ON THE THERMOLUMINESCENT (TL) STUDY OF X-IRRADIATED BASO4:EU PHOSPHORS FOR DIFFERENT DOPING CONCENTRATIONS

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Abstract:

The phosphors $BaSO_4$:Eu for different doping concentrations have been prepared by chemical methods. TL glow curves of the phosphors after irradiation with X- rays have been recorded. The observed TL glow curves of the phosphors show a complex glow curve consisting of a prominent peak at temperature around (410-435)K and a smaller peak at around (456-470) K. The dose-response of phosphors has also been recorded. Trapping parameters of TL glow curves of the phosphors are also evaluated using CGCD technique.

Key words: Phosphors, Trapping parameters, Glow curves ,CGCD, Dosimetry.

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Introduction:

During the last three decades, the TSL dosimetry has taken a decisive lead both in individual and in environmental radiation monitoring over photography, radio photoluminescence, thermally stimulated exo-electron emission, thermally stimulated current [1]. Daniels was the first to propose the phenomenon of thermoluminescence(TL) for radiation dosimetry [2]. TL is a powerful technique used for estimation of doses of high-energy ionizing radiations and TL intensity on stimulation is proportional to the radiation doses. A number of commercial TL dosimeters are available for this purpose [3&4]. The commonly used TL materials are $CaSO_4$ and $BaSO_4$ doped with rare-earth elements because of their high thermoluminescent sensitivity and their negligible fading [5&6]. Among the TL materials, $BaSO_4$ is very interest because of its high equivalent absorption coefficient (Z_{eff}=45), low cost and easy handling process and therefore it is particularly suited for the application in personal and environmental dosimetry [7]. Thermally stimulated luminescence (TSL) of $BaSO_4$ both natural and synthetic doped with various impurities has been extensively studied [8]. Many workers reported that $BaSO_4$:Ln(Ln= Sm, Dy, Tm) have extremely higher TL intensities than that of $CaSO_4$:Dy and $CaSO_4$:Tm, which were used in radiation dosimetric applications [9].

In continuation of the above facts, we are intended to study the Thermoluminescent (TL) of X-irradiated $BaSO_4$:Eu phosphors for different doping concentrations. In the present study, $BaSO_4$:Eu phosphors for different doping concentrations have been prepared by chemical method [10-14]. The variation of TL intensity for different doping concentrations has been reported. And, the variation of TL intensity for different doses of X-rays has also been recorded. The kinetic parameters of the recorded TL glow curves of γ- irradiated and X-irradiated samples have been calculated.

Sample preparation:

In a typical synthesis of 0.13 mol % of dysprosium, 2 g of $BaCl_2.2H_2O$ (99.9%, Aldrich) and 5 mg of $Eu(NO_3)_3.H_2O$ (99.9%, Sigma Aldrich) are dissolved in 20 ml distilled water. The solution is stirred homogeneously with the help of a magnetic stirrer. Concentrated H_2SO_4 (Merck, AR grade) is added drop by drop to the solution until the precipitation is completed. The precipitate ($BaSO_4$:Eu) is collected and washed repeatedly by distilled water till the excess acid is removed. The sample is kept in an oven for 1 hour and then annealed at 750 K for 1 hour and made into powdered form. The sample thus obtained is $BaSO_4$:Eu. Similar processes are observed for different samples of $BaSO_4$:Eu for different concentrations 0.34, 0.27, 0.20, 0.13 and 0.06 mol % of Eu are prepared.

Results and Discussions:

Figure 1 shows the XRD patterns of as prepared $BaSO_4$:Eu (0.13 mol% of Eu) phosphor. The patterns are agreed well with ICDD (Ref. No. 00-046-1415) which shows the diffraction peaks of orthorhombic structure.

