which is Hr free excitation suitable for the purpose of solid state lighting showing sharp emission peak ,observed in the red visible region.

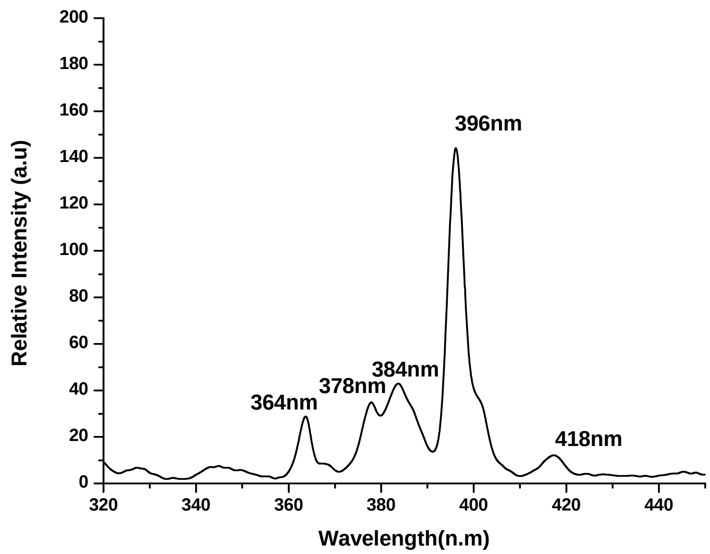

Fig.1 Excitation spectra of $MgPbAl_{10}O_{17}$:Eu^{3+} monitoring the emission at 618 nm

The Eu^{3+} activated $MgPbAl_{10}O_{17}$ phosphor, having doping concentration varying from 5m% to 0.5 m % excited by using wavelength 396 nm showing main emission peaks at 592 nm and 618 nm. As the concentration of trivalent europium ion increases, the significant virtual intensity of both transitions such as 592 ($^5D_0 \rightarrow {}^7F_1$) and 618 ($^5D_0 \rightarrow {}^7F_2$) increases.From the emission spectrum of $MgPbAl_{10}O_{17}$:Eu^{3+} phosphor ,observed that maximum emission intensity measured to be 167.204 a.u for 5 m % of concentration while minimum emission intensity observed as 41.801 a.u for 0.5m% . From the emission and excitation spectrum we observed that the prepared compound using Eu^{3+} as a activator, suitable for red emission for the purpose of solid state lighting.

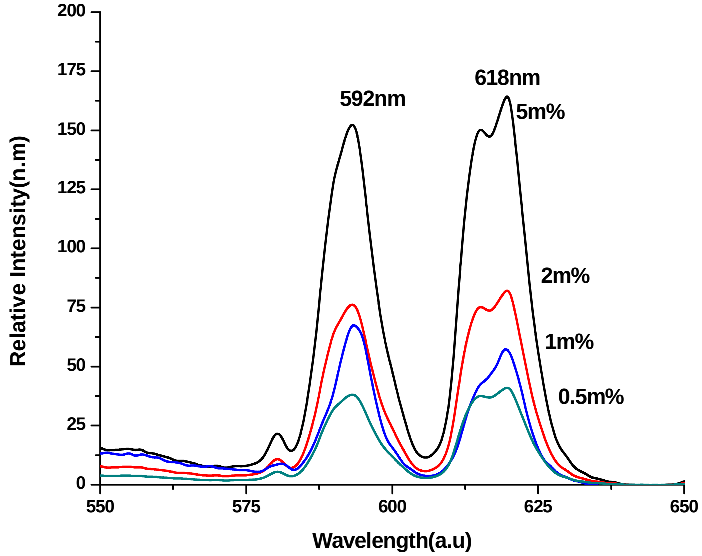

Fig 2.Emission spectra of $MgPbAl_{10}O_{17}:Eu^{3+}$ under excitation at 396 nm

Effect of the concentration of Eu^{3+} on luminescent relative intensity of $MgPbAl_{10}O_{17}$:Eu^{3+} phosphor

