International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Thermoluminescence Properties Of Doped Lithium Tetraborate Phosphor

[1]Th. Ranjan Singh, [2]L. Ragumani Singh and [3]S. Nabadwip Singh*

[1]Department of Physics, Moirang College, Moirang

[2]Department of Physics, D.M. College of Science, Imphal

[3]Department of Physics, Oriental College, Takyel, Imphal

ABSTRACT

Lithium tetraborate doped with Cu, Ag and P phosphors were prepared by sintering technique with different concentration levels of the activators. The glow curves of the phosphor with different heat treatment at the sintering temperature 800îC were measured. The TL output was found to be maximum for the heat treatment of 3hrs for both the concentration levels of 0.02wt% and 0.04wt%. The glow curves has been analysed by Computerised Glwo Curve deconvolution(CGCD) technique in the framework of kinetic formalism and Various Heating Rate (VHR) method. The activation energy in different techniques are in the range 0.83 to 1.46eV and frequency facors are in the range 10^8 *to* 10^{12} s^{-1}.

Key words: Trapping parameters, Activation energy, Frequency factor.

INTRODUCTION:

The process of Thermoluminescence (TL) during a thermal scan of a previously excited solid is probably one of the direct evidence of the existence of trapping levels [1]. The determination of the trapping parameters such as activation energy (E), frequency factor (s) and order of kinetic (b), relevant to the experimental TL glow curve is one important approach for analysing TL glow curves. A variety of methods for analysing TL glow curve has been developed and applied to obtain the trapping parameters of the glow peaks [2-4]. Though there exist several methods for decoding a glow curve and retrieved the desire parameters, Computerised Glow Curve Deconvolution (CGCD) may be thought of as the most rigorous method. CGCD is the fitting of TL glow curves consisting of one or more TL peaks, which is widely used in various area of TL studies and its well documented. [5-6]. The another method Various Heating Rate (VHR) is simple, rapid and reliable technique for extracting trapping parameter based on repeated measurements of a certain glow peak keeping all the parameters constants [7-8].

Lithium tetraborate $Li_2B_4O_7$ as its effective atomic number (7.39) is almost equal to that of human tissue (7.42) is consider the most perspective material for TL based radiation dosimeter [9]. This property has attracted attention of researcher in lithium tetraborate based TL dosimeter and has been basic foundation in research and applications for several decades [10-11]. In this paper sensitivity of doped lithium tetraborate at different sintering temperatures as concentration levels of dopants was studied. The spectroscopic investigation of the TL glow curves of the phosphor was carried out by VHR method using different heating rate and by CGCD in the framework of kinetic formalism.

MATERIALS AND METHODS:

$Li_2B_4O_7$ in powder from Merck Company was doped with Cu, Ag and P as activators by sintering method [12] at Thermoluminescence Dosimetry Laboratory, Thoubal College, Thoubal, Manipur. $CuCl_2$. $2H_2O$, Ag NO_3 and H_3PO_3 (analytical purity) was added to pure $Li_2B_4O_7$ first and then mixed with acetone.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

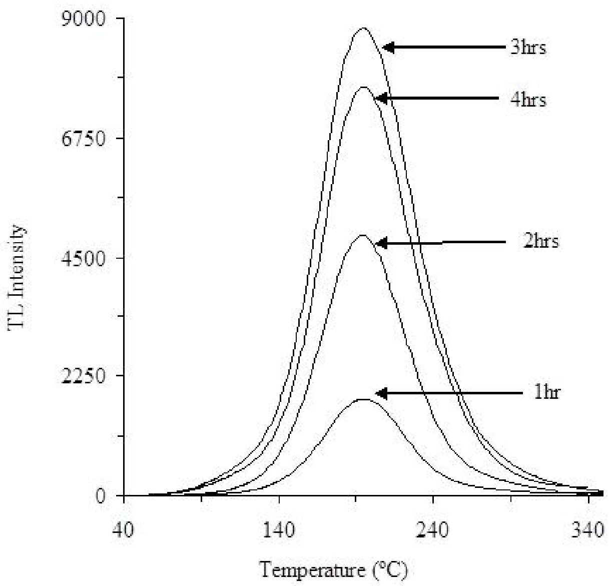

Figure 1: Glow curves of doped Lithium tetraborate with different duration of heat treatment at sintering temperature 800°C. (Heating rate = 2°C/sec)

