CHAPTER V

GENERAL DISCUSSION AND CONCLUSIONS

This Chapter is devoted to the general discussion of the results obtained in the present investigation. Although some interpretations and inferences drawn from specific studies are described at the end of the preceding Chapters, they are summarized and further discussed.

5.1 Preparation of Phosphors : Firing Temperature and Duration of Firing:

An attempt has been made to prepare good luminescence $ZnO:Cu:Dy$ phosphors. From literature survey of ZnO phosphors, it was found that addition of 50 mg of sulphur in 10 gm of ZnO shows good luminescence efficiency. The phosphors were fired at different temperatures for different time periods. The phosphors fired at 1000°C in continuous flow of nitrogen gas for one hour were found to give good luminescence efficiency. Thus, optimum conditions for preparation of good luminescent phosphors are: (i) firing temperature 1000°C, and (ii) firing period of one hour. The phosphors of the present investigation have been prepared under similar conditions.

5.2 EL Brightness-Voltage Dependence:

The voltage dependence of EL brightness at different

frequencies is studied. It has been found that the plots between logB and logV exhibit fair linearity over a wide range of voltages suggesting a power law relation:

$$B = a(V-V_0)^n \qquad \ldots \qquad (5.1)$$

with V = 0 and 'a' and 'n' being constants, hold good between B and V. Besides the power law relation:

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

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

5.3 EL Brightness-Frequency Dependence:

When logB is plotted against logF, it is found that at low frequencies, the brightness increases with frequency almost linearly. The frequency range over which linear relationship holds good depends upon exciting voltages. At higher frequencies, the brightness increases more rapidly than at lower ones and no saturation effect is observed in the voltage and frequency range studied. The observed behaviour is in accordance with equations obtained theoretically by Thornton [3] and D.Curie [4,5]

5.4 Electrical Characteristics of Phosphors:

The a.c. field I-V characteristics show two distinct

regions and two distinct relationships: (i) $I \propto exp.(a\sqrt{V})$ holds good upto 400 volts; and (ii) relation $I \propto exp.(aV)$ holds good above 400 volts. This implies that the exhaustion of Mott-Schottky type barrier exists in phosphor [6] and the width of the barrier increases as square root of applied voltage. This is also supported by power law dependence of device current on brightness.

5.5   Emission Characteristics:

A)   <u>EL Emission Characteristics of ZnO:Cu Phosphors:</u>

The EL emission bands are observed in green and yellow regions and peaking at about 5250°A and 5750°A, respectively. The intensity of first band is greater than the second one and is shown in Fig.(3.13).

B)   <u>EL Emission Characteristics of ZnO:Cu:Dy Phosphors:</u>

EL emission spectra of ZnO:Cu:Dy phosphors (shown in Figs.3.13 and 3.14) also consists of two bands at about 5250°A and 5750°A. The relative intensity of bands depends upon the relative concentration of Cu and Dy impurity content [7].

The first band in ZnO:Cu and ZnO:Cu:Dy phosphors is due to characteristic emission of copper impurity. Many other workers [8,9,10] have also reported the same band which is due to copper impurity. The second band in ZnO:Cu sample observed in the present investigation is due to any

trace impurity in the host material. However, addition of Dy^{3+} impurity increases the peak intensity of both bands. Moreover, intensity of the second band enhances than the first band. The second band emission is attributed to the transition $^4F_{9/2} \rightarrow$ $^6H_{13/2}$ of Dy^{3+} ions.

5.6   Effect of Addition of Activators on Electroluminescence Behaviour:

It has been found that for various samples containing different concentrations of activator (Cu,Dy), the nature of voltage and frequency dependence of brightness and electrical characteristics is almost similar (see Figs.3.1, 3.2 and 3.7 to 3.12). This suggests that the activator does not significantly affect the behaviour of these phosphors.

5.7   Mechanism of Electroluminescence:

The variation of brightness according to relation:

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

indicates that the barriers of Mott-Schottky [11] are formed, in which the thickness of the barrier increases as square-root of the applied voltage. The mechanism of excitation is, therefore, an acceleration-collison type [12]. It is also observed that the phosphors required comparatively high fields [13] (threshold voltage being greater than 300V).   This behaviour alongwith power law relationship between brightness

and voltage suggests that the mechanism of excitation is likely to be direct field ionization of either valence band electrons or impurity centres, where transfer of electrons in conduction band takes place by quantum mechanically tunnelling process [14].

5.8   X-ray Diffraction Studies:

A well defined diffraction peaks show perfect crystalline nature of the prepared samples. (See Figs.4.4 to 4.8). The values of lattice parameters of prepared ZnO:Cu:Dy phosphors are compared with standard values given in ASTM data. This suggests that the phosphors in the present investigation possess hexagonal structure with a = 3.249A°, c = 5.204A° and c/a = 1.602 (average values). The peak positions of the samples remain almost at the same positions as of pure zinc oxide. This indicates that incorporation of activator does not bring about any appreciable change in the crystal structure. But the relative peak intensities of different X-ray diffraction pattern of ZnO:Cu:Dy phosphors are affected by the concentration of activator. The values of lattice parameters obtained for our phosphors are well in good agreement with those obtained by H.Schulz and K.H. Thiemann [15].

5.9 Scanning Electron Microscopy Studies:

From the SEM photographs (shown in Fig.4.9), it may be seen that the grain size of the particles increases with addition of impurity. The values calculated by line intercept method are 1.58 µm, 1.73 µm and 2.14 µm for ZnO. ZnO:Cu and ZnO:Cu:Dy phosphors, respectively. The increase in the grain size indicates that added impurities segregate to the host material.

5.10 Conclusions:

The principal findings of the present investigation may be summarized as follows:

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

$$B = a(V-Vo)^n$$

With Vo = 0 and 'a' and 'n' as constants oveer wide range of voltages, while a relation:

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

with 'a' and 'b' as constants over limited range.

2) EL brightness is found to increase in frequency.

3) The exponential relationship between the brightness-current and current-voltage characteristics predict the existence of Mott-Schottky type exhaustion barrier.

4)   The probable excitation mechanism of EL in these phosphors is likely to be direct field inionization or acceleration-collison type.

5)   The concentration quenching effect is observed for Cu impurity in ZnO matrix. The maximum intensity is observed at 0.05 weight (%) of Cu content in ZnO. No such effect is observed in ZnO:Cu:Dy phosphors within the studied range of Dy^{3+} concentration.

6)   From EL emission spectra, it is observed that for ZnO:Cu phosphors emission bands observed at about 5250°A and 5750°A. With addition of Dy^{3+} concentration also, two peaks are observed at about 5250A° and 5750A°. But intensity of second peak increases with the increase in Dy^{3+} concentration.

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

8.   From SEM micrographs, it may be seen that the grain size increases with the addition of impurity in the host material.

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