



UNIVERSITI PUTRA MALAYSIA

**ELASTIC, ELECTRICAL AND THERMAL PROPERTIES OF TELLURITE
GLASS SYSTEMS**

HALIMAH BT MOHAMED KAMARI

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**DOCTOR OF PHILOSOPHY
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GLASS SYSTEMS**

By

HALIMAH BT MOHAMED KAMARI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

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ELASTIC, ELECTRICAL AND THERMAL PROPERTIES OF TELLURITE GLASS SYSTEMS

By

HALIMAH MOHAMED KAMARI

February 2007

Chairman : Associate Professor Sidek Haji Abdul Aziz, PhD

Faculty : Science

Three series of tellurite glass were synthesized by melt quenching technique. The binary tellurite was $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ with $x = 60, 63, 65, 70, 73, 75, 78, 80$ mol%, the ternary tellurite $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ consists of three series that is $x = 60, 65$ and 70 mol% with $y = 10, 15, 20, 25$ and 30 mol% and quaternary tellurite glass $\{[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ with $z = 5, 8, 10, 13, 15$ mol%. The experimental investigation was divided into two categories. The minor experimental work, which provides supportive evidence to elastic and electrical properties, consists of work on x-ray diffraction, thermal expansion coefficient and optical absorption spectra. The main experiments consist of work on ultrasonic and electrical measurements. The electrical measurements consist of dielectric and ac conductivity properties were measured at low frequencies from 10^{-2} to 10^6 Hz while ultrasonic properties were determined with MATEC 8000 at 5MHz resonating frequency and at room temperature.

The amorphous structures of the glass samples were evident by the XRD spectrum. Thermal expansion measurement showed that thermal expansion coefficient was composition dependence. The optical absorption spectra of these glasses were



measured, the Urbach rule has been applied to evaluate the fundamental absorption edges for all the glasses from the obtained spectrum. The optical band gaps were calculated from the absorption edge and it was found that the optical band gap energy, E_{opt} depended on the glass composition. The optical band gaps energy showed a decreasing pattern with composition for binary and ternary tellurite glass however it behaves otherwise for quaternary tellurite glasses.

Elastic moduli were found dependent on compositions; for binary tellurite system the elastic moduli increased with the increase of TeO_2 and for ternary and the quaternary system elastic moduli decreased with Ag_2O and AgI respectively. The increase of elastic moduli for binary system was due to the mix former effect and the decreased elastic moduli for ternary was due to Ag_2O breaking the bonds of the borotellurite glass system while AgI iodide caused network expansion of the glass structure and weakened the glass structure of this quaternary tellurite system. The Debye temperature and microhardness had the same trend as the elastic moduli but the Poisson's ratio always the inverse of the elastic moduli.

The results of dielectric response measurements and the results of the equivalent circuit analysis show that electrode polarization at low frequency, orientation polarization at intermediate frequency and polarization of defect glass structure at high frequency are the most probable process responsible for the observed dielectric behaviour of the studied glass samples. The dependence of the alternating current conductivity with frequency at various fixed temperature revealed three distinguishable regions; high frequency dispersion, low frequency dispersion and

electrode polarization. The electrical conductivity of tellurite based glass was found to obey the exponential double power law.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falasafah

SIFAT KENYAL, ELEKTRIK DAN TERMA SISTEM KACA TELURIT

Oleh

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Februari 2007

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Tiga siri kaca telurit telah disintesis dengan teknik sepuh lindap. Telurit binari adalah $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ dengan $x = 60, 63, 65, 70, 73, 75, 78, 80$ mol%, telurit ternary $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ terdiri daripada tiga siri iaitu $x = 60, 65$ and 70 mol% dengan $y = 10, 15, 20, 25$ dan 30 mol% and kaca telurit kuaternari $\{[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ dengan $z = 5, 8, 10, 13, 15$ mol%. Penyelidikan eksperimen terbahagi kepada dua kategori. Eksperimen minor yang memberi maklumat sokongan kepada ciri kenyal dan elektrik, terdiri daripada pembelauan sinar-x, pekali pengembangan terma dan spektrum penyerapan optik. Eksperimen utama pula terdiri daripada pengukuran ultrasonik dan elektrik. Ciri dielektrik dan kekonduksian arus ulang alik diukur pada frekuensi rendah daripada 10^{-2} to 10^{-6} Hz dan ciri ultrasonik ditentukan dengan MATEC 8000 bergetar pada frekuensi 5MHz dan pada suhu bilik.

