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Studies on Thermoluminescence (TL) from $BaAl_2O_4$: Dy phosphor

Mohammad Ziyauddin[1*], Nameeta Brahme[2], D. P. Bisen[3], R.S. Kher[4]

[1]Professional Institute of Engineering & Technology, Raipur, Chhattisgarh, India.
[2]S.O.S. in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, India.
3S.O.S. in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, India.
4Govt. E. R. R .P. G. Science College, Bilaspur, Chhattisgarh, India.

Abstract

Dy doped Barium Aluminate phosphors were synthesized by combustion method using urea as a fuel at initiating temperature of 600˚c. The Thermoluminescence of BaAl2O4: Dy phosphor has been investigated for UV irradiation and it is seen that TL intensity increases with increasing UV dose and attains a maximum for 15 min. irradiation time and it seems to be saturated for higher irradiation time.

Keywords: Combustion synthesis, Thermoluminescence (TL), Barium Aluminate.

1. INTRODUCTION

It has been a long history since people begun to study the phosphorescent materials. However, conventional phosphorescent materials such as ZnS:Cu can hardly have bright and long afterglow time for the application. The rare earth-activated alkaline earth aluminates are an important class of phosphorescence materials because of their high quantum efficiency in visible region [1], long persistence of phosphorescence, color purity, good stability and good chemical, thermal and radiation resistance [2-3].
Thermoluminescence is the emission of light from an insulator or semiconductor when they are thermally stimulated following the previous absorption of energy from radiation [4]. It is very important and convenient method of investigating the nature of traps and trapping level in crystals [5].

The synthesis of oxide phosphors has been achieved by a variety of routes. Combustion process is very simple, safe, energy saving and takes only a few minutes. The method makes use of the heat energy liberated by the redox exothermic reaction at a relative low igniting temperature between metal nitrates and urea as fuel. It was found that the $BaAl_2O_4$:Dy prepared at initiating temperature 600°C exists as a single phase monoclinic structure [6]. In this paper we have reported the TL behavior of Dy-doped $BaAl_2O_4$ prepared by combustion synthesis at initiating temperature of 600° C.

2. EXPERIMENTAL

Analytical grade barium nitrate $Ba(NO_3)_2$, aluminum nitrate $Al(NO_3)_3.9H_2O$, Disposium oxide Dy_2O_3 and urea $CO(NH_2)_2$ were used as the staring materials. The starting materials are weighted according to the stoichiometry. First of all Dy_2O_3 is converted into $Dy(NO_3)_3$ by mixing Dy_2O_3 into 2 ml of dil. HNO_3. Then weighed quantities of each nitrate and urea were mixed together and crushed into mortar for 1 hour to form a thick paste. The resulting paste is transferred to crucible and introduced into a vertical cylindrical muffle furnace maintained at 600°C initiating temperatures. Initially the mixture boils and undergoes dehydration followed by decomposition with the evolution of large amount of gases. The process being highly exothermic continues and the spontaneous ignition occurs. The solution underwent smoldering combustion with enormous swelling, producing white foamy and voluminous ash. The flame temperature, as high as 1400 - 1600 °C, converts the vapor phase oxides into mixed aluminates. The foamy product can easily be milled to obtain the precursor powder. Absorption spectra was recorded using

* Corresponding author: khan_mz2000@yahoo.com
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Shimadzu UV-1700 UV-Visible spectro-photometer. For recording TL glow curve TLD 1009I Nucleonix setup was used.

3. RESULTS AND DISCUSSIONS

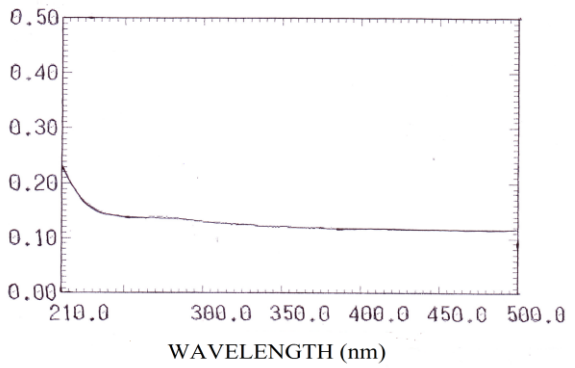

Fig.1: Absorption spectra of $BaAl_2O_4$ having absorption edge at 230 nm

The study of optical absorption is important to understand the behavior of crystal. A fundamental property is the band gap, the energy separation between the filled valence band and the empty conduction band. Optical excitation of electron across the band gap is strongly allowed, producing an abrupt increase in absorption at the wavelength corresponding to the band gap energy. This feature in the optical spectrum is known as the optical absorption edge. Fig (1) Shows the optical absorption spectra of $BaAl_2O_4$:Dy in the range of 210 nm-500 nm. It can be seen that the spectra is featureless and no absorption occur for wavelength $\lambda > 390$ nm (visible). The optical absorption edge was found at $\lambda = 230$ nm. The band gap was calculated corresponding to absorption edge (230 nm). The band gap Eg was found to be 5.40 eV.

