Thermoluminescence (TL) study of CeSO₄Cl: Dy Phosphor for
γ-radiation dosimetry

Gedam S.C.
K.Z.S. Science College Kalmeshwar, Nagpur 441501, INDIA

Available online at: www.isca.in

Received 20th February 2013, revised 25th February 2013, accepted 15th March 2013

Abstract

CeSO₄Cl: Dy phosphor is prepared by wet chemical method. The thermoluminescence (TL) study of CeSO₄Cl:Dy phosphor has been presented in this paper. The strong sensitivity of the CeSO₄Cl: Dy phosphor is obtained with the breadth of the glow peak for various concentrations of Dy and different γ-rays doses. The phosphors CeSO₄Cl: Dy has a simple TL glow curve structure with a single prominent peak at around the temperature 169°C indicating single trapping sites. The phosphor may be quite suitable for use in dosimetry of ionizing radiations.

Keywords: Thermoluminescence, Inorganic material, wet chemical, γ-radiation, dosimetry.

Introduction

The use of sulphates doped with rare earth (RE) ions as dosimeters have been investigated for many years. Some examples are CaSO₄: Dy, CaSO₄: Eu, P and CaSO₄: Tm, CaSO₄: Dy and CaSO₄: Tm phosphors have been widely used in environmental radiation monitoring due to their high dose response sensitivity and ease of preparation. At present, thermostimulated luminescence dosimeter (TLD) materials are widely used for personal and environmental radiation monitoring. Among the different types of TLD materials, RE-doped sulphates, especially CaSO₄: Dy or CaSO₄: Tm phosphors, developed are in use in many countries for dosimetry due to their high sensitivity, stability and low cost.

Blassé has listed the Eu²⁺ doped compounds, which shows that the emission color of Eu²⁺ can vary in a broad range, from ultraviolet to red. The dosimetric characteristic of any TL phosphor mainly depends on its trapping parameters which describe the defect centers responsible for the TL emission. Recently Moharil et. al have reported several sulfate phosphor possessing properties useful for TL dosimetry of ionizing radiations. Other than sulphates and mixed sulphates, some investigations are going in progress on halosulphate-based materials. Klement synthesized the halosulphate Na₄Ca₆(SO₄)₃F₂ and characterized this compound by XRD. Also, the compounds Na₄Pb₄(SO₄)₃Cl₂₈, Na₄Cd₄(SO₄)₃Cl₈ and Na₈,45Ca₃,55(SO₄)₆(FeCl₃)₄,15 have been reported recently. Na₄Ca₆(SO₄)₃F₂ has been synthesized by water-soluble sulphate salt of Europium was then added to the solution to obtain CeSO₄Cl: Dy. Confirming that no undissolved constituents were left behind and all the salts had completely dissolved in water and thus reacted. CeCl₃ + Ce₂(SO₄)₃ → 3CeSO₄Cl

The compounds CeSO₄Cl (pure) and CeSO₄Cl: Dy in its powder form was obtained by evaporation on 80°C for 8 hours. The dried samples were then slowly cooled at room temperature. The resultant polycrystalline mass was crushed to fine particle in a crucible. The powder was used in further study. For TL characteristics samples were exposed to gamma rays from a Co⁶⁰ source at room temperature at the rate of 0.995 kGy/hr for 500 rad (5 Gy). After desired exposures, TL glow curves were recorded for 2 mg of sample each time at a heating rate of 2°C/sec. TL glow curves were recorded on TL reader.

