Solid State Science and Technology, Vol. 19, No 1 (2011) 78-82
ISSN 0128-7389

THERMAL PROPERTIES OF TERNARY TELLURITE GLASS SYSTEM

M.K. Halimah*, W.M. Daud, H.A.A. Sidek, S.M. Iskandar,
A.W. Zaidan and A.M. Khamirul

Department of Physics, Faculty of Science, Universiti Putra Malaysia,
43400 Serdang, Selangor, Malaysia

**Corresponding Author: halimah@science.upm.edu.my*

ABSTRACT

Ternary tellurite glass system of $[(TeO_2)_{60}\ (B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses had been synthesized by melt quenching method. The thermal expansion coefficient of the glasses was determined between 30°C and 210°C. Experimental results indicate that the thermal expansion varies with micro structural of the glass system. Transition temperature and Debye temperature decrease with Ag_2O due to loose packing of the glass network.

Keywords: tellurite; glass; Debye temperature, Ag_2O;

INTRODUCTION

The physical properties of tellurite glasses have attracted the attention of many researchers, not only because of the numerous potential and realized technical applications for these properties but because of a fundamental interest in their microscopic mechanisms. Some tellurite glasses are also reported to be suitable for setting up optical fiber amplifiers [1], electronic behavior-notable semiconductivity and electronic switching effects [2]. Tellurite glasses have attracted a great deal of attention both in fundamental research and also in optical devices fabrication. This is because the optical tellurite glasses based shows good transparency in the visible–infrared, relatively low phonon energy compared with other oxide glasses such as silicate and phosphate glasses, resistance against corrosion, and have the ability to incorporate a large amount of rare earth. In addition, tellurite glasses could be used in production of fiber, planer broadband amplifiers, and lasers [3,4]. Although the thermal properties of crystalline solids are generally well understood but this is not the case for amorphous materials. The aim of the present work is to study the thermal properties of ternary tellurite glass system and their influence on the structure with Ag_2O contents.

MATERIALS AND METHOD

The $[(TeO_2)_{60}\ (B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses were prepared by mixing together specific weights of tellurium dioxide (Aldrich 99.5%), boron oxide B_2O_3 (Alfa Aesar, 97.5%), silver dioxide Ag_2O (Aldrich 99%) in a closed alumina crucible. The mixture were kept for 400°C for a period of 30 minutes, the crucible was then transferred to a second

Solid State Science and Technology, Vol. 19, No 1 (2011) 78-82
ISSN 0128-7389

furnace for 60 minutes at 800°C. The melt was then poured into a stainless steel cylindrical shaped split mould which had been preheated and then the sample was annealed at 350°C .The prepared samples were cut into required dimension for thermal properties measurements. The glass transition temperature (T_g) were determined by differential thermogravimetric analysis (Setaram Instrumentation Labys DTA/6) at heating rate of 20 K min^{-1}. The thermal expansion coefficient was measured using L75D1250 Dilatometer with the rectangular parallelepiped 3 x 3 x 6 mm^3 samples. The prepared samples were ground into powder form for x-ray diffraction measurement using X'pert Pro Panalytical.

RESULTS AND DISCUSSION

The X-ray diffraction patterns of the studied glass system revealed the absence of any discrete or sharp crystalline peaks indicating that the samples are amorphous as seen in Figure 1