Struktur amorfus bagi sample kaca dapat dibuktikan menggunakan spektrum XRD. Pengukuran pengembangan terma menunjukkan bahawa pekali pengembangan terma bagi setiap siri kaca telurit adalah bersandar kepada komposisi. Spektrum penyerapan optik bagi kaca ini telah diukur, peraturan Urbach digunakan untuk

mengukur asas pinggir serapan bagi semua spektra yang diperolehi. Jurang jalur optik telah ditentukan daripada asas pinggir serapan dan didapati tenaga jalur optik E_{opt} bersandar ke atas komposisi kaca. Tenaga jalur optik menunjukkan corak berkurangan dengan komposisi bagi kaca binari dan ternari telurit tetapi berbeza sebaliknya untuk kaca kuaternari telurit .

Modulus kenyal didapati bersandar dengan komposisi; untuk sistem binari telurit modulus kenyal meningkat dengan penambahan TeO_2 dan untuk sistem ternari dan kuaternari modulus kenyal berkurangan dengan Ag_2O dan AgI masing-masing. Peningkatan modulus kenyal sistem binari adalah disebabkan oleh kesan campuran pembentuk dan pengurangan modulus kenyal untuk ternari disebabkan oleh Ag_2O memutuskan ikatan sistem kaca borotelurit di mana iodida menyebabkan pengembangan rangkaian struktur kaca dan melemahkan struktur kaca bagi sistem kuaternari telurit. Suhu Debye dan kekerasan mikro mempunyai corak yang sama dengan modulus kenyal tetapi nilai nisbah Poisson sentiasa songsang relatif kepada modulus kenyal.

Keputusan pengukuran tindakbalas dielektrik dan analisis litar setara menunjukkan pengutuban elektrod pada frekuensi rendah, pengutuban orientasi pada frekuensi pertengahan dan pengutuban oleh kecacatan struktur kaca pada frekuensi tinggi kemungkinan menjadi penyumbang besar proses yang menyebabkan kelakuan dielektrik bagi sampel kaca yang dikaji. Kebersandaran kekonduksian arus ulang alik dengan frekuensi pada beberapa suhu tertentu menunjukkan tiga bahagian; serakan frekuensi tinggi, serakan frekuensi rendah dan pengutuban elektrod. Kekonduksian elektrik bagi kaca berasaskan telurit didapati mematuhi hukum eksponen kuasa berganda.

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I certify that an Examination Committee has met on 15th February 2007 to conduct the final examination of Halimah Mohamed Kamari on her Doctor of Philosophy thesis entitled “Elastic, Electrical and Thermal Properties of Tellurite Glass System” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee Recommends that the candidate be awarded the relevant degree. Members of the examination Committee are as follows

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

HALIMAH MOHAMED KAMARI

Date : 25 April 2007

TABLE OF CONTENTS

	Page
DEDICATION	
ABSTRACT	ii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xiii
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS	xxxiii
CHAPTER	
1 INTRODUCTION	1.1
1.1 Overview of Tellurite Glass System	1.1
1.2 Objectives	1.5
2 LITERATURE REVIEW	2.1
2.1 Structure of Tellurite Glass	2.1
2.2 Thermal Properties	2.3
2.3 Optical Properties	2.6
2.4 Elastic Properties	2.8
2.5 Electrical Properties	2.15
3 THEORY	3.1
3.1 Definition of Glass	3.2
3.2 Formation of Glass	3.4
3.3 Kinetic Theory of Glass Formation	3.7
3.4 Structure Theories of Glass Formation	3.14
3.5 Borate Glass	3.17
3.6 Structure of Tellurite Glass	3.21
3.7 Thermal Expansion	3.25
3.8 Optical Properties	3.28
3.9 Elastic Properties	3.31
3.9.1 Terminology of elastic	3.32
3.9.2 Mackishima and Mackenzie Model	3.38
3.9.3 Bulk Compression Model	3.39
3.9.4 Microhardness of Glass	3.43
3.10 Electrical Properties	3.44
3.10.1 Dielectric Theory	3.44
3.10.2 AC Conductivity	3.55
3.10.3 Equivalent Circuit	3.61

