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Structural and Optical Properties of Samarium oxide Zinc Tellurite Glass System Doped with Silver Oxide

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Abstract: Samarium oxide zinc tellurite glass system doped with silver oxide with composition of $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$, y = 0.005. 0.01, 0.015, 0.02 and 0.025 molar fraction were synthesized using melt quenching technique. Structural changes were measured using X-ray diffraction (XRD). Optical absorption studies were performed using ultra violet visible (UV-Vis) spectrometer. Density were measured using Archimedes' principle while molar volume was calculated. Optical properties such as optical band gap (E_{opt}), Urbach energy (ΔE) and refractive index have been determined from optical absorption data and were found to be dependent on the glass composition.

Keywords: Tellurite glasses, Band gap energy, Samarium oxide, and Silver oxide.

Tellurite glasses are known for a variety of technological applications due to their important physical properties [1]. In this research, tellurium oxide was selected to be one of the glass former because of its low melting point, good chemical durability, high thermal stability as well as significant rare earth ion solubility [2]. Since tellurium oxide is a conditional glass former the combination of zinc oxide should help in improving the glass forming ability[3]. The optical research on rare earth doped glasses draws much attention due to their wide applications in optical areas such as optical switches for laser and sensors and optical communications [4]. The addition of silver oxide will leads to the enhancement in the optical properties of the glass network. This work is aim at synthesizing samarium oxide zinc tellurite glass doped with silver oxide and to study the structural and optical properties of the fabricated glasses.

Samarium oxide zinc tellurite glass system doped with silver oxide were fabricated with composition of $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$, with y = 0.005, 0.01, 0.015, 0.02 and 0.025 molar fraction. The chemical powders (99.99%, Alfa Aesar) of tellurium oxide (TeO_2), zinc oxide (ZnO), samarium oxide (Sm_2O_3) and silver oxide (Ag_2O), were measured for glass fabrication. The chemical powders were stirred for about 30 minutes for homogeneous mixture. Preheating and melting process was observed at 400^{o}C for 30 minutes and 900^o C for 1 hour to remove water vapour and to ensure that the reaction between the chemical powders occur. The molten liquid was poured rapidly in to the preheated mould and immediately transferred for annealing in the first furnace at 400^o C for 1 hour 30 minutes. The glasses were polished with sand papers of various grade for other characterization.

Density is used in measuring the compactness in the structure of tellurite doped glasses [6]. Archimedes principles is used to obtain the density of each sample. The result show steady increasing trend while the molar volume exhibited a decreasing trend. The increase in density is due to the replacement of lower molecular weight of TeO_2 by a higher molecular weight of Ag_2O in the glass network while the decreasing molar volume reflect the decrease in free volume of the glass system[7].The calculated values of density and molar volume are listed in Table 1 and presented in Figure 1.

Table 1: Density and molar volume of $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$ glass system

Molar fraction	Density (g/cm^3)	Molar volume (cm^3/mol)
0.005	5.199	26.678
0.01	5.230	26.611
0.015	5.269	26.505
0.02	5.315	26.360
0.025	5.374	26.159

