UNIVERSITI TEKNOLOGI MARA

EFFECT OF INCREASING Na_2O ON STRUCTURAL, ELASTIC AND OPTICAL PROPERTIES OF $(90\text{-}x)GeO_2\text{-}xNa_2O\text{-}10PbO$ GLASS SYSTEM IN THE GERMANATE ANOMALY REGION

CHE NORAIDA BINTI MOHD ZAINUDIN

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulation of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledge as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulation the conduct of my study and research.

Name of Student	:	Che Noraida Binti Mohd Zainudin
Student I.D No.	:	2012877268
Programme	:	Master of Science
Faculty	:	Faculty of Applied Sciences
Thesis Title	:	Effect of Increasing Na_2O on Structural, Elastic and Optical Properties of $(90\text{-}x)GeO_2\text{-}xNa_2O\text{-}10PbO$ Glass System in the Germanate Anomaly Region
Signature of Student	:	.....
Date	:	July 2016

ABSTRACT

Ternary germanate glasses with the chemical formula (90-x)GeO_2-$x$$Na_2O$-10PbO ($x$ = 10, 15, 20, 25, 30 mol %) have been prepared by melt-quenching method. XRD patterns showed the amorphous nature of the glass samples for $x \leq 20$ mol % and emergence of minor crystalline peaks in a mainly amorphous matrix for $x > 20$ mol %. Density, ρ increased with Na_2O content up to 20 mol % before decreasing beyond 20 mol % while molar volume, V_a showed an opposite trend to the density, with a minima at 20 mol % of Na_2O content indicating the presence of the germanate anomaly below 20 mol %. Ultrasonic velocity measurements showed both longitudinal, v_l and shear, v_s velocities increase up to 20 mol % before decreasing with further addition of Na_2O. Independent longitudinal, L and shear, G moduli along with Young's modulus, Y, mean sound velocity, v_m, Debye temperature, Θ_D, and hardness, H also recorded maxima at 20 mol % of Na_2O content. The initial increase in L and G up to 20 mol % of Na_2O content was suggested to be related to structural modification occurring due to the conversion of six-membered GeO_4 rings to three-membered ring of GeO_4 which changed the bond density and compactness of the glass systems. The increased in elastic moduli also indicates that the structural change was accompanied by an increase in rigidity and stiffness of the glass. Beyond 20 mol % of Na_2O, the decreased L and G could be due to depolymerization of the glass network. Further analysis using bulk compression and ring deformation models also showed the ratio of ideal bulk modulus to the experimental bulk modulus, K_{bc}/K_e increased from 10 to 20 mol % addition of Na_2O accompanied by reduction in average atomic ring size, l in the germanate anomaly region. The minimum K_{bc}/K_e values was observed at x = 25 mol % which coincides with minima for l. The optical properties the glass system showed optical energy gap, E_{opt} decreased with addition of Na_2O up to 20 mol % and increased beyond 20 mol %, while Urbach energy, E_U and refractive index, n showed opposite trends to E_{opt}. The changes in the optical behaviors are suggested to be related to the changes in NBO concentration in the glass samples.

TABLE OF CONTENTS