4	METHODOLOGY	4.1
	4.1 Sample preparation	4.1
	4.2 Experimental setup	4.6
	4.2.1 Structural Properties	4.6
	4.2.2 Thermal Measurements	4.7
	4.2.3 UV-Visible Measurement	4.8
	4.2.4 Ultrasonic Measurements	4.8
	4.2.5 Dielectric Measurements	4.11
5	RESULTS AND DISCUSSION	5.1
	5.1 Structural Properties Measurements	5.1
	5.1.1 X-ray Diffraction (XRD)	5.2
	5.2 Thermal Expansion	5.4
	5.3 UV-Visible Measurement	5.14
	5.4 Ultrasonic measurement	5.26
	5.4.1 Density and Molar Volume	5.26
	5.4.2 Ultrasonic velocity	5.37
	5.4.3 Elastic Modulus	5.41
	5.4.4 Poisson's ratio	5.47
	5.4.5 Debye Temperature	5.51
	5.4.6 Microhardness (H) and Transition temperature (T_g)	5.53
	5.4.7 Softening temperature (T_s)	5.60
	5.4.8 Elastic Theoretical Models	5.64
	5.5 Dielectric Properties	5.117
	5.5.1 Binary Tellurite Glass $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$	5.117
	5.5.2 Ternary Tellurite Glass $[(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}]_{1-y}[\text{Ag}_2\text{O}]_y$	5.142
	5.5.3 Quaternary Tellurite Glass $\{[(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}]_{1-y}[\text{Ag}_2\text{O}]_y\}_{1-z}\{\text{AgI}\}_z$	5.157
	5.5.4 Effect of Composition on Dielectric Behaviour	5.170
	5.6 A.C Conductivity	5.176
	5.6.1 Binary Tellurite Glass $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$	5.176
	5.6.2 Ternary Tellurite Glass $[(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}]_{1-y}[\text{Ag}_2\text{O}]_y$	5.188
	5.6.3 Quaternary Tellurite Tellurite Glass $\{[(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}]_{1-y}[\text{Ag}_2\text{O}]_y\}_{1-z}\{\text{AgI}\}_z$	5.203
	5.6.4 Scaling	5.215
	5.6.5 Electrical Modulus	5.221
	5.6.6 Equivalent Circuit	5.243
6	CONCLUSIONS	6.1
	6.1 Conclusions	6.1
	6.2 Further Research	6.7
	REFERENCES	R.1
	APPENDICES	A.1
	BIODATA OF THE AUTHOR	V.1
	LIST OF PUBLICATIONS	V.2

LIST OF TABLES

Table	Page
5.1 Thermal expansion coefficient $\alpha \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$ for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.13
5.2 Thermal expansion coefficient $\alpha \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$ for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.13
5.3 Thermal expansion coefficient $\alpha \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$ for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.13
5.4 Optical measurements for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.25
5.5 Optical measurements for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.25
5.6 Optical measurements for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.25
5.7 Density, molar volume, ultrasonic velocity, elastic moduli, Debye temperature and microhardness of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses at room temperature	5.29
5.8 Density, molar volume, ultrasonic velocity, elastic moduli, Debye temperature and microhardness of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses at room temperature	5.32
5.9 Density, molar volume, ultrasonic velocity, elastic moduli, Debye temperature and microhardness of $[(\text{TeO}_2)_{65} (\text{B}_2\text{O}_3)_{35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses at room temperature	5.33
5.10 Density, molar volume, ultrasonic velocity, elastic moduli, Debye temperature and microhardness of $[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses at room temperature	5.34
5.11 Density, molar volume, ultrasonic velocity, elastic moduli, Debye temperature and microhardness of $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{Ag}_2\text{O}\}_z$ glasses at room temperature	5.35
5.12 Debye temperature (θ_D), glass transition temperature (T_g) and softening temperature (T_s) for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.56
5.13 Debye temperature (θ_D), glass transition temperature (T_g) and softening temperature (T_s) for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.58