Results and Discussion

TL glow curves by the concentrations of Dy: Figure 1 shows the typical TL glow curves of CeSO₄Cl: Dy a) 0.1mol%, b) 0.2 mol%, c) 0.3 mol.% phosphor. The glow curves have been recorded at a heating rate of 2 ksec⁻¹ and irradiated at a dose rate of 0.995 kGy/hr for 5 Gy. Repetitive cycles of annealing and irradiation at the same dose reveal the same glow curve structure. Further, in changing the concentration level the general structure of the TL curve is not observed to undergo change in peak temperature, but intensity is found to increase as the concentrations of Ce increased. The low temperature peak of CeSO₄Cl: Dy0.1mol% is obtained may be due to the effect of host material and is seen to be present at about 169°C. The appearance of single peak in the glow curves indicates that there is possibly only one kind of trapping sites due to γ-irradiated effect. The glow curve peak for all concentrations is obtained at 169°C as a main peak while other low intensity peaks also at the same temperature.
Figure-1
TL glow curve of CeSO₄Cl: Dy a) 0.1 mol%, b) 0.2 mol%, c) 0.3 mol.% phosphor exposed to γ –rays for 5 Gy at the rate of 0.995 kGy/h⁻¹.

Figure-2
TL glow curves of CeSO₄Cl: Dy phosphor exposed to γ –rays for different doses at the rate of 0.995 kGy/h⁻¹.
 a) 0.1 Gy b) 0.5 Gy c) 1 Gy d) 5 Gy e) 10 Gy
Figure-3

TL response to $\gamma$-irradiation of CeSO$_4$Cl: Dy phosphor at the rate of 0.995 kGyh$^{-1}$

**TL glow curves by the $\gamma$-rays dose:** Figure 2 shows TL glow curves for $\gamma$-irradiated CeSO$_4$Cl: Dy phosphor with varying doses with a linear heating rate 2 $^\circ$C sec$^{-1}$ which exhibits a single glow peak at 169$^\circ$C. All the phosphors were exposed to a dose range of 0.5 Gy to 10 Gy. It is observed that TL intensity increases with the increase in dose. This change in the relative intensity of the peaks has been attributed to the change in the population of the luminescent/trapping centers. With a simple glow curve structure, easy method of preparation and no saturation in the exposed range CeSO$_4$Cl: Dy phosphor resembles the characteristics close to an ideal phosphor. Generally, Dy and Mn doped phosphors are the efficient TLD materials, such as doping in CaSO$_4$ and LiF materials. However the sensitivity of all the phosphors is up to the dosimetric level even for only to the 10 Gy dose of $\gamma$-rays.

**TL response curves:** A TL response curve of CeSO$_4$Cl: Dy phosphor exposed to different doses of $\gamma$-rays is given in figure 3. The peak heights were used for measuring the TL intensities. On exposing the phosphor to doses ranging from 0.5 Gy to 10 Gy, it was found that phosphor exhibits a linear response to $\gamma$-rays doses throughout the dose range. Below 1 Gy it is sub-linear but after this it is linear. This range is in a good result for the material which can be used as a dosimeter. The total amount of light emitted (response) is not perfectly proportional to the absorbed dose. Response / Gy is greater at higher dose levels. Because the higher exposure creates additional traps and hence makes the material more sensitive, this is known as supralinearity. The response / Gy for most TLD depend upon radiation type and quality. More appreciable results are expected for higher $\gamma$-rays doses to explain behavior of TL material.

**Conclusions**

From the results it can be concluded that, the sensitive typical TL glow curves was obtained for various concentrations of Dy in CeSO$_4$Cl host which was recorded at a heating rate of 2 ksec$^{-1}$ and irradiated at a dose rate of 0.995 kGyh$^{-1}$ for 5 Gy. It was also found that higher the concentration of Dy, higher is the TL intensity. TL sensitivity also measured by giving different $\gamma$-radiation doses and found that the phosphor is also suitable for higher doses. A TL response curve of CeSO$_4$Cl: Dy phosphor exposed to different doses of $\gamma$-rays is linear. Below 1 Gy it is sub-linear but after this it is linear. This range is a good for the dosimeter material. More results are expected for higher $\gamma$-rays doses to explain behavior of TL material. The detail study for higher $\gamma$-radiation doses is under consideration.

**Acknowledgements**

Author is thankful to University Grant Commission (UGC), New Delhi Government of India, for the financial support.

**References**


