CHAPTER 6

CONCLUSIONS AND FUTURE PROJECTIONS

This chapter deals with the overall conclusions of the present study. At the end of this chapter, the future projections of this thesis work are also discussed.

6.1 CONCLUSIONS

In this thesis the dosimetric aspects of boron based nanocrystalline phosphors such as Lithium borate, Magnesium borate and Boron carbonoxynitride have been studied. X-Ray diffraction (XRD) and Transmission electron microscopy (TEM) techniques have been used to confirm the formation of material in the nano size. Thermogravimetric analysis (TGA) has been performed to study the thermal stability of synthesized material. The synthesized nanophosphors were exposed to gamma rays, proton (3 MeV and 150 MeV) beam and electron (4 MeV, 9 MeV) beam to investigate their TL properties for their applications in radiation dosimetry. The results of our investigation lead to the following conclusions:

1. XRD pattern of the synthesized Li$_2$B$_4$O$_7$ nanophosphor reveals that it posses tetragonal structure. The average grain size of the concerned compound is found to be approximately 25 nm from XRD pattern, whereas TEM photograph shows that the particles are of rod shape with their average diameter approximately 30 nm. It further shows that the particles are of quite uniform shapes and sizes.

2. The analysis of TGA thermogram concludes that the weight loss of synthesized Li$_2$B$_4$O$_7$ is 14.5 % and that of Li$_2$B$_4$O$_7$:Cu is 2.5 % only, before the phosphor reaches its melting point. So, the synthesized lithium borate is found to be thermally stable phosphor that is the essential requirement for being a good thermoluminescence dosimeter.

3. The TL response of nanocrystalline Li$_2$B$_4$O$_7$ and commercially available microcrystalline Li$_2$B$_4$O$_7$ phosphor to gamma rays in the dose range $1 \times 10^{-3}$ to $1 \times 10^{3}$ Gy, has been reported in this work. It is concluded that both synthesized
and commercial samples do not show a linear pattern for low doses below $1 \times 10^1$ Gy, hence Li$_2$B$_4$O$_7$ is not recommended as dosimeter within this range. Further the synthesized Li$_2$B$_4$O$_7$ nanophosphor shows a linear response in the range $1 \times 10^1$ Gy to $4.5 \times 10^2$ Gy, whereas the commercially available microcrystalline Li$_2$B$_4$O$_7$ do not show any linear pattern. So, the synthesized Li$_2$B$_4$O$_7$ may be used as TLD material in this range.

4. TL response of Li$_2$B$_4$O$_7$: Cu (doped with 1000 ppm Cu) is found to be maximum when irradiated with gamma dose in the range $2 \times 10^{-4}$ to $1 \times 10^1$ Gy. Further with increase in radiation dose, the Li$_2$B$_4$O$_7$: Cu (doped with 2500 ppm Cu) also starts giving better results for TL response. It is found that for the dose of $5 \times 10^1$ and $1 \times 10^2$ Gy, the samples doped with Cu of concentration 1000 ppm and 2500 ppm gives same TL response. With further increase in dose upto $5 \times 10^3$ Gy, Li$_2$B$_4$O$_7$: Cu (doped with 2500 ppm Cu) gives the better TL response than that of 1000 ppm doped samples.

5. Li$_2$B$_4$O$_7$: Cu doped with Cu (1000 ppm and 2500 ppm) exhibits a linear response for gamma dose ranging $1 \times 10^0$ to $5 \times 10^3$ Gy. The fading for Li$_2$B$_4$O$_7$:Cu (doped with Cu 2500 ppm and 1000 ppm) is around 7 % and 10 % respectively. The results reveals to the conclusions that Li$_2$B$_4$O$_7$:Cu nanophosphor possess easy and inexpensive method of preparation, good sensitivity, high thermal stability, simple glow curve structure, linear TL response over a wide range of exposure, low fading and excellent reproducibility. These characteristics makes it useful for its application in radiation dosimetry of high dose measurements of gamma radiations.

6. Nanocrystalline Li$_2$B$_4$O$_7$:Cu (doped with 1000 ppm Cu) exposed to 3 MeV proton beam shows a linear TL response in the range $1 \times 10^{11}$ ions/cm$^2$ to $5 \times 10^{13}$ ions/cm$^2$ and upto $7 \times 10^{13}$ ions/cm$^2$ for sample doped with 2500 ppm Cu. The total fading in one month for Li$_2$B$_4$O$_7$:Cu doped with Cu (1000 ppm and 2500 ppm) is 7 % and 7.5 % respectively. Since the energy is very low, so this material can be useful for its application in radiation dosimetry using 3 MeV proton beam for the treatment of very superficial skin cancer.

7. Li$_2$B$_4$O$_7$:Cu (doped with 1000 ppm and 2500 ppm Cu) shows a linear TL response in the range $1 \times 10^0$ Gy to $3 \times 10^1$ Gy and fading of 6.8 % and 7.8 %
respectively for exposure to 150 MeV proton beam. Since the energy is high, so this material can be used as a radiation dosimeter using 150 MeV proton beam for the treatment of deep tumors.

8. Nanocrystalline Li$_2$B$_4$O$_7$:Cu, doped with 1000 ppm and 2500 ppm Cu shows a linear TL response in the range $1 \times 10^{-1}$ Gy to $1 \times 10^1$ Gy for 4 MeV and 9 MeV electron beam. The total fading in one month is around 7%. So this material can be used as a radiation dosimeter for electron beam used in the treatment of skin cancer at different depths.

