CHAPTER-6

OVERALL CONCLUSIONS AND FUTURE PERSPECTIVES

This chapter summarizes and concludes the overall findings of this research work and presents a discussion of their significances for the study of swift heavy ion and gamma rays induced modifications in optical, dielectric, structural, chemical and thermoluminescence properties of phyllosilicate minerals. The scope for future work has also been presented in this chapter.

6.1. OVERALL CONCLUSIONS

Heavy ions and gamma rays irradiation induced modification is a most valuable and very significant technique used for modifying and improving properties of material than any other method. In this thesis, the systematic investigations of optical, dielectric, structural, chemical and thermoluminescence properties of phyllosilicate minerals before and after irradiation were carried out. The interesting results of these investigations lead to the following conclusions:

1. Samples of Phlogopite mica have been irradiated with 80 MeV oxygen ion at different fluences. A systematic reduction in both the direct and indirect optical band gap is observed with increasing ion fluence from UV-VIS spectra, which is associated with oxygen ion induced defects and disordering in phlogopite. The value of urbach energy increases with increase in ion fluence which may be attributed to increase in degree of structural disorder with ion irradiation.

2. Irradiated phlogopite shows a decrease in dielectric constant values with increasing ion fluence at all frequencies. Irradiation leads to formation of defects resulting in the increase in $\tan \delta$ and ac conductivity. Obtained data show that ac conductivity is proportional to $n$th power of frequency ($f^n$) in pristine and irradiated phlogopite mica, with slope $n$ ranging between 0.62 and 0.77 which indicates that electronic conduction takes place through hopping process.

3. The analysis of XRD data also reveals that the damage in phlogopite due to irradiation as the crystallite size decrease. The outcome of XRD study is in accordance with the results of UV-VIS and dielectric study.
4. The FTIR spectra show an overall decrease in transmittance after irradiation. The sample irradiated at highest fluence shows radiolysis of water from hydroxyl group and leads to the disappearance of Si-H bands.

5. TL analysis of oxygen ion irradiated natural phlogopite mica shows that phlogopite can be used as a thermoluminescent material for high temperature dosimetry applications.

6. The results of UV-VIS spectra show that the direct and indirect optical band gap can be monitored with the help of gamma irradiations. The structural disorder calculated using Cody Model has been used to describe the variation in Urbach energy due to gamma irradiation.

7. Dielectric properties of natural phlogopite mica are enhanced by gamma irradiation. The results of XRD analysis are in good agreement with UV-VIS and dielectric results.

8. FTIR spectra of pristine and irradiated samples show that natural phlogopite mica is chemically stable. The investigations reveal the changes in the optical, structural and dielectric properties of the natural phlogopite mica with gamma irradiation.

9. It may also be concluded that the phlogopite mica has a good potential for dosimetry of high gamma radiation and therefore recommended as a TLD for measuring radiation doses.

10. The SHI irradiation induced changes in natural muscovite mica sheets using optical, dielectric measurements, XRD, FTIR and TL techniques have been investigated. The simultaneous existence of direct and indirect band gap in natural muscovite mica has been observed. UV-VIS spectra revealed a shift in the absorbance edge towards higher wavelength side with increasing ion fluence which reflects a decrease in both direct and indirect band gap. This decline in both direct and indirect band gap may be due to increase in defects states with increasing ion fluence.

11. Urbach energy increases with the increase of ion fluence, which may be attributed to increase in degree of structural disorder with ion irradiation. The calculation using Cody model shows an increase in structural disorder with increase of ion fluence during irradiation.
12. The dielectric measurements reveal that the dielectric constant decreases, while tanδ, dielectric loss and ac conductivity increases upon irradiation.

13. The XRD analysis reveals that micro strain and dislocation density increases upon ion irradiation which may be assigned to the high concentration of irradiation induced defects and dislocations. These results of XRD study are in conformity with the UV-VIS and dielectric results.

14. The FTIR spectra of irradiated samples do not show any prominent change in the bands of the material. From the TL studies, it is confirmed that natural muscovite mica is a good material for high temperature dosimetry applications.