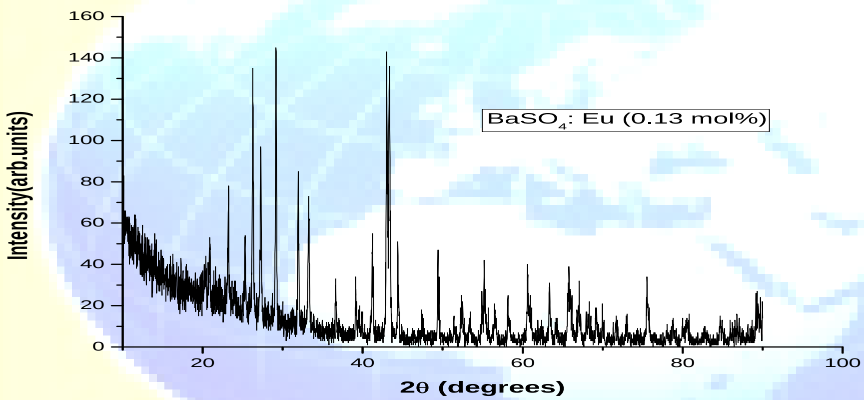

Fig 1 XRD patterns of $BaSO_4$:Eu (0.13 mol% of Eu) phosphor

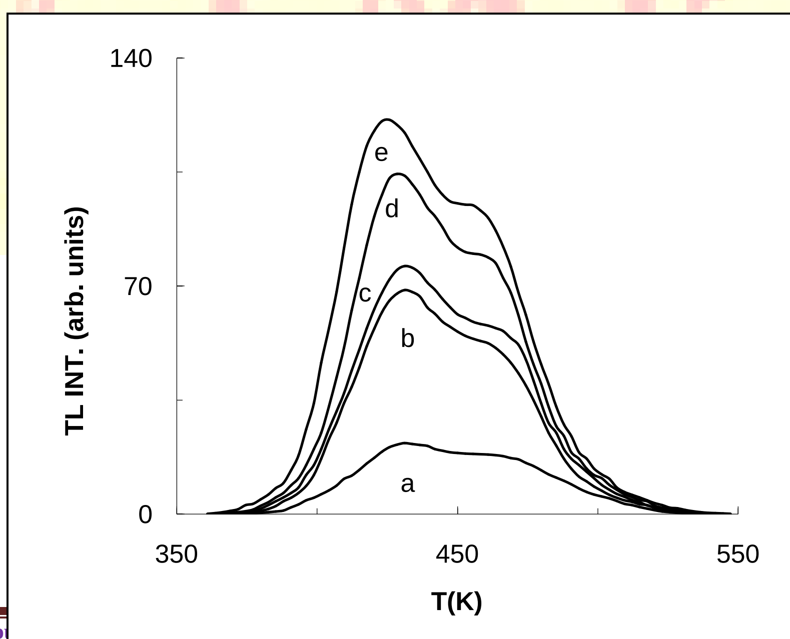

Fig.2 TL glow curves of X-irradiated $BaSO_4$:Eu for different doping concentrations

The TL glow curves of $BaSO_4$:Eu phosphor for different doping concentrations annealed at 770 K for 1 hour have recorded with a constant heating rate of 2.28ºC/S after irradiation with X-rays for 2 hours as shown in Fig.2. Here, the curves a, b, c, d and e show the TL glow curves of $BaSO_4$:Eu for different concentrations of Eu 0.06, 0.13, 0.20, 0.27 and 0.34 mol % respectively. In each TL glow curve, a prominent peak at temperature around (410-435)K and a smaller peak at around (456-470) K are observed. As indicated by the experiment, the TL intensity increases with the increase of the concentration of Eu in the present study.