9. The synthesized MgB$_4$O$_7$:Dy nanophosphor possesses orthogonal structure as confirmed from its XRD pattern. The average grain size of the concerned compound is found to be approximately 22 nm from XRD pattern whereas TEM photograph shows that the particles are of tubular shape with their diameter ranging between 19 to 36 nm approximately.

10. MgB$_4$O$_7$: Dy shows a total weight loss of 47% at 1150°C (close to its melting point). So, the synthesized MgB$_4$O$_7$:Dy is found to be thermally unstable compound at higher temperature that is the main disadvantage of this synthesized material.

11. MgB$_4$O$_7$: Dy samples irradiated with $1 \times 10^3$ Gy of gamma rays yields maximum TL intensity for 1000 ppm concentration of dopant (Dy) and with further increase in dopant concentration, the TL intensity decreases.

12. MgB$_4$O$_7$: Dy nanophosphor shows a remarkable linear pattern for lower doses in the range $4 \times 10^{-4}$ to $4.5 \times 10^{-2}$ Gy. When dose is increased further to $1 \times 10^{-1}$ Gy, the material shows sublinear behaviour and from $1 \times 10^0$ Gy to $5 \times 10^3$ Gy, TL response becomes linear. On further increasing the dose, the response initially becomes supralinear (from $5 \times 10^3$ Gy to $1 \times 10^4$ Gy), then sublinear and finally resulting into saturation over $1.5 \times 10^4$ Gy. The fading is found to be around 8%. So, it may be concluded that the synthesized MgB$_4$O$_7$:Dy nanophosphor can be used as dosimeter in the range $4 \times 10^{-4}$ to $4.5 \times 10^{-2}$ Gy and $1 \times 10^0$ Gy to $5 \times 10^3$ Gy of gamma radiations.

13. Nanocrystalline MgB$_4$O$_7$:Dy shows a linear response in the range $1 \times 10^{11}$ ions/cm$^2$ to $1 \times 10^{13}$ ions/cm$^2$ for 3 MeV proton beam. The fading in one month
is 7 %. Since the energy is very low, so this material can be useful for their applications in radiation dosimetry for 3 MeV proton beam used in the treatment of very superficial skin cancer.

14. Nanocrystalline MgB$_4$O$_7$:Dy shows a linear response in the range $5 \times 10^0$ Gy to $1 \times 10^2$ Gy for 150 MeV proton beam. The total fading recorded in one month is 8.2 %. Since the energy is high, so this material can be used as a radiation dosimeter for 150 MeV proton beam used in the treatment of deep tumors.

15. Nanocrystalline MgB$_4$O$_7$:Dy shows a linear TL response in the range $1 \times 10^{-1}$ Gy to $5 \times 10^0$ Gy for 4 MeV electron beam and $1 \times 10^{-2}$ Gy to $2 \times 10^0$ Gy for 9 MeV electron beam. The total fading recorded in one month is around 7 %. So this material can be used as a radiation dosimeter for electron beam used for the treatment of skin cancer at different depths.

16. The average grain size of the BCNO compound is found to be 30 nm using XRD pattern. The compound exhibits hexagonal structure with lattice parameters $a = 0.251$ nm, $b = 0.251$ nm and $c = 0.666$ nm. The TEM image shows that the grains are nearly spherical in shape with the size distributed between 30.42 nm to 46.88 nm having an average diameter of 38 nm.

17. From TGA thermogram it can be concluded that the weight loss is 37.5 % before the phosphor reaches its melting point. So, the synthesized BCNO is found to be thermally unstable phosphor.

18. It is concluded that the doping of BCNO with Dy and Cu leads to the quenching of its TL properties when exposed to gamma rays.

19. The synthesized BCNO nanophosphor shows a linear response in the gamma range $1 \times 10^2$ to $2 \times 10^3$ Gy, that is the range in which it may be used as TLD material for gamma rays. Further BCNO is found to be non sensitive to 3 MeV proton beam and 6 MeV electron beam.

20. The disadvantages of this material are its low thermal stability and high fading, so further studies, using some more dopants of varying concentrations in BCNO are needed for exploring this material before concluding it as the best dosimeter for gamma rays, electron beam and proton beam.
6.2 FUTURE PROJECTIONS

No study is complete in itself, there are always some loose ends which remain uninvestigated and from where the work can be started in future. The future prospects of the present work are as follows:

1. The thermoluminescence properties of the synthesized materials (lithium borate, magnesium borate and Boron carbooxynitride) can be compared with the commercially available materials (e.g. TLD-900, TLD-700, TLD-100, TLD-700H), for their wide applications.

2. Techniques such as ESR, FTIR, Raman spectroscopy etc can be used to study the detailed mechanism of the luminescence in synthesized compounds.

3. Swift heavy ion modifications in the properties of synthesized materials can also be studied.

4. The thin films of the synthesized nanophosphors can be deposited on different substrates for their further characterization.

5. The nanophosphors can be investigated with wide range of dopants such as Eu, Tb, Sm, Pr etc. Moreover different combinations of codopants can be used for studying the thermoluminescence properties.

6. Theoretical investigations can be carried out to study the mechanism of luminescence in the better manner in boron based nanophosphors.