UNIVERSITI PUTRA MALAYSIA

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UNIVERSITI PUTRA MALAYSIA

2007

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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

February 2007

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

ELASTIC, ELECTRICAL AND THERMAL PROPERTIES OF TELLURITE GLASS SYSTEMS

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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 $(TeO_2)_x$ $(B_2O_3)_{1-x}$ with x = 60, 63, 65, 70,73, 75, 78, 80 mol%, the ternary tellurite $[(TeO_2)_x$ $(B_2O_3)_{1-x}]_{1-y}$ $[Ag_2O]_y$ 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 $\{[(TeO_2)_x$ $(B_2O_3)_{1-x}]_{1-y}$ $[Ag_2O]_y\}_{1-z}$ $\{AgI\}_z$ 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 mirohardness 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

HALIMAH MOHAMED KAMARI

Februari 2007

Pengerusi : Profesor Madya Sidek Haji Abdul Aziz, PhD

Fakulti : Sains

Tiga siri kaca telurit telah disintesis dengan teknik sepuh lindap. Telurit binari adalah $(TeO_2)_x$ $(B_2O_3)_{1-x}$ dengan x = 60, 63, 65, 70,73, 75, 78, 80 mol%, telurit ternary $[(TeO_2)_x (B_2O_3)_{1-x}]_{1-y} [Ag_2O]_y$ terdiri daripada tiga siri iaitu is x = 60, 65 and 70 mol% dengan = 10, 15, 20, 25 dan 30 mol% and kaca telurit kuaternari $\{[(TeO_2)_x (B_2O_3)_{1-x}]_{1-y} [Ag_2O]_y\}_{1-z} \{AgI\}_z$ 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 komposissi kaca. Tenaga jalur optik menunjukkan corak berkurangan dengan komposisi bagi kaca binari dan ternari tellurit 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 kuartenari 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, pengutupan orientasi pada frekuensi pertengahan dan pengutupan 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 pengutupan elektrod. Kekonduksian elektrik bagi kaca berasaskan telurit didapati mematuhi hukum eksponen kuasa berganda.

ACKNOWLEDGEMENTS

First and for most I would like to express my deep gratitude to my supervisor, Associate Professor Dr. Sidek Haji Abdul Aziz, for his constant encouragement, constructive suggestions and continuous discussion throughout the project. I would also like to extend my sincere appreciation to my co-supervisors Associate Professor Dr. W. Mohamad Daud W. Yusoff and Dr. Zainul Hassan for their guidance, suggestion and comments throughout the research work.

My special thanks to Cik Yusnita (XRD) and Puan Wan Yusmawati (XRD), Puan Noriza Marlan, Cik Kamsiah and all the laboratory technicians for their help

I am extremely grateful to all my lab mates and Emma Zizzie for their constant encouragements and help throughout these few years.

The financial support from the Ministry of Science and Technology and Universiti Putra Malaysia is grateful acknowledged. Without this support, it is impossible for me to pursue this project with success.

Last but not least, I would like to give my sincere thanks to all the members of my family for their love, continuous support, encouragement and understanding.

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

Hishamuddin Zainuddin., **Ph.D**
Associate Professor
Faculty of Science
University Putra Malaysia
(Chairman)

Abdul Halim Shaari, Ph.D
Professor
Faculty of Science
University Putra Malaysia
(Internal Examiner)

Mansor Hashim, Ph.D
Associate Professor
Faculty of Science
University Putra Malaysia
(Internal Examiner)

Muhamad Mat Salleh, Ph.D
Professor
Principal Research Fellow/Professor of Physics
University Kebangsaan Malaysia
(External Examiner)

HASANAH MOHD GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
University Putra Malaysia

Date :

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Sidek Haji Abdul Aziz, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

W. M. Daud W. Yusoff, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

Zainul Abidin Hassan, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date : 10 May 2007

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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