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# Luminescence in $Sr_2Al_2SiO_7:Eu^{2+},Dy^{3+}$ phosphor

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**Abstract:**

A series of double doped $Sr_2Al_2SiO_7:Eu^{2+},Dy^{3+}$ is prepared by solid state reaction. Photoluminescence and thermoluminescence properties have been studied. Photoluminescence emission peak intensity has been increased after annealing the sample in reducing atmosphere. One broad peak is obtained at 505nm due to transition from $4f^7$ state to $4f^65d^1$ excited state. TL peak is obtained at 89° C low temperature.

**Keywords:** solid state reaction; photoluminescence; thermoluminescence; phosphor

## 1. Introduction

Long afterglow materials are the materials in which they can absorb UV light and emit visible light for longer time after excitation stops. Nowadays, these kinds of material are widely studied by the scientists as they can have wide application in low power consumptions LED, radiation dosimetry, display sign, emergency lighting, displays in dark environment, road signs, graphic art, bill boards, escape route markings, safety indications, interior decoration, and identification markers etc. Mostly in all long lasting phosphor it observed that $Eu^{2+}$ act as a emission centre and $Dy^{3+}$ acts as trap developer, which helps in emission after excitation ceases.$Eu^{2+}$-doped alkaline earth silicates are well known for their excellent luminescent properties such as high thermal stability, high efficiency, easy fabrication, and wide availability of inexpensive raw materials. $Eu^{2+}$-doped silicates have also wide significant applications in white light-emitting diodes (W-LEDs) because the phosphors can absorb ultraviolet (380– 460nm) light efficiently emit visible light [1-5].

## 2. Experimental

**Synthesis of phosphor:** We have prepared a series of double doped $Sr_2Al_2SiO_7:Eu^{2+},Dy^{3+}$ by high temperature solid state reaction. Starting material used were $SrCO_3$ (98.9%), $Al_2O_3$(AR), $SiO_2$ (98.9%), $Eu_2O_3$(GR) and $Dy_2O_3$ (GR). The sample prepared with different concentration of Dy ( 0.3 mole%, 0.5mole%, 0.75mole%, 1mole%) and constant concentration of Eu (0.3 mol %).

All these material were weighted stoichiometrically and mixed thoroughly in an agate mortar for 2 hrs. This sample then kept in furnace at 1250°C, for four hours. Then the prepared sample aneal at 1000° C in reducing atmosphere for 3 hours. Following reaction was used during preparation of sample.

$$2SrCO_3+Al_2O_3+SiO_2+Eu_2O_3+Dy_2O_3 \longrightarrow Sr_2Al_2Si_2O_7:Eu^{3+},Dy^{2+}$$

**Characterization of phosphor:** The photoluminescence (PL) properties of the phosphors (excitation and emission spectra) were measured using a Shimadzu RF-5301 PC spectrofluorophotometer at room temperature. Small amount of sample was used for each measurement. Figure shows the emission and excitation spectra which is recorded using a spectral slit width of 1.5 nm. 5 mg sample was irradiated by gamma rays from $^{60}Co$ source and TL glow curves were recorded with the usual set-up Nucleonix (TL – 1009), consisting of a small metal plate heated directly using a temperature programmer, photomultiplier tube (931B), dc amplifier and milivolt recorder. The same amount of sample in the form of fine powder was heated each time at a rate of 10°C/s. Fig shows the TL glow curves of $Sr_2Al_2Si_2O_7:Eu^{3+},Dy^{2+}$ phosphor .

## 3. Results and Discussion

**Emission spectra:** Fig 1 shows the emission spectra of $Sr_2Al_2Si_2O_7$: $Eu^{3+},Dy^{2+}$ for different concentration of Dy ions before annealing the sample. From emission spectra one can clearly observed the emission peaking at 481nm, 492nm and 573nm.

