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STUDY ON THERMOLUMINESCENCE GLOW (TL) CURVES OF X- IRRADIATED $BaSO_4$: DY PHOSPHORS

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Abstract

The $BaSO_4$: Dy phosphors for different concentrations of Dy have been prepared by simple chemical route. TL glow curves of the X-irradiated $BaSO_4$: Dy phosphors have been recorded at room temperature. The observed TL glow curves of the phosphors show two sharp peaks at T_m =(375-383) K and Tm = (433-437) K. Also, TL glow curves of $BaSO_4$: Dy phosphor at a particular concentration of Dy irradiated with different doses of X-rays have been recorded. And trapping parameters of the glow curves were evaluated by CGCD technique. The study of the dose-response curves of the phosphors at a particular dopant concentration shows that $BaSO_4$: Dy may be used as dosimeters.

Key words: CGCD, Trapping parameters, Thermoluminescence(TL), X-irradiation

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Introduction

Thermoluminescence(TL) is a powerful technique for estimation of doses of high-energy ionizing radiations, as the energy absorbed during irradiation and the TL intensity on stimulation(heating) is proportional to the radiation flux(doses). [1] A number of commercially available thermoluminescent dosimeters are available for this purpose. [2,3] TL studies on $BaSO_4$ phosphor can find potential applications in personal and environmental dosimetry. [4] $BaSO_4$ doped with suitable impurities (Eu, P) can find an application as an X-ray storage phosphor due to its high TL sensitivity coupled with high atomic number, [5] There has been a constant need for high sensitivity TL dosimetry phosphor [6] and for increasing the sensitivity, a suitable dopant is needed. Further, Nagpal et al claimed that $BaSO_4$:Eu phosphor is more sensitive than $CaSO_4$:Dy phosphor. [7]

In the present study, Barium sulphate doped with different concentrations of Dy has been reported by simple chemical route.[8-12] The variation of TL glow curves of $BaSO_4$:Dy phosphors for different concentrations of Dy after X-ray irradiation have been recorded. TL glow curves of $BaSO_4$:Dy phosphor at a particular Dy concentration irradiated with different X-ray doses have also been recorded. The trapping parameters of the recorded TL glow curves of X-irradiated $BaSO_4$:Dy phosphors have also been evaluated and studied its applications.

Sample preparation

A R grade hydrated $BaCl_2.2H_2O$ was dissolved in distilled water with 0.26 mol AR grade anhydrous Dysprosium Chloride ($DyCl_3.6H_2O$) and the solution was stirred for 1h for homogeneity with the help of a magnetic stirrer. Conc H_2SO_4 was added drop by drop to the solution until the precipitation was completed. The ppt $BaSO_4$:Dy was collected and washed repeatedly with distilled water for removal of excess acid completely. The sample was kept in an oven for drying and then annealed at 870 K for 2 h and crushed into $BaSO_4$:Dy powdered form. Similarly, different samples of $BaSO_4$:Dy for different concentrations at 0.34, 0.19, 0.13 and 0.06 mol respectively were prepared.

Results and Discursions

The XRD patterns of as prepared $BaSO_4$:Dy samples recorded at RT is shown in Fig.1. All relatively sharp diffraction peaks can be perfectly indexed to the high purity and high crystallinity of $BaSO_4$. These diffracted peaks are in agreement with the standard JCPDS card for

$BaSO_4$ **(JCPDS card No. 24-1035**). The XRD pattern of $BaSO_4$: Dy fitted well shows the orthorhombic structure.

The TL glow curves of the same $BaSO_4$: Dy samples for different concentrations after iradiation with X-rays (say 2 h) have been recorded at RT at the same linear heating rate 2.23 $°CS^{-1}$ is shown in Fig. 2. Here, curves a, b, c, d and e show the TL glow curves of $BaSO_4$:Dy at different cons 0.06, 0.13, 0.19, 0.26 and 0.34 mol % of Dy respectively. In each TL glow curve, two prominent peaks are observed around Tm=(375-383) K and (433-437) K which show shifting lower temperature (towards lower side) side with increasing Dy concentrations.

