Luminescence studies of Dy doped $MgSrAl_{10}O_{17}$ phosphor

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ABSTRACT

In this study Dy doped $MgSrAl_{10}O_{17}:xDy^{3+}$ phosphor has been synthesized by Combustion method for different concentrations of Dy (x = 0, 0.0005, 0.001, 0.002, 0.005, 0.01 and 0.02). The synthesized phosphor was characterized for its thermoluminescence (TL) and photoluminescence (PL) properties that included TL glow curves and PL excitation & emission spectra . TL intensity was found to increase with increase in concentration of dopant Dy and was found to show best result for x=0.02. Further PL characterization of $MgSrAl_{10}O_{17}:0.02Dy^{3+}$ phosphor exhibits two main emission peaks, at 484 and at 575 nm due to Dy^{3+} ion, when excited with 350 nm wavelength. So, emission of the Dy^{3+} luminescence is close to white region and hence $MgSrAl_{10}O_{17}:xDy^{3+}$ phosphor can be a good candidate in solid state lighting for white light emission.

Keywords: $MgSrAl_{10}O_{17}$; thermolumenescence ; photoluminescence

1. Introduction

There is a growing demand for economically viable phosphors for newly emerging display devices with ongoing technological advancements. Various aluminates are used in luminescent applications as hosts for doping rare earth ions for best applications. Green emitting phosphor $MgSrAl_{10}O_{17}$: Mn was successfully synthesized by one step solution combustion route in single phase and the luminescence, EPR investigations have been reported (Singh et al., 2008; Singh et al., 2008). Blue emitting Eu doped $MgSrAl_{10}O_{17}$ phosphor was prepared and characterized for luminescence properties (Singh et al., 2008). Further the photoluminescence and energy transfer of Eu^{2+}, Cr^{3+} co doped $MgSrAl_{10}O_{17}$ have been studied (Shao et al., 2011) and defect centres in $MgSrAl_{10}O_{17}$: Sm have also been investigated (Singh et al., 2011). Synthesis and characterization of Tb^{3+} doped $MgSrAl_{10}O_{17}$ green emitting phosphor is also reported (Panse et al., 2013). Very recently EPR and optical properties of Eu^{2+} and Mn^{2+} co doped $MgSrAl_{10}O_{17}$ blue green light emitting phosphor have been reported (Singh et al., 2016). From the literature survey, it is noticed that Dy doped $MgSrAl_{10}O_{17}$ has never been reported and moreover the study of TL properties is one of the gap in the studies already reported. So, in the present study, $MgSrAl_{10}O_{17}$: Dy phosphor was successfully synthesized by solution combustion synthesis and the luminescence properties including PL and TL of $MgSrAl_{10}O_{17}$: Dy have been studied for its applications as LED material and radiation dosimeter.

2. Experimental

$MgSrAl_{10}O_{17}:xDy^{3+}$ (x = 0, 0.0005, 0.001, 0.002, 0.01 and 0.02) were synthesized by combustion synthesis method. AR grade $Sr(NO_3)_2$, $Mg(NO_3)_2$, $Al(NO_33$ and Dy_2O_3 were used as starting materials. Urea was used as fuel. All the precursors were weighed as per the stoichiometric ratio and transferred to a porcelain china dish. The precursor chemicals along with urea were mixed thoroughly until they formed a paste. The china dish containing

this pate is then kept in a muffle furnace pre-heated to 550 ^{o}C. The combustion reaction takes place accompanied by a flame that lasts for 13 seconds. The resultant product has a porous nature with less crystallinity. The phosphor powder was then crushed and annealed at 600 ^{o}C for 4 hours. After cooling, the phosphors were collected and characterized for their thermoluminescence (TL) properties. The samples were irradiated using Co^{60} gamma ray source for 700 Gy dose and then their TL glow curves were recorded on Nucleonix TL1009I TL reader. The photoluminescence (PL) excitation and emission spectra of $MgSrAl_{10}O_{17}:xDy^{3+}$(x = 0.02) were recorded in Shimadzu RF5309PC Spectrofluorophotometer.

