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# Effect of Dopants to the Thermoluminescence Glow Curves of Lithium Tetraborate

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Abstract— By sintering method  $Li_2B_4O_7$ :Cu, Ag, P,  $Li_2B_4O_7$ :Cu, La,  $Li_2B_4O_7$ :Cu, Ag, Eu and  $Li_2B_4O_7$ :Cu, Ag, P, Eu phosphors were prepared with the same concentration of dopants (0.02 wt %). The glow curves of these phosphors measure with the same heating rate 2°C/sec shows different patterns. The glow curve of  $Li_2B_4O_7$ :Cu, Ag, P phosphor shows a single peak system with the main peak at temperature 188 °C. The phosphor  $Li_2B_4O_7$ :Cu, La shows a multi peak system with main peak at 203.45°C and two shoulder peaks at 133.26°C and 310.4°C. The phosphors  $Li_2B_4O_7$ :Cu, Ag, P, Eu glows multi peak system with the main peaks at 109°C and 159°C and a shoulder peak at 230°C. The phosphor  $Li_2B_4O_7$ :Cu, Ag, P, Eu glows multi peak system with main peak at 100°C and 228°C. The main peak temperature of the phosphors change with the change of dopants and the phosphors with contain Eu gives the 110°C peak.

Keywords— Thermoluminescence, Glow curves, Spectroscopic, Computerised Glow Curve Deconvolution, Trapping Parameters.

## 1. INTRODUCTION

Lithium tetraborate is one of the potential candidate for thermoluminescence dosimetry as its effective atomic number ( $Z_{eff}$ =7.39), which is much closed to that of human tissue ( $Z_{eff}$ =4.2). The near tissue equivalent of lithium tetraborate has attracted attention of researcher in this phosphor based TL dosimeters and has been basic foundation in research and applications for several decades [1-3]. The sensitivity of lithium tetraborate change with dopants, so several investigators used various dopants for the improvements of the sensitivity of this phosphor.

The first TL materials based on lithium tetraborate activated by Mg ( $\text{Li}_2\text{B}_4\text{O}_7$ : Mn) been introduced in radiation dosimetry. However, this material gives poor sensitivity caused partly by the emission in the 600 nm region of the spectra, which is far from the ideal wavelength region for most commercial photomultipliers (~ 400 nm). Afterward different methods was developed but different activators gives rather different TL characteristic i.e., glow curves, sensitivity, linearity, etc. [4-5]. In order to provide the high parameters of dosimeters based on lithium tetraborate many workers has been worked on the doping of lithium tetraborate by Ce, Eu & Tm[6], Cu[7], Cu, K,A and Ga [8], Cu, Mn & Mg [9], etc. In the present work we carried out spectroscopic investigations of the Lithium tetraborate doped with Cu, Ag, P, Cu, La, Cu, Ag, Eu and Cu, Ag, P, Eu prepared by similar method with same concentration of the doping materials.



Fig. 1: TL glow curves of Lithium Tetraborate with different activators. (Heating rate = 2.0°C/sec)

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Figure 2: Computerised Glow curve deconvolution of the TL glow curves of Lithium Tetraborate.

## 2. EXPERIMENTS

The Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub>:Cu,Ag,P phosphors was prepared by sintering method [10] with the addition of CuCl<sub>2</sub>.2H<sub>2</sub>O, AgNO<sub>3</sub>, H<sub>3</sub>PO<sub>3</sub> (0.02 wt% each) to Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub> powder, Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub>:Cu,La phosphor was prepared by similar method with the addition of CuCl<sub>2</sub>.2H<sub>2</sub>O with 0.02 wt% and LaN<sub>2</sub>O<sub>3</sub>.6H<sub>2</sub>O with 0.04%, Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub>:Cu,Ag,Eu phosphor was prepared by similar method by the addition of CuCl<sub>2</sub>.2H<sub>2</sub>O,AgNO<sub>3</sub> and EuNO<sub>3</sub>.6H<sub>2</sub>O(0.02 wt% each) and Li<sub>2</sub>B<sub>4</sub>O<sub>7</sub>:Cu,Ag,P,Eu was prepared by the addition of CuCl<sub>2</sub>.2H<sub>2</sub>O,AgNO<sub>3</sub>, H<sub>3</sub>PO<sub>3</sub> and EuNO<sub>3</sub>.6H<sub>2</sub>O(0.02 wt% each). The mixtures were mixed with acetone then homogenized by stirring for ~30min using a magnetic stirrer with hot plate. Afterwards acetone was allowed to evaporate at ambient temperature in the hot plate. Drying was completed in a laboratory oven at 100°C for 15hrs. The dry powder were kept in a quartz crucible and sintered at 800°C for 3 hours and rapidly cool down to room temperature in air. The material was then grounded to fine powder and annealed at 525°C for 30 min.