The concentrations of Cu, Ag and P were 0.02 wt% in one case and 0.04 wt% in another case. The mixtures were homogenized by stirring for half an hour using a magnetic stirrer with hot plate. Afterwards acetone was allowed to evaporate at ambient temperature in the hot plate. Draying was completed in a laboratory oven at 100°C for 15 hrs. The samples were divided into four parts and each part were kept in a quartz crucible and sintered for different periods of time i.e., 1, 2, 3 and 4 hrs respectively at 800°C in a laboratory furnace in air. Then the samples were rapidly cooled down to room temperature and finally grounded to fine powder before annealed at 525°C for 30 min.

The samples which were exposed to heat treatment for 3hrs at 800°C were irradiated by γ-radiation from ^{60}Co-source at Life Science Department, Manipur University at higher doses and RIMS, Imphal at lower doses.

The TL glow curves of the samples were measured by using commercial TL Research Reader (Nucleonix Systems) at the Environmental Radiation Dosimetry Laboratory, Oriental College, Imphal. A second read out was performed to record the background radiation which included the black body radiations. The data presented were all with background subtraction. Different heating rates were used in the present analysis to which the low heating rates namely 0.5 and 1.0°C/sec were used for suitable correction of thermal lag.

RESULT AND DISCUSSION:

The TL glow curves of the sample for different heat treatments i.e., 1, 2, 3 & 4hrs at the sintering temperature 800°C for the concentration of 0.02wt% of the dopants Cu, Ag & P shows the same pattern of glow curves with TL peak at around 200°C (Figure 1). The same pattern also observed for the concentration of 0.04wt% of the activators. From the result of analysis it shows that the sensitivity of TL output for different duration of heat treatments and concentration levels of dopants is maximum for heat treatment of 3hrs and concentration levels of 0.02wt% in the present study.

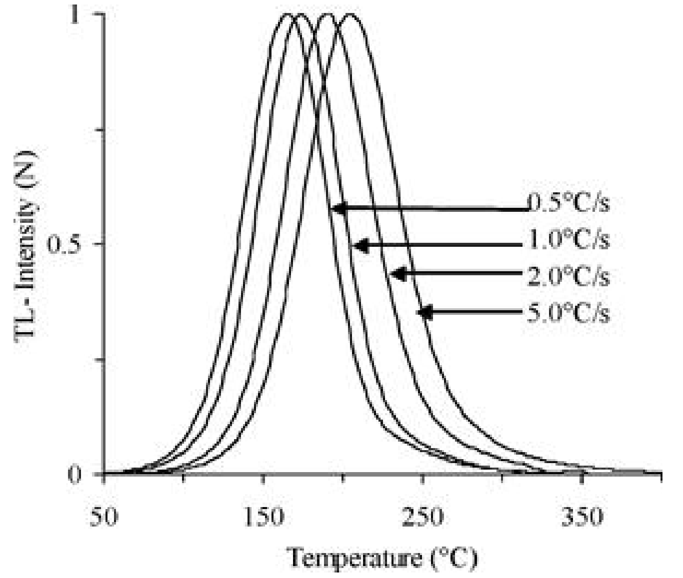

Figure 2: TL glow curves of lithium borate phosphor with different heating rates.

The TL glow curves of the phosphor with various heating rate are presented in figure 2. In all the cases, the same pattern of glow curves are observed with a systematic shifting of peak position from lower to higher temperature region as the heating rate increased. The graph of the TL peak height as a function of heating rate is presented in Figure 3.

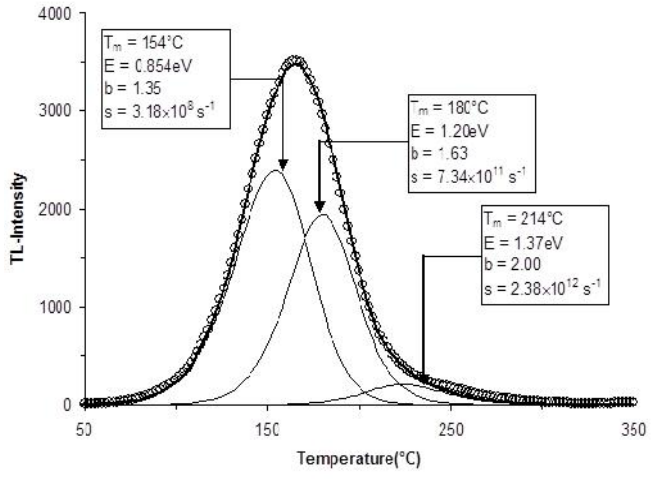

Figure 5: CGCD of lithium tetraborate phosphor for heating rate 0.5°C/sec.
°°°°°° Experimental Curve
——— Numerically generated curve.
– – Sum of the numerically generated best curves.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