5.14	Debye temperature (θ_D), glass transition temperature (T_g) and softening temperature (T_s) for $[(TeO_2)_{65}(B_2O_3)_{35}]_{1-y}[Ag_2O]_y$ glasses	5.58
5.15	Debye temperature (θ_D), glass transition temperature (T_g) and softening temperature (T_s) for $[(TeO_2)_{70}(B_2O_3)_{30}]_{1-y}[Ag_2O]_y$ glasses	5.58
5.16	Debye temperature (θ_D), glass transition temperature (T_g) and softening temperature (T_s) for $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90}[Ag_2O]_{10}\}_{1-z}\{Ag_2O\}_z$ glasses	5.59
5.17	The coordination number (n), the cation anion bond length (r) and the first order stretching force constant (f) of the oxide	5.65
5.18	Number of bonds (n_b), average bond stretching force constant (F), ring diameter (l), average cross-link density (n_c) of $(TeO_2)_x(B_2O_3)_{1-x}$ glasses	5.65
5.19	Elastic moduli calculated according to Makishima–Mackenzie model, packing density (V_t) and dissociation energy (G) of $(TeO_2)_x(B_2O_3)_{1-x}$ glasses	5.72
5.20	The comparison of experimental elastic moduli (E_e , G_e and K_e), bond compression model (E_{bc} , G_{bc} and K_{bc}) and Makishima–Mackenzie (E_m , G_m and K_m) for Young's modulus, shear and bulk modulus respectively and Poisson's ratio (σ_e , σ_{bc} and σ_m) of $(TeO_2)_x(B_2O_3)_{1-x}$ glasses	5.74
5.21	Number of bonds (n_b), average bond stretching force constant (F), ring diameter (l), average cross-link density (n_c) of $[(TeO_2)_x(B_2O_3)_{1-x}]_{1-y}[Ag_2O]_y$ glasses	5.77
5.22	Elastic moduli calculated according to Makishima–Mackenzie model, packing density (V_t) and dissociation energy (G) of $[(TeO_2)_x(B_2O_3)_{1-x}]_{1-y}[Ag_2O]_y$ glasses	5.82
5.23	The comparison of experimental elastic moduli (E_e , G_e and K_e), bond compression model (E_{bc} , G_{bc} and K_{bc}) and Makishima–Mackenzie (E_m , G_m and K_m) for Young's modulus, shear and bulk modulus respectively and Poisson's ratio (σ_e , σ_{bc} and σ_m) of $[(TeO_2)_{60}(B_2O_3)_{40}]_{1-y}[Ag_2O]_y$ glasses	5.84
5.24	The comparison of experimental elastic moduli (E_e , G_e and K_e), bond compression model (E_{bc} , G_{bc} and K_{bc}) and Makishima–Mackenzie (E_m , G_m and K_m) for Young's modulus, shear and	5.85

