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# Effects of annealing temperature on fading characteristics of $BaSO_4$: Dy, Mn phosphor

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**Abstract**
This study examines the effect of annealing on TL glow curve structure. For this, studies of $Ba_{0.92}SO_4:Dy_{0.04}Mn_{0.04}$ phosphor subjected to pre-irradiation high temperature treatment was carried out. Analysis of the TL glow curve indicated that there was drastic change in the glow curve structure of the phosphor annealed at high temperature. The TL peak at 401 K disappears, whereas the intensity of the other peaks increases with increase in the annealing temperature in the temperature range 873-1173 K. To test post-irradiation fading, the annealed samples were irradiated with gamma ray and stored at room temperature for 7- 10 days and TL glow curves were recorded everyday over these days.
Keywords TL, annealing, fading

## 1.INTRODUCTION

Investigation on the characteristics of the TL glow curve of different thermoluminescent phosphors, one come across decrease in TL intensity of a phosphor with the increase in storage time. Such a decrease in TL intensity is known as fading. Fading can be normal or anomalous. Normal fading have several causes, but the most prevalent one is thermal fading. Wide variation in fading characteristics of LiF:Mg, Ti demonstrates the complexity involved in characterizing a fading rate [1-3]. Fading rate depends on many factors like variations in annealing procedures, TLD handling and the type of radiation used. In the present study, the post-irradiation fading behaviour of the individual peaks of glow curves of $BaSO_4$:Dy, Mn phosphor annealed at different temperatures are measured at different time intervals. The samples are kept in a black box at room temperature and TL glow curves are recorded.

## 1.1 EXPERIMENTAL

$Ba_{1-x-y}SO_4:Dy_x$, $Mn_y$ (where $0 \leq x < 1$, $0 \leq y < 1$) phosphors were prepared by the chemical co-precipitation method. Barium chloride ($BaCl_2$. $2H_2O$), manganese chloride ($MnCl_2$. $4H_2O$) and dysprosium chloride ($DyCl_3$. $6H_2O$) are mixed and dissolved in deionised water and stirred with magnetic stirrer. Concentrated sulphuric acid ($H_2SO_4$) has been added drop wise until the formation of precipitate is completed. The precipitate settled at the bottom of the beaker has been collected and washed repeatedly in deionised water and dried in oven at 373 K for around 1 h. The acid traces present even after washing were also removed in drying the sample. The dried precipitate was ground to powder and sieved to get fine powders. The white polycrystalline powder thus formed is annealed at different temperatures.

## 1.2 RESULTS AND DISCUSSION

### 1.2.1 TL glow curves of $Ba_{0.92}SO_4:Dy_{0.04}$, $Mn_{0.04}$ phosphor annealed at different temperatures

Fig. 1 shows the TL glow curves of the phosphor annealed at 773, 973 and 1173 K in air for 2 h and irradiated with 600 Gy. The TL glow curve annealed at 773 K has three peaks at 376, 409 and 455 K. Further increasing of annealing temperature from 773-973 K causes an increase in the intensity of the TL peaks at 381 and 458 K by factors of 2 and 1.87 respectively. Moreover, when the sample is annealed at 773 K, the peak at 409 K is seen clearly but it does not show any response to γ-rays when annealed at 973 K and a peak in the higher temperature side at around 508 K starts appearing. When the sample is annealed at 1173 K, TL peaks at 382 and 458 K are suppressed, enhancing the peak at 504 K. The numbers of peaks present in the complex glow curve are found to be four i.e. at 376-382, 409, 452-458 and 504-508 K. Thus the TL glow curve structure as well as peak intensities undergo changes with increasing pre-irradiation annealing temperature.

Fig. 2 shows the TL glow curves of annealed at 873 K for different durations. It is clear from the figure that for different annealing periods the TL glow curve structure changes. For the annealing period of 2 h, the prominent peak is at 375 K but for the other annealing period, peak at around 409 K is more

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prominent. As the annealing period increases from 1-2 h, the TL intensity at 375 K increases without considerable changes for the other two peaks. For the annealing period of 3 h the TL intensity of all the peaks becomes very low. With further increasing the annealing period, the TL sensitivity becomes very high and a peak at 498 K appears.