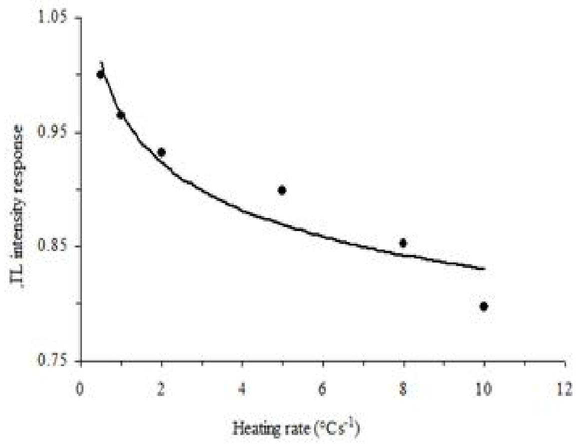

Figure 3: TL response as function of heating rate.

The experimental evidence of the reduction of the TL as a function of heating rate has been observed in many different materials [13-14]. The result of TL reduction with heating rate indicate that it suffer thermal quenching as glow peak shifts to higher temperature. The peak temperatures of the main glow peak for all the glow curves were determined by the minima of the second derivative plot of the curves. The plot of $ln\left(\frac{T_m^2}{\beta}\right) \sim \frac{1}{T_m}$ is shown in Figure 4 and trapping parameters i.e., activation energy and frequency factor calculated from the slope and intercepts are found to be 0.83eV and $1.09\times10^{8}s^{-1}$ respectively.

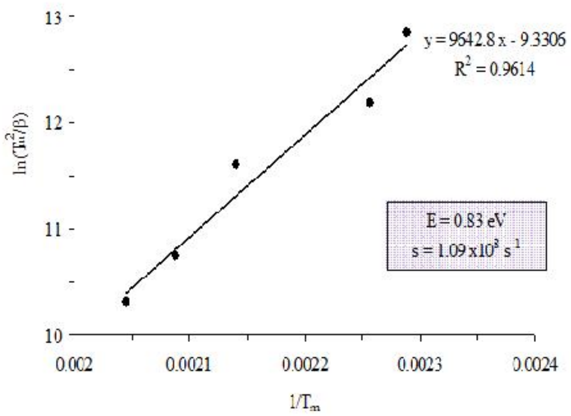

Figure 4: Plot of $ln\left(\frac{T_m^2}{\beta}\right) \sim \frac{1}{T_m}$. Inset: Values of E and s.

All the glow curves are subjected to CGCD within the frame work of kinetic formalism [15] after thermal correction. The glow curves can be deconvoluted to three constituent peaks and one of the fittings is shown in Figure 5. The trapping parameters obtain during the deconvolution of the curves with different heating rates are presented in Table 1. The outcome of the analysis shows that the key trapping parameters namely activation energy (E),

Table 1: Trapping parameter as obtained using CGCD of the glow curves with different heating rates. frequency factor (s) and order of kinetics (b) are in the physically realistic range.

Heating rate (°C/s)	Peaks	T_m (°C)	E (eV)	b	s (s^{-1})	FOM (%)
0.5	I	154	0.854	1.35	3.18×10^{8}	1.1
	II	180	1.200	1.63	7.34×10^{11}	
	III	214	1.370	2.00	2.38×10^{12}	
1.0	I	164	0.864	1.27	4.74×10^{8}	0.67
	II	190	1.300	1.95	9.46×10^{12}	
	III	250	1.460	2.00	6.03×10^{12}	
2.0	I	180	0.890	1.19	7.91×10^{8}	0.82
	II	210	1.300	1.80	4.54×10^{12}	
	III	259	1.410	2.0	2.34×10^{12}	
5.0	I	196	0.89	1.35	8.37×10^{8}	0.84
	II	226	1.300	1.99	3.86×10^{12}	
	III	282	1.460	2.00	4.70×10^{12}	

