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Study of Optical, Physical and Upconversion Properties of Tellurite Base Glasses Codoped With Lanthanide Ions-A Review

Suresh P. Mahato[1*] A. K. Sharma[2] Ghizal F. Ansari[3]

[1,2,3] Physics Department, Madhyanchal Professional University, Bhopal (M.P.) 462044, India

Abstract – Tellurite base glasses are highly promising candidate in the field of photonics. Since last three decades researchers are working on tellurite base glasses doped with heavy metal oxides(HMOs) and codoped with lanthanide ions. HMO moderate the physical properties where as lanthanide ions are used to activate upconversion properties.

Key words – Tellurite Base Glasses; Heavy Metal Oxides; Upconversion.

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INTRODUCTION

Glasses doped with lanthanides (Ln3+) get a great deal of interest for photonic applications because of their advantages over crystalline materials in terms of ease of synthesis, low cost, ability to manufacture a desired form and size, and shorter synthesis time [1]. Phosphate glasses, a subset of oxide glasses, have a number of benefits over their counterparts, including a low refractive index, high gain density, high transparency, and a low melting point [2]. The luminescence characteristics of phosphorus can be improved by forming bonds with Ln3+ ions and transition metal ions. Solid-state lasers, memory switching, electrical threshold sensors, and batteries all employ Ln3+ ions activated phosphate glasses because of their vast technical uses [3]. For 1.53 m near infrared (NIR) lasers and optical amplifiers, Erbium (Er3+) is the most significant ion among the Ln3+ ions due to its emission transition of 4 $I_{13/2} \rightarrow$ 4 $I_{15/2}$. Furthermore, Er3+ ion also shows emissions at the wavelengths of green and red are attributable to the 2 $H_{11/2}$ + 4 $S_{3/2} \rightarrow$ 4 $I_{15/2}$ and 4 $F_{9/2} \rightarrow$ 4 $I_{15/2}$ transitions respectively [4]. A large full width at half maximum (FWHM) of an emission band in the near infrared (NIR) region infers abundant prospective applications in optical amplifiers, waveguides and permitting for simultaneous traffic on quite a few channels of communication [5]. Er3+-doped fiber amplifiers (EDFA) have played a vital role in optical communication for a long distances operated in the C-band region (1530–1565 nm). EDFAs are also co-doped with Er3+ ions in order to broaden their range in the required area Ln3+ ions that includes Yb^{3+}, Tm^{3+}, Nd^{3+} and Pr^{3+} [6–9]. Silicate glasses are used to manufacture commercial EDFA fibres with a bandwidth of 40 nanometers, which limits broadband transmission. EDFA applications necessitate an investigation of a suitable glass composition[10]. When compared to other glasses, tellurite base glasses are the best choice since chemical endurance may be easily improved by adding heavy metal oxides. In the present piece of work we collect the and analyse work done by various researcher on tellurite base glasses doped with HMOs and codoped with lanthanide ions.

LITERATURE REVIEW

Mohd Azam and Vineet Kumar Rai (2019) TeO2WO3 (TW) glasses with Er3+/Yb3+ ions in heavy metal oxide tungstate were synthesised by melting and quenching. Analysis of absorption spectra has yielded information on the optical band gap, Urbach energy, and type of bonding between RE ions and the surrounding oxygen atoms. Energy transfer from Yb3+ to Er3+ and local field alterations surrounding RE ions have been proposed as explanations for the increase in UC emission intensity seen following 980 nm excitation. The ionic character of the link between RE ions and the surrounding oxygen atoms has been highlighted. The UC emission spectra of Er3+/Yb3+-codoped TWPTi glass exhibits maximum intensity in all measured emission bands, and the colour produced by the glass does not change with pump power. A NIR to green upconverter, optical display devices, and home appliances with high CP can all benefit from the Er3+/Yb3+:TWPTi glass. [11].