The variation in TL intensity with different UV exposure time is shown in figure 2. Dy doped barium aluminate was prepared by combustion synthesis which was irradiated with UV-ray. The TL properties of Dy doped barium aluminate phosphor has been investigated for UV irradiation and it is seen that TL intensity increases with increasing UV dose and attains a maximum for 10 min irradiation time (fig. 3) and it seems to be saturated for higher irradiation time.

The TL intensity increases with increase in UV dose due to increase in colour centres with irradiation dose and after that it is saturated because of saturation in colour centres at higher UV dose. Single peak at 120.8^{0}C has been observed. TL spectra shows intense peak around 440 nm which shows Eu^{2+} emission figure 4. The order of kinetics and the activation energy of glow curve with irradiation time 10 min was found using Chen's empirical formulae [7].

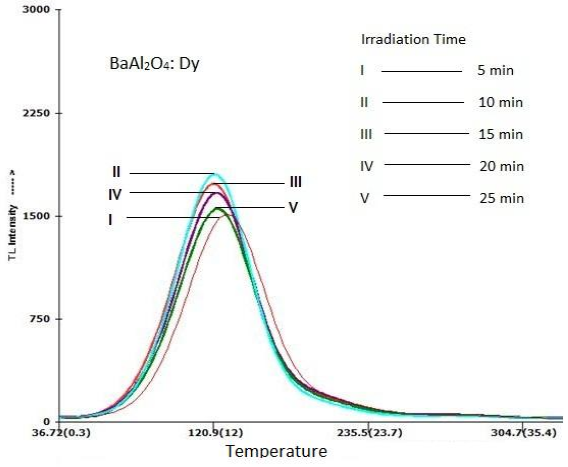

Fig.2: Intensity vs temperature plot for different time of irradiation

Theoretically the form factor μ_g is found using formula $\mu_g = (T_2-T_m)/(T_2-T_1)$. Where, Tm is the peak temperature at the maximum and T1 and T2 are respectively, the temperatures on either side of Tm, corresponding to half intensity. Using the value of T_m, T_1 and T_2 from the experimentally obtained maximum TL glow curve in Fig.(3) the form factor of $BaAl_2O_4$:Eu is found 0.47, which shows first order kinetics in it.

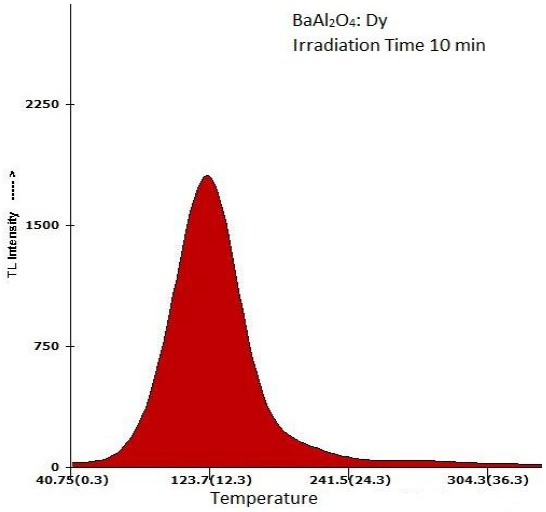

Fig.3: Maximum TL peak of $BaAl_2O_4$: Dy for 10 min exposure time

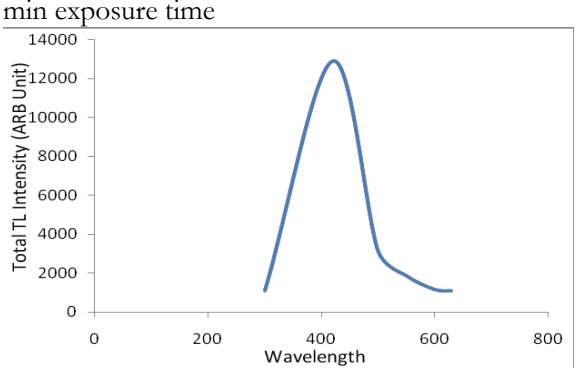

Fig.4: TL spectra of UV irradiated Dy doped $BaAl_2O_4$.

The calculation of Activation Energy and other parameters for irradiation time 10 min have been summarized in table 1.

Im = 1806.32, Tm = 123

Half width towards rising end: $\tau = Tm - T1 = 31.96$

Half width towards fall off end: $\delta = T2 - Tm = 29.3$

Total half width $\omega = T2 - T1 = 61.26$

Table 1

T_m	Order of Kinetics (μ_g) $= \delta/\omega$	Activation energy(eV)			
396.15K	Symmetry Factor	E_δ	E_τ	E_ω	E_{av}
	0.478289	0.63	0.58	0.61	0.60

2.0 CONCLUSION

Dy doped barium aluminate was prepared by combustion synthesis which was irradiated with UV-ray. The TL properties of Dy doped barium aluminate phosphor has been investigated for UV irradiation and it is seen that TL intensity increases with increasing UV dose and attains a maximum for 15 min irradiation time and it seems to be saturated for higher irradiation time. The TL intensity increases with increase in UV dose due to increase in colour centres with irradiation dose and after that it is saturated because of saturation in colour centres at higher UV dose. Single TL glow peak at 120 ^{0}C has been observed. The absorption spectra show the absorption edge at λ = 235nm, thus the band gap energy was found to be 5.28 eV.

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