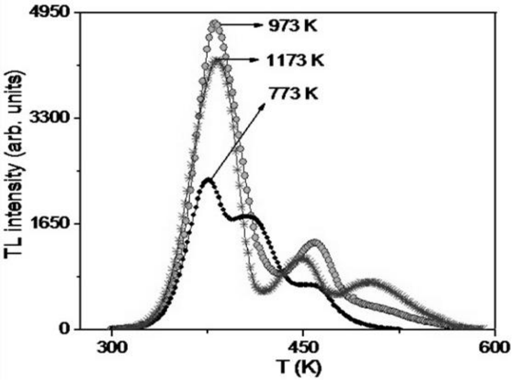


**Fig. 1:** TL glow curves of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ annealed at 773, 973 and 1173 K for 2 h and irradiated with 600 Gy of $\gamma$-rays ($\beta$ = 1.37 K $sec^{-1}$).

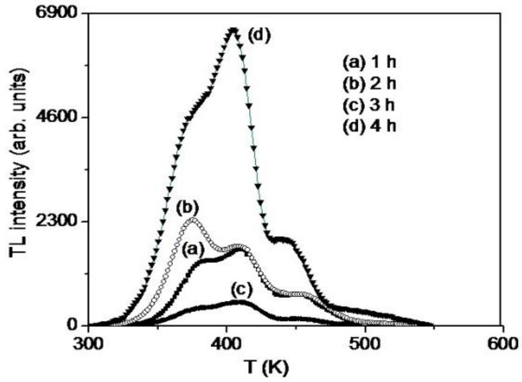


**Fig. 2**: TL glow curves of $BaSO_4$:Dy, Mn annealed at 773 K for different periods and irradiated with 600 Gy of $\gamma$-rays ($\beta$ = 1.37 K $sec^{-1}$).

1.2.2 Fading patterns of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ phosphor annealed at different temperatures

1.2.2.1 Fading of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ phosphor annealed at 773 K for 2 h

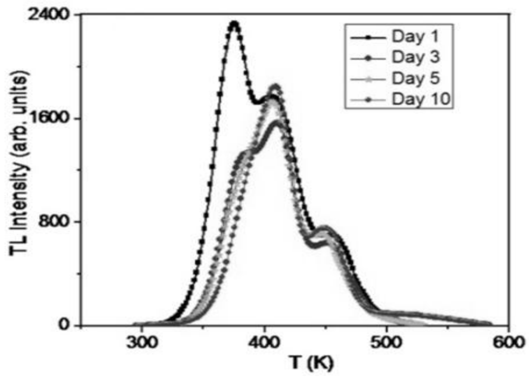


**Fig. 3**: Fading of TL glow curves of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ annealed at 773 K.

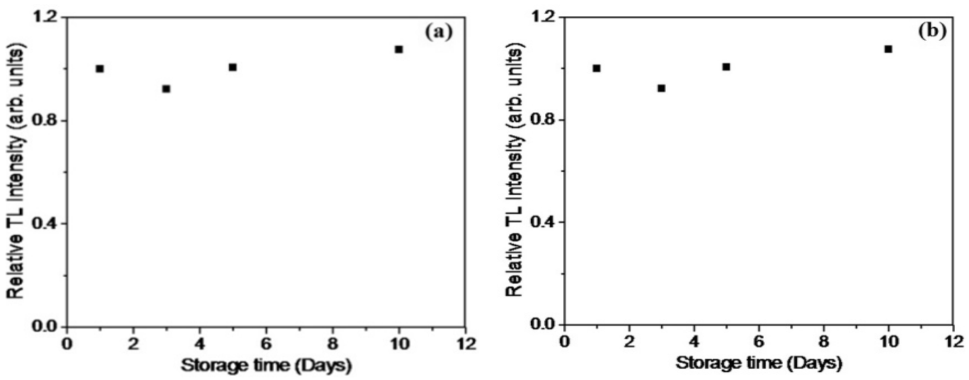


**Fig. 4**: Decay curve of TL peak at (a) 410, (b) 455 K of $BaSO_4$:Dy, Mn phosphor annealed at 773 K.

**Fig.** 3 shows the TL glow curves of $Ba_{0.92}SO_4:Dy_{0.04}$, $Mn_{0.04}$ recorded over storage of 10 days after annealing at 773 K and irradiating with $\gamma$-ray ($\beta$ = 3.17 K $sec^{-1}$). As shown in this figure, the TL glow curve structure changes significantly. Peak at 376 K faded very fast and almost completely faded in 10 days after irradiation. But the fading trends of the other two peaks at 409 and 455 K are similar but varied from the peak at 376 K. As shown in Fig. 4, the TL intensities of both the peaks decrease first over storage of three days, after that start increasing.