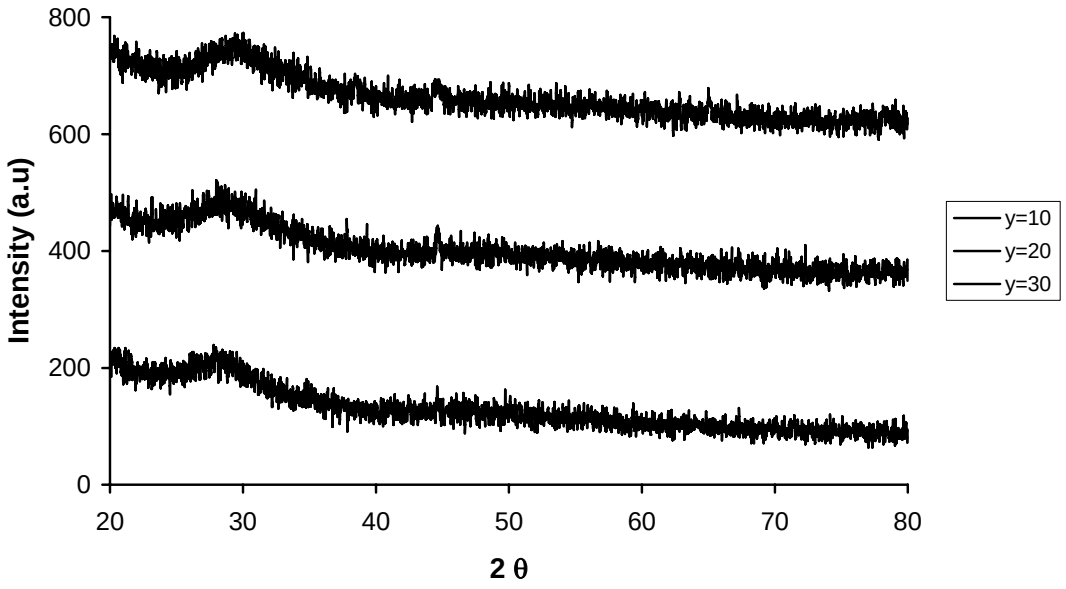

Figure 1: XRD spectrum of $[(TeO_2)_{60}(B_2O)_{40}]_{1-y}[Ag_2O]_y$ glasses

Figure 2 shows the thermal expansion coefficient with Ag_2O content for $[(TeO_2)_{60}(B_2O_3)_{40}]_{1-y}[Ag_2O]_y$. As the Ag_2O increases the thermal expansion coefficient increases progressively. There are two inflections or shallow minima and all curves unite at 30 mol% of Ag_2O. The first inflection is at 15 mol% Ag_2O thermal expansion coefficient decrease. This decrease is due to the increase of cross-linking density and the bonding strength in the glass network [5]. As Ag_2O content increases the thermal expansion coefficient increases. This increase in Ag_2O leads to more Ag-O bonds in the glass

structure and this causes a weakening of the glass network structure; consequently higher thermal expansion values and lower transition temperature and softening temperature is expected [6]

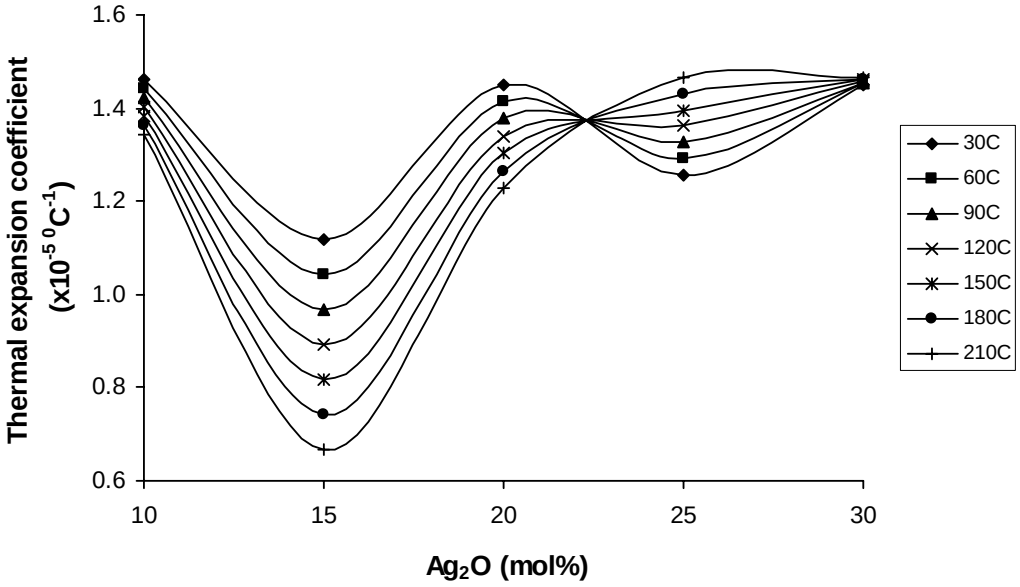

Figure 2: Thermal expansion coefficient of $[(TeO_2)_{60}(B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses as a function of Ag_2O mol% at different temperature

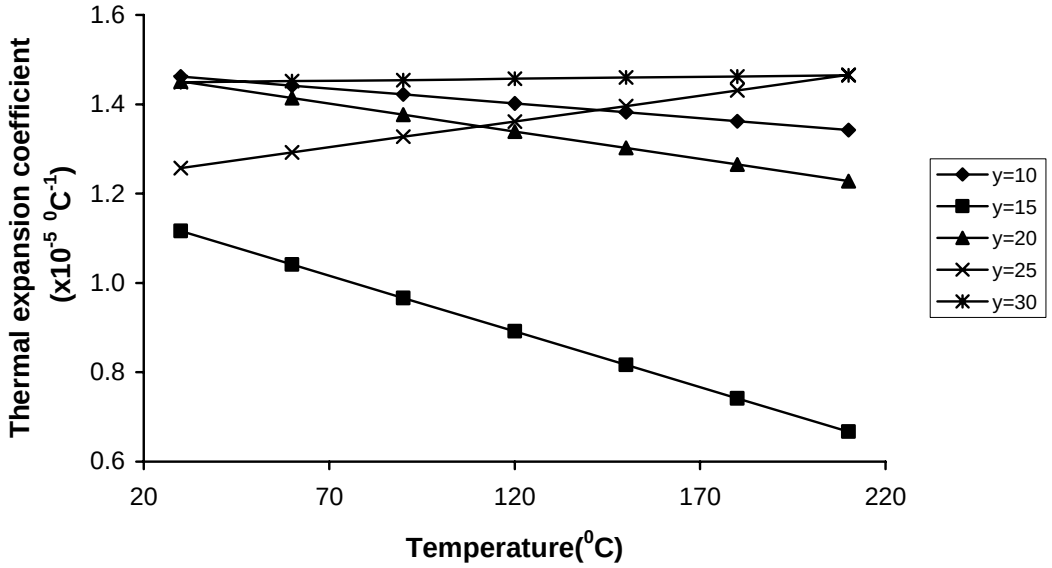

Figure 3: Thermal expansion coefficient of $[(TeO_2)_{60}(B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses

