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Analysis Of Thermoluminescence Spectroscopy

DR. Praveen Kumar Singh

Associate Professor- Physics, Mahant Avaidyanath Rajkiya Mahavidyalay Jungle Kaudia Gorakhpur (U.P.), India

Received- 12.10. 2021, Revised- 17.10. 2021, Accepted - 21.10.2021 **E-mail: pk75singh@gmail.com**

***Abstract:** In the study of defects in materials, personnel dosimetry, dating, clinical dosimetry, environmental dosimetry. Thermoluminescence spectroscopy is a very useful and powerful technique to study defects in materials, dating, personnel dosimetry, clinical dosimetry, environmental dosimetry and accidental dosimetry. Since Thermoluminescence spectroscopy is a powerful tool therefore in the present paper we review the importance of thermoluminescence spectroscopy.*

Key Words: Trap sites, glow curve, Trap centre, TL glow curve, environmental, accidental dosimetry.

1. INTRODUCTION- When the thermo-luminescent materials are exposed to ionising radiations like ?, ?, ?, n, the system absorbs energy and changes from equilibrium to a metastable state. This change is through the transit of electrons from the valence band to the conduction band resulting in creation of free electron and hole. Thermoluminescence (TL) is the emission of light phenomenon from some solids commonly called phosphors, which can be observed when it is heated. Thermoluminescence spectroscopy is a technique which employs thermoluminescence as a probe to measure radiations absorbed by a crystalline / non-crystalline material. The phenomenon is sensitive to the structural changes resulting due to impurity and presence of defects.

2. MECHANISM - Thermoluminescence (TL) dating is based on the fact that natural minerals can absorb and store energy from ionizing radiation. If a mineral is heated to a sufficiently high temperature, some of the stored energy is released in the form of light called TL.The mechanism of thermoluminescence can be explained by considering the band structure of material exhibiting Luminescence. The impurities in solids introduce additional energy/discrete energy levels in between conduction and valence band of the host lattice.

There are two delocalized bands, conduction band (CB), and valence band (VB), in this energy band found just two localized level, one behave as a recombination center, and the other behave as a trap. For the production of thermo luminescence the host material should (i) possess ordered structure and must be wide band gap semiconductor (ii) and should possess defects /traps. The defects/traps of different types are created as (a) vacancy/ imperfections produced at the time of crystal formation (b) distortions produced on addition of foreign ions of larger or smaller radii to host ions (c) consequence of irradiative bombardment. The mechanism of thermoluminescence can be explained by considering the band structure of material exhibiting Luminescence. The impurities in solids introduce additional energy/discrete energy levels in between conduction and valence band of the host lattice. These energy levels are called localized energy levels thereby leading to local disturbances.

When the thermo-luminescent materials are exposed to ionising radiations like n, the system absorbs energy and changes from equilibrium to a metastable state. This change is through the transit of electrons from the valence band to the conduction band resulting in creation of free electron and hole. These free charge carriers move freely within the lattice and may get trapped at the defect sites thereby leading the storing of irradiation energy by crystal. This crystal when heated may release the stored charge followed by the relaxation of the system back to the equilibrium.

The temperature at which the charge carriers are released from trap depends upon energy difference of trap depths and conduction/valence band. The released electron from the traps transits from conduction band following an intermediate transition to ground state resulting in recombination and thereby producing a luminescence (Fig 1). The defect where the electron is released is called trapping centre or trap and where the electron and hole recombine is called recombination centre or luminescent centre.

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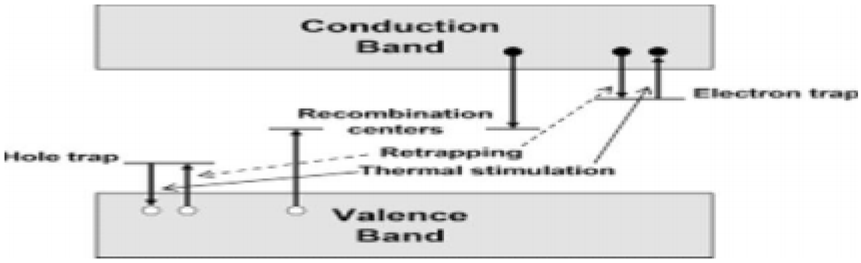

Fig. 1: Band model of thermoluminescence

3. EXPERIMENTAL SET-UP- A basic schematic diagram of a TLD reader is shown in Fig. 2. A reader system for Thermoluminescence Dosimeter consists of a planchet for keeping and heating the dosimetric material, to detect the thermoluminescence light emission, a Photo multiplier tube is used PMT which also convert emitted light into an electrical signal.