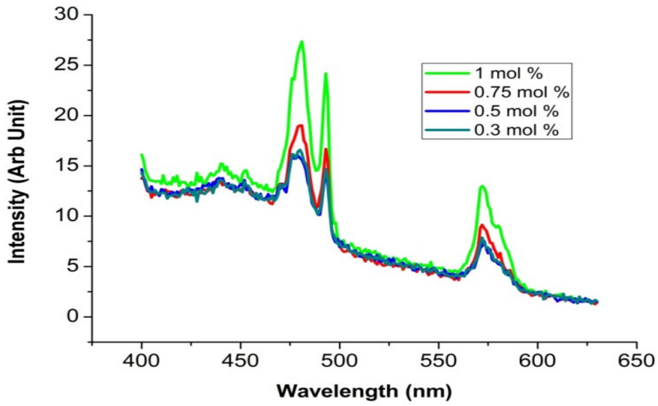


**Figure 1.Emission spectra of $Sr_2Al_2Si_2O_7:Eu^{2+}Dy^{3+}$ before annealing**

Here we can observe that maximum intensity is obtained at 1 mole % concentration of Dy.

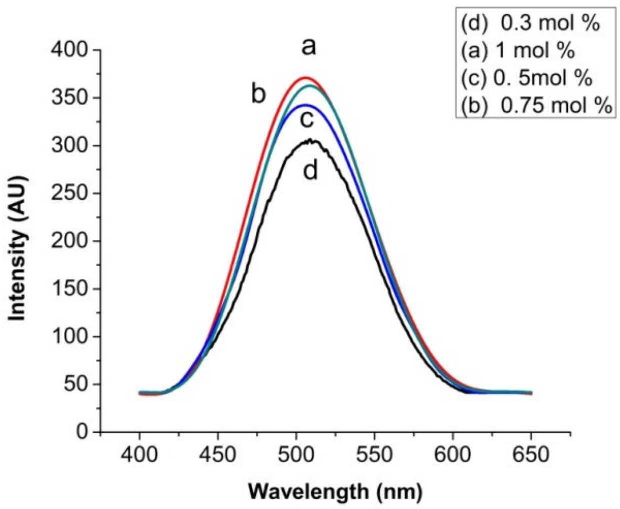


**Figure 2 Emission of $Sr_2Al_2Si_2O_7:Eu^{2+},Dy^{3+}$ after annealing**

Fig 2 shows the broad emission peak in blue green region peaking at 505 nm due to $4f^6$ $5d^1$ to $4f^7$ transition of $Sr_2Al_2Si_2O_7:Eu^{2+},Dy^{3+}$ after annealing the sample at high temperature (369 nm excitation wavelength). Maximum intensity is obtained at 1mol % concentration of Dy ion. Fig 3 shows the excitation peak of the sample at 505nm peaking were excitation wavwlength is 369 nm.

