ABSTRACT

The present work concerns with the spectroscopic investigations on Nd^{3+}:BBFB, Nd^{3+}:BLFB, Er^{3+}:BBFB and Er^{3+}:BLFB glasses for infra-red laser applications. Glass is a non-crystalline solid and a super cooled liquid which are prepared by melt quenching technique. In the view of their scientific and technological applications, glasses are exposed to spectroscopic investigations for their characterization. Borate glasses are potential candidates for applications in solid-state infrared lasers, colour filters and optoelectronics devices, etc. Laser is a coherent high energy radiation in the electromagnetic spectrum. Glasses are used in lasers as active and passive components. Particularly in the insulating host lasers, the glasses are the active components like gain media. In glasses, trivalent lanthanide ions can be doped as active ions. Changing the lanthanide ions can change the lasing properties. Host material may also alter the broadness of the emission peaks, and hence host selection is important from luminescence point of view.

The thesis consists of six chapters and as follows.

Chapter I is devoted to with the introduction of glasses, formation of glasses and classification of glasses with its applications. The detailed analysis of trivalent lanthanide ions and its structure in the host matrix, Development history of Judd-Ofelt theory are described. The structural and optical characterization with physical and luminescence parameters also discussed.

Chapter II presents the new series of neodymium doped barium bismuth fluoroborate glasses with the chemical composition of (70-x)H_3BO_3 - 5Bi_2O_3- 10$BaCO_3$ - 7.5CaF_2 - 7.5ZnO - xNd_2O_3 (where x= 0.05, 0.1, 0.25, 0.5, 1, 2 (in wt %) have been prepared by the conventional melt quenching method. The powder x-ray diffraction pattern confirms the amorphous nature of the prepared glasses. The Urbach energy reveals the minimum disorderness of the glass

samples. Judd-Ofelt intensity parameters (Ω_λ=2, 4 and 6) were derived from the absorption spectrum and were used to calculate the emission properties. The near infrared emission spectra recorded with 808 nm laser diode excitation for different concentrations of Nd^{3+} ions and the emission for the $^4F_{3/2}\rightarrow^4I_{11/2}$ transition at 1060 nm found to be high intense. The measured decay curves for $^4F_{3/2}$ fluorescent level exhibit single exponential nature with shortening of lifetime with increase in concentration. The laser parameters such as stimulated emission cross-section, branching ratios, gain band width and optical gain values are found to be high for BBFB:Nd^{3+} (0.5 wt %) glass. Hence, the results suggested that the present BBFB:Nd^{3+} (0.5 wt %) glass could be used as an efficient infrared laser source around 1.06 μm region.

Chapter III deals the neodymium doped barium lithium fluoroborate (Nd^{3+}: BLFB) glasses with the chemical composition (70-x) H_3BO_3 - 10 Li_2CO_3 - 10 $BaCO_3$- 5 CaF_2-5 ZnO - x Nd_2O_3 (where x = 0.05, 0.1, 0.25, 0.5, 1, 2 in wt %) have been prepared by the conventional melt quenching technique and characterised through optical absorption, near infrared emission and decay-time measurements discussed. The x-ray diffraction studies confirm the amorphous nature of the prepared glasses. The optical absorption spectra and emission spectra were recorded in the wavelength ranges of 190-1100 nm. The optical band gap (E_g) and Urbach energy (ΔE) values were calculated from the absorption spectra. The Judd-Ofelt intensity parameters were determined from the systematic analysis of the absorption spectrum of neodymium ions in the prepared glasses. The emission spectra exhibited three prominent peaks at 874, 1057, 1331 nm corresponding to the $^4F_{3/2}\rightarrow^4I_{9/2,\ 11/2,\ 13/2}$ transitions levels respectively in the near infrared region. The emission intensity of the $^4F_{3/2}\rightarrow^4I_{11/2}$ transition increases with the increase in neodymium concentration up to 0.5 wt% and the concentration quenching mechanism was observed for 1 wt% and 2 wt% concentrations. The lifetime of the $^4F_{3/2}$ level was found to decrease with increasing Nd^{3+} ion concentration. The nature of energy transfer process was a single exponential curve which was studied for all the glasses and analysed.

Chapter IV reports the spectroscopic investigations on different concentrations (0.05, 0.1, 0.25, 0.5, 1 and 2 in wt %) of erbium doped barium bismuth fluoroborate glasses (Er^{3+}:BBFB) with the chemical composition of (70-x) H_3BO_3- 5 Bi_2O_3 - 10 $BaCO_3$ - 7.5 CaF_2 - 7.5 ZnO - x Er_2O_3 have been prepared by melt quenching method. Density, refractive index, optical path length and other physical properties were determined for all the glasses. The non-crystalline nature of the glasses were analysed through XRD measurements. The nature of bonding parameter is explored from the optical absorption spectra and was found to be covalent nature. The Judd-Ofelt intensity parameters, Ω_2, Ω_4 and Ω_6 were determined by applying least square analysis method. The Judd-Ofelt parameters were used to analyse the transition probability (A), branching ratio (β_R) and stimulated emission cross- section (σ_P^E) of the $^4I_{13/2}\rightarrow{}^4I_{15/2}$ level. The emission intensity corresponding to the $^4I_{13/2}\rightarrow{}^4I_{15/2}$ was found to increase with the increase in Er^{3+} ion concentration from 0.05 to 0.5 wt% but thereafter was found to decrease due to the concentration quenching mechanism. The lifetime corresponding to the $^4I_{13/2}$ level of the title glasses has been found to decrease with increase in Er^{3+} ion concentration. Intense emission at 1550 nm confirms that the prepared glasses are suitable for laser sources and can be employed in fiber amplifier media.

Chapter V focuses on the spectral investigations on erbium doped barium lithium fluoroborate glasses of the composition (70-x) H_3BO_3 -10 Li_2CO_3 - 10 $BaCO_3$ - 5 CaF_2- 5 ZnO - x Er_2O_3 (where x = 0.05, 0.1, 0.5, 1, 2 in wt %) were prepared by the conventional melt quenching technique. Dielectric constant, refractive index, electronic susceptibility, reflection loss and interionic distance were calculated for all the glass samples. The X-ray diffraction spectrum confirmed the amorphous nature of the prepared glasses. The optical properties of the prepared glasses were investigated by UV-Vis-NIR absorption and emission spectra. Nephelauxetic ratio and bonding parameters were determined from the absorption spectra and are found to be ionic in nature. Optical bandgap corresponding to the direct and indirect allowed transition were calculated to understand the electronic band structure and the Urbach energy values. Judd-Ofelt intensity parameters (Ω_λ =2, 4 and 6) were determined from the absorption spectrum. These JO parameters were used to analyse the transition probability (A), branching ratio (β_R), and the stimulated emission cross section (σ_P^E) parameter for different emission intensities. The emission of infrared at 1550 nm indicates that the glass material can act as a promising wave guide laser source and is suitable in optical fiber amplifier applications.

Chapter VI presents a brief summary and direction for the future work.

A list of references has been cited at the end of the thesis.