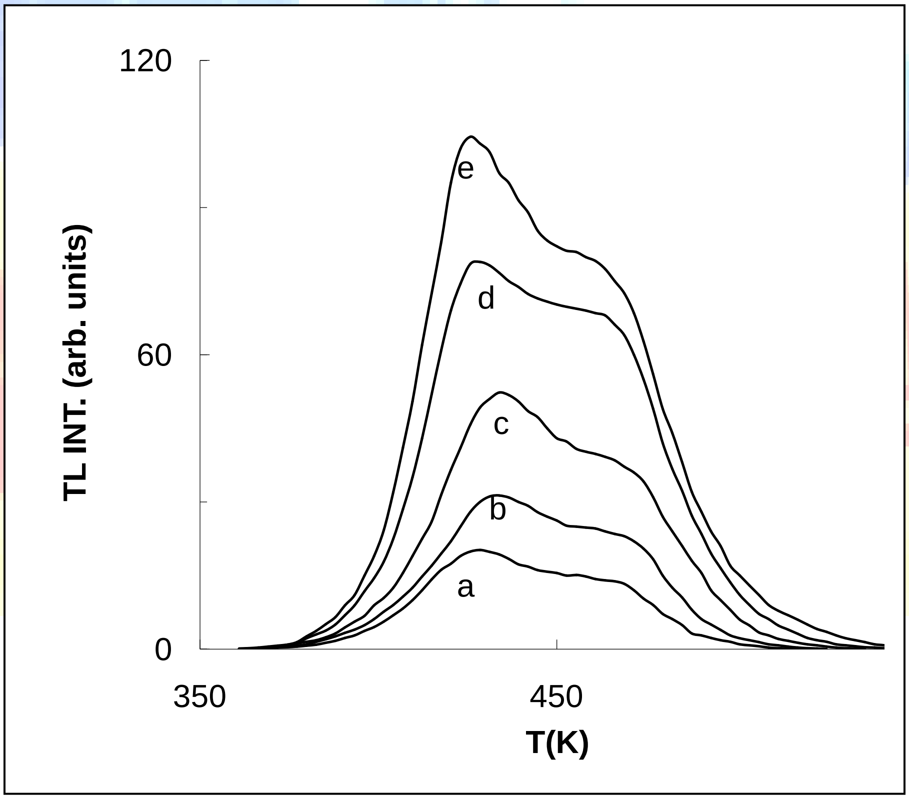

Fig. 3 TL glow curves of $BaSO_4$:Eu phosphor for different doses of X-rays.

In order to search for a dosimetric material, one of the most important techniques is to draw the dose-response curve of the sample. In connection to this matter, the TL glow curves of $BaSO_4$:Eu for a particular concentration of Eu (0.27 mol%) annealed at 770 K for 1 hour have recorded with the same linear heating rate of 2.28°C/S but irradiated with different doses of X-rays (as shown in Fig.3). Here, curves a, b, c, d and e represent the TL glow curves of $BaSO_4$:Eu sample irradiated with different doses of X-rays 5, 15, 30, 60 and 120 minutes respectively. As observed, the TL intensity increases with increase of the duration of irradiation of X-rays.

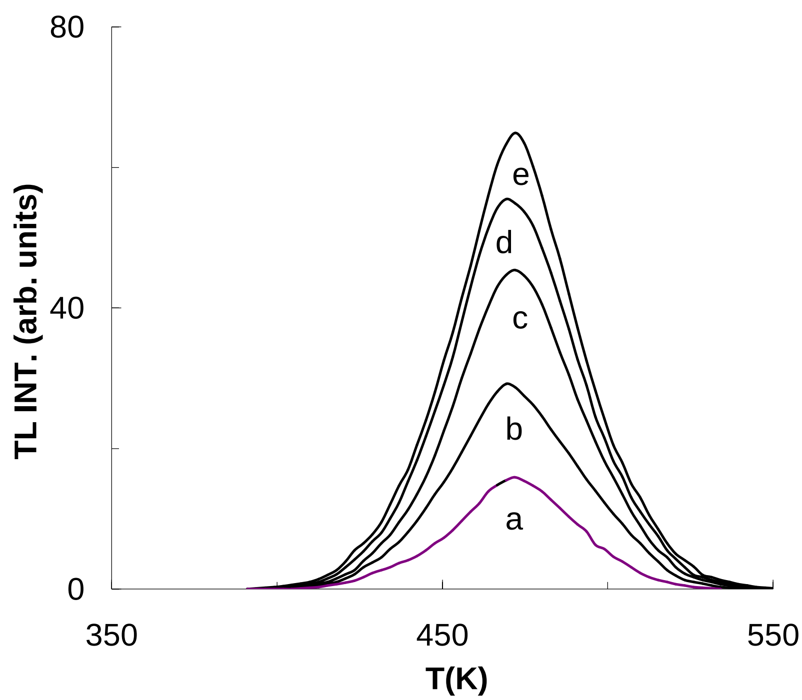

Fig. 4 TL glow curves of $BaSO_4$:Eu (0.27 mol%) phosphors irradiated with different doses of X-rays after Tc=440 K.