	bulk modulus respectively and Poisson's ratio (σ_e , σ_{bc} and σ_m) of $[(\text{TeO}_2)_{65}(\text{B}_2\text{O}_3)_{35}]_{1-y}[\text{Ag}_2\text{O}]_y$ glasses	
5.25	The comparison of experimental elastic moduli (E_e , G_e and K_e), bond compression model (E_{bc} , G_{bc} and K_{bc}) and Makishima–Mackenzie (E_m , G_m and K_m) for Young's modulus, shear and bulk modulus respectively and Poisson's ratio (σ_e , σ_{bc} and σ_m) of $[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{1-y}[\text{Ag}_2\text{O}]_y$ glasses	5.86
5.26	Number of bonds (n_b), average bond stretching force constant (F), ring diameter (l), average cross-link density (n_c) of $\{[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{90}[\text{Ag}_2\text{O}]_{10}\}_{1-z}\{\text{AgI}\}_z$ glasses	5.88
5.27	Elastic moduli calculated according to Makishima–Mackenzie model, packing density (V_t) and dissociation energy (G) of $\{[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{90}[\text{Ag}_2\text{O}]_{10}\}_{1-z}\{\text{AgI}\}_z$ glasses	5.88
5.28	The comparison of experimental elastic moduli (E_e , G_e and K_e), bond compression model (E_{bc} , G_{bc} and K_{bc}) and Makishima–Mackenzie (E_m , G_m and K_m) for Young's modulus, shear and bulk modulus respectively and Poisson's ratio (σ_e , σ_{bc} and σ_m) of $\{[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{90}[\text{Ag}_2\text{O}]_{10}\}_{1-z}\{\text{AgI}\}_z$ glasses	5.95
5.29	Theoretically calculated and experimental elastic moduli for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.104
5.30	Theoretically calculated and experimental elastic moduli for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.110
5.31	Theoretically calculated and experimental elastic moduli for $[(\text{TeO}_2)_{65} (\text{B}_2\text{O}_3)_{35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.110
5.32	Theoretically calculated and experimental elastic moduli for $[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.111
5.33	Theoretically calculated and experimental elastic moduli for $\{[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ glasses	5.111
5.34	Activation energy for binary, ternary and quaternary tellurite glass system.	5.132
5.35	(a) Fitting master plot parameter of permittivity for $(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}$ glasses (b) Fitting master plot parameter of permittivity for $(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}$ glasses	5.168
5.36	Fitting master plot parameter of permittivity for	5.168

	$[(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	
5.37	Fitting master plot parameter of permittivity for $\{[(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ glasses	5.169
A.1	Conductivity fitting parameter for $(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}$ glasses	A.1
A.2	Conductivity fitting parameter for $[(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	A.3
A.3	Conductivity fitting parameter for $\{[(\text{TeO}_2)_x(\text{B}_2\text{O})_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ glasses	A.9
A.4	Value of Kohlraush exponent β and full width half maxima (FWHM) from electrical modulus for binary, ternary and quaternary tellurite glass system.	A.11

LISTS OF FIGURES

Figure	Page
3.1 The volume-temperature diagram for glass-forming liquid	3.6
3.2 A time-temperature curve for a glass forming melt	3.9
3.3 Atomic structure representation of (a) A_2O_3 crystal (b) A_2O_3 glass (Vershneya, 1994)	3.12
3.4 Structural presentation of hypothetical crystalline compound AO (Vershneya, 1994)	3.12
3.5 Schematic illustration of the effect of the addition of alkali Na_2O to silica (Elliot, 1990)	3.14
3.6 The creation of non-bridging oxygen by adding alkali oxides (Vershneya,1994)	3.18
3.7 Creation of BO_3 group to BO_4 group by addition of alkali oxide (Vershneya,1994)	3.18
3.8 Some structural groupings in borate glasses as indicated from nuclear magnetic resonance experiments (Bray, 1985). Small solid circles represent borons atom, open circles oxygen atoms and an open circle with negative sign indicate a non-bridging oxygen.	3.20
3.9 Classification of structural unit of TeO_3 type, TeO_{3+1} and TeO_4 (Sakida, 1999a)	3.23
3.10 Model showing a modification of TeO_2 glass by addition of an M_2O (Sakida, 1999b)	3.24
3.11 Condon-Morse curve illustrating the cause of the thermal expansion of bonds	3.27
3.12 Illustration of the three couples of forces acting along the x direction; σ_{xx} is a tensile stress; τ_{xy} and τ_{xz} are shear stresses; τ_{xy} represent a force acting along the x-axis in a plane perpendicular to the y-axis. Similar forces act along the y and z-axes.	3.33
3.13 Illustrated definitions of constants of elasticity . (a) Young's modulus; (b) shear modulus; (c) bulk modulus.	3.36