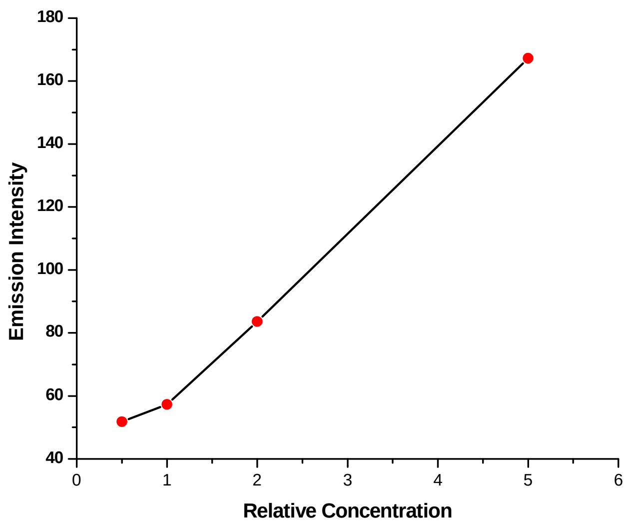

Fig.3.Effect of the concentration of Eu^{3+} on luminescent relative intensity of $MgPbAl_{10}O_{17}$:Eu^{3+} phosphor

In order to optimized the luminescence properties of Eu^{3+} as a activator with $MgPbAl_{10}O_{17}$ phosphor ,we studied the effect of concentration of activator on luminescent relative intensity of $MgPbAl_{10}O_{17}$:Eu^{3+} phosphor . Fig. 3 expalins the maximum emission intensity which is shown at 05 mol% which is 163 a.u. and minimum emission intensity shown at 0.05 mol% which is 47 a.u. of Eu^{3+}ions.

Luminescent property of $MgPbAl_{10}O_{17}$:Dy^{3+} Phosphor

Figure 4 shows the excitation spectrum of $MgPbAl_{10}O_{17}$:Dy^{3+} phosphors by monitoring the emission wavelength at 484 nm. The excitation spectra consist of four peaks located at 330nm($^6H_{15/2} \rightarrow {}^6P_{3/2}$), 350nm($^6H_{15/2} \rightarrow {}^6P_{7/2} + {}^4I_{13/2}$), 365($^6H_{15/2} \rightarrow {}^6P_{5/2}$),nm and 389nm($^6H_{15/2} \rightarrow {}^4I_{13/2} + {}^4K_{17/2}$) [12]. The intense excitation peak located at 350. Figure 5 presents the emission spectra of $MgPbAl_{10}O_{17}$:Dy^{3+} phosphors under 350 nm excitation. The emission spectra of the prepared phosphor measured in the wavelength range 400nm to 650nm. The emission spectra consist of two peaks located at 484 nm due to transition $^4F_{9/2} \rightarrow {}^6H_{15/2}$ and 574nm due to transition $^4F_{9/2} \rightarrow {}^6H_{13/2}$. The strong emission located at 484 nm corresponds to the hypersensitive transition which is dependent on the external environment of the Dy^{3+} ions in the host [113].

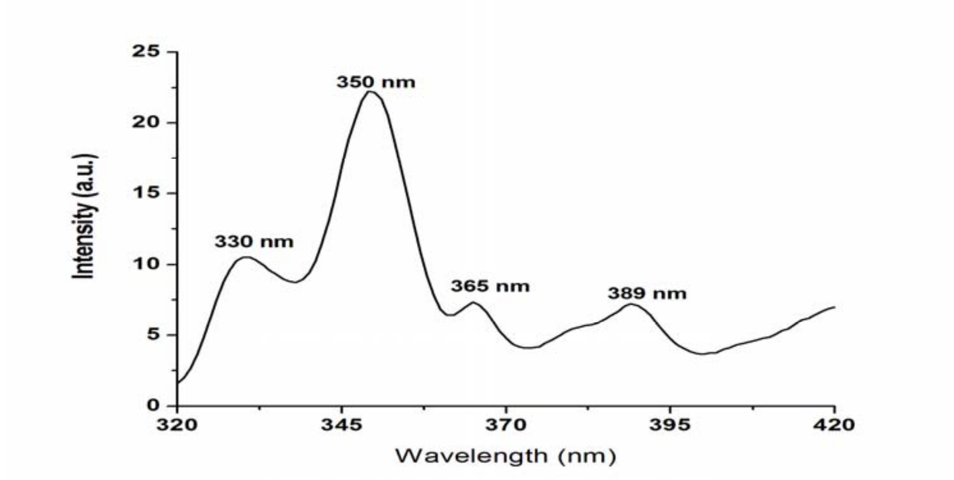

Fig.4. Excitation spectrum of $MgPbAl_{10}O_{17}$:Dy^{3+} phosphors monitored at emission wavelength of 484nm

