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Thermoluminescence (TL) properties of rare-earth doped $BaMgAl_{10}O_{17}$ phosphor

A. P. Zambare, S. D. Kadlag[1], S. K. Thorat[1] and K. V. R. Murthy[2]
Department of Physics, Agasti Arts, Commerce & Dadasaheb Rupwate Science College, Akole
Tal- Akole, Dist- Ahmednagar, Pin – 422 601.(M.S.)
E-mail-avinashzambare2003@yahoo.co.in
[1] Department of Physics, Adv. M. N. Deshumkh Arts, Science and Commerce College, Rajur
Tal- Akole, Dist- Ahmednagar, Pin – 422 605.(M.S.)
[2] Applied Physics Department, Faculty of Tech. & Engg. ,Kalabhavan, Baroda –1
E-mail-drmurthykvr@yahoo.com

Abstract :

Thermoluminescence properties of some rare-earth elements doped $BaMgAl_{10}O_{17}$ (BAM) phosphor with Co^{60} gamma irradiated (1KGy) were investigated. The $BaMgAl_{10}O_{17}$:Eu phosphor exhibits two well defined peaks at 180°C and 330°C. But Ce doped BaMg- aluminate exhibits three peaks at 140, 230 and 330 °C. In $BaMgAl_{10}O_{17}$:Nd phosphor, two well defined peaks at 155°C and 330°C are observed. While same aluminate doped with Pr exhibits two well isolated peaks are at 170 and 330°C. The double doped double doped Ce: Eu exhibits peaks at 170 and 340°C but Ce:Nd doped BAM exhibits 170 and 330°C peak, while Ce:Pr doped BAM exhibits 170 and 340°C peaks. These changes are may be due to electronic charges and sizes of the added impurity ions.

Key worlds: Dosimetry, aluminates, phosphor, peak, gamma.

1.Introduction :

Thermoluminescence radiation dosimetry (TLD) is a very good area of research in luminescence field. Many researchers have done tremendous work in this field to establish new TLD phosphors[1-2]. The well-known phosphors developed are $LaPO_4$: Ce , $LaPO_4$: Tb, NaCl: Tb, NaCl: Ca, $CaSO_4$:Dy, and aluminates in mono-, di and tri-valent doped forms[3]. In this work, TL-properties of $BaMgAl_{10}O_{17}$ doped with rare-earth impurities have been examined in order to investigate the effect of impurities on TL- behavior of BaMg-aluminates and to find out the best peak (and dopant) suitable for dosimetric application.

2.Experimental:

$BaMgAl_{10}O_{17}$ doped with rare-earth impurities have been prepared by solid state reaction [4]. The appropriate oxides were thoroughly ground and fired at 1200°C for four hours. The specimens thus obtained have been characterized through standard XRD technique. Thermally stimulated luminescence glow curves were recorded at room temperature by using standard experimental set-up described elsewhere [5]. Phosphor under the examination were irradiated upto 10 KGy Gamma dose.

3.Result and Discussions:

Figure exhibits the TL glow curves observed in rare-earth impurities activated $BaMgAl_{10}O_{17}$ phosphors under influence of standard gamma dose 1 kGy (High Dose). The speed of X-Y recorder was 1 mV/cm. The main glow peaks exhibit by the phosphors at 300°C /min heating rate. Are shown in Figure 1.

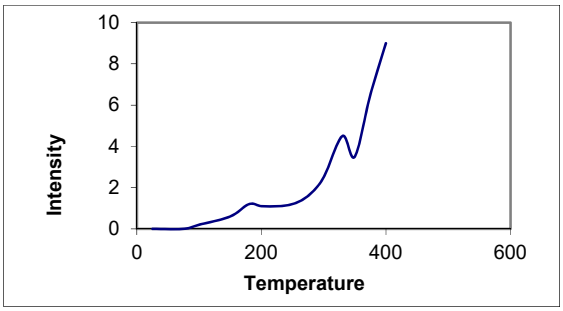

Figure1: TL glow curve of $BaMgAl_{10}O_{17}$:Eu - γ dose 1 kGy

it is seen that Eu doped BaMg- aluminate phosphor irradiated at 1 KGy exhibits two well isolated peaks at 180°C and 330°C. The peak at 180°C is more intense than 330°C peak. The TL-glow curve of $BaMgAl_{10}O_{17}$: Ce after exposure to 1 KGy dose are presented in figure 2.