3.14	Frequency dependence of the polarization mechanisms in glass. Upper: contribution charging constant (representative value of ϵ'). Lower: contribution to the loss factor (representative value of ϵ'')	3.47
3.15	Schematic of polarization mechanism in a glass a) electronic b) atomic or ionic c) high frequency oscillatory dipoles d) low frequency cation dipole e) interfacial polarization at heterogeneities	3.48
3.16	Different types of dielectric dispersion and conduction behaviour. Empty diamond shape is ϵ' and filled diamond shape is ϵ''	3.55
3.17	Top showing the behaviour dielectric dispersion (real and imaginary part of permittivity) consists of combination of relaxation and quasi dc process. Below showing the corresponding conductivity as a function of frequency of the imaginary part of permittivity ($\sigma = \omega\epsilon_0\epsilon''$).	3.56
3.18	Left: types of dielectric relaxation and conduction. Right: the corresponding modulus plot of each relaxation. Inset: model equivalent electrical circuit for relaxation and conduction	3.62
4.1	Schematic processes in glass preparation	4.4
4.2	Glass forming range of $\text{TeO}_2\text{-B}_2\text{O}_3$ and $\text{TeO}_2\text{-B}_2\text{O}_3\text{-Ag}_2\text{O}$ glasses	4.5
4.3	Glass forming range of $\text{TeO}_2\text{-B}_2\text{O}_3\text{-Ag}_2\text{O-AgI}$ glasses	4.5
4.4	MBS-8000 system configuration block diagram (Matec Instrument)	4.10
4.5	Figure 4.5: Connection of the Novocontrol Novotherm units and the sample cell	4.12
5.1	XRD spectrum of $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$ glasses	5.2
5.2	XRD spectrum of $[(\text{TeO}_2)_{60}(\text{B}_2\text{O}_3)_{40}]_{1-y}[\text{Ag}_2\text{O}]_y$ glasses	5.2
5.3	XRD spectrum of $[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{1-y}[\text{Ag}_2\text{O}]_y$ glasses	5.3
5.4	XRD spectrum of $\{[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{90}[\text{Ag}_2\text{O}]_{10}\}_{1-z}\{\text{AgI}\}_z$ glasses	5.3
5.5	Thermal expansion coefficient of $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$ glasses as a function of TeO_2 mol% at different temperature.	5.10
5.6	Thermal expansion coefficient of $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$ glasses	5.10

5.7	Thermal expansion coefficient of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses as a function of Ag_2O mol% at different temperature.	5.11
5.8	Thermal expansion coefficient of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.11
5.9	Thermal expansion coefficient of $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses as a function of AgI mol% at different temperature.	5.12
5.10	Thermal expansion coefficient of $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.12
5.11	Optical absorbance spectra for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.15
5.12	Plot of $(\alpha h\omega)^2$ against photon energy for direct band gap measurement for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.15
5.13	Plot of $(\alpha h\omega)^2$ against photon energy for indirect band gap measurement for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.16
5.14	Optical absorption coefficient against photon energy for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.16
5.15	Optical absorbance spectra for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.19
5.16	Plot of $(\alpha h\omega)^2$ against photon energy for direct band gap measurement for $[(\text{TeO}_2)_{65} (\text{B}_2\text{O}_3)_{35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.19
5.17	Plot of $(\alpha h\omega)^{1/2}$ against photon energy for indirect band gap measurement for $[(\text{TeO}_2)_{65} (\text{B}_2\text{O}_3)_{35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.20
5.18	Optical absorption coefficient against photon energy for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.20
5.19	Optical absorbance spectra for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.22
5.20	Plot of $(\alpha h\omega)^2$ against photon energy for direct band gap measurement for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.22
5.21	Plot of $(\alpha h\omega)^{1/2}$ against photon energy for indirect band gap measurement for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.23
5.22	Optical absorption coefficient against photon energy for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses.	5.23

