

## Photoluminescence in $\text{Li}_2\text{BaSiO}_4$ : $\text{Eu}^{2+}$ and $\text{Ce}^{3+}$

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**Abstract:** Phosphor  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Eu}^{2+}$  and  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Ce}^{3+}$  are prepared through solid state reaction method at 700 C for 12 to 14 hrs. The photoluminescence of given phosphors are studied. PL emission of  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Eu}^{2+}$  is observed in bluish green region. Emission is due to  $\text{Eu}^{2+}$  transition between the ground state  $8S_{7/2}(4f^7)$  and the excited states of  $4f^65d1$  configuration. Weak long after glow emission is also observed. In  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Ce}^{3+}$ , emission peak is observed at 392 nm at excitation of 330 nm.

**Keywords:** Photoluminescence,  $\text{Eu}^{2+}$  and  $\text{Ce}^{3+}$  transition.

### I. Introduction

Nowadays, the studies on red/green/blue tricolor phosphors suitable for UV excitation have attracted more and more attention because of their significant applications in solid state lighting (SSL), Plasma display panel, Liquid crystal display etc.. Up to now, many phosphors suitable for near-ultraviolet (UV) excitation have been reported, including orthosilicates, akermanites, aluminates, sulfides, molybdates, oxynitrides/nitrides, and so on[1].

Optical transitions of divalent europium  $4f^7$  have been investigated in many silicate phosphors. The spectra of  $\text{Eu}^{2+}$  doped compounds are due to electric dipole  $4f^7 - 4f^65d$  transitions which are parity-allowed so that they occur with high transition probabilities. The  $\text{Eu}^{2+}$  emission color varies from UV to red depending on the host lattice, covalency, the size of the cation, and the strength of the crystal field. Researchers are taking interest in development of phosphors like  $\text{Li}_2\text{CaSiO}_4$ ,  $\text{Li}_2\text{BaSiO}_4$ , and  $\text{Li}_2\text{MgSiO}_4$ .

### II. Experimental

In present work  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Eu}^{2+}$  and  $\text{Li}_2\text{BaSiO}_4$ :  $\text{Ce}^{3+}$  phosphors are prepared through solid state reaction. Initially,  $\text{BaSiO}_3$ : $\text{Eu}$  (2%)/ $\text{Ce}$ (1%) was precipitated from aqueous solution of Barium nitrate by slowly adding  $\text{Na}_2\text{SiO}_3$  solution. The precipitate formed was filtered, dried and then annealed in air at 700 C for 1 hour.  $\text{Li}_2\text{BaSiO}_4$  was prepared by heating  $\text{BaSiO}_3$  with  $\text{Li}_2\text{CO}_3$  at 700 C for 12 hours. The obtained phosphor is reduced at 800 C for 1 hr.

### III. Results And Discussion

Fig1. shows the XRD pattern of  $\text{Li}_2\text{BaSiO}_4$ , which excellently matched with that reported by Kulshreshtha et al [2] and the data calculated by He et al [3], indicating that the compound crystallizes in the hexagonal structure (P63cm,  $a = 8.1 \text{ \AA}$ ,  $c = 10.6$ ,  $Z = 6$ ). Fig.2, shows the hexagonal crystal structure of  $\text{Li}_2\text{BaSiO}_4$ .

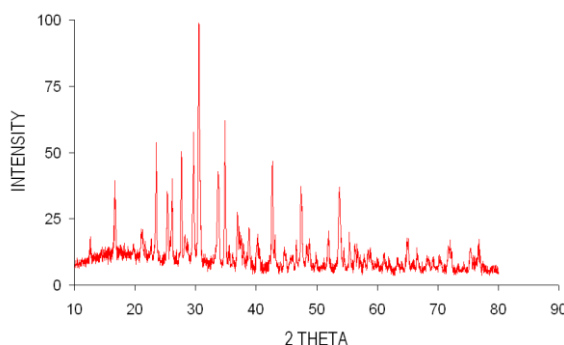


Figure 1: XRD pattern of  $\text{Li}_2\text{BaSiO}_4$

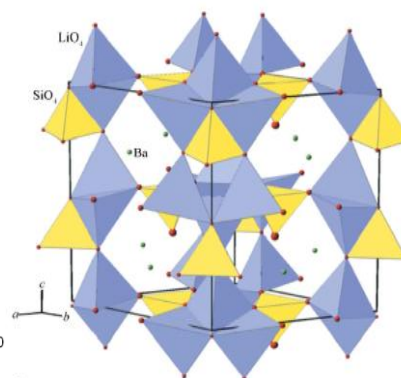
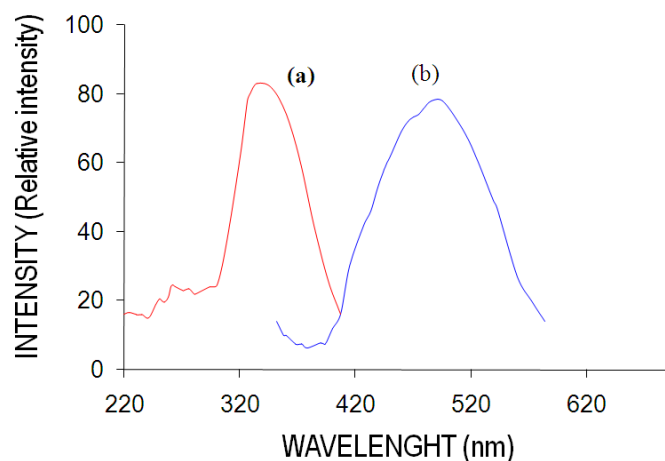


