Kinetic Parameter and TL Glow Curve of γ Irradiated DY Doped Nacl Crystals

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Abstract: ***The present work reports the thermally stimulated luminescence displayed by sodium chloride with different percentages of Dy as impurity. The doped NaCl:Dy crystal after exposure to γ dose is studied. The thermal glow curves exhibited by NaCl: Dy shows interesting results. The dependence of dopant concentration on TL in NaCl: Dy crystal is investigated. The interaction of ionizing radiations with matter leads to various effects, some of which leave memory in the target material. This memory effect can be seen as the after effects of the irradiation. This paper describes the sequence of the physical events beginning with the incidence of an ionizing particle. Leading to trail of atomic and electronic displacements which stabiles in the form of so called defect centres. The kinetics of the thermoluminescence process has been explained phenomenological. The TL phenomenon has found many particle applications. The paper deals mainly with the physical processes involved in the TL emission and allude briefly to its involvement in applied areas.***

Keywords: Activation energy, Thermoluminescence, Kinetic Parameters of alkali halide crystals.

I. INTRODUCTION:

Alkali halides polycrystalline powders, which were colored by high energy irradiation at room temperature, display a tendency to thermoluminescence (TL). Several analysis methods were previously proposed [1-8] in order to obtain the parameters that characterized the electron traps formed during exposure. However, for these substances, there is considerable disagreement between the results reported by various authors regarding the activation energy of traps.

II. EXPERIMENTAL SAMPLE PREPARATION:

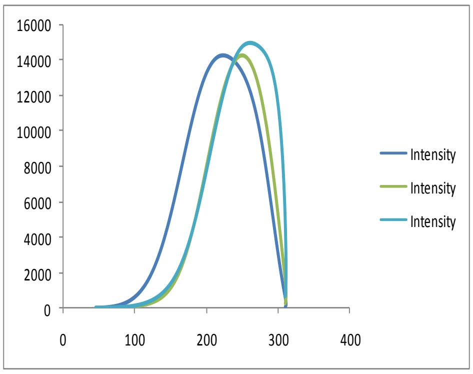
The starting material used for the preparation of the NaCl:Dy crystal were NaCl powder and Dy_2O_3 the sodium chloride was taken according to the proper ppm and known concentration of dopant Dy was added along with it. This mass was properly crushed and mixed using a mortar and pestle. The mixture so obtained was fired in the central zone of a high temperature muffle furnace at 1000^0 C for 1 hour. After firing the mixture was cooled by varying the temperature by 100^0C at every hour. The resulting crystal was then effectively cut at known dimensions was used for the study.

γ rays irradiation was done by using and crystals were excited for 60 min dose given 0.8 Gy by using source ^{137}Cs GAMMATOR M-38-2 respectively and the TL glow curve was recorded with a PC based TL system supplied by Nucleonix with linear heating rate 3.8^0C/s.

III. RESULT AND DISCUSSION:

The thermoluminescence phenomenon is known to be due to radiative recombination of thermally released electrons by trapping levels with holes bound to luminescent centres. Fig.1 shows the glow curves for the samples of study. The thermal activation energy (E) for emission of thermoluminescence is equivalent to the energy needed to release the charge carriers from the involved trapping levels. For the determination of the trap depth starting from the experimental glow curves, it was necessary to establish first the kinetic order of the thermally stimulated recombination of the opposite charge carriers. For the entire examined Dy doped NaCl, the probability retrapping was found to be larger in comparison with the probability of recombination, which is equivalent to a second order process. One possible mechanism consists of the thermal activation of an electron from a trap to the conduction band followed by its retrapping before combination with a hole resulting in the emission of light.

The color centres of F type form the most important lattice defects in the irradiated alkali halides. They are defined as halide ion vacancies, which have captured an electron. The observed colour due to the presence of F centre induced by gamma irradiation is yellow for NaCl. The thermoluminescence phenomenon is known to be due to radaiative recombination of thermally released electrons by trapping levels with holes bound to luminescent centres.