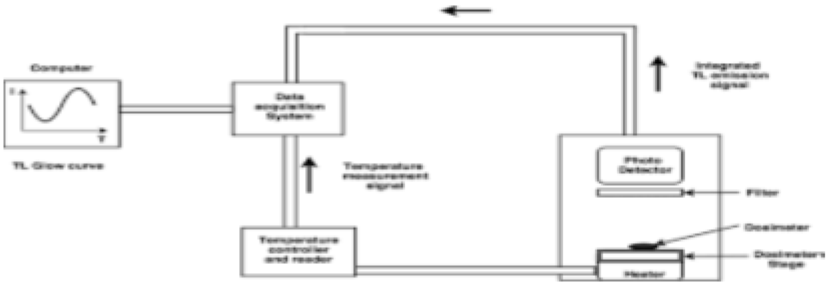

Fig. 2: A Schematic for TLD reader

Defects in materials are either inherently present or can be incorporated externally by doping the sample with impurities. Materials with defects when exposed to radiations causes trapping of charge carriers at defect sites. Subsequent heating of these may release trapped charges, which in turn recombines at luminescent centre which leading to thermoluminescence. By analyzing the emission spectra the properties of luminescent material and the application to which it can be put is revealed.

4. THERMOLUMINESCENCE EMISSION SPECTRA- Thermoluminescence emission spectra also termed as Glow curve can be employed for analysis of defects, trap depth determinations, radiation dose determination etc. The presence of defects and its position with respect to conduction and valence band strongly influences the luminescent properties of materials.

The Glow curve is a plot of luminescence intensity as a function of temperature, it is a smooth and continuous spread out over a wider temperature interval resulting in a broader glow peak Fig-3a, total intensity, the area under the glow peak depends on the absorbed dose delivered before the readout. Further the wide spread is composed of a number of overlapping peaks, each peak corresponds to different trap depths and it obtained from the release of electrons from these traps of different depths. Fig3(b). Thermoluminescence graphs shows with increase in temperature TL intensity increases firstly reaches its maximum this may be due to increase in probability of evacuation of traps, which in turn increases the probability of irradiative recombination of electrons and trapped holes, the decrease in intensity with temperature may be due to de-trapping finally decreases as the number of charge carriers becomes depleted. The different peak in spectra corresponds to different electron traps with different depths.

The shift in maxima of a thermoluminescence (TL) glow curve with increasing heating rate, the occurrence of TL glow peak is observed at higher temperature. The irradiation time influences the TL intensity linearly and could be related directly to production of traps in TL materials, which increases linearly with exposure duration as is depicted by Fig.4. Further activation energy/ depth height can be the obtained from plot of log of intensity of TL vs inverse of kT. Fig. 5 show the variation of intensity with (1 / kT).

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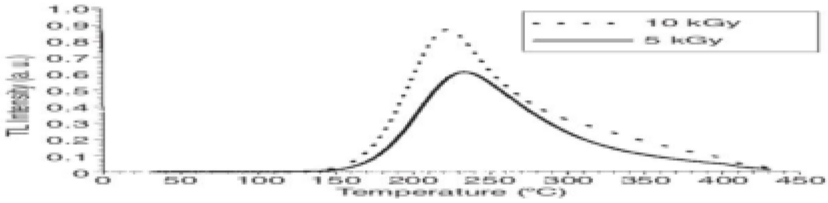

Fig. 3: Glow curve (a) Thermoluminescence intensity as the function of temperature

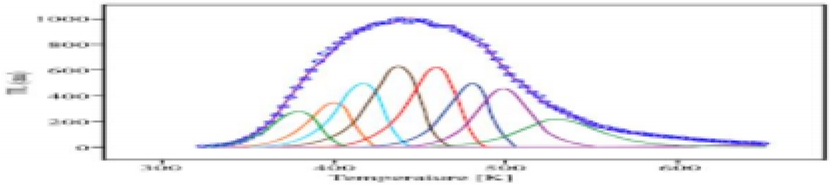

Fig. 3: Glow curve (b) fitting different peaks to wide curve

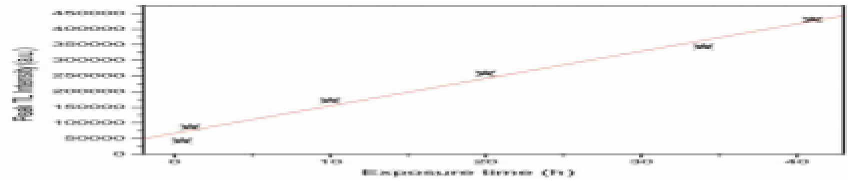

Fig. 4: Effect of irradiation time on intensity of TL

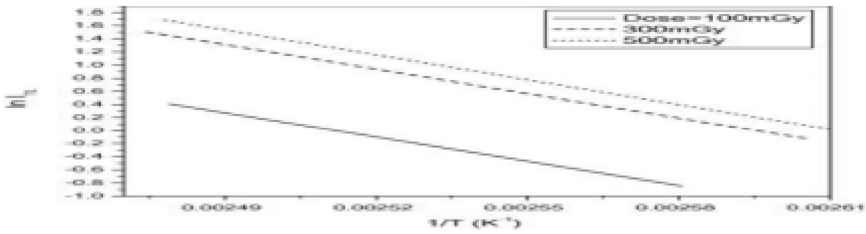

Fig. 5: Plot to determine activation energy for maximum TL peak at different temperatures

5. CONCLUSION- A thermoluminescence curve, obtained by plotting the intensity of light emission against temperature, intensity against Radiation dose, intensity against exposure time is very sensitive and precise technique to measure defect locations in a crystal, radiotherapy, radiation protection.

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