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Study the [Eu^{3+}, Nd^{3+}, Sm^{3+}, Pr^{3+}] doped Tellurite glasses for the application of opto-electronic devices

Abstract

Tellurite glass materials are very exciting and technologically useful materials among the family of oxide glass formers such as silicates, borates, germinate, and boro-silicates. TeO_2 forms glasses, glass-ceramics and crystalline materials with a variety of alkali, alkaline-earth, transition metals, and heavy metal oxides. The transparent or translucent glass-ceramics are advantageous over the single crystals and polycrystalline materials since these are easier to fabricate over a wide range of compositions. Tellurite-based glass materials show very high non-linear optical coefficients and low loss parameters in optical fibers or waveguides.

Alkali, alkaline earth, and transition metal oxides (TMO) are mixed with TeO_2 to get qualitatively better glass materials. It is significant to have information about the short-range and medium-range structure of glass materials for representation and designing the mechanical, optical, dielectric, and thermal properties. TeO_2 is a semiconducting material with strong covalent bonding between oxygen with tellurium. This bonding does not allow creating the required level of deformation to form the glass itself by TeO_2. Doping of rare-earth oxides helps to enhance the optical property of tellurite glasses.

The aim of the present thesis is preparation and investigation of the structural, thermal, optical, and electrical properties of the following tellurite and rare-earth doped tellurite glass systems:

1. $0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$
2. (100-x) ($0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$)-xEu_2O_3 (x = 0.5, 1.0, 1.5 and 2 wt %)
3. (100-x) ($0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$)-xNd_2O_3
4. (100-x) ($0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$)-xSm_2O_3
5. (100-x) ($0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$)-xPr_2O_3

The glass materials have been prepared by the melt-quenching method and characterized by X-ray Diffraction (XRD), UV-Visible spectroscopy, photoluminescence

(PL) spectroscopy, LCR meter, and Fourier transform infrared (FTIR) spectroscopy. The glass materials have also been analyzed by Differential Thermal Analysis (DTA) and Thermo Gravimetric Analysis (TGA). The glass forming properties of the $0.1Na_2O$-$0.2ZnO$-$0.7TeO_2$ (NZT) and rare-earth doped NZT glass materials have been investigated. The stability of glass materials and melt-quenching rates decreases due to the high concentration of rare-earth ions (0.5 to 2.0 wt%).

The glass is a disordered solid which has long-range order of cations but the anions (oxygens) are arranged in a disordered manner. Generally, the X-ray diffraction curves of glass materials exhibit broad peaks while their vibrational spectra, as measured by FTIR spectroscopy show broad bands that are very similar to those of the glassy phase of the same composition. The spectroscopic properties of the glasses have been studied using absorption, and fluorescence spectra. Using absorption spectra, absorption cross-section, emission cross-section, bonding parameters like intermolecular distance, polaron radius, and field strength have been calculated to identify the nature of the RE^{3+}-ligand bond in the glass network. Band gap energy and refractive index have been estimated from absorption spectra. The CIE chromaticity coordinates have been estimated from photoluminescence spectra for pure and rare-earth doped glass samples to know the suitability of laser emission of these glass samples. The dielectric constant of rare-earth doped glass materials is almost independent in the large range of frequency (500 Hz to 2 MHz). The variation of conductivity of the glasses exposed to the Arrhenius mechanism of conduction with the temperature.

The thesis discusses the results of the thermal, structural, optical and electrical properties of rare-earth doped tellurite glass system.

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