To draw the dose-response curve of the peak at the falling side at Tm(=456-470) K, the TL glow curves of the particular sample have recorded after thermal cleaning to Tc= 440 K, as shown in fig. 4.

To check the number of peak present in the TL glow curve of X-irradiated $BaSO_4$:Eu phosphor, the thermal cleaning technique is applied. Fig. 5 shows the TL glow curve of a particular phosphor (0.27 mol% of Eu) after thermal cleaning to Tc=440 K. It observes almost an isolated peak having peak temperature 467 K. Thus, it is able to know the presence of two TL peaks of X-rays irradiated $BaSO_4$:Eu at the temperature range (400-470) K.

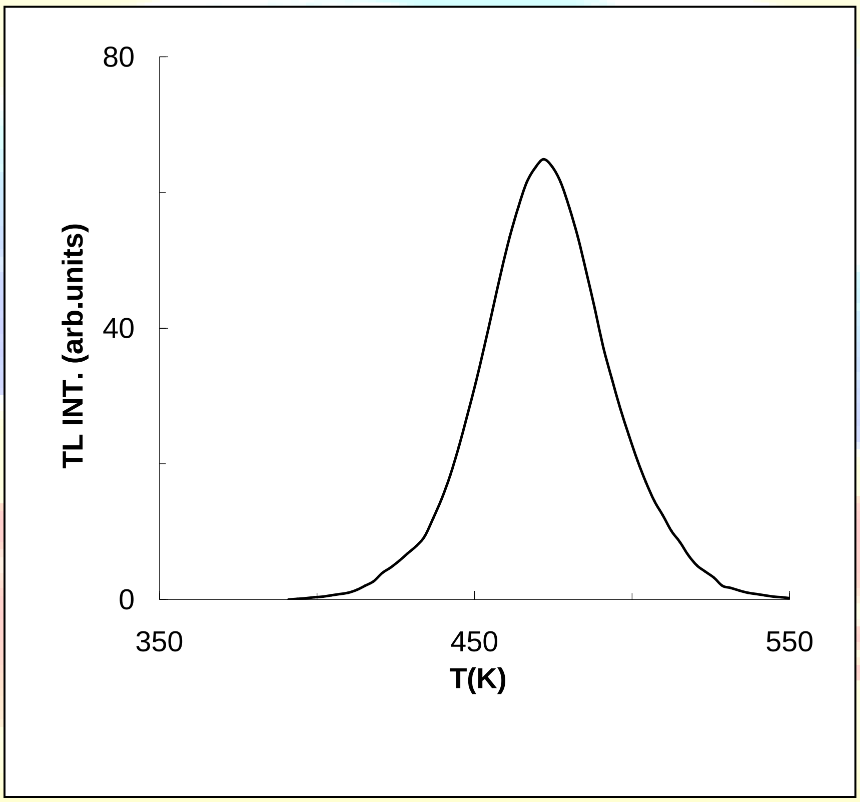

Fig. 5 TL glow curves of X-irradiated $BaSO_4$:Eu (0.27 mol%) phosphor after Tc=440K.

To calculate the activation energy of the isolated peak (Fig. 5), it is required to define the shape factor, $\mu_g(=\delta\backslash\omega)$ which indicates the order of kinetics. For the isolated peak, the half width at the rising portion, (τ), the half width at the falling portion, (δ) and the full width at half maximum intensity, (ω) are 20.8, 21.6 and 42.45 respectively. As μ_g (=0.50) is greater than 0.42 but less than 0.52, the TL glow curve is neither first order nor second order but of non-first order kinetics. By the use of peak shape formula [15] to isolated peak, one can easily obtain the activation energy of the observed TL glow peak. The values of E_τ, E_δ, and E_ω of the isolated peak are 1.41, 1.38 and 1.42 eV respectively.