3. Results and Discussion

3.1 TL properties

TL glow curves of synthesized $MgSrAl_{10}O_{17}:xDy^{3+}$ phosphor for different values of x (x = 0, 0.0005, 0.001, 0.002, 0.01 and 0.02) for 700 Gy exposure of gamma rays were observed and are shown in **Fig. 1**. It is observed that the phosphor shows an isolated peak at around 180 °C and the intensity of TL peak keeps on increasing with increase in the dopant concentration. The sensitivity of $MgSrAl_{10}O_{17}:xDy^{3+}$ was found to be 7 times greater than the pure host material $MgSrAl_{10}O_{17}$. So, the dopant plays an important role in defining the TL properties of phosphor. Dopant introduces predominantly deeper trapping levels in $MgSrAl_{10}O_{17}$ and also results in the enhancement of TL intensity. The change in trap distributions may be due to the lattice perturbation caused by incorporation of Dy in $MgSrAl_{10}O_{17}$. An activator which acts as a luminescent centre is surrounded by the non luminescent host centres. Therefore the released charge carriers cannot recombine directly with the luminescent centres. Most probably the energy is transferred non-radiatively through the host lattice to the activator, which on recombination gives characteristic emission (Kumar et al., 2009).

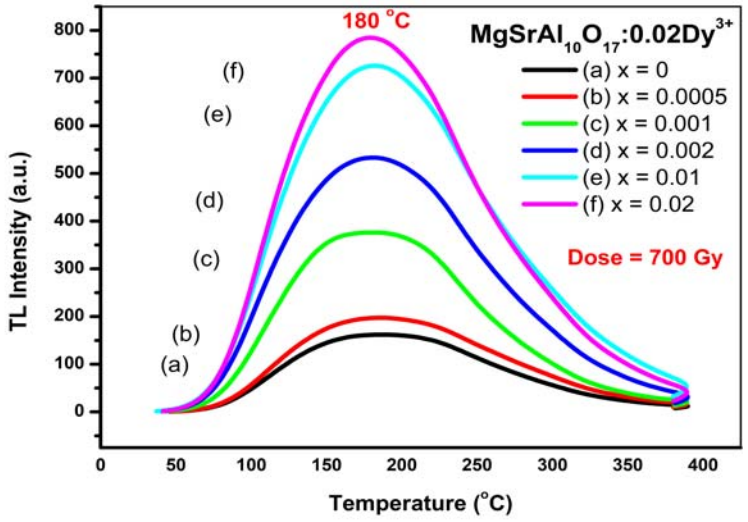

Fig.1 Effect of dopant concentration on TL glow curves of $MgSrAl_{10}O_{17}$: Dy samples exposed to 700 Gy gamma rays