CONCLUSION:

TL glow curves of Lithium tetraborate doped with Cu, Ag and P follow non-first order kinetics. The activation energy of the main peak-170°C was found to be 0.83eV and frequency factor $1.09\times10^{8}s^{-1}$. When the glow curves are subjected by CGCD in the farme work of kinetic formalism, found that the glow curves can be deconvoluted into three constitutents peaks. The activation energy obtained by the deconvolution of the glow curves are in the range 0.85 to 1.46eV and frequency factor ~10^{8} to $10^{12}s^{-1}$.

ACKNOWLEDGMENT:

The authors are thankful to UGC, NERO for financial assistant in the form of Minor Research Project. The authors also thankful to Dr. A. Nabachandra Singh, Associate Prof. Depatment of Physics, Thoubal College, Thoubal for allowing the preparation of the sample in his laboratory “Thermoluminescence Dosimetry Laborator”, and Life Science Department, Manipur University and Radiotherapy Department, RIMS, Imphal for providing the facility of γ-irradiation.

One of the author Dr. S.Nabadwip Singh is grateful to AERB, Mumbai, for financial support in the form of a Research Project “Studies on levels and effects of natural radiation in the environment of different regions of Manipur”.

REFERENCE

[1] Braunlich, P., Kelly,P. and Fillered, J.P., 1979. Thermally Stimulated Relaxation in Soilds, ed. P. Braunlich (Springer-Verlag, berlin, 1979), p. 35.
[2] Booth, A.H., 1954. Calculation of Electron Trap Depths from TL Maxima, Cand. J. Chem. 32. pp 214.
[3] Bohn, A. 1954. Thermoemission and Photoemission Von Natrumchloride, Czech. J. Phys. 4. Pp. 91.
[4] Singh, L. L. and Gartia, R.K., 2013. Derivation of an expression for lifetime (τ) in OTOR model, Nucl. Inst. Methods B 308 21.
[5] Gartia, R.K. and Singh, S.D., 1993. Analysis of Peak V of LiF TLD-100 by Curve FittingPhys, Status Solidi, A 135, K83.

[6] Singh, A.N., Singh, S.N. and Singh, L.L., 2015. Analysis of thermoluminescence of $Li_2B_4O_7$:Cu, Ag, P phosphor by simplified General on Trap differential equation, Indian J. Phys, V89, 41-44.

[7] Hoogenstraaten, W., 1958. Electron traps in phosphors, Philips Res. Reps. 13 515.

[8] Gartia, R.K., Singh, O.B. & Sharma, B.A. Proceeding, NCLA-2005 (eds KVR Murthy and BN Lakshminarasappa, LSI Publication) p 359-362 (2005).

[9] Kotomi, Y., and Takeuchi, N., 1986. Thermoluminescence in Lithium Tetraborate doped with Activators, J. Mater, Sci. Lett. 5(1). Pp 51-53.

[10] Takenaga,M., Yamamoto, O. and Yamashita, T., 1980. Preparation and characteristics of $Li_2B_4O_7$: Cu phosphor, Nucl. Instru. Methods 175 77.

[11] Furetta, C., Prokic, M., Saomon, R., Prokic, V. and Kitis, G., 2001. Dosimetric characteristics of tissue equivalent thermoluminescent solid TL detectors based on lithium borate, Nucl. Instru. Methods A 456-411.

[12] Takenaga, M., Yamamoto, O., Yamashita, T., 1980 Preparation and characteristics of $Li_2B_4O_7$:Cu phosphor. Nucl Instrum Methods, 175, pp. 77 - 78.

[13] Kathuria, S.P. and Sunta, C.M., 1982. Orde of kinetics for thermoluminescence LiF TLD-100, J. Phys. D: Appl. Phys. 15 pp 497.

[14] Gartia, R.K., Singh, S.J. and Mazumdar, P.S., 1988. Symmetry Factor and Order of Kinetics in Thermally stimulated Luminescence, Phys. Stat. Sol. (a106. Pp291).

[15] Randall, J.T and Wilkins, M.H.F., 1998. A simple method to correct for temperature lag in TL glow curve measurements, J. Phys. D:Appl. Phys. 31, pp. 2065.