Solid State Science and Technology, Vol. 19, No 1 (2011) 78-82
ISSN 0128-7389

Figure 3 shows the thermal expansion coefficient against temperature. It is observed that at 15 mol% of Ag_2O the gradient is very steep and thermal expansion coefficient values decreases drastically. This due to the increase in cross-linking density as mentioned above. At 25 mol%, when number of non-bridging oxygens increases thermal expansion increases with temperature but at 30 mol% there is a slight decrease in the thermal expansion. This is due to the Ag (1.26 Å) ion is smaller than Te (2.21 Å) ion. The smaller cations with higher field strengths seem to produce tighter, stronger bound structures than the larger cations [7,8].

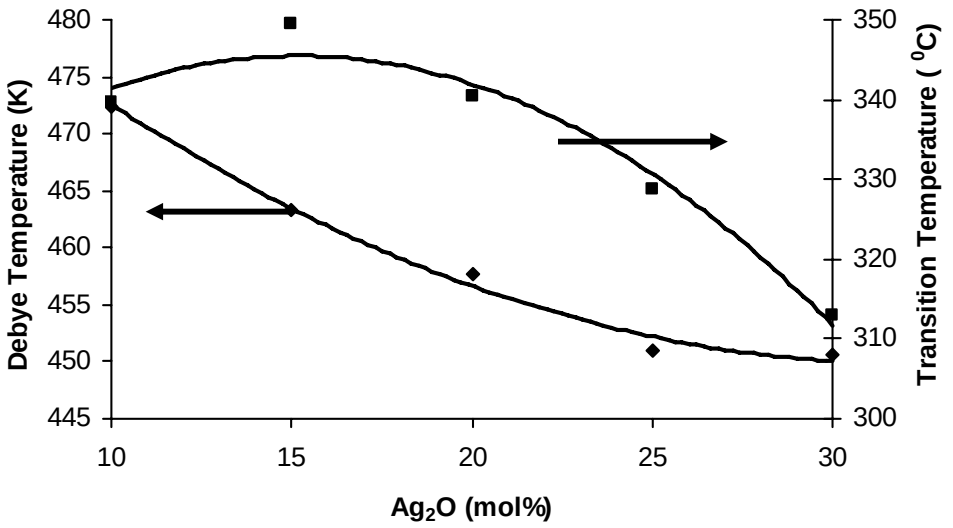

Figure 4: Transition temperature and Debye temperature of $[(TeO_2)_{60}\ (B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses

Glass transition temperature and Debye temperature decrease as the Ag_2O content increases. Tellurite glasses with Ag_2O have a lower value of transition temperatures, that is Ag_2O oxide creates a weaker tellurite glass [9,10,11]. This is attributed to the progressive transformation from the rigid structure of borotellurite to a matrix of ionic behaviour bonds (NBOs), which results in loose packing of the glass network [11].

CONCLUSION

Thermal expansion is composition dependent, transition and Debye temperature decrease due to the progressive transformation from the rigid structure of borotellurite to a matrix of ionic behaviour bonds, which results in loose packing of the glass network.

ACKNOWLEDGEMENTS

The financial support of the Ministry of Science, Technology and Innovation, Malaysia under Fundamental (FRGS) vote 5523645 is gratefully acknowledged.

REFERENCES

[1] R. El-Mallawany and I.A. Abbas, *Journal of Materials Science*, **43** (2008) 5131-5138
[2] V. Pilla, E. F. Chillcce, A. A. R. Neves E. Munin, T. Catunda, C. L. Cesar and L. C. Barbosa, *Journal Materials Science* , **42** (2007) 2304–2308
[3] A.A. Baghat, I.I. Shaltout and A.M. Abu Elazam, *Journal of Non-Crystalline Solids*, **150** (1992) 179-184
[4] Shilong Zhaoa, Xiuli Wang, Dawei Fang , Shiqing Xua and Lili Huc, *Journal of Alloys and Compounds,* **424** (2006) 243-246
[5] P.Y.Shih, *Materials Chemistry and Physics*, **84** (2004) 151-156
[6] H. Darwish, S.M. Salama and S.M. Salaman, *Thermochimica Acta*, **374** (2001) 129-135
[7] D.R. Uhlmann and R.R. Shaw, *Journal of Non-Crystalline Solids*, **1** (1969) 347-359
[8] N.A. Ghoneim and A.F. Abbas, *Thermochimica Acta*, **66** (1983) 91-103
[9] R. El-Mallawany *Materials Chemistry and Physics*, **60** (1999) 103-131
[10] R.H. Doremus, *Glass science,* (John Wiley & Sons, New York, 1973).
[11] D.G.Holloway, *The physical properties of glass,* (Wykeham Publication Ltd., London, 1973).