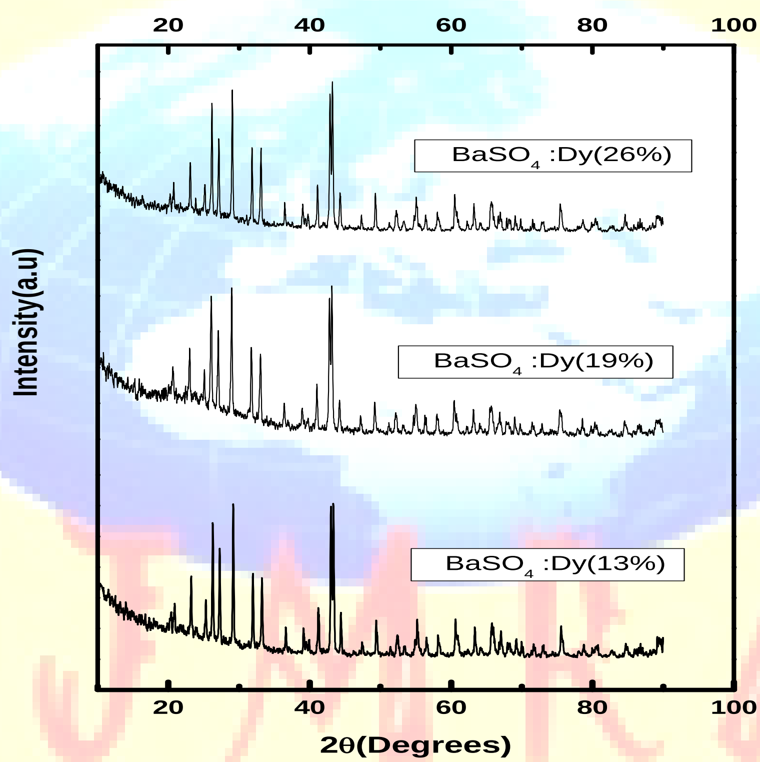


Fig.1. XRD patterns of $BaSO_4$:Dy samples

This may be due to change in relative populations of these traps at high Dy concentrations.[13] As expected, the TL intensity increases with the increase of Dy concentration. This indicates that the interaction between intrinsic defects and dopants increases strongly with the increase of the Dy concentration[4]. In other words, the increase in TL intensity with the increase of the Dy concentration may be expected that the number of defect atoms in the crystal increase with the increase of the Dy concentration within the saturation condition and consequently increases the number of recombination of the holes and the electrons when maximum TL is observed.

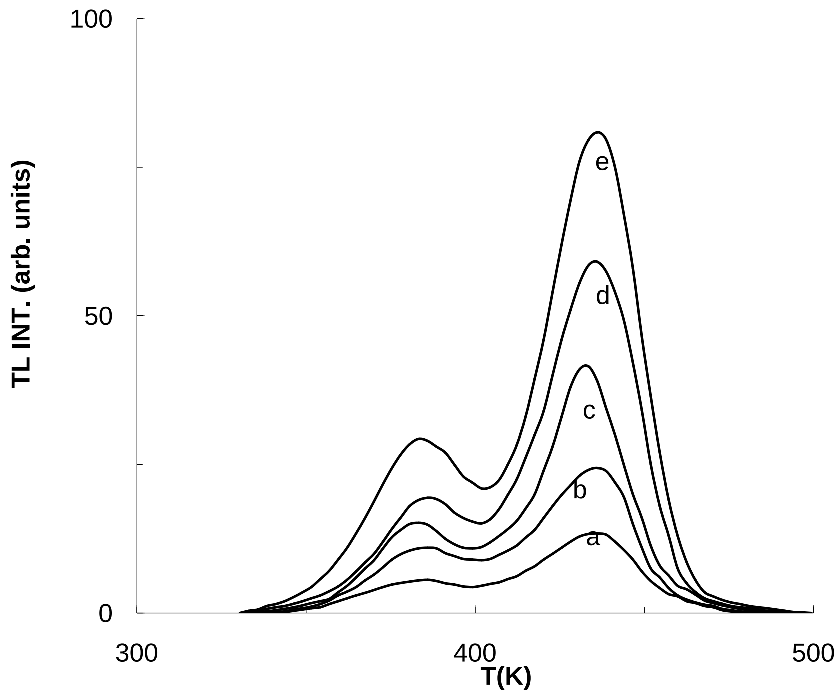


Fig. 2. **TL glow curves of X-irradiated $BaSO_4$:Dy for different concentrations of Dy**.