5.23	Suggested energy band diagrams (energy E versus wave vector, k) for tellurite glass system	5.24
5.24	Density and molar volume of $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$ glasses	5.30
5.25	Density and molar volume of $[(\text{TeO}_2)_{0.60}(\text{B}_2\text{O}_3)_{0.40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.30
5.26	Density and molar volume of $[(\text{TeO}_2)_{0.65}(\text{B}_2\text{O}_3)_{0.35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.31
5.27	Density and molar volume of $[(\text{TeO}_2)_{0.70}(\text{B}_2\text{O}_3)_{0.30}]_{1-y} [\text{Ag}_2\text{O}]_y$ glass	5..31
5.28	Density and molar volume of $\{[(\text{TeO}_2)_{0.70}(\text{B}_2\text{O}_3)_{0.30}]_{0.9} [\text{Ag}_2\text{O}]_{0.1}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.36
5.29	Ultrasonic velocity of $(\text{TeO}_2)_x(\text{B}_2\text{O}_3)_{1-x}$ glasses	5.39
5.30	Ultrasonic velocity of $[(\text{TeO}_2)_{60}(\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.39
5.31	Ultrasonic velocity of $[(\text{TeO}_2)_{65}(\text{B}_2\text{O}_3)_{35}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.40
5.32	Ultrasonic velocity of $[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.40
5.33	Ultrasonic velocity of $\{[(\text{TeO}_2)_{70}(\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.41
5.34	Elastic moduli of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.44
5.35	Elastic moduli of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.44
5.36	Elastic moduli of $[(\text{TeO}_2)_{65} (\text{B}_2\text{O}_3)]_{35} [\text{Ag}_2\text{O}]_y$ glasses	5.45
5.37	Elastic moduli of $[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)]_{30} [\text{Ag}_2\text{O}]_y$ glasses	5.45
5.38	Elastic moduli of $\{[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)]_{1-x} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ glass	5.46
5.39	Variation of Poisson's ratio with crosslink density for tensile stresses applied parallel to oriented chains. The force resisting lateral contraction increase with cross-link density: (a) crosslink density = 0; (b) crosslink density = 1; crosslink density = 2.	5.49
5.40	Poisson's ratio and Debye temperature of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.50
5.41	Poisson's ratio and Debye temperature of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.50

5.42	Poisson's ratio and Debye temperature of $\{[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)]_{1-x} [\text{Ag}_2\text{O}]_y\}_{1-z} \{\text{AgI}\}_z$ glasses	5.51
5.43	Micro-hardness and Transition temperature of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ Glasses	5.54
5.44	Micro-hardness and Transition temperature of $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.54
5.45	Microhardness and transition temperature of $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses. Inset shows $\text{AgI} = 0$ mol%	5.55
5.46	Softening temperature of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.60
5.47	Softening temperature of $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.61
5.48	Softening temperature of $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses. Inset shows $\text{AgI} = 0$ mol%	5.61
5.49	Cross link-density of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.67
5.50	The number of network bonds per unit volume of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.67
5.51	The estimated atomic ring size of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glass	5.68
5.52	The calculated bond compression bulk modulus of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.68
5.53	Variation of estimated atomic ring size with values of K_{bc}/K_e of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.60
5.54	Variation of estimated atomic ring size with the value of K_{bc}/K_e	5.60
5.55	Packing density of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.73
5.56	Dissociation energy of $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.73
5.57	Cross link-density of $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.76
5.58	The number of network bonds per unit volume of $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.76
5.59	Estimated atomic ring size of $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.79
5.60	Bond compression bulk modulus of $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.79