Figure 2: Hexagonal structure of  $\text{Li}_2\text{BaSiO}_4$

Photoluminescence spectra are studied. In photoluminescence spectra of  $\text{Li}_2\text{BaSiO}_4$ : $\text{Eu}^{2+}$  emission spectrum is obtained at 495 nm at excitation 335 nm (Fig.3). The intense bluish green emission is obtained. Both

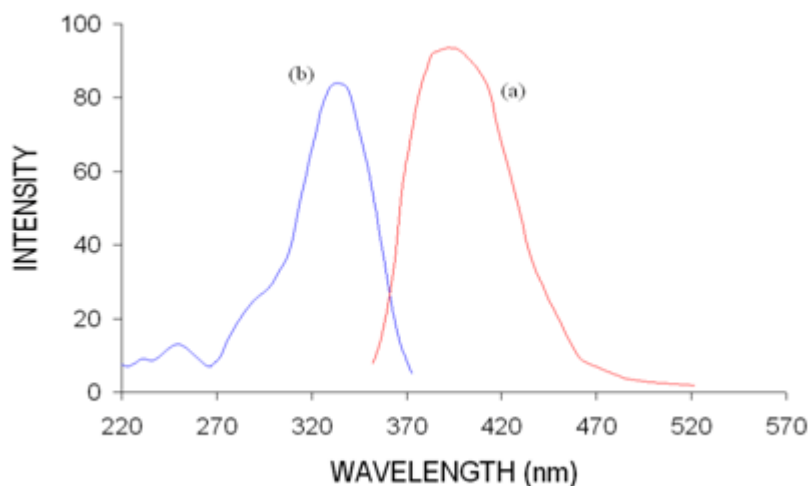
the emission

and excitation bands can be assigned to the well-known  $\text{Eu}^{2+}$  transitions between the ground state  $8S_{7/2}$  ( $4f^7$ ) and the excited states of  $4f^65d1$  configuration. As the position of the band corresponding to  $4f^65d$  configuration is strongly influenced by the host, the emission can be anywhere from 365 nm to 650 nm. Baginskiy et al [4]. Weak long after glow emission is obtained, which is not measured. Hence given phosphor may possess the characteristics of thermoluminescence. This phosphor maybe used in light emitting diode



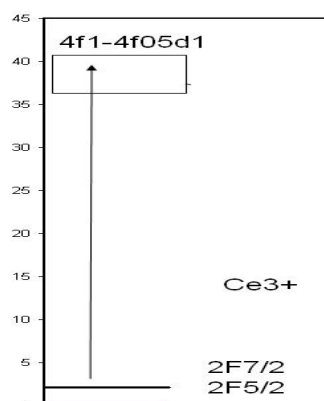
**Figure 3:** Photoluminescence (PL) spectra of  $\text{Li}_2\text{BaSiO}_4$ . (a)  $\text{Eu}^{2+}$  emission for 335 nm excitation (b)  $\text{Eu}^{2+}$  excitation for 495 nm emission

The photoluminescence spectra of  $\text{Li}_2\text{BaSiO}_4:\text{Ce}^{3+}$  is also studied. Fig.4, shows the PL spectra of  $\text{Li}_2\text{BaSiO}_4:\text{Ce}$ . The peak of emission spectrum is observed at 392 nm at excitation of 330 nm. PL spectra of  $\text{Ce}^{3+}$  can be conveniently discussed in terms of the scheme used by Dorenbos[5,6,7]. The  $\text{Ce}^{3+}$  ion has, from a spectroscopic point of view, a very simple electron configuration in the ground and excited state:  $4f^1$  and  $5d^1$ , respectively. The  $4f^1$  state is split by spin-orbit coupling into a doublet ( $2F_{5/2}$ ,  $2F_{7/2}$ ) with an energy difference of  $2000 \text{ cm}^{-1}$ . The  $5d^1$  state is split by the crystal field into several components with an averaged total splitting of some  $10000 \text{ cm}^{-1}$ . The emission consists of a transition from the lowest crystal-field component of the  $5d^1$  state to the ground state. The emission band has two maxima due to the spin-orbit splitting of the ground state. The spin-orbit split  $2D_{3/2}$  and  $2D_{5/2}$  states of the  $5d$  configuration of free  $\text{Ce}^{3+}$  are located at  $49700$  and  $52100 \text{ cm}^{-1}$  above the  $4f^1$  ( $2F_{5/2}$ ) ground state of  $\text{Ce}^{3+}$ . When  $\text{Ce}^{3+}$  is introduced in a compound the average energy of the  $5d$  configuration is lowered and the  $2D_{3/2}$  and  $2D_{5/2}$  states are further split by the crystal field. Depending on the site symmetry at most five distinct  $5d$  states may form.



**Figure 4:** Photoluminescence (PL) spectra of  $\text{Li}_2\text{BaSiO}_4:\text{Ce}$ : (a)  $\text{Ce}$  emission for 392 nm excitation (b)  $\text{Ce}$  excitation for 330 nm emission

The energy difference between the maxima of the highest and lowest 5d band in spectra is defined as the total crystal field splitting (cfs). The energy shift of the average of the 5d configuration is defined as the centroid shift (c).



**Figure 5:** Transition in  $\text{Ce}^{3+}$

#### IV. Conclusion

Photoluminescence spectra are studied. In  $\text{Li}_2\text{BaSiO}_4:\text{Eu}^{2+}$ , emission peak is observed at 495 nm at excitation 335 nm. The intense bluish green emission is obtained. Weak long after glow emission is obtained, which is not measured. Hence given phosphor may possess the characteristics of thermoluminescence. This phosphor maybe used in light emitting diode. In  $\text{Li}_2\text{BaSiO}_4:\text{Ce}^{3+}$  emission peak of spectrum is observed at 392 nm at excitation of 330

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