CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSION

C H A P T E R - V

GENERAL DISCUSSION AND CONCLUSION

This chapter is devoted to the general discussion and result obtained in the present investigation. Some interpretations and inferences drawn from specific studies are summarised and further discussed.

5.1 EL BRIGHTNESS - VOLTAGE RELATION

It has been found that the plots between log B and log V exhibit fair linearity over a wide range of voltage implying a power law relation

$$B = a \ (V - V_o)^n \qquad \qquad ...\ (5.1)$$

with $V_o = 0$ and a and n are constants.

Besides the power law a relation

$$B = a \ \exp \ (-b/ \sqrt{v}) \qquad \qquad ...\ (5.2)$$

with a and b are constants, is also found suitable over a limited range of voltage. Such a simultaneous validity of both the equation was also observed by other workers.[1,2,3]

5.2 EL BRIGHTNESS - FREQUENCY RELATION

In most of the studies on frequency dependance of electro-luminescence[4,5,6] it is observed that at low voltage with increasing

frequency, brightness increases slowly, but at high voltages, it increases almost rapidly. The frequency dependence of brightness can be understood on the basis of relation proposed by Thornton

$$B = N_o f \left(1 - \exp\left(-\frac{A}{F}\right)\right) \qquad \ldots (5.3)$$

Where N_o is initial concentration of electrons in the conduction band and A is the function of voltage which increases with increase of applied voltage. At very low voltage, depletion of ionised activator does not occur during cycle even at low frequency and N_o is expected independent of frequency. At higher voltages, however, depletion of ionised activator is strong, and N_o varies as square root of applied frequency and therefore the slope of curve increases at higher voltage.

5.3 ELECTRICAL CHARACTERISTICS OF PHOSPHOR

A) Brightness-Current Characteristics :

From the plots of log B versus log I under a.c. field excitation it is observed that the Brightness (B) is seen to be increasing function of current in initial part, but curve bends towards the current axis in later part. In the initial region the variation can be desdcribed by the equation of the form

$$B \propto I^m \qquad \ldots (5.4)$$

where m is an exponent whose value depends upon current region chosen. The bending of the plots may be due to heating effects become apparant at higher current levels. The linear dependence of brightness on device current is often observed for radiative recombination associated with high field impact ionisation process.[7] The power law

dependence of brightness on current $(B \propto I^m)$ and exponential relation between brightness and voltage $(B \propto \exp(-b/\sqrt{v}))$ indicates that the mechanism on EL process is likely to be an acceleration collision.

B) **Current-Voltage Characteristics :**

The variation of log of device current (I) with applied voltage (V) exhibits two distinct regions.

The region towards the low voltage side, obeys the relation $I \approx \exp(a\sqrt{v})$ while on the higher voltage side, follows the relation $I \approx \exp(av)$.

The change in current-volt characteristics from $\exp(a\sqrt{v})$ to $\exp(av)$ at higher voltage predicts the existance of an exhaustion barrier. The effective field across the barrier increases at higher voltages and the current through EL cell follows the relation $\exp(av)$ at higher voltages (8). This is supported by the power dependence of device current on brightness (fig. 3.19).

5.4 EFFECT OF ADDITION OF ACTIVATOR ON ELECTROLUMINESCENCE BEHAVIOUR

For various samples containing different concentration of activator, it has been found that the nature of voltage and frequency dependence of brightness and electrical characteristics is similar. When EL brightness is plotted as function of Er concentration, EL brightness increases, attains a maximum value and then decreases.[3] This effect is known as concentration quenching effect.

