



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

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