M. Venkateswarluet al. (2014) optical absorption, optical absorption, and photoluminescence spectra were used to characterise the glasses. XRD studies have confirmed that the LTT host glass is glassy. J–O intensity parameters (2, 4 and _6) have been computed from the measured intensities of various absorption bands of these glasses using the traditional as well as modified J–O theories. Researchers employed modified J–O theory J–O parameters to examine the glasses' spectrum absorption and luminescence characteristics. The fluorescence levels of Pr3 in these glasses have been analysed using this theory for a variety of radiative attributes, such as radiative transition probability (AR), total transition probability (AT), branching ratio (R), and radiative lifespan (R). Lasers in the red wavelength range might be generated using all of these glasses' visible emission spectrum, stimulated emission cross sections, and branching ratio. [12].

Kostova, I. et al. (2018) has discovered that the Zinc-boron-phosphate glasses are a relatively new material that has a wide range of applications for several optical systems. The reason for this is that they are a good host matrix for various rear earths, particularly a samarium ion, which in turn results in a bright glow in the visible spectrum. Based on some previous studies of the structure, chemical durability, thermal stability, physical and optical properties it is found that this matrix is not only a good candidate as a host material for different RE ions but it is also applicable in sensing and valuable documents protection. New rare earth (Eu, Gd, Tb, Nd) ZBP glasses have been synthesised and their absorption and fluorescence characteristics have been studied in this paper.. For the synthesis, a muffle furnace set to 950° C uses the classic melt quenching method. Despite the fact that all synthetic glass does not contain any gases, some of them are fully transparent. Fluorescence in the visible and near-infrared ranges is strongly correlated with various doping ions [13].

F.B. Costa et al.have investigated preparations of neodymium-doped tungsten–tellurite glasses characterised by their spectroscopic characteristics. A conversion of TeO4 to TeO3 units was caused by the addition of Nd3þ into the glass, which was confirmed by absorption spectra and by Judd–Ofelt parameter behavior. The relaxation of the 4 F3/2 level is dominated by radiative decay and cross-relaxation between Nd3þ and Nd3þ ions. The energy transfer from Nd3þ to the hydroxyl group is negligible when compared to the cross-relaxation. The luminescence quantum efficiency values of the 4 F3/2 level decreases as the Nd3þ concentration increases, independently if determined by the Judd–Ofelt method or by the thermal lens technique. In order to increase luminescence quantum efficiency, the reported decrease in IR absorption associated with OH groups was ineffective [14].

A. Mohan Babua et al. (2011) Glasses doped with varying amounts of Dy3+ have been created and described using optical absorption, photoluminescence, and decay studies. XRD tests have validated the LTT host's glassy nature. Using the Judd–Ofelt (J–O) theory, the three phenomenological intensity parameters (J = 2, 4, 6) were calculated from the absorption spectral intensities. The amplitude of the 2 parameter has also been used to explore the hypersensitivity of the 6H15/2 6F11/2 transition. Several radiative characteristics, including as spontaneous transition probabilities (AR), fluorescence branching ratios (R), and radiative lifetimes (R), have been computed using the J–O intensity parameters. Dy3+ ion concentration has also been shown to affect the emission intensity of 4F9/2 6HJ transitions. [15].

M. Venkateswarlu et al. (2015) Utilizing optical absorption and photoluminescence spectrum analyses, different quantities of Ho3 ions have been incorporated into produced Lead Tungsten Tellurite glasses, which have then been analysed to better understand their visible emission characteristics. The photoluminescence spectra recorded for LTT glasses give three emission bands in green, red and NIR regions at 546, 679 and 755 nm corresponding to the transitions 5 F4-5 I8, 5 F5-5 I8 and 5 F4-5 I7 respectively. The luminescence quenching observed for 5 F4-5 I8 emission transition at 1 mol% of Ho3þ ion concentration is attributed to the RET among the excited Ho3þ ions. In comparison to other LTT glasses, LTTHo10 glass has the highest branching ratio and stimulated emission cross-section values. [16].