15. The results of UV-VIS spectra of gamma irradiated muscovite mica show that the optical indirect and direct band gap increases with increase in gamma dose from 1 to 100 kGy and decrease by further increasing the gamma dose upto 2000 kGy. The increase of optical band gap with gamma irradiation makes natural muscovite fits for efficient optoelectronic devices.

16. Gamma irradiation resulted in an increase of dielectric constant and decrease of tanδ and ac conductivity upto 100 kGy; however vice versa with further increase upto 2000 kGy. Data show that a.c. conductivity is proportional to $f^n$ in pristine and irradiated muscovite mica, with a slope n ranging between 0.69 and 0.88 which indicates that electronic conduction takes place through a hopping process.

17. Gamma irradiation upto 100 kGy leads to the increase in crystallite size, reduction in the defects and the decrease in structural disorder and microstrain. The positions of FTIR characteristics bands do not change which shows that crystalline structure of muscovite mica is stable under gamma irradiation.

18. Gamma irradiated natural muscovite mica has eminent applications in radiation dosimetry due to observation of well defined single peak at 141 °C. Therefore, irradiation of natural muscovite mica with gamma rays improves its utility as an electronic insulator in optoelectronic devices and for dosimetry.

19. The results of optical analysis reveal that the optical band gap decreases with increase of ion fluences due to increase in structural disorder in the vermiculite mineral.
20. The observed change in dielectric properties after ion irradiation was collaborated with opto-structural modifications in the vermiculite. Frequency dependence of ac conductivity reveals that the ac conductivity obey Jonscher's power law in both pristine and irradiated samples.

21. A significant reduction in crystallite size in irradiated vermiculite is observed which indicates the local disordering of vermiculite structure as microstrain and dislocation density increases.

22. Predictions of the chemical composition based on EDS analysis were also confirmed by the FTIR spectroscopy. The FTIR band corresponding to 2350 cm\(^{-1}\) disappears at higher fluences depicts least tendency to absorb CO\(_2\) from the atmosphere.

23. A prominent TL peak around 148 °C and enhancement in its intensity with ion fluence make vermiculite a perfect TLD and explore its potency for magnificent applications in radiation dosimetry.

24. The results of opto-structural, dielectric, chemical and thermoluminescence properties of γ-irradiated vermiculite indicates that irradiation induces structural changes that lead to the creation of new material with enhanced properties. It is concluded from UV-VIS analysis that the increase of optical band gap with gamma irradiation makes natural vermiculite mineral fits for efficient optoelectronic devices.

25. A notable increase in the dielectric constant of the vermiculite with gamma dose of 1000 kGy has been observed which improves its utility as an electronic insulator.

26. A negative slope in the Williamson-Hall plot indicates the presence of compressive strain experienced by the particle of vermiculite. Gamma irradiation upto 1000 kGy leads to the improvement in the crystallinity due to the increase in crystallite size, reduction in the defects and the decrease in structural disorder and microstrain. The outcomes of FTIR analysis are in good agreement with the UV-VIS, Dielectric and XRD results.

27. From the TL studies, it is confirmed that natural vermiculite is a good material for TL dosimeter for innovative dosimetry applications in radiation rich
environment. Thus we can conclude that the gamma irradiation can be utilized as a tool for tailoring the various properties of vermiculite in the field of insulation and radiation rich environment.

6.2. FUTURE PERSPECTIVES

The work presented in this thesis opens up a lot of avenues for future research in the field of radiation induced modifications in minerals. Possible extensions of the present work are given below:

1. Opto-structural, dielectric and thermoluminescence properties of other phyllosilicate minerals (Lepidolite, Kaolinite, Halloysite, Chlorites, monazite) can be studied in order to use them in insulation and radiation dosimetry.
2. Electron and neutrons irradiation induced modifications in Opto-structural, dielectric and thermoluminescence properties of these phyllosilicate minerals can also be studied.
3. Techniques such as ESR, Mossbauer spectroscopy etc can be used to study the more detailed mechanism of the luminescence in phyllosilicate minerals.
4. Magnetic properties of these minerals can also be studied using different techniques like VSM.