The emission peak located at 574nm belongs to the hypersensitive transition with ΔJ=2, which is less sensitive to the host. The blue emission (484nm) and yellow emission(574nm) is attributed to the magnetic dipole , electric dipole transition respectively [14,15]. The peak position and shape of the emission spectra does not change with the increase in Dy^{3+} concentration but there is change in emission intensity. A series of $MgPbAl_{10}O_{17}$:Dy^{3+} phosphor with various concentration were prepared for finding the optimum concentration of Dy^{3+} ions in the host. The dependence of emission intensity of 484nm on the Dy^{3+} doping concentration is shown in figure 6. When we increased the concentration of Dy^{3+} the emission intensity increased upto 1mole % and after 1 mole % it is decreasing due to concentration quenching effect [16]. The highest emission intensity was observed at 1 mole%. The concentration quenching effect observed at 1mole% of Dy^{3+} ions originates from the energy migration among the Dy^{3+} ions at 1mole%. The combination of blue emission (484nm) and yellow emission (574nm) give white light emission [17]. The photoluminescence result indicates that the phosphor could find possible applications in solid state lighting.

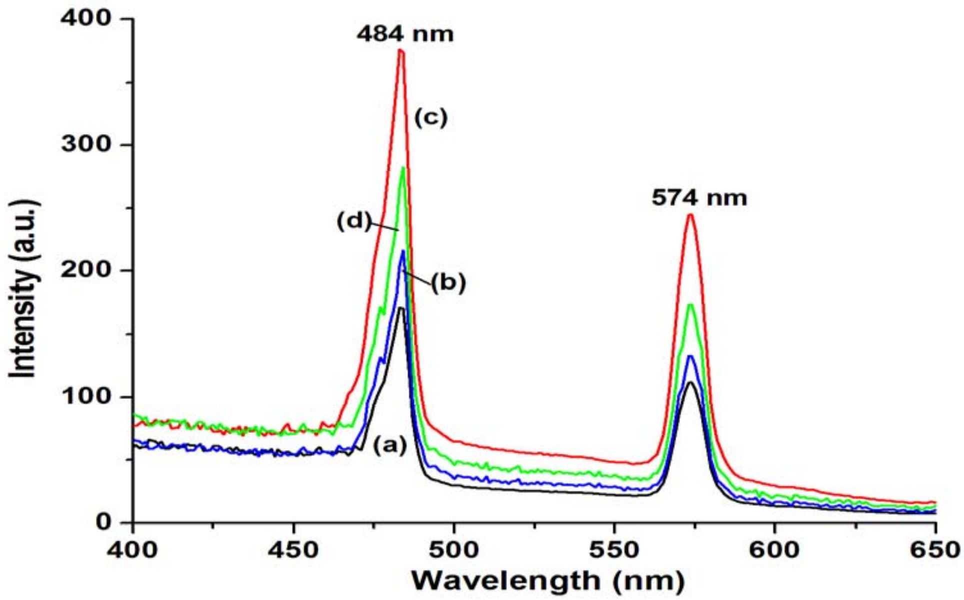

Fig.5. Emission spectra of $MgPbAl_{10}O_{17}:Dy^{3+}$ phosphors under 350nm excitation, Where (a) Dy^{3+} = 0.2 mol% (b) Dy^{3+} = 0.5 mol% (c) Dy^{3+} = 1 mol% (d) Dy^{3+} = 2 mol%.