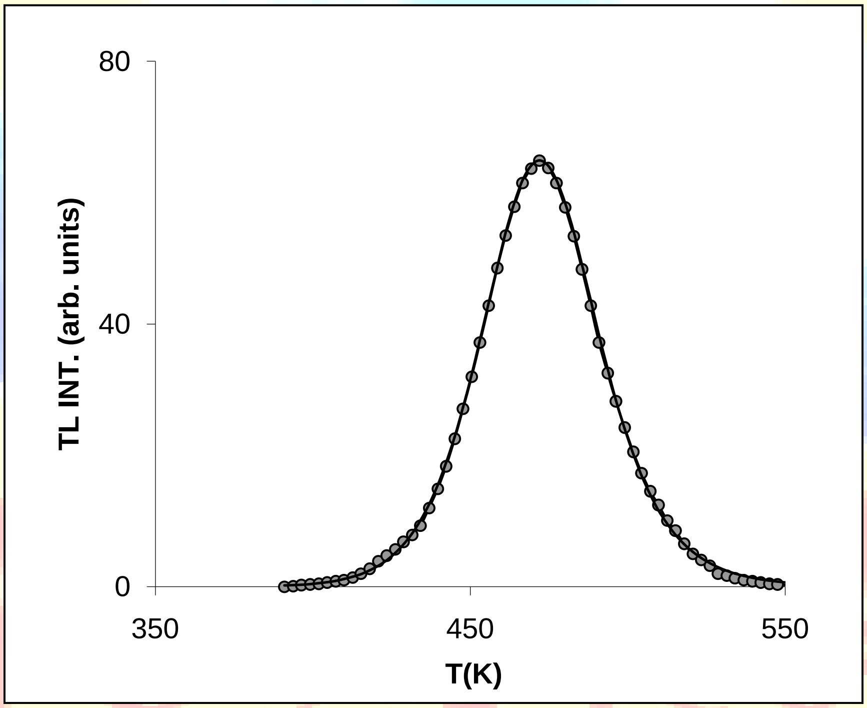

Fig. 6 Curve fitting of the isolated peak of X-irradiated $BaSO_4$:Eu phosphor (Tc=440 K)

Using the activation energy obtained by peak shape method as input parameter, the curve fitting technique [12-17] is used to fit the isolated peak of X-irradiated $BaSO_4$:Eu. Fig. 6 shows the curve fitting of the isolated peak with activation energy E=1.42eV, frequency factor, s =2.3x10^{14} and order of kinetics, b= 1.84.

Computerised glow curve deconvolution (CGCD) technique [12-17] is used to decode the full TL glow curve . Fig. 7 shows the glow curve deconvolution of the TL glow curve of X-irradiated $BaSO_4$:Eu (0.27 mol%) phosphor annealed at 770 K for 1 hours. The curve can be nicely fitted with two peaks with activation energies 1.24 and 1.42eV, frequency factors 7.2×10^{13} and 4.5×10^{14} and order of kinetics 1.5 and 1.8 respectively.