1.2.2.2 Fading of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ phosphor annealed at 873 K for 1 h

Over storage of 7 days TL glow curve structure of $Ba_{0.92}SO_4:Dy_{0.04}$, $Mn_{0.04}$ phosphor annealed at 873 K for 1 h does not change significantly, there is only difference in the fading pattern of the peaks. Fig. 5 shows the relative TL response versus storage time of the TL peak at 384 K. TL response decreases by 40% in seven days. But for the peak at 450 K, TL intensity increases by 13% after one day of irradiation, after which it starts decreasing (Fig. 5 (b)). The decrease in TL signal in 7 days is only 6%.

1.2.2.3 Fading of $Ba_{0.92}SO_4:Dy_{0.04}, Mn_{0.04}$ phosphor annealed at 973 K for 2 *h*

Fig. 6 shows the fading of TL glow curves of $Ba_{0.92}SO_4:Dy_{0.04}$ $Mn_{0.04}$ annealed at 973 K over storage of 7 days. There is no change in glow curve structure over these days, only the relative intensity changes. The fading trends of the peaks at 381 and 458 K are same. Relative TL intensities of these peaks increase by 6.5% and 16% on storing one day after irradiation, but starts decreasing after two days (Fig. 7 (a) and Fig. 7 (b)). On storage of 4 days relative TL intensity of the peak at 410 K decreases by 34%, after which the sensitivity of the peak does not significantly change. But the relative intensity of the peak at 450 K decreases by 17% over 3 days after irradiation, after that it shows no significant change.