R. Baldaet al. (2009) The near-infrared emission characteristics of Tm3+-Er3+ codoped tellurite TeO2-WO3-PbO glasses under 794 nm excitation have been documented. From 1350 to 1750 nm, the Tm3+ and Er3+ emissions may be seen. Broadband width is raised to 160 nm at half-maximum by increasing [Tm]/[Er] concentration ratio. Codoping Tm3+ ions with Er3+ ions results in infrared luminescence and visible upconversion of Er3+ ions. [17].

S.H. Elazoumi et al. (2018) The EDX spectra indicated that the partial dissolution of Al2O3 in melt induced by an aluminum-based crucible affected the original composition of the x = 0, 0, 0, 10, 15, 20, 25, 30, 40 percent mole percent glasses. Contaminated Al2O3 makes around 6% to 7% of total Al2O3 production. Glass densities range from 4930 to 6231 kg/m3 for PbO concentrations ranging from 0 to 30 mol percent. The mole percentage of PbO decreased from 32.37 cubic centimetres per mole to 28.68 cubic centimetres per mole. Since TeO2 and PbO are the basic structural elements in base glass, this absorption band at 600 cm-1 might be assigned to base glass. The optical band gap was narrowed as a result of increased rigidity and a smaller number of (NBOs). The optical energy gap narrows as the refractive index rises as PbO concentration rises. In the glassy system under investigation, the concentration of PbO was shown to be negatively correlated with both the metallization requirements and the dielectric constant. [18].

H. A. Salah et al. (2018) The melt quenching approach has been used to create the Tellurite glass systems with [ZnO]x [(TeO2)0.7-(PbO)0.3]1-x with x = 0.15, 0.17, 0.20, 0.22, and 0.25 mol percent. All samples have been tested for XRD. Both UV-Vis and UV-Vis spectra (200–800 nm) were studied. Each glass sample was tested for its optical band gap and refractive index. To get an idea of how much oxygen was packed into the glass, molar volume, and density were calculated (OPD). There were a range of 3.41–3.94 eV for the direct and 2.40–2.63 eV for the indirect band gaps as ZnO concentration increased. Dielectric constant and refractive index were measured at 17 moles of zinc oxide (ZnO) in solution. The molar polarizability, metallization threshold, and polaron radius of each glass composition have been calculated.. [19].

B ERAIAH (2010) investigated For the first time, a novel family of (40–60TeO2) glasses has been developed. It is described in terms of the composition and structure of the glass. 04 mol percent of Sm2O3 in both situations is determined to be the same in terms of samarium concentration. Oxide ions' refractive indices and polarizability are likewise affected by this change. Pb2+ ions, which play an important role in the optical characteristics of these glasses, were not solely responsible for the variance at 04 mol percent Sm2O3 in these glasses. [20].

Ansari G. F.et al. (2021) These bismuth tellurite glasses compositionsTeO2-Bi2O3-Na2O co-doped with rare earth ions Er3+-Yb3+ ions by melt-quench and press technique show optical and upconversion capabilities. 80-x-y percent TeO2, 10 percent Bi2o3 and 10 percent Na2O, y-x percent Er2O3 and (0.1, 0) percent Yb2O make up the batch composition (0.5, 0.5). The thermal evaluation of the synthesised sample is carried out utilising Differential Scanning Calorimetry (DSC). Amorphous compounds can be identified using an X-ray diffractogram. According to the computed density of the glass sample, which is 5.26gm/cc and the R.I. of the sample is 2.05, the heaviness of the samples is justified. With a band gap of 3 eV, Urbatch is suitable for photonic devices, as its energies are 300 meV and above. For the TBNEY glass, Er3+-Yb3+ ions are the source of upconversion luminescence. Excitation at 980 nm resulted in excellent green and red upconversion emissions. [21].