5.61	Variation of estimated atomic ring size with values of K_{bc}/K_e of $[(TeO_2)_x(B_2O_3)_{1-x}]_{1-y} [Ag_2O]_y$ glasses	5.80
5.62	Packing density of $[(TeO_2)_x(B_2O_3)_{1-x}]_{1-y} [Ag_2O]_y$ glasses	5.80
5.63	Dissociation energy of $[(TeO_2)_x(B_2O_3)_{1-x}]_{1-y} [Ag_2O]_y$ glasses	5.81
5.64	Cross-link density of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses	5.89
5.65	The number of network bonds per unit volume of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses. Inset shows $AgI = 0$ mol%	5.89
5.66	Atomic ring size of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses. Inset shows $AgI = 0$ mol%	5.91
5.67	Bond compression bulk modulus of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses. Inset shows $AgI = 0$ mol%	5.91
5.68	Variation of estimated atomic ring size with values of K_{bc}/K_e of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses	5.92
5.69	Packing density of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses. Inset shows $AgI = 0$ mol%	5.92
5.70	Dissociation energy of $\{[(TeO_2)_{70}(B_2O_3)_{30}]_{90} [Ag_2O]_{10}\}_{1-z} \{AgI\}_z$ glasses	5.93
5.71	The experimental bulk modulus (K_e), the bond compression bulk modulus (K_{bc}), Makishima-Mackenzie bulk modulus (K_m) and the calculated bulk modulus (K_{cal}) for $(TeO_2)_x (B_2O_3)_{1-x}$ glasses	5.100
5.72	The experimental Young's modulus (E_e), the bond compression Young's modulus (E_{bc}), Makishima-Mackenzie Young's modulus (E_m) and the calculated Young's modulus (E_{cal}) for $(TeO_2)_x (B_2O_3)_{1-x}$ glasses	5.100
5.73	The experimental shear modulus (G_e), the bond compression shear modulus (G_{bc}), Makishima-Mackenzie shear modulus (G_m) and the calculated shear modulus (G_{cal}) for $(TeO_2)_x (B_2O_3)_{1-x}$ glasses	5.101
5.74	Correlation between calculated and experimental bulk modulus for $(TeO_2)_x (B_2O_3)_{1-x}$ glasses	5.101

5.75	Correlation between calculated and experimental shear modulus for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.102
5.76	Correlation between calculated and experimental longitudinal modulus for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.102
5.77	Correlation between calculated and experimental Young's modulus for $(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}$ glasses	5.103
5.78	The experimental bulk modulus (K_e), the bond compression bulk modulus (K_{bc}), Makishima-Mackenzie bulk modulus (K_m) and the calculated bulk modulus (K_{cal}) for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.103
5.79	The experimental Young's modulus (E_e), the bond compression Young's modulus (E_{bc}), Makishima-Mackenzie Young's modulus (E_m) and the calculated Young's modulus (E_{cal}) for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.106
5.80	The experimental shear modulus (G_e), the bond compression shear modulus (G_{bc}), Makishima-Mackenzie shear modulus (G_m) and the calculated shear modulus (G_{cal}) for $[(\text{TeO}_2)_{60} (\text{B}_2\text{O}_3)_{40}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.106
5.81	Correlation between calculated and experimental bulk modulus for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.108
5.82	Correlation between calculated and experimental shear modulus for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.108
5.83	Correlation between calculated and experimental longitudinal modulus for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.109
5.84	Correlation between calculated and experimental Young's modulus for $[(\text{TeO}_2)_x (\text{B}_2\text{O}_3)_{1-x}]_{1-y} [\text{Ag}_2\text{O}]_y$ glasses	5.109
5.85	The experimental bulk modulus (K_e), the bond compression bulk modulus (K_{bc}), Makishima-Mackenzie bulk modulus (K_m) and the calculated bulk modulus (K_{cal}) for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.113
5.86	The experimental Young's modulus (E_e), the bond compression Young's modulus (E_{bc}), Makishima-Mackenzie Young's modulus (E_m) and the calculated Young's modulus (E_{cal}) for $\{[(\text{TeO}_2)_{70} (\text{B}_2\text{O}_3)_{30}]_{90} [\text{Ag}_2\text{O}]_{10}\}_{1-z} \{\text{AgI}\}_z$ glasses	5.113