CHAPTER X

SUMMARY AND CONCLUSIONS

10.1 Summary of the work

The first chapter of the thesis is a concise review on the subject of EL giving special importance to high field EL. In the initial part, the importance of II-VI semiconducting materials as the phosphors for the development of large area format display systems is brought out and then an account of the various activators and co-activators used in some important EL materials and their method of preparation is given. This is followed by a description of the various physical mechanisms involved in both high field (intrinsic) and injection electroluminescence phenomena. The second part of this chapter gives a comprehensive report of the state of art ACTFEL devices along with the essential physics of memory and non memory EL devices. The empirical requirements for the preparation of ACTFEL cells showing memory phenomenon are also noted.

In the second chapter, the details of the experimental setup used for the various investigations by the author are described. It contains an account of the procedure for preparation of the EL phosphors, the vacuum furnace used for their preparation, the setup for recording the spectrum of the EL emission etc. It also gives the details of a PMT.
preamplifier used for recording the spectrum of weak EL emission. Towards the end of the chapter, the method adopted to estimate the brightness of the EL cells in foot-lamberts is described.

The third chapter describes the details of a series of experiments done on ZnS:Cu,Cl phosphor with different concentration of chlorine added to the premixture. It is found that all the experimentally observed facts can be explained on the basis of a new energy level scheme which includes levels corresponding to Cu$^{2+}$, Cu$^+$ and Cl$^-$ in the forbidden gap of ZnS. In contrast to the previous models this scheme is found to explain satisfactorily the occurrence of the red emission as well. Here this particular emission is attributed to transition from the donor (Cl$^-$) to the acceptor (Cu$^+$) centre. Another important investigation presented here is on the preparation and study of ZnS:Cu,Mn,Cl and ZnS:Cu,Dy,Cl phosphors. However, these phosphors are found to be less efficient. The EL spectrum of ZnO which is discussed at the end of the chapter gives a new ultraviolet band, in addition to the previously reported green band.

The method of preparation of an efficient CaS:Ce EL phosphor together with the detailed description of their electrical and spectral characteristics are the main topic of discussion in chapter IV. Here it is concluded that the luminescent centre giving rise to the EL emission is the Ce$^{2+}$ ion. The brightness-frequency characteristics of
these phosphors are found to exhibit an anomalous behaviour. It is explained on the basis of the field controlled trapping and detrapping of charge carriers. Such a characteristic is observed in the case of all CaS phosphors. Another important result presented in this chapter is the quenching of the emission from Ce in the CaS:Ce,Nd phosphor. This is explained as due to the resonance radiationless energy transfer from Ce to Nd. The various emission lines and bands observed in the spectrum of this phosphor are identified. It is concluded that they are essentially due to the Nd$^{2+}$ luminescent centres.

Chapters V and VI report the EL emission spectra of CaS:Er, CaS:Sm, CaS:Dy and CaS:Mn. The emission groups occurring in the spectra of each phosphor are identified. On the basis of a group theoretical calculation the sites of the Er and Sm luminescent centres in CaS host material are found out. An interesting observation on the EL spectra of the CaS:Dy is that its most intense band occurs as a result of a transition from an excited state to a level next to the ground state. It is speculated that this may be due to the hypersensitive nature of this transition. CaS:Mn phosphor shows a single band in its emission spectrum but it is found to be of very low intensity.

Chapter VII presents a detailed account of the fabrication of DC powder EL cells. It contains a brief discussion of the phosphor preparation, DC forming, the equivalent circuit for the DCPEL cells and the dependence
of the circuit parameters on the degradation. Here a
detailed description of the preparation of ZnS:Mn and CaS:Ce,
DCPEL cell and some of the experimental results obtained on
CaS:Ce DCPEL cells are given.

In chapter VIII a description of the experimental
setup used for the fabrication of an ACTFEL cell is given.
It starts with an outline of a typical device fabrication
method followed by a brief description of the various experi­
mental setup used. It includes the fabrication details of two
vacuum coating units, the evaporation system (both resistive
and EBE), substrate heater and film thickness measurements.
It also describes the method by which films of predetermined
thickness values were deposited with the help of a quartz
film thickness monitor. At the end of the chapter a detailed
account of the spray pyrolysis method used for the deposition
of transparent conducting electrodes of SnO₂ is given.

A concise report of the detailed experimental procedure
for the fabrication of an SnO₂-MgF₂-ZnS:Mn-MgF₂-Al device by
resistive heating, and an SnO₂-Y₂O₃-ZnS:Mn-Y₂O₃-Al devices by
EBE technique is given in chapter IX. The latter device has
the same characteristics as reported by various workers.
But the former, apart from the brightness saturation at high
excitation fields, shows a strong dependence of the thres­
hold voltage (for the onset of light emission) on the fre­
quency of the excitation.
10.2 Scope for further work

The thesis contains the procedures for preparation and studies of a number of EL phosphors. Emission spectra, B-V characteristics, B-f characteristics and brightness waves are the important aspects studied here in the case of these materials. However, many other aspects like temperature dependence of emission, time resolved spectrum etc. still remain to be investigated.

In the investigations presented here no attempt is made to find out the optimum condition for the preparation of different phosphors except in the case of CaS:Ce. The method adopted to optimise the CaS:Ce can be extended to the other phosphor systems as well. The proposed energy level scheme put forward to explain the EL emission from ZnS:Cu,Cl is formulated mainly on the basis of the emission spectra observed for phosphors containing different concentrations of chlorine and on the chemical method used for its preparation. This model can be asserted further by studying the time resolved EL spectrum of this material. It is also possible to extend the work on ACTFEL by using insulator materials other than MgF2 and Y2O3.

It is hoped that, the studies described in the thesis have been able to shed some light on certain aspects of the phenomenon of EL. It also reports some new EL phosphor
materials which will be of interest to physicists as well as to display technologists. Obviously, there exists immense scope for further work directed towards the development of new phosphor materials and EL devices.