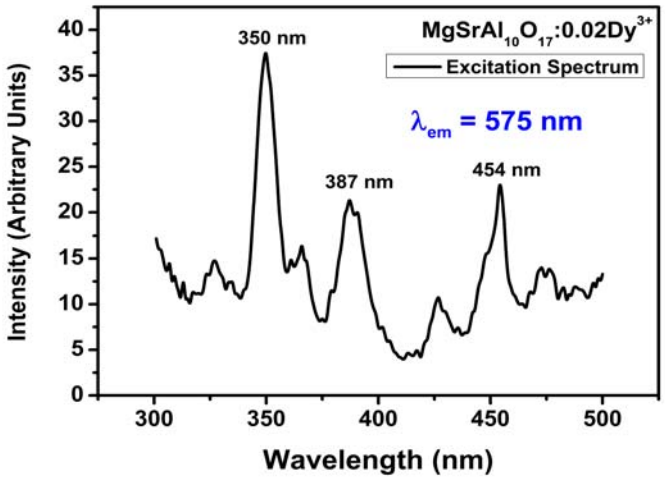

Fig.2 .PL Excitation spectrum of $MgSrAl_{10}O_{17}$: Dy phosphor,

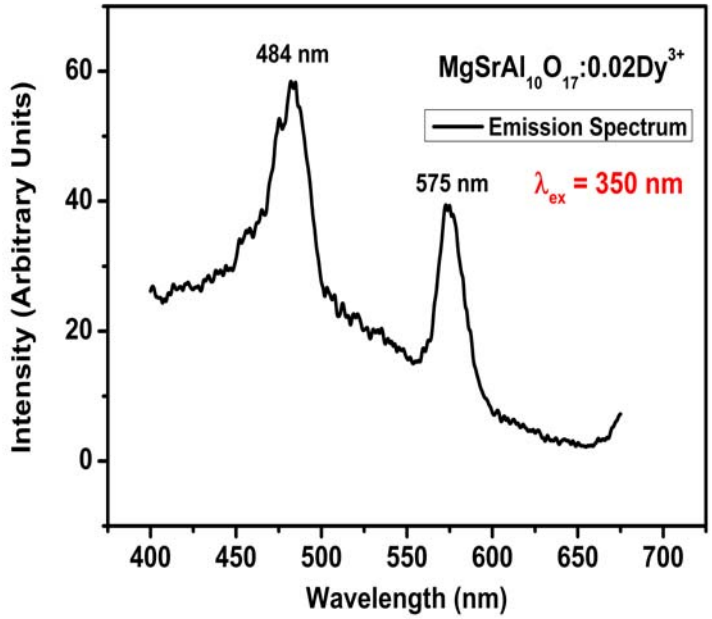

Fig.3 PL emission spectra of $MgSrAl_{10}O_{17}$: Dy phosphor.

3.2 PL Properties

The PL excitation spectrum of $MgSrAl_{10}O_{17}$:0.02Dy^{3+} phosphor, monitored at the emission wavelength 575 nm ($^4F_{9/2}\rightarrow{}^6H_{13/2}$) is presented in **Fig.2**. The PL excitation spectrum shows number of peaks at 324, 350, 387 and 454 nm are ascribed to the $^6H_{15/2}\rightarrow{}^4D_{7/2}$, ($^4M$, $^4I)_{15/2}$, $^4I_{13/2}$ $^4G_{11/2}$ transitions, respectively due to f–f transitions of Dy^{3+} ion (Dieki et al., 1968; Zhang et al., 2011; Xue et al., 2009). Upon 350 nm excitation, the PL emission spectrum of $MgSrAl_{10}O_{17}$:0.02Dy^{3+} phosphor in the spectral region 400–650 nm is shown in **Fig.3**. This emission spectrum exhibits two main emission peaks, at 484 and at 575 nm. Dy^{3+} ion emission around 484 nm is attributed to $^4F_{9/2}\rightarrow{}^6H_{15/2}$ is of allowed magnetic dipole origin, and the peak centered at 575 nm is assigned to $^4F_{9/2}\rightarrow{}^6H_{13/2}$transition due to electric dipole origin (Oza et al, 2014). It has been reported in the literature that emission of the Dy^{3+} ion luminescence is close to white region (Li et al., 2007). So, $MgSrAl_{10}O_{17}$:0.02Dy^{3+} phosphor excited with

350 nm wavelength shows white emission which suggests that this phosphor could be a good candidate in solid state lighting for white light emission.

4. Conclusions

$MgSrAl_{10}O_{17}$doped with Dy was successfully prepared by using combustion method for different concentrations of Dy (x = 0, 0.0005, 0.001, 0.002, 0.005, 0.01 and 0.02) and was found to show single peak TL glow curve at 180 °C. In case of photoluminescence, $MgSrAl_{10}O_{17}$:0.02Dy^{3+} phosphor excited with 350 nm shows two main emission peaks, at 484 and at 575 nm, attributed to $^4F_{9/2}\rightarrow{}^6H_{15/2}$ and $^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition respectively. So, the Simple TL glow curve structure of $MgSrAl_{10}O_{17}$:0.02Dy^{3+} phosphor and white light emission suggests that this phosphor can be a good candidate in solid state lighting for white light emission and for future work on radiation dosimetry.

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