5.5 MECHANISM OF ELECTROLUMINESCENCE :

In the present investigation, it is observed that the phosphors require comparatively high fields[3] (Threshold voltage being greater than 300 volts). This behaviour, along with the existance of power law relationship between brightness and voltage, suggests that the probable mechanism of excitation in these phosphors is likely to be the direct field ionisation of either the valence band electrons or impurity centres, where transfer of electrons in the conduction band takes place by quantum mechanical tunneling process.[9] Besides the power law, a relation $B = a \exp(-b/\sqrt{v})$ is also found suitable over a limited range of voltage, indicating thereby the luminescence emission also results from a potential barrier of Mott-Schottky type, where field is proportional to $\sqrt{v}$, and mechanism of excitation is acceleration collision type[10,11,12]. The studies of electrical characteristics also is in favour of existance of potential barrier of Mott-Schottky type. Thus, it may be concluded that the probable mechanism of EL in these phosphors is liekly to be the direct field ionisation of either valence band electrons or impurity centres, where transfer of electrons into the conduction band take place by quantum mechnical tunneling process through the Mott-Schottky type barrier existing at the grain boundaries. These electrons at the latter stage recombine radiatively with impurity centres or holes created in the valence band giving EL emission.
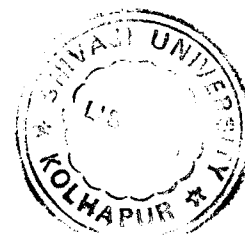
5.6 KINETICS OF LUMINESCENCE :

The kinetics of luminescence is inferred from electrolumines-cence measurements. The existance of power law relation between brightness and voltage points the possibility of bimolecular process[13] However, besides the power law, the relation $B = a \exp(-b/\sqrt{v})$ is also found suitable over a certain range of voltage. Thus it cannot be concluded that the recombination of electrons with luminescence centre is bimolecular, but it needs supports from other experimental results.

5.7 SPECTRAL ENERGY DISTRIBUTION OF EL EMISSION :

From emission spectra shown in fig. 3.21 it is observed that the green emission band at about 5250 A° for ZnO : Cu : Phosphors. But with the additioin of Er^{+++} concentration two bands are observed at about 4500 A° and 5250 A°. Further increase of Er^{+++} concentra-tion the relative intensities of first band decrease while that of second band increases. This can be explained in terms of radiative capture cross sectioin of electron hole pair.[14]

5.8 X-RAY DIFFRACTION STUDIES :

The well defined X-ray diffraction peaks show a perfect crysta-lline nature of prepared samples. The values of lattice parameters of prepared samples are compared with the standard values of ZnO given in A.S.T.M. data. This suggest that the ZnO phosphors in the present investigation possess the hexagonal structure with a = 3.2639 A°,

C = 5.2338 A° and $\frac{c}{a}$ = 1.6035. The peak positions of samples remains almost at the same position of zinc oxide. This indicates that incorporation of activator does not bring about any appreciable change in crystal structure. The values of lattice parameters obtained by H.Schulz and K.H.Thiemann[15] are in well agreement with our results.

5.9 CONCLUSIONS :

The principal findings of the present investigatioin may be summarised as follows :

1)   EL brightness (B) and applied voltage (V) follow the relation

$$B = a (v - v_o)^n$$

With v_o = 0, and   a and n as constant, over a wide range of voltage, while a relation

$$B = a \exp (-b/ \sqrt{v})$$

With a and b as constants, over a limited range.

2)   EL brightness is found to increase with increase in frequency.

3)   Mott-Schottky type exhaustion barrier are found to contribute to the emission process.

4)   Probable mechanism of EL process on these phosphors is likely to be the direct field ionisation of either valence band electrons or impurity centres, where transfer of electrons into the conduction band takes place by a quantum mechanical tunneling process through the Mott-Schottky type barrier existing at the grain boundaries. These electrons, at a latter stage

recombine radiatively with impurity centres or holes created in the valence band giving rise to EL emission.

5) From EL spectra, it is observed that, for ZnO : Cu : Phosphor green emission is observed at 5250 A° and with addition of Er^{+++} concentration two peaks are observed at 4500 A° and 5250 A°. Further with increase in Er^{+++} concentration, there is change in relative intensities of the two bands.

6) The X-ray peak positions of prepared samples are almost invariably at the same position of ZnO. This indicates that the structure of prepared sample is hexagonal.

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