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$_{17}$; thermoluminescence; 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). 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$_3$)$_3$ and Dy$_2$O$_3$ 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 paste is then kept in a muffle furnace preheated to 550 °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 °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](image-url)  
**Fig.1** Effect of dopant concentration on TL glow curves of MgSrAl$_{10}$O$_{17}$: Dy samples exposed to 700 Gy gamma rays
3.2 PL Properties

The PL excitation spectrum of MgSrAl10O17:0.02Dy3+ phosphor, monitored at the emission wavelength 575 nm (\(4F_{9/2} \rightarrow 6H_{15/2}\)) is presented in Fig.2. The PL excitation spectrum shows number of peaks at 324, 350, 387 and 454 nm are ascribed to the \(6H_{15/2} \rightarrow 4D_{7/2}, (4\text{M}, 4\text{I})_{15/2}, 4\text{I}_{13/2}, 4\text{G}_{11/2}\) 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 MgSrAl10O17:0.02Dy3+ 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. Dy3+ ion emission around 484 nm is attributed to \(4F_{9/2} \rightarrow 4H_{15/2}\) 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 Dy3+ ion luminescence is close to white region (Li et al., 2007). So, MgSrAl10O17:0.02Dy3+ 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

MgSrAl10O17doped 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, MgSrAl10O17:0.02Dy3+ 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 MgSrAl10O17:0.02Dy3+ 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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