

C H A P T E R V I

D I S C U S S I O N

A N D

C O N C L U S I O N S

CHAPTER VI

DISCUSSION AND CONCLUSIONS

6.1 Introduction :

The experimental finding arising from the studies of the decay, thermoluminescence of CaS phosphor activated with bismuth lead and both together have already been reported in previous chapters. In this chapter we proceed to re-examine them in some-what detail. They are summarised and further discussed.

6.2 Decay Law :

The decay measurement reveals that the plots of logarithm of intensity (I) versus logarithm of time (t) are almost linear indicating that the decay is not exponential which suggest that they are of type (1, 2, 3) represented by equation (1)

$$I = I_0 t^{-b} \quad \dots \quad (1)$$

where I is intensity at time t,  $I_0$  is the intensity at time  $t = 0$  i.e. at start of decay. b is the decay constant.

The hyperbolic decay is explained on the basis of Randall And Wilkins (1). Monomolecular theory, according to which such hyperbolic decay is result of superposition of exponentials corresponding to different traps, which can be expressed by equation.

$$I = I_{o1} \exp. (-P_1 t) + I_{o2} \exp (-P_2 t) + \dots + I_{on} \exp (-P_n t) \quad \dots \quad (2)$$

where  $I_{on}$  is phosphorescence intensity in trap of energy  $E_n$  and  $P_n$  is the transition probability of an electron escaping from a trap of depth  $E_n$ .

### 6.3 Trap depth from Decay Curve :

Each decay curve has been split up into two to three exponentials and trap depth corresponding to these exponential have been calculated by the 'Peeling Off' procedure. The trap depths thus evaluated and are found in good agreement with those obtained from glow curve. The activation energies are calculated by using formula.

$$p = S \exp ( -E/kT ) \quad .. \quad (3)$$

### 6.4 Distribution of Trapping states :

The distribution of trapping states is ascertained by using the relation.

$$I = \frac{NkT}{t} \left[ 1 - \exp (st) \right] \quad .. \quad (4)$$

which for uniform trap distribution takes the form

$$I = I_0 t^{-b}$$

In present case power and  $t$  ( the  $b$  values i.e. decay constant) is not unity this rules out the possibility of uniform or quasi uniform trap, distribution. However, the values of  $n$  for samples are less than unity indicating thereby the trap distribution is likely to be non-uniform.

$$I = x t^{-(BkT + 1)} \quad : x = \text{constant.}$$

for an exponential trap distribution.

$b = (BkT + 1)$  which means  $b > 1$ , for our samples,  $b$  fluctuates between 0.05 to 0.26. This excludes the possibility of exponential trap distribution.

Above conclusion is supported by a plot between  $I.t$  and  $\log t$ . obtained for the present samples, the curves are neither straight lines paralalled to  $\log t$  axis for exponential as required by

uniform and exponential trap distribution respectively. However they are increasing ones suggesting the trap distribution to be non-uniform the curves thus obtained gives an idea about the density of trap at various depths contributing to phosphorescence decay.

#### 6.5 Glow Curves :

All glow curves show apperent single peak around  $423^{\circ}\text{K}$  when exicted source used is cobalt 60, gamma source, given for 30 minutes and if the uv excitation source is used for 10 minute dose the apperent single peak is observed around  $373^{\circ}\text{K}$ .

Glow Curves plotted using uv excitation source are *recorded* 5 minutes after dose is given while for gamma irradiated source the TL glow curve are plotted after 45 days. The shift in temp. indicates that for a given phosphors the TL contains number of peaks first peak present around  $373^{\circ}\text{K}$  which is fast decaying peak and second peak is subsided under the first peak, while for gamma irradiated sample as 1st peak is fast decaying peak it is not recorded and 2nd peak is obtained around  $423^{\circ}\text{K}$  so there may present number of peaks around this temperature, and in both cases it is indicative that peak around  $423^{\circ}\text{K}$  is comparatively stable peak and may have small decay constant.

#### 6.6 Activation Energy :

Due to apparent single broad TL glow peak, various formulae based on shape of TL glow curve are attempted to calculate activation energies for various samples. These energies are in the range between 0.1 to 0.5 eV. These values indicate comparatively shallower traps. The unsystematic variation in values of activation energies with varying concentrator.

of both Bi and Pb are indicative of different types of traps involved in TL processes. The difference in TL glow curves recorded for uv excited and gamma irradiated samples (difference in glow peak temp.) suggest that an apparent single peak is a composite peak. Probably due to this reason slight shift in glow peak temp.

is found (table no.5.1 to 5.4). In order to have more correct estimate of activation energies of low temperature glow peak initial rise method which is irrespective of order of kinetics is attempted (figure 5.23) The straight line one with different slope than straight line 2, 3, 4 brings out the fact that the TL glow peaks are closely spaced giving an overall single peak indication. However isolation of glow peaks by partial bleaching technique could not be undertaken due to limitation of instruments used.

Attempts made to understand the order of kinetics indicates the possibility of second order kinetics, however this requires further confirmation.

As a part of study calculation of frequency factor is done and the results are presented (Table No.5.9 to 5.12). These results of S factors are used to calculate activation energies from the photoluminescence ( Table No.2.2) The results obtained of activation energy from photoluminescence studies and Thermoluminescence studies are in agreement.

#### 6.7 Effect of addition of activators on trap distribution :

Addition of activators (Bi, Pb) does not change the form of decay. More over the variation observed in the values of both decay constant and activation energy  $E$ , which are the trap parameter, is also negligible small and unsystematic thus indicates that the addition of activator only modifies the relative importance of the

traps responsible for phosphorescence and thermoluminescence but not their mean depth (2, 3).

Glow peak temperatures for CaS CaS:Pb, CaS : Bi and CaS:Bi:Pb are different fig.(5.12). As such Pb increases the TL output to small extent, Bi seem to be a good activator (in agreement with earlier workers) ( 2, 4, 5<sup>-</sup> ), however in presence of Pb TL output decreases. The different glow peak temperatures are indicative of different types of traps. As such, presence of Pb in CaS Bi decreases TL out put but creates a new trap.

#### 6.8 Dose dependence of Thermoluminescence :

As the <sup>x</sup> excitation time is increased, the peak intensity increases reaches a maximum value and then falls down (ref. fig. no.4.22) the <sup>t</sup> saturation dose obtained is about 45 minutes.

#### 6.9 Kinetics of Luminescence :

The decay measurements reveal that the semilog plots between I and t do not form a straight line as required by the first order kinetics and also the slope of log I versus log t plots is not equal to two which is the case for the second order kinetics. However, the observed decay behaviour is well explained on the basis of monomolecular superposition theory which indicates that the kinetics involved to likely to be monomolecular but from the glow curve shape, calculation of  $U_g$  (symmetry factor) shows that the kinetics involved in luminescence processes is of second order.

The decay studies indicate monomolecular and the calculations of TL studies indicate bimolecular kinetics involved. Whether monomolecular, bimolecular or intermediate (General order kinetics) requires further confirmation.