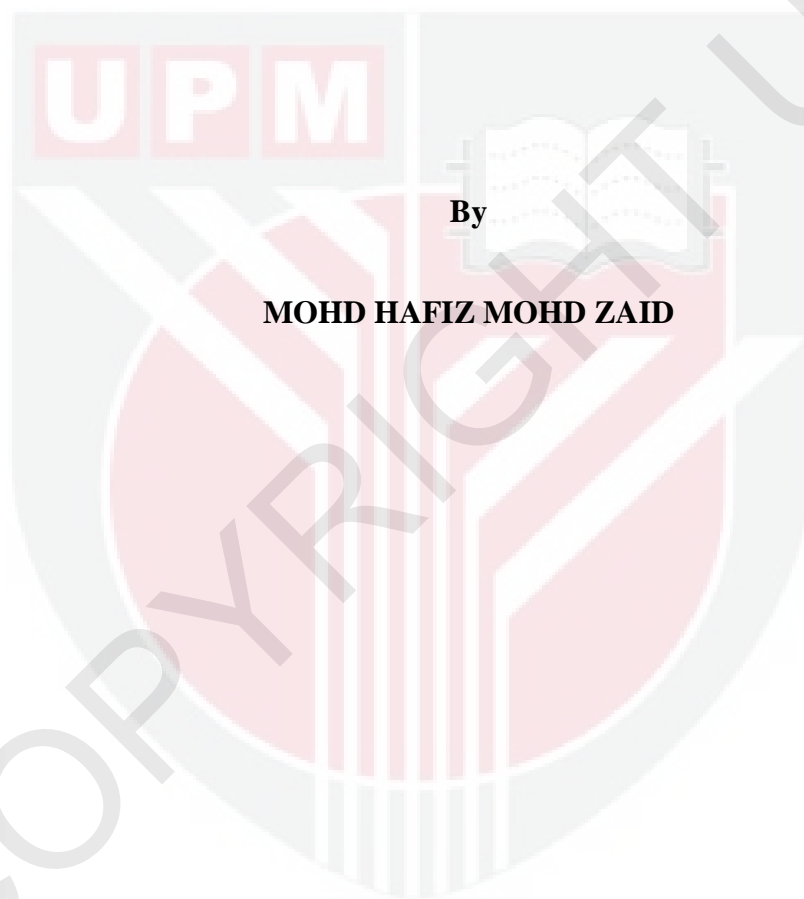# UNIVERSITI PUTRA MALAYSIA

STRUCTURAL, OPTICAL AND ELASTIC PROPERTIES OF ZINC OXIDE SODA LIME SILICATE GLASS

MOHD HAFIZ MOHD ZAID

FS 2011 58

STRUCTURAL, OPTICAL AND ELASTIC PROPERTIES OF ZINC OXIDE SODA LIME SILICATE GLASS

By

MOHD HAFIZ MOHD ZAID

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

December 2011

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

STRUCTURAL, OPTICAL AND ELASTIC PROPERTIES OF ZINC OXIDE SODA LIME SILICATE GLASS

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December 2011

Chair   : **Khamirul Amin Matori, PhD**

Faculty   : **Faculty of Science.**

So far, most research had been done to understand the properties and advantages of soda lime silicate (SLS) glass compare to others glass and also to improve their quality. Addition of oxide into the glass system had been a topic of research for nearly half century, but many questions still remain unanswered concerning to the effect of the addition of some oxide to the properties and the structure changes of the glass. In this research, fabrication of a series of $(ZnO)_x(SLS)_{1-x}$ glasses with weight percentage x from 0.05 to 0.40 were carried out by the melting and quenching technique. The chemical composition of the $(ZnO)_x(SLS)_{1-x}$ glasses were determined using Inductive Couple Plasma (ICP) and Energy Dispersive X-ray Fluorescence (EDXRF). The amorphous structure of the glass samples were confirmed using X-ray diffraction (XRD) measurement. The glass density was measured by using Archimedes' principle. The

densities of the glass sample were increased with the addition of ZnO. The molar volume of the glass samples shows a same trend with the density of the glasses which is increased with the increased of ZnO content. Their physical properties such as elastic properties were determined at room temperature by using non-destructive test; the digital signal processing technique of Matec DSP MBS 8000. The experimental data of wave velocities and densities were then used to determine the longitudinal modulus, shear modulus, Young modulus, bulk modulus, Poisson's ratio, fractal bond connectivity and Micro-hardness in each series of $(ZnO)_x(SLS)_{1-x}$ glass system. It was found that the longitudinal modulus, shear modulus, Young modulus and bulk modulus decreased with the addition of ZnO in the SLS glasses. These elastic properties of glasses were found closely related to the strength of the glass structure. The values of the elastic properties had been compared with the Rocherulle's model and this model shows a same trend which is the values of the longitudinal modulus, shear modulus, Young modulus and bulk modulus of the glass samples decreased with the addition of ZnO. The bonding in the $(ZnO)_x(SLS)_{1-x}$ glasses were measured using IR Spectroscopy. The shift band of IR spectroscopy must be occurs due to the addition of ZnO, which means increase the non-bridging oxygens (NBOs) in the glass structure and resulting the structural of the glass samples become weaker. The optical properties of the $(ZnO)_x(SLS)_{1-x}$ glass system were measured using UV-Visible spectroscopy. The values of the optical band gap decreased with the addition of ZnO in the SLS glass system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

STRUKTUR, OPTIK DAN SIFAT KEKENYALAN KACA ZINK OKSIDA SODA LIME SILIKA

Oleh

MOHD HAFIZ MOHD ZAID

Disember 2011

Pengerusi   : Khamirul Amin Matori, PhD

Fakulti   : Fakulti Sains

Sehingga kini, banyak penyelidikan telah dilakukan untuk memahami sifat-sifat dan kelebihan kaca soda lime silika (SLS) berbanding dengan kaca yang lain di samping untuk meningkatkan kualiti kaca tersebut. Selain itu, penambahan oksida ke dalam sistem kaca telah menjadi topik penyelidikan untuk hampir setengah abad, tetapi masih terdapat banyak persoalan yang tidak terjawab mengenai kesan pernambahan oksida ke atas sifat-sifat dan perubahan pada struktur kaca. Dalam kajian ini, fabrikasi siri kaca $(ZnO)_x(SLS)_{1-x}$ dengan x peratusan berat 0.05-0.40 telah dijalankan dengan menggunakan teknik lindapan leburan. Komposisi kaca $(ZnO)_x(SLS)_{1-x}$ telah ditentukan menggunakan (ICP) dan (EDXRF). Struktur amorfus sampel kaca telah disahkan dengan menggunakan pengukuran XRD. Seterusnya, ketumpatan kaca telah diukur dengan menggunakan prinsip Archimedes. Ketumpatan sampel kaca telah meningkat dengan penambahan ZnO. Isipadu molar sampel kaca juga menunjukkan bentuk yang

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sama dengan ketumpatan gelas yang meningkat dengan peningkatan kandungan ZnO. Sifat-sifat fizikal kaca seperti sifat kenyal ditentukan pada suhu bilik dengan menggunakan teknik pemprosesan isyarat digital Matec DSP MBS 8000. Data halaju gelombang dan ketumpatan kemudian digunakan untuk menentukan nilai modulus memanjang, modulus ricih, Young modulus, pukal modulus, nisbah Poisson, penyambungan bond fraktal dan micro-kekerasan dalam siri setiap daripada kaca $(ZnO)_x(SLS)_{1-x}$. Didapati bahawa modulus memanjang, modulus ricih, modulus Young dan modulus pukal menurun dengan pernambahan ZnO dalam kaca SLS. Ciri-ciri kenyal kaca ini telah didapati berkait rapat dengan kekuatan struktur kaca. Nilai ciri kenyal kaca ini telah dibandingkan dengan nilai teori daripada model Rocherulle dan model ini menunjukkan bentuk yang sama dengan nilai-nilai modulus membujur, modulus ricih, modulus Young dan modulus pukal sampel kaca menurun dengan penambahan ZnO yang diperolehi dari eksperimen. Ikatan dalam kaca $(ZnO)_x(SLS)_{1-x}$ dikaji dengan menggunakan IR spektroskopi. Jalur peralihan IR spektroskopi mesti berlaku disebabkan oleh tambahan ZnO, yang bermakna meningkatkan (NBOs) dalam struktur kaca dan mengakibatkan struktur sampel kaca menjadi lemah. Kemudiannya, ciri-ciri optik kaca diukur dengan menggunakan spektroskopi *UV-Visible*. Nilai-nilai jurang jalur optik menurun dengan penambahan ZnO dalam sistem kaca SLS.

ACKNOWLEDGEMENTS

First of all, I glad to say thank you ALLAH for providing me an effort and courage to complete my study efficiently.

I would like to express my gratitude and lot of thanks especially to my project supervisor, Dr. Khamirul Amin Matori for his invaluable advice patience and constructive critics during the preparation of this thesis. Without his persistent and exceptional generosity, valuable advices, critical comment and suggestion, this work would not have been possible. Especially thanks to my co-supervisor, Assoc. Prof. Dr. Zaidan Abdul Wahab, Prof. Dr. Azmi Zakaria and Dr. Halimah Mohamed Kamari for giving a lot of support and precious guidelines during my study.

I would like to acknowledge Malaysia Ministry of Higher Education and Universiti Putra Malaysia for funding this research through Graduate Research Foundation scheme (GRF) and giving the opportunity to undertake and complete this study.

Finally, grateful thanks also to my dearest father, Mr. Mohd Zaid bin A. Bakar, my beloved mother, Mrs. Kamsiah binti Mustaffa and my sister that have been so supportive throughout my study. Credits are given to all the lecturers in Physics Department, all Faculty of Science staff and friends who have directly and indirectly give me a helping hand.

I certify that a Thesis Examination Committee has met on 13 December 2011 to conduct the final examination of Mohd Hafiz Mohd Zaid on his thesis entitled "Structural, Optical and Elastic Properties of Zinc Oxide Soda Lime Silicate Glass" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I declare that the thesis is my work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

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MOHD HAFIZ MOHD ZAID

Date: 13 December 2011

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