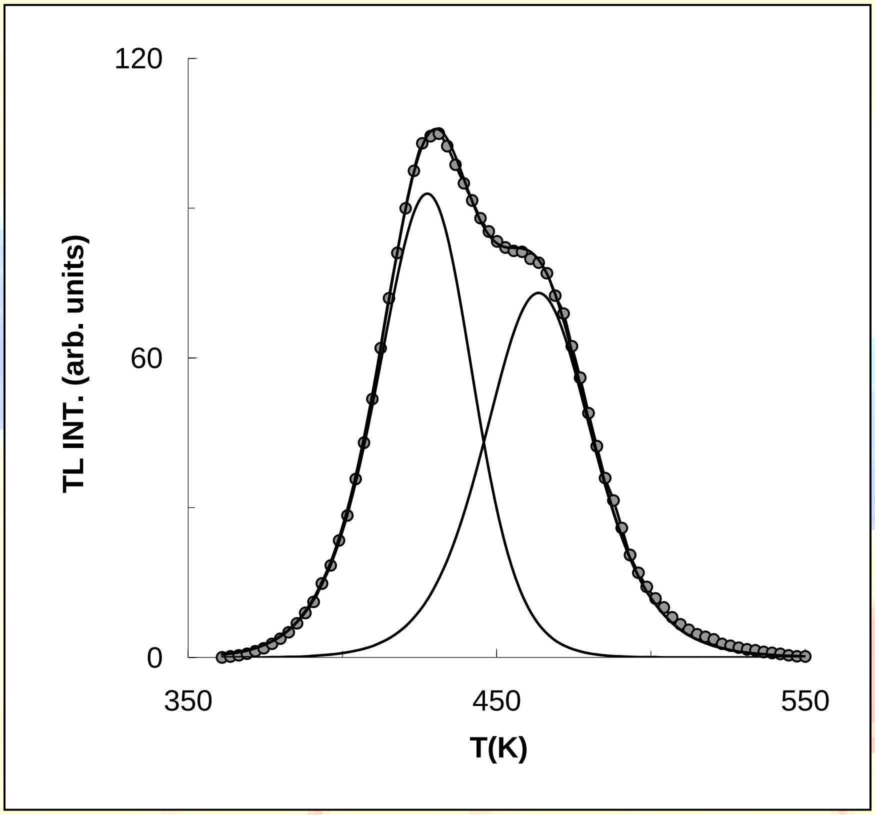

Fig. 7: Glow curve deconvolution of X-irradiated $BaSO_4$:Eu phosphor

Lastly, the dose- response curve of X-irradiated $BaSO_4$:Eu phosphor at Tm(=456-470) K is shown in Fig 8. It indicates that the phosphor may have been used as a dosimeter at the absorption of X-rays for longer time.

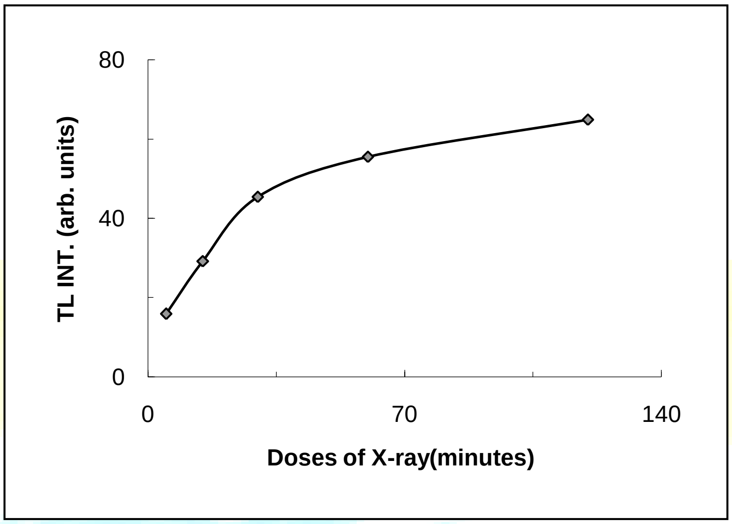

Fig. 8 Dose-Response curve of X-irradiated $BaSO_4$:Eu phosphor at Tm=(456-470)K

Conclusions:

BaSO4:Dy phosphors for different doping concentrations have been successfully prepared by chemical methods. TL glow curves of X-irradiated $BaSO_4$:Eu phosphors show two peaks system at temperature around (410-435) and (456-470) K with activation energies 1.24 and 1.42ev, order of kinetics 1.5 and 1.8 and frequency factors ranges from $7.0x10^{13}$ to $45x10^{14}$ $sec^{-}1$. And, at the higher doses of X-rays, the phosphor may have been used as dosimeter.

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