To investigate the dose response curve, the TL glow curves of $BaSO_4$:Dy for a particular dopant concentration (Dy = 0.26 mol% annealed at 870 K for 2 h) irradiated with different doses of X-rays have been recorded at a linear heating rate of 2.2°C S^{-1} (Fig.3). Here, curves a, b, c, d and e represent the TL glow curves of $BaSO_4$;Dy for different doses of X-rays of irradiation for 15, 30, 60, 120 and180 mins respectively. As expected, the TL intensity increases with increase of the duration of irradiation of X-rays. The increase in the intensities of the glow curves with the increase of irradiation dose can be understood by the fact that more and more traps responsible for these glow peaks are getting filled with increasing irradiation dose and subsequently these traps release their charge carriers on thermal stimulation to finally recombine with their counterparts, thus giving rise to different glow peaks. [14]

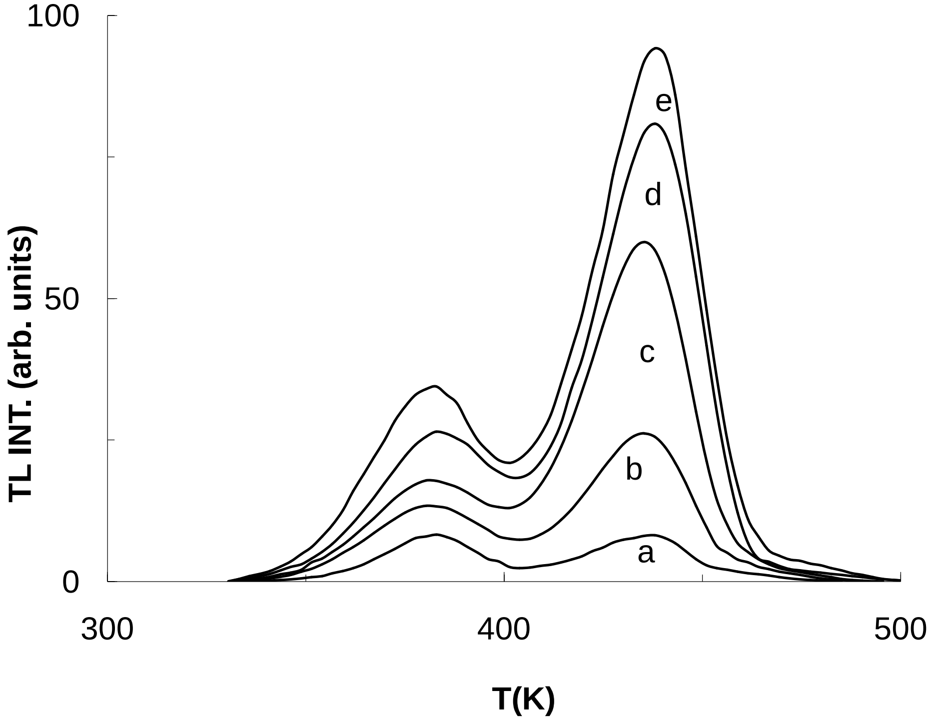
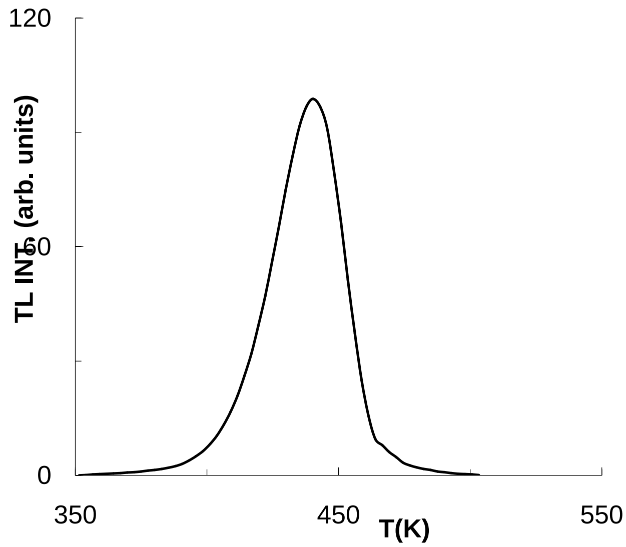


Fig. 3. TL glow curves of $BaSO_4$:Dy for different doses of X-rays.