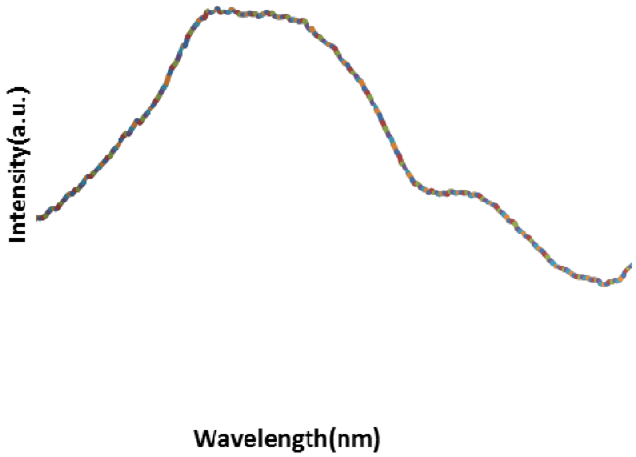


**Fig. 3 Excitation of $Sr_2Al_2SiO_7Eu^{2+}Dy^{3+}$at Emission 505nm**

Before annealing emission spectra of $Sr_2Al_2SiO_7Eu^{2+}Dy^{3+}$ was noted for the excitation 369 nm and maximum PL intensity is obtained at 481nm which may be due to transition of $Eu^{2+}$ ions in the host lattices. After annealing the sample in reducing carbon atmosphere, broad emission spectrum is observed due to transitions between the ground state $4f_7$ and the excited states of $4f_6$ $5d_1$ of $Eu^{2+}$ for excitation 369 nm. This transition is caused due to outermost 5d electron shell to inner 4f shell which is affected due to crystal field environment, therefore emission band is wider and change in emission wavelength is observed. Therefore here emission is obtained at 505nm [7].The wavelength peak is nearly same for all concentrations of Dy. So we can say that crystal field effect is same for all concentration of Dy ion. Detail energy level diagram shown in Fig 4.

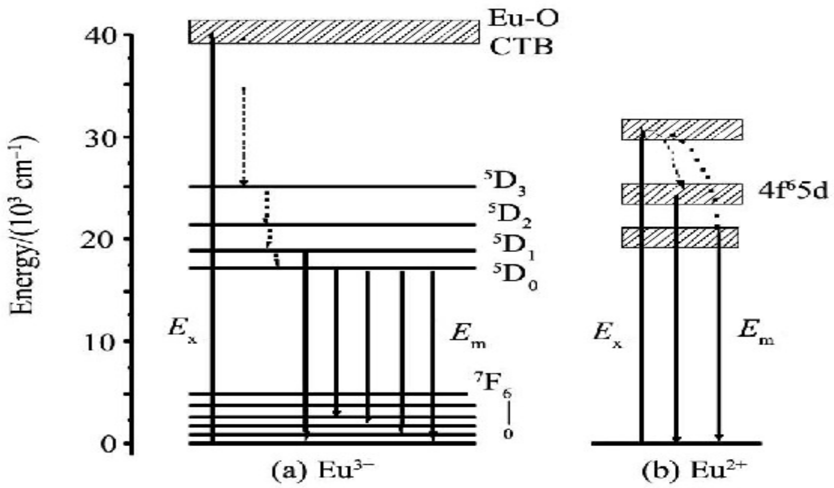


**Fig.4. Energy level diagram of $Eu^{2+}$and $Eu^{3+}$ [6]**

## Thermoluminescence property

Figure shows the glow curve of $Sr_2Al_2SiO_7Eu^{2+},Dy^{3+}$ .A single peak is observed at $89^{o}$ C for 0.3 mole % which is having maximum intensity. Trap depth $E_t$ can be calculated from TL peak by following equation

$E_t = T_m / 500.$

TL peak parameters are calculated for 0.3 mol % of Dy in following table.

| **TL parameters for 0.3 mole %** | |
|---|---|
| $T_m$ (k) | 362 |
| Trap depth($E_t$/eV) | 0.47 |
| Frequency factors($s^{-1}$) | 35x$10^7$ |

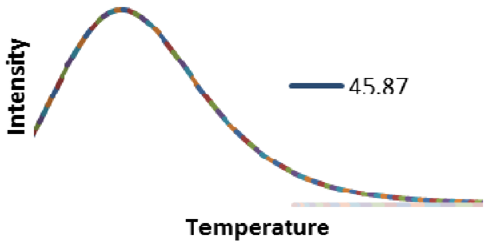


**Fig 4. Glow curve of $Sr_2Al_2SiO_7Eu^{2+}Dy^{3+}$**

As here we can see the TL peak for 0.3mole % is obtained at 362K, which is nearly above room temperature, we got the long lasting phosphorescence for this concentration. Low temperature TL peak indicates the shallower charge trap depth which helps for long lasting phosphorescence [8]. From decay analysis we observed that decay for the present sample is in the range of nanoseconds.

## 4. Conclusion

From the above observations and discussion we can conclude that europium is the emission center in the present sample, and Dy can be used as trap developer which helps for long lasting decay of sample. As excitation of the sample is in UV range, this phosphor can also be used in solid state lightning.

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