Temp ^{0}C

Fig 1 TL glow Curves of γ irradiated NaCl:Dy Crystals

Fig 1 shows the glow curves for the studied halide with Dy doped. These samples had been exposed to gamma rays. As it can be seen, the NaCl:Dy samples present a glow curve with large peak at 261^{0}C, 228^{0}C and 221^{0}C respectively.

Glow curve shape method:

The method based on the shape of glow curve proposed by Chen [12] was used to verify the trapping parameters calculation. The following shape parameters were determined: total half intensity width ($\omega = T_2 - T_1$); the high temperature half width ($\delta = T_2 - T_m$), and; the low temperature half width ($\tau = T_m - T_1$), where T_m is the peak temperature and the T_1 and T_2 are two temperatures on either side of T_m corresponding to half peak intensity. Table 1 shows the different parameter.

Order of kinetics

The order of kinetics (b) was determined by calculating the symmetry factor (μ) of the glow peak, using the known values of the shape parameters

$$\left\{ \mu_g = \frac{T_2 - T_m}{T_2 - T_1} \right\} \qquad \text{-------- (1)}$$

Activation energy: Activation energy (E) was calculated by using the Chen equations, giving the trap depth in terms τ, δ, ω. A general formula for E was given by Chen [9] as follow:

$$E_\alpha = c_\alpha \left[\frac{kT_m^{\ 2}}{\alpha} \right] - b_\alpha (2kT_m) \text{------(2)}$$

To analyze the observed TL curves the symmetry factor (μ) [$\mu = \delta / \omega$, $\delta = T_2 - T_m$, $\omega = T_2 - T_1$, T_m being the peak temperature at the maximum, T_1 and T_2 are respectively, the temperatures on either side of T_m, corresponding to half intensity is calculated. The peak parameters (peak temperature, full widths, and shape factor) are shown in Table 1.

TABLE 1: shape factors (μ), Activation Energy E and Order of Kinetics b of Dy doped NaCl pure crystal and irradiated by γ Source:

γ dose	τ	δ	ω	μ = δ / ω	activation energy E (eV)	Frequency factor S
60 min pure	55.47	67.89	123.4	0.55	1.16	$6X10^6$
100 ppm	49.47	50.08	99.55	0.503	1.64	$2X10^7$
500 ppm	46.07	61.7	107.8	0.573	1.60	$1X10^8$

Table 2 The trap depth for the prominent glow peaks of the studied alkali halides, evaluated from second order kinetics

Methods	Reference	Activation energy, E (eV)		
		60 min pure	100 ppm	500 ppm
$E\ (eV) = T_m(K)/500$	[9]	1.06	1.00	0.98
$E(eV) = 23KT_m$	[10]	1.052	0.99	0.97
$E(eV) = 38KT_m$	[11]	1.73	1.64	1.60
$E\ (eV) = \frac{2KT_m^2}{\delta}$	[12]	1.16	0.79	0.90
$E_\omega = C_\omega \frac{KT_m^2}{\omega} - b_\omega (2KT_m)$	[12]	0.58	0.50	0.56
$E_\tau = C_\tau \frac{KT_m^2}{\tau} - b_\tau (2KT_m)$	[12]	0.54	0.45	0.52
$E_\delta = C_\delta \frac{KT_m^2}{\delta} - b_\delta (2KT_m)$	[12]	0.63	0.55	0.61

The experimental results described in the present paper show a relative good agreement between the activation energies determined by several methods based on the symmetry of glow curve and T_m.

IV. CONCLUSION:

1. The TL intensity was studied as function of irradiation dose emphasizing the occurring of retrapping phenomenon.
2. The trap depths were evaluated using different calculation methods based on the shape of glow curves.
3. The recombination kinetics of charge carriers follows the second order law.

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