By thermal cleaning technique, the number of peaks present in the complex glow curve of X-irradiated $BaSO_4$:Dy sample can be ascertained. Fig. 4 shows the observed TL glow curve of X-irradiated $BaSO_4$:Dy sample for a particular concentration of Dy (0.26 mol%) after thermal cleaning to 400 K. It shows a single peak with peak temperature 441.3 K (Fig.4). Thus, it is able to know the presence of two TL peaks of X-irradiated $BaSO_4$:Dy samples in the temperature range (373-473) K.

Using the peak shape formula[15], one can easily determine the activation energy (E) of isolated peak. The values of E□, E□ and E□ of the isolated peak (Fig.4) are found 1.33 eV,1.33 eV and 1.32 eV respectively.



fter Tc=400K

Using these activation energy values as input parameter, the curve fitting technique [13,16,17] is used to fit the isolated peak. The curve fitting of the isolated peak of X-irradiated $BaSO_4$:Dy sample (Fig.4.) is shown in Fig.5 with activation energy, E=1.34 eV, frequency factor, $s=3.7\times10^{14}s^{-1}$ and order of kinetics, b=1.12.

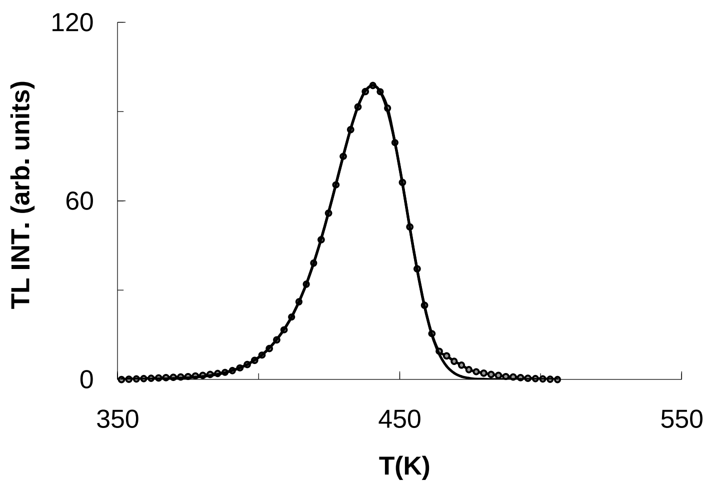


Fig. 5. Curve fitting of TL glow curve of X-irradiated $BaSO_4$:Dy sample after Tc=400K.

Computerized Glow Curve Deconvolution (CGCD) technique [15-17] is used to decode the complex glow curve. Fig.6 shows the glow curve deconvolution of the TL glow curve of X-irradiated $BaSO_4$:Dy annealed at 870 K for a particular concentration of Dy (0.26 mol%). The curve can be nicely fitted with two peaks of activation energies 1.03 eV and 1.34 eV with order of kinetics 1.4 and 1.13 and frequency factors 6.9×10^{12} and 5.1×10^{14} S^{-1} respectively.