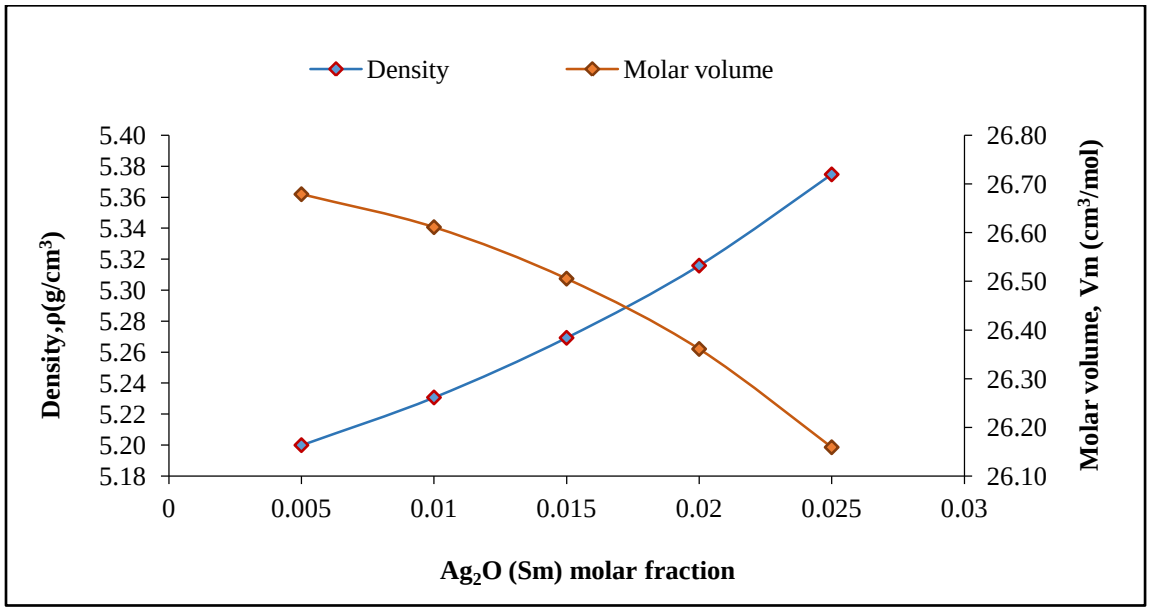

Figure 1: Density and molar volume of $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$ glass system

X-ray diffraction is mainly observed for face identification in both crystalline and non-crystalline materials. The XRD analysis show the absence of crystalline peaks in the spectra and is amorphous[8]. Figure 2 present the XRD spectra of the glass system.

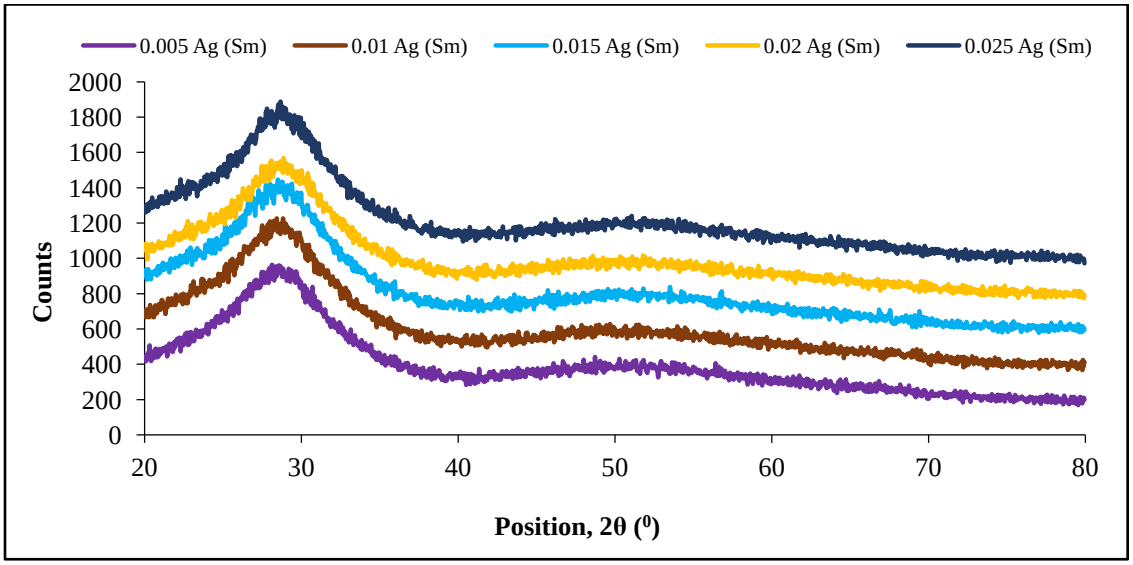

Figure 2: XRD pattern of prepared glass sample with different concentration of dopant

Refractive index is an important parameter in optical properties of glass material [9]. Urbach energy describe the degree of defects in the glass system. The Urbach energy and refractive index decreases with increase in dopant. The decrease in Urbach energy indicate the decrease in more defects in the glass system [10]. Furthermore, the decreasing refractive index is attributed to the decrease in the amount of non-bridging oxygen in the glass network[11].The values of refractive index and Urbach energy are listed in Table 2 and presented in Figures 3 and 4.