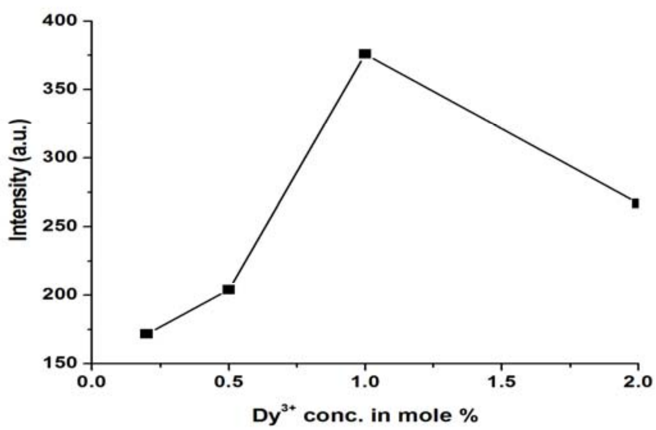

Fig.6. Dy^{3+} concentration dependence of relative luminescence intensity at 484 nm of the $MgPbAl_{10}O_{17}:Dy^{3+}$ phosphor.

Chromaticity coordinates

The chromaticity diagram is a tool to specify how the human eye will experience light with a given spectrum, which could intuitively illuminate the changes of the emission color of the phosphor.[18]

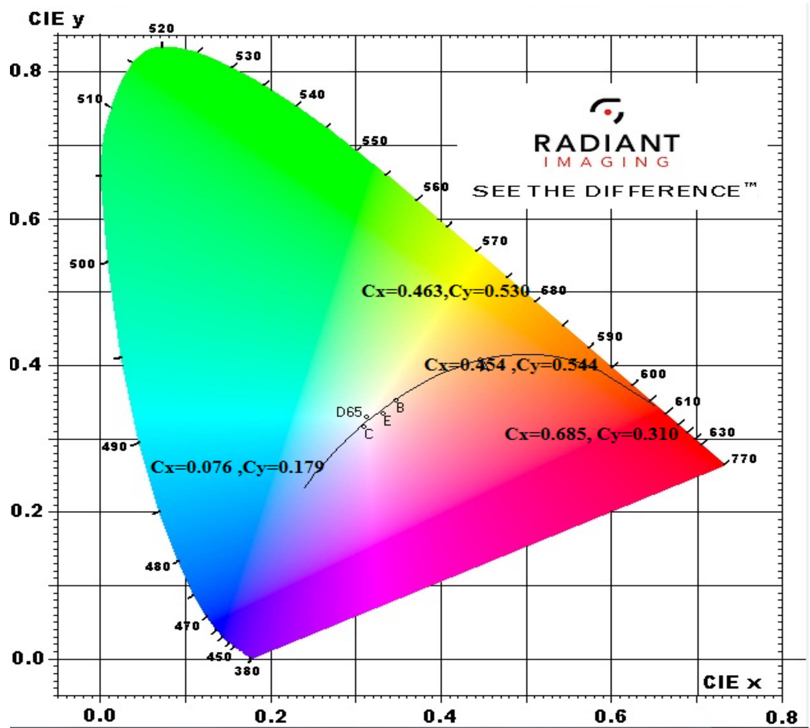

Fig.07 Chromaticity coordinates of $MgPbAl_{10}O_{17}$: Eu^{3+} and Dy^{3+} phosphor

The variation of the ratio of PL intensity between Eu^{3+} and Dy^{3+} induces changes in chromaticity coordinates. The chromaticity coordinates of $MgPbAl_{10}O_{17}$ phosphors are calculated based on their PL spectra, and are shown in the 1931 CIE chromaticity diagram as shown in Fig.7 and found to be in case of Eu^{3+} it is calculated to be (Cx=0.454 and Cy=0.544) and (Cx=0.685 and Cy=0.310) while in case of Dy^{3+} it is calculated to be (Cx=0.076 and Cy=0.179) and (Cx=0.463 and Cy=0.530)

Conclusion

Here we prepared the $MgPbAl_{10}O_{17}$: Eu^{3+} and Dy^{3+} phosphor successfully by using combustion synthesis method with additional heat treatment.The luminescence analytical studies from emission and excitation spectrum explains that the prepared phosphor i.e. $MgPbAl_{10}O_{17}$: Eu^{3+} and Dy^{3+} was the promising candidates used for the purpose of solid state lighting, showing red and blue with yellow emission for energy consumption and eco friendly solid state lighting applications.

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