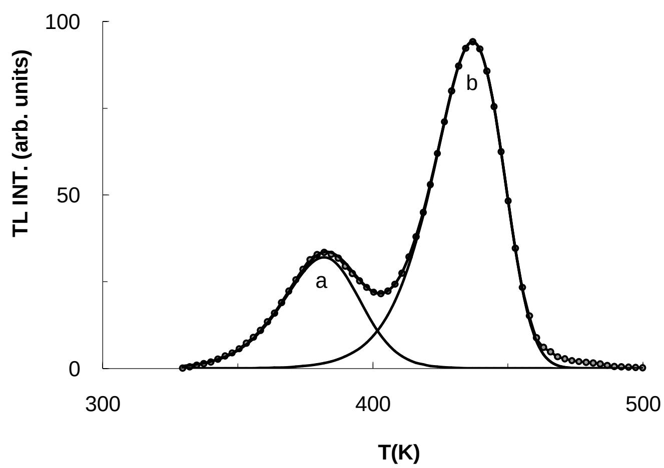


Fig. 6. CGCD of TL glow curve of X-irradiated $BaSO_4$:Dy

The dose response curves of the first peak at Tm (=380-383)K and the second peak at Tm (=435-438)K of X-irradiated $BaSO_4$:Dy recorded in Fig.3 have been shown in fig 7 and fig 8 respectively. In both cases, the dose-response curves are slightly linear at higher doses of X-rays. This indicates that at higher doses, the sample may be used as dosimeter.

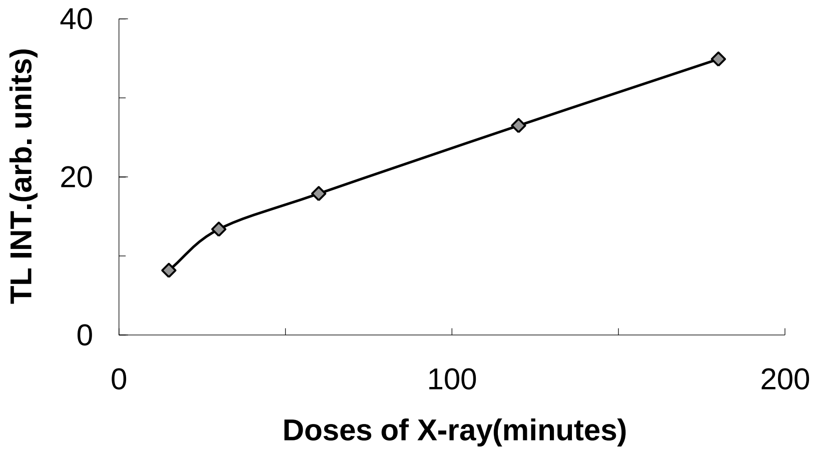


Fig 7. Dose-response curve of first peak at Tm=(380-383) K of X-irradiated $BaSO_4$:Dy.

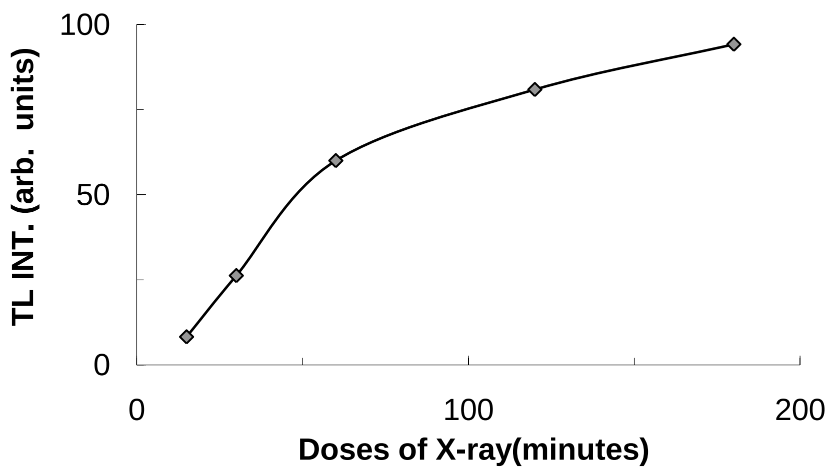


Fig. 8. Dose-response curve of second peak at Tm= (435-438) K of X-irradiated $BaSO_4$:Dy.

Conclusions

The complex TL glow curve of X-irradiated $BaSO_4$:Dy annealed at 870 K has two peaks -- Tm=(375-383) K and (433-437) K at activation energies 1.03 eV and 1.34 eV with the order of kinetics 1.4 and 1.13 frequency factors 6.9×10^{12} and 5.1×10^{14} s^{-1} respectively. This suggests that at higher duration of X-irradiation, the $BaSO_4$:Dy sample may be used as dosimeter.

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