Table 3: Refractive index and Urbach energy for $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}$ $(Ag_2O)_y$ glass system

Molar fraction	Refractive index (n)	Urbach energy ΔE (eV)
0.005	2.405	0.260
0.01	2.381	0.249
0.015	2.378	0.232
0.02	2.372	0.213
0.025	2.369	0.209

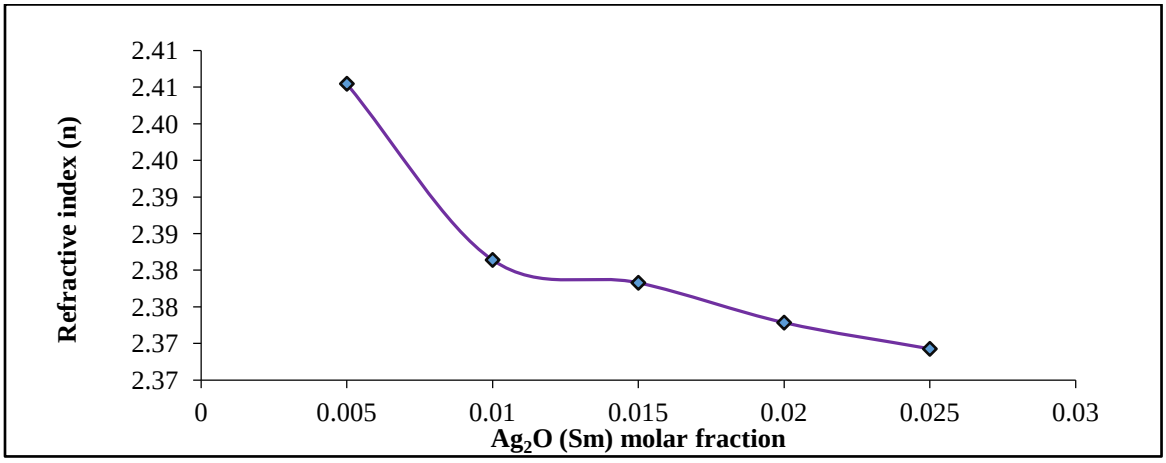

Figure 3: Refractive index for $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$ glass system

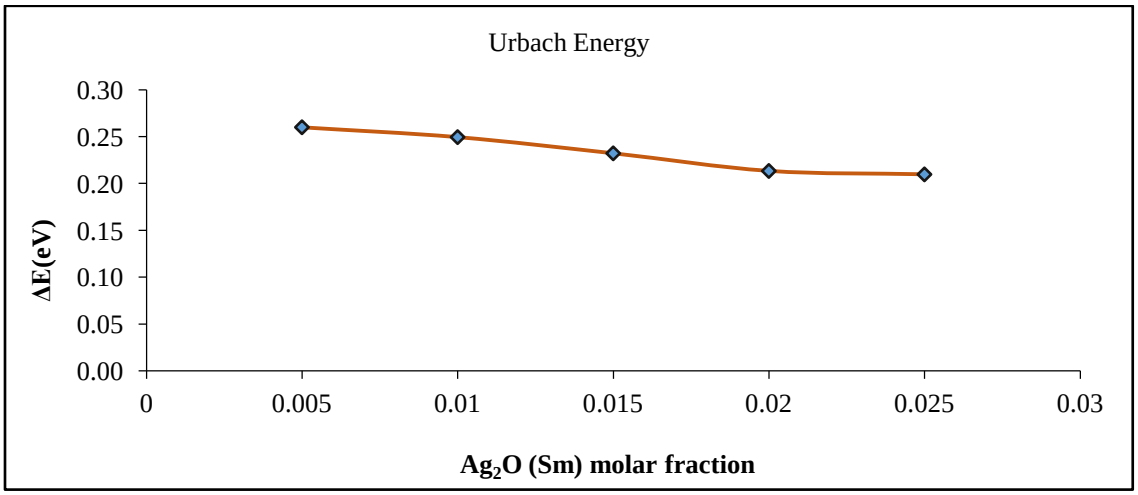

Figure 4: Urbach energy for $[\{(TeO_2)_{0.7}\ (ZnO)_{0.3}\}_{0.99}\ (Sm_2O_3)_{0.01}]_{1-y}\ (Ag_2O)_y$ glass system

In conclusion, in this study, the density and molar volume of the glass system were calculated. The density result show steady increasing trend while molar volume exhibited a decreasing trend. X-ray diffraction (XRD) is used to study the structure of the glass system. The glass refractive index and Urbach energy was obtained using band gap energy. The refractive index and Urbach energy decreases which can be attributed to the reduction of more non-bridging oxygen and defects structure in the glass matrix.

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