Preface:

Study of optical properties of rare earth ions in different glass host matrices are of current interest as they exhibits lasing transitions that are influenced by host material. Glasses doped with rare earth ions are good material for mode locked femtosecond lasers because of larger line broadening. The upconversion phenomenon observed in various glass hosts doped with different rare earth has many applications. Er – doped amplifiers are used in 1.5 \( \mu m \) optical communication systems while Dy\(^{3+} \) and Pr\(^{3+} \) are useful in 1.3 \( \mu m \) range. The Nd\(^{3+} \) doped phosphate glass laser with large output power are used in fusion research. Glasses based on heavy metals are gaining in importance as laser because of their high referective index and low phonon energies. The reduced phonon energy enhances the quantum efficiency of fluorescence.

In the present work we have studied changes in the optical properties of rare earth ions in TeO\(_2\) based glasses and also on addition of heavy modifiers viz \(\text{Ba}_2\text{CO}_3, \text{PbO}_2\). We have used lead oxide (and barium carbonate) as glass modifier together with lithium carbonate. The concentration of these two varied and it is observed that a stable glass is formed even when other modifiers are completely replaced by these modifiers up to a certain limit. Beyond that limit formation of glass becomes difficult. The glass is stable
when a part of the glass former (Tellurium Oxide) is replace by PbO₂ / Ba₂CO₃. We found that quantum yield of fluorescent transition in rare earth doped glasses increases on addition of these modifiers.

The chemical compositions of rare earth doped glasses are given in respective chapters. The glasses have been prepared using the standard melt and quenching technique. The rare earth ions, which we used, are Ho³⁺ and Er³⁺. Transitions between the levels of 4fⁿ configuration are forbidden for a free ion by selection rules. The rare earth ions in a glass host are however in an inhomogeneous electrostatic field distorts the energy levels causing the higher energy configuration (4fⁿ⁻¹5d) to admix with 4fⁿ and hence the f – f transitions appear.

The observed spectrum has been analyzed with the help of Judd – Ofelt theory which permits evaluation of various parameters such as transition probability, radiative life time, branching ratios and stimulated emission cross – section. UV – Vis – NIR absorption, fluorescence and life time measurements have been undertaken.

Rare earth doped glasses / crystals can also be used to estimate the temperature of any object by using fluorescence intensity ratio (FIR) technique. In this connection we have tested Ho³⁺ and Er³⁺ doped tellurite lattice to use as temperature sensing device.
The thesis has been divided in six chapters. The first chapter is a general introduction and the importance of rare earth doped glasses, basic properties of glasses, the optical properties and the thermal properties of rare earth ions in glasses along with the theory used to explain them are given in this chapter. The experimental techniques for studying various optical and thermal properties of rare earth doped glasses are briefly described.

In chapter two we will give a historical coverage of upconversions in Lanthanides doped in different kinds of lattice.

In chapter three results of our investigations of optical properties and upconversions and also the effect of addition of PbO$_2$ and Ba$_2$CO$_3$ of Ho$^{3+}$ doped in TeO$_2$ network have been described. The concentration of Ho$^{3+}$ / PbO / BaO are varied up to different extents. Many glass samples have been prepared corresponding to these concentrations. UV – Vis – NIR absorption have been recorded for glasses with different PbO / BaO concentrations. Fluorescence has been excited by 476 nm of Ar$^+$ laser, 812 / 890 nm of Ti – Sapphire laser and 532 nm of NdYAG laser. The radiative life time of the fluorescing level has been also estimated from the fluorescence decay curve. A single exponential curve is assumed. It is observed that the fluorescence intensity increases with PbO / BaO concentration and maximum for 6 mol % of PbO and 45 mol % of BaO. Judd – Ofelt parameters are evaluated from
the absorption spectra and the variation of these parameters with composition is discussed. These parameters are used to estimate various optical parameters. We have also studied the replacement of Ho$^{3+}$ by Er$^{3+}$ in the same network. These things have been discussed in the fourth chapter.

In chapter five we have tested the temperature sensing properties of Ho$^{3+}$ and Er$^{3+}$ in tellurite network using fluorescence intensity ratio technique. The purpose of this investigation is to employ an optical temperature sensor for the measurement of temperature where other various available temperature sensors cannot be used.

Chapter six deals with results obtained from the non-radiative energy transfer studies from Ho$^{3+}$ to Er$^{3+}$ doped in tellurite glass. We have followed the donor acceptor energy transfer theory first suggested by Foster and extended by Dexter. The energy transfer was found to be dominated by dipole–dipole interaction. These changes have also been used to estimate the energy transfer efficiency ($\eta$) and transfer probability in this case.

Some of the publications resulting from the above work and conferences / symposia attended to complete my PhD are given below.