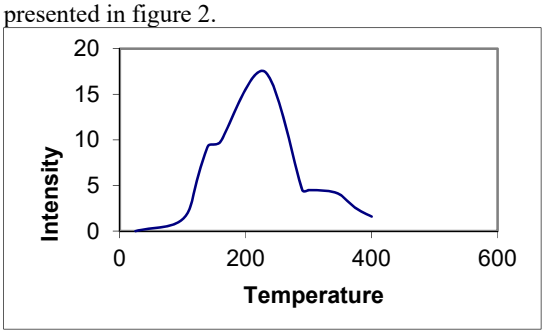

Figure 2 TL glow curve of $BaMgAl_{10}O_{17}$:Ce - γ dose 1kGy

It exhibits three peaks are at 140, 230 and 330°C. The peak 180°C is more intense than 140 and 330°C peaks. Figure3 shows that Nd doped $BaMgAl_{10}O_{17}$ phosphor irradiated at 1 kGy exhibits two well isolated peaks at 155°C and 330°C. The peak 155°C

is broad and more intense than 330ºC peak. The Pr doped with Barium Magnesium aluminate represents two single isolated peaks at 170 and 330ºC as shown in figure 4.

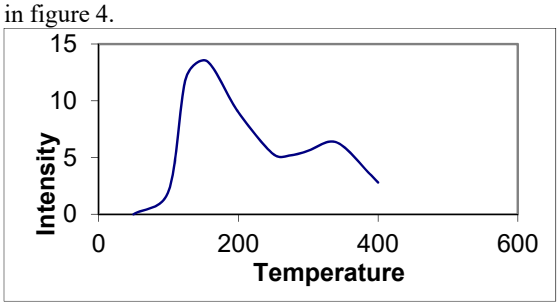

Figure 3 TL glow curve of $BaMgAl_{10}O_{17}$:Nd - γ dose 1 kGy

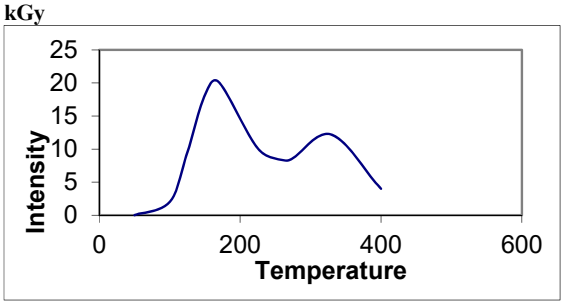

Figure 4. TL glow curve of $BaMgAl_{10}O_{17}$:Pr - γ dose 1 kGy

Figure 5 shows the TL glow curve of double doped Ce: Eu, which exhibits 170 and 340ºC But Ce: Nd phosphor reveals two prominent peaks at 170 and 330ºC (figure 6).

