Chapter 6

Summary and Future Scope

6.1 Summary

The summary of the development of FPGA based TL/OSL system with EMCCD camera is presented in this chapter. It is followed by the summary of the synthesis and characterization of nano phosphor. This also includes the TL/OSL characteristics of the phosphor after it was annealed. Annealing was needed to make the phosphor TL/OSL sensitive.

6.1.1 Development of the TL/OSL spatial luminescence system

An FPGA based hardware system for imaging both Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL) has been developed for the spatial investigation of luminescent materials. It allows TL and OSL to be performed using various user defined parameters like heating rate, final temperature, heating duration, isothermal TL or TL with linear heating rate, different modes of OSL like LM-OSL and CW-OSL.

A feasibility study of various light detectors was done to assess their suitability as photodetector for this system. Light detectors capable of giving spatial distribution of luminescence and light detectors that integrate the detected luminescence were studied. This study highlights that PMT is a superior detector compared to all others in detecting extremely low level optical signal. The next most suitable detector is the digital SiPM. It has sufficiently large detection area but its minimum detectable power is high for TL/OSL applications. For the case of spatial analysis EMCCDs are found to be the best because of their spectral range, high photon sensitivity, and high speed along with other desirable features.

Due to EMCCD's wide spectral range of 300 nm to 1000 nm the emitted luminescence can be detected in any spectral window by using appropriate filters. User-interface, graphical display of data and instrument control has been implemented using LabVIEW. The system has been thoroughly tested in terms of proper thermal and optical stimulation. In the thermal stimulation the average error was less than 0.35 ˚C and for optical stimulation it was less than

0.1%. Dose recovery tests were done for quartz and feldspar and the results for most of the grains were found to be within ±10% of the real value. Thus this system enables the luminescence researcher to explore the realm of spatial luminescence with a more versatile instrument.

6.1.2 Synthesis and characterization of nano-phosphor

Nano scale Calcium Fluoride was synthesised. From its structural analysis it is confirmed that the material is Calcium Fluoride and by using Scherrer's formula the size of its constituent grains was found to be in nano scale.

From the optical analysis it is seen that the characteristic absorption peak of the material is present in the UV region. The absorption peak is at 239 nm. The optical band gap energy (E_g) was found to be 2.9 eV.

In the PL, broad emission was observed at 345 nm along with a small but distinct emission peak at 482 nm, when the sample was excited at 239 nm. These emission peaks can be attributed to self trapped exciton states. The emission at 345 nm corresponds to an energy level of 3.59 eV and the emission peak at 482 nm corresponds to the energy level of 2.57 eV. It could be possible that the broad emission at 345 nm is due to the traps which are responsible for the closely placed first and second peaks in the TL glow curve. The sharp emission peak at 482 nm could correspond to the unstable higher temperature peak.

It is found that annealing temperature of 600 ˚C is the best annealing temperature when the annealing duration is kept constant at 1.5 h. But when annealing durations were varied keeping the annealing temperature constant at 500 ˚C and 600 ˚C, it was found that the former gave better results. It was concluded from the observations that the phosphor annealed at 500 ˚C for 2.5 h become maximum luminescent.

The above results indicate that as the annealing parameters are varied systematically, the luminescence properties are enhanced up to a certain extent, beyond this if the annealing parameters, i.e. temperature or duration, are increased there is a reversal in the observed trend. The decrease in the crytallinity beyond this point and the increase in the crytallinity till this point of reversal could be the reason for the observed trend in the luminescence of the material.

The study of the TL characteristics of this phosphor revealed that it follows the general order kinetics. The activation energy *E* of this phosphor was found by various methods. It is around 1.04 eV. The symmetry factor μ of the glow curve is 0.54. The minimum detectable dose is 5 mGy and it reaches saturation around 2 kGy. This phosphor is especially suitable for environmental dosimetry due to its high sensitivity. Lack of tissue equivalence prevents its use for medical dosimetry.

The phosphor has maximum emission in the range 480 to 600 nm for IR stimulation. Blue stimulation with detection in the UV region (280 to 370 nm) gave the maximum count which was around 33 times more than that obtained for IR stimulation in the 330 to 600 nm range. In the study to find the correlation between the TL and OSL of the phosphor, it was found that the first peak in the TL glow curve contributed around 30% to the total luminescence in the OSL decay curve. The remaining 70% of the luminescence was due to the second peak. The third high temperature peak which was unstable does not seem to have any effect on the OSL, or it might be destroyed after the first OSL cycle. This indicates that the thermal traps and the optical traps may mostly be the same for this phosphor.

For OSL this phosphor gave a linear dose response till around 100 Gy. After that non-linearity is observed but still an increase in emitted counts is observed with increasing dose. The phosphor dose response saturates around 2500 Gy.

The phosphor did not give any response for IRRL. This implies that the electron density at the corresponding trap is zero. It is probable that there are no traps at the corresponding level i.e. at the level where its trapping will give emission in the IR region.

6.2 Future scope

Use of multicolor LEDs can be explored so that the optical stimulation could be possible using any wavelength of choice. Three terminal multicolor LEDs are available in the market. By applying appropriate voltages at the three terminals wavelength of any light in the visible region can be obtained. Such an instrument will also require a spectrometer to determine the wavelength of the stimulating light.

The system can be upgraded such that in the image captured the contribution of different wavelength can be known.

A radiation source can be incorporated in the system. The use of an X-ray source could be explored as it avoids the legal issues involved with a radioactive source.

Appropriate software can be developed which can reduce the complications involved in the image analysis. It could do the calculations for determining the TL and OSL parameters, age determinations, dose recovery, etc.

A field based compact system can be developed.

The system can have in-built annealing facilities with options for different annealing atmosphere like annealing in air, vacuum or Nitrogen.

A non-contact mode of heating like gas heating, induction heating or laser heating can be explored.

Appropriate protocol which could find wide acceptability needs to be developed for the case of spatial luminescence.

In the case of phosphor development a clearer understanding is required about the role of annealing parameters with regards to TL/OSL characteristics.