T. R. Tasheva and V. V. Dimitrov (2017) they have been obtained Glasses of TeO2- Bi2O3-B2O3 have been polarised using the Lorentz-Lorenz equation. The high refractive index (1.713-1.938), strong electronic ion polarizability (1.785-2.2763), and high optical basicity of the glasses were determined (0.734-0.936). Theoretically, the glasses should have a refractive index of. A third-order nonlinear optical susceptibility may be calculated using this method. 0.64-2.31x10-13 esu are the glasses' third-order nonlinear optical susceptibilities. The interaction parameter and the average cation-oxide ion (M-O) bond strength can be used to determine the glasses' chemical bonding. The low single bond strength and interaction parameter of the glasses were found to indicate the presence of flimsy chemical bonds. Such bonds, namely B-O-Te, B-O-Bi, Te-O-Te and Bi-O-Bi probably interconnect TeO_4, TeO_3, BiO_6, BO_3 and BO_4 groups which were confirmed by IR spectral analysis of the glasses [22]

D.K. Gaikwad et al. (2019) In order to make these ternary tellurite glass systems, we used a typical melt quenching approach to create the glass systems with the composition 20WO3-xBi2O3- (80-x) TeO2. The amorphous nature of the materials was confirmed by X-ray diffraction. An increase in oxygen packing density (OPD) as well as an increase in the concentration of ions (N and Vm) revealed that Bi2O3 had an effect on glass structure. All of these optical parameters are affected by changes in Bi2O3 content: the optical band gap (Eopt), the optical electronegativity, the refractive index, the cationic polarizability, and the optical basicity (). There has been evidence that the optical characteristics change with the concentration of Bi2O3. According to the results of the FTIR analysis, the glasses comprise the structural elements TeO4, BiO6, and WO4. In order to use these glasses in optical-based systems with strong radiation shielding performance, additional shielding properties including effective atomic number, radiation protection efficacy, and mean free path were computed. [23]

Reza Dousti, M. et al. (2013) We've looked at the effects of NP concentration and annealing time on structural and optical properties. The face-centered cubic structure of silver NPs is clearly seen in the HR-TEM picture. Silver NPs with a Gaussian size distribution and an average diameter of 12 nm were found in the TEM micrograph. Silver NPs have plasmon absorption bands that are quite strong. In the Raman spectra, the introduction of silver NPs causes quenching. An eight-fold increase in vibrational spectrum intensity was generated by the heat treatment. However, by prolonging the annealing duration to 4 hours and adding more silver NPs, the PL exhibits five times the electronic transition enhancement. However, continued annealing resulted in a decrease in visible Er3+ ion emissions due to the breakdown of aggregated NPs. We've begun to understand how heat treatment works with silver nanoparticles and silver itself. Nanophotonics might benefit from our scientifically systematic, experimental, and theoretical methods of investigation. [24].

Faeghinia, A. et al. (2015) Deformed TeO4 groups were found in the 80mol. percent TeO2-20mol. percent LiF glasses that were doped with 0.05 and 0.2 mole percent Gd2O3, respectively, using FT-IR visible findings. Absorption in the ultraviolet and visible ranges of the spectra of the G5 and G2 samples revealed some reasonably large bands. The 320nm absorption edge was captured. In the 431nm and 627nm ranges, emission was seen after 320nm excitation. When the excitation wavelength is changed, the pattern of PL peaks shifts to better reflect the disordered Te4+ ions. [25].

CONCLUSION

Tellurite base glasses are simple to synthesise and have a glass transition temperature of 350 degrees Celsius. Optical and physical properties can be achieved by doping appropriate HMOs. For the lanthanide ions, tellurite base glasses are an obvious solvent and upconversion agent.

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Corresponding Author

Suresh P. Mahato*

Physics Department, Madhyanchal Professional University, Bhopal (M.P.) 462044, India

mahatos648@gmail.com