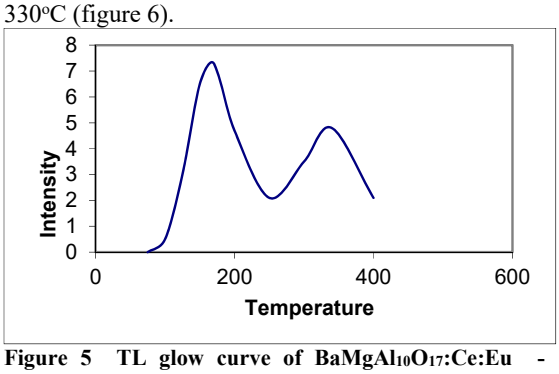

Figure 5 TL glow curve of $BaMgAl_{10}O_{17}$:Ce:Eu - γ dose 1K Gy

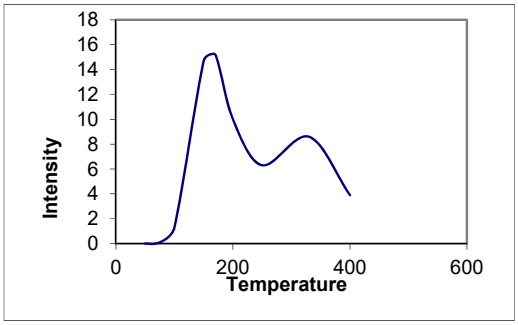

Figure 6. TL glow curve of $BaMgAl_{10}O_{17}$:Ce:Nd - γ dose 1k Gy

Due to double doping of Ce:Eu, 330ºC peak is suppressed as compared to 170ºC peak and in Ce: Nd doped 155ºC peak is totally suppressed and 170 ºC peak is observed. Ce:Pr doped sample also shows170 and 340ºC peaks as presented in figure 7.

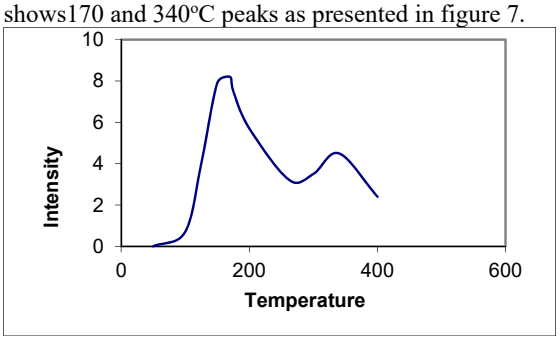

Figure 7. TL glow curve of $BaMgAl_{10}O_{17}$:Ce:Pr - γ dose 1k Gy

The effects of gamma rays (γ dose 1 kGy) on the TL behavior of RE activated barium magnesium aluminate have been examined under identical experimental conditions. The trap parameters viz.: activation energy or trap depth (E), frequency factor (S) were determined by different heating rates method, while order of kinetics were determined by peak shape method for the prominent peak and are given in Table 1

Table 1 Trap parameters

Sample	Peak Temp (ºC)	Activation energy (E) (eV)	Frequency Factor (s) Sec^{-1}	Order of Kinetics 1st order	Order of Kinetics 2nd order	Probability □□Sec^{-1}
$BaMgAl_{10}O_{17}$: Eu	180	1.12	$9.04x10^{11}$	-	0.42	0.343
$BaMgAl_{10}O_{17}$:Ce	230	1.3	$3.1x10^{12}$	0.2	-	0.295
$BaMGAl_{10}O_{17}$: Nd	155	0.995	$1.6x10^{11}$	-	0.65	0.31
$BaMgAl_{10}O_{17}$: Pr	170	1.3	$0.23x10^{15}$	-	0.55	0.368
$BaMgAl_{10}O_{17}$:Ce,Eu	170	1.0	$o.69x10^{11}$	-	0.54	0.296
$BaMGAl_{10}O_{17}$:Ce,Nd	170	1.0	$0.69x10^{11}$	-	0.53	0.296
$BaMgAl_{10}O_{17}$:Ce,Pr	170	1.0	$0.69x10^{11}$	-	0.52	0.296

The order of kinetics is determined by peak shape method. This experimentally observed changes in TL properties of BaMg-aluminates can be explained on the basis of change in micro-electrical and mechanical fields in host lattice created due to differences in charge and sizes of impurities introduced in BaMg-aluminates. It is believed that the peak around 443ºC in doped BaMg-aluminates is isolated, well defined and intense one, therefore it may be useful in TL- dosimetry. Detailed and systematic dosimetric studies may strengthen the utility of these phosphors in radiation dosimetry.

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