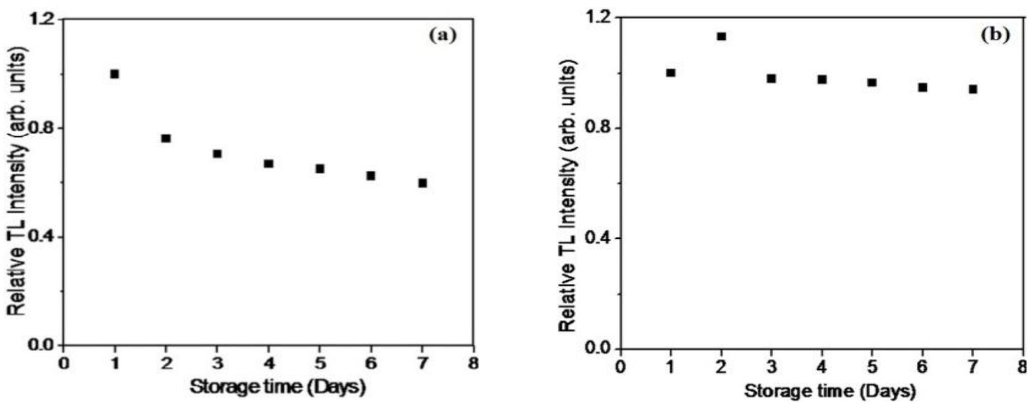


**Fig. 5**: Decay curve of TL peak at (a) 384, (b) 459 K of $BaSO_4$:Dy, Mn phosphor annealed at 873 K

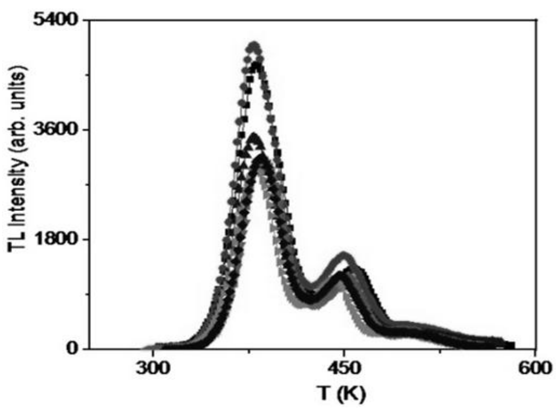


**Fig. 6:** Fading of TL glow curve of $Ba_{0.92}SO_4:Dy_{0.04}$, $Mn_{0.04}$ phosphor annealed at 973 K.

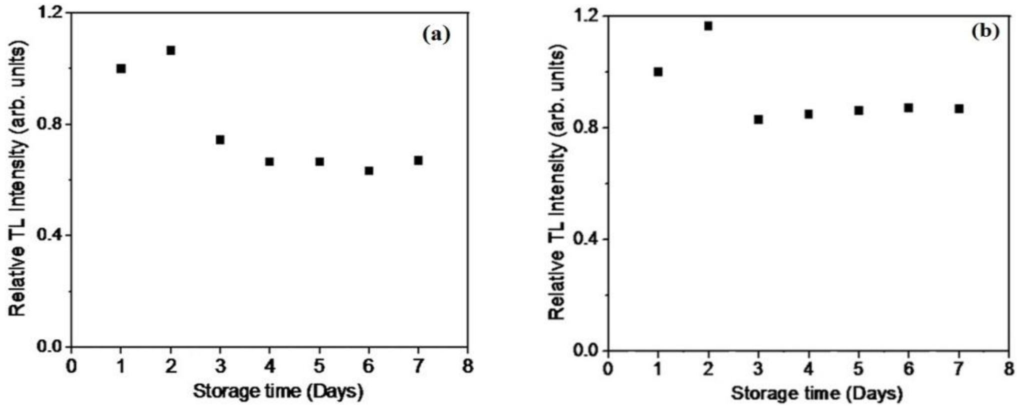


**Fig. 7**: Decay curve of TL peak at (a) 381, (b) 458 K of $Ba_{0.92}SO_4$:$Dy_{0.04}$, $Mn_{0.04}$ phosphor annealed at 973 K.

1.2.2.4 Fading of $Ba_{0.92}SO_4$:$Dy_{0.04}$, $Mn_{0.04}$ phosphor annealed at 1173 K for 2 h

Fig. 8 shows the fading of TL glow curve of $Ba_{0.92}SO_4$:$Dy_{0.04}$, $Mn_{0.04}$ annealed at 1173 K and irradiated with 600 Gy on storing at room temperature for 7 days. There is no significant change in the structure of TL glow curve, but shows a sizeable 28% loss in the TL response over the 7 days. There is slight difference in pattern of fading for the three peaks at 382,452 and 504 K. Fig. 8 (a) shows that the TL intensity of the peak at 382 K remains almost constant for 5 days after a significant loss in the TL response of 8% after the first day. On 6th and 7th day the TL response reduces by 12.4 and 13% respectively w.r.t that of first day. Fig. 8 (b) is the decay curve of the peak at 452 K. It shows that the total TL signal loss over 7 days is less than 10%. As shown in Fig. 8 (c) the peak at 504 K has loss TL response of 6.4% after two days. But after three days of storage TL response starts increasing. The overall loss of TL response of the peak over storage of 7 days is only 1.9%.

## 1.0 CONCLUSION

Glow curve structure of $Ba_{0.92}SO_4$:$Dy_{0.04}$, $Mn_{0.04}$ phosphor strongly depends on the pre-irradiation annealing temperature as well as annealing duration. Moreover fading depends on pre-irradiation annealing temperatures. Therefore, when preparing this dosimeter for use in different dosimetry applications, the proper annealing condition should be selected and applied to all the stages of the dosimetry cycles.

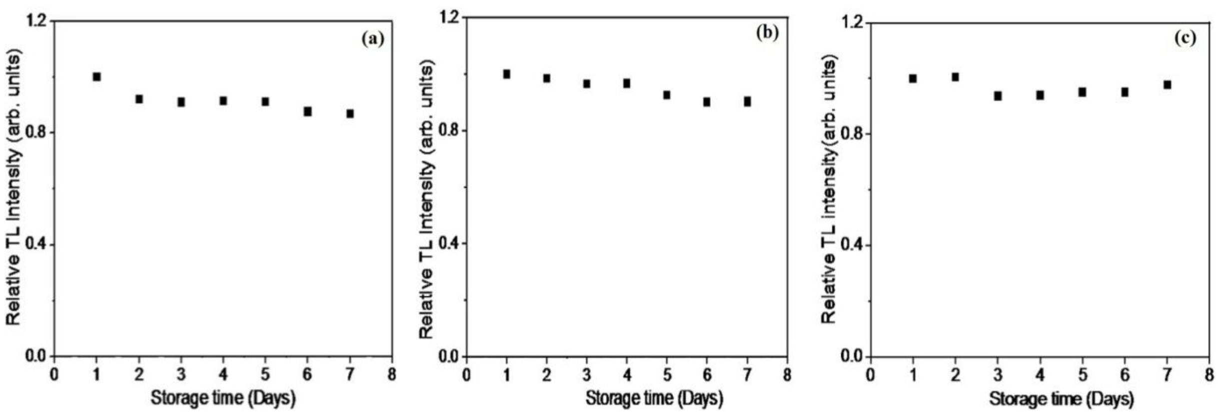


**Fig. 8**: Decay curve TL peak at (a) 382, (b) 452, (c) 504 K of $BaSO_4$:Dy, Mn phosphor annealed at 1173 K.

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