The powder samples were exposed to  $\gamma$ -ray from <sup>60</sup>Co source at Radiotherapy Department, RIMS, Imphal. TL glow curves of the samples were measured at Environmental Radiation Dosimetry Laboratory, Oriental College, Imphal by using the commercial TL Reader Model 1900I (Nucleonix Systems Pvt. Lt. Hyderabad, India) at the heating rate 2.0°C/sec. A second readout was performed to record the background radiation which includes the black body radiation. The data presented are all with the background subtraction.

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| Material   | Glow Peak | Tm(°C) | E (eV) | b    | $s (sec^{-1})$        |
|--|-----------|--------|--------|------|-----------------------|
| Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> :Cu,Ag,P.    | Ι         | 180    | 0.89   | 1.19 | 7.91×10 <sup>8</sup>  |
|  | II        | 210    | 1.30   | 1.80 | 4.54×10 <sup>12</sup> |
|  | III       | 259    | 1.41   | 2.00 | 2.34×10 <sup>12</sup> |
| Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> :Cu,La.      | Ι         | 135    | 0.79   | 1.46 | 5.95×10 <sup>8</sup>  |
|  | II        | 201    | 0.90   | 1.42 | 3.6×10 <sup>8</sup>   |
|  | III       | 306    | 1.22   | 1.25 | 3.49×10 <sup>9</sup>  |
| Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> :Cu,Ag,Eu.   | Ι         | 109    | 0.88   | 1.05 | 6.43×10 <sup>10</sup> |
|  | II        | 162    | 0.88   | 1.10 | 1.9×10 <sup>9</sup>   |
|  | III       | 187    | 0.89   | 1.20 | 6.12×10 <sup>8</sup>  |
|  | IV        | 240    | 1.20   | 1.40 | $7.17 \times 10^{10}$ |
| Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> :Cu,Ag,P,Eu. | Ι         | 112    | 0.85   | 1.00 | $2.02 \times 10^{10}$ |
|  | II        | 163    | 0.92   | 1.20 | 5.40×10 <sup>9</sup>  |
|  | III       | 188    | 1.09   | 1.35 | 1.09×10 <sup>11</sup> |
|  | IV        | 232    | 1.20   | 1.90 | 1.10×10 <sup>11</sup> |

Table 1: Trapping parameters as obtained using CGCD of the glow curves of different phosphors.

### 3. RESULTS AND DISCUSSION

The TL glow curves of the different phosphors with same heating 2.0 C/sec are shown in Fig 1. The patter of the glow curves changed with the change of dopants. The glow curves of the phosphors which contain Cu, Ag, P shows single peak but other glow curves which contain rare earth elements shows multi peak systems. The phosphor which contain Eu shows 110°C peak but the intensity is decreased by the presence of P for this peak.

The glow curves are subjected to Computerized Glow Curve Deconvolution (CGCD) in the frame work of kinetic formalism [11]. The glow curves after deconvolution found that they essentially consist of a complex structure. The glow curves which are doped with Cu, Ag, P and Cu, La can be deconvoluted into three constituent peaks whereas those glow curves which consist of Eu can be deconvoluted in to four constituent peaks. The location of the glow peak temperatures are determined by the minima of the second derivative plot of the curves [12]. The results of the analysis are presented in Table 1. The outcome of the analysis shows that the traps are in the 0.79 eV to 1.1 eV and obey non first order kinetics. The realistic values frequency factor ~  $10^8$  to  $10^{12}$  s<sup>-1</sup> justify the deconvolution.

#### 4. CONCLUSION

The glow curves of the lithium tetraborate shows different shape with the change of dopants. But the activation energies of the constituents peaks for all the glow curves obtain by CGCD of the glow curves are almost similar and all the peaks also shows non first order kinetic. The result of the analysis shows that the formation of defect centre to lithium tetraborate phosphor by doping different impurity are different but the trap depth are almost similar.

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