UNIVERSITI PUTRA MALAYSIA

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MASTER OF SCIENCE

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By

ZARIFAH BT HJ NADAKKAVIL ALASSAN

Thesis Submitted to the School of Graduate Studies Universiti Putra Malaysia in Fulfillment of the Requirement for the Degree of Master Of Science

August 2012

DEDICATIONS

To my beloved parents Nadakkavil Alassan Kunju Ahmad and Napisah Muhammaduni
For their love and care…

To my siblings and family
For making my life complete…

To all my very wonderful friends

For making my life full of joy and happiness…

To all my lecturers

For helping me at a lot throughout my study…

To me

May Allah bless me always

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

STRUCTURAL, MAGNETIC AND DIELECTRIC PROPERTIES OF Fe_2O_3-TeO_2 GLASS WITH STARTING MATERIALS OF DIFFERENT PARTICLE SIZE

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Chairman: Halimah Mohamed Kamari, PhD

Faculty: Science

Tellurite based glasses have physical properties that are important for both fundamental and practical applications which are low melting temperature, high dielectric constant, high refractive index, good infrared transmittance and high chemical durability while oxide glass with iron oxide are important due to their magnetic, optical and electrical properties. Hence we proposed to study the structural, magnetic and dielectric properties of Fe_2O_3-TeO_2 glass with different particle size of the starting materials. Glasses in a wide range of composition in the binary system $(Fe_2O_3)_x$-$(TeO_2)_{1-x}$ where x ranges from 0.10 to 0.30 in the interval of 0.05 have been prepared using different sizes of the starting materials by conventional melt quenching technique with Fe_2O_3 and TeO_2 as the starting raw materials. All the glasses in the present work have been confirmed to be amorphous by X-Ray diffraction (XRD) analysis. The short range structures of those binary glasses were examined by Fourier-transform infrared (FTIR)

spectroscopy. The density of the glasses was determined by Archimedes Principle. From the empirical data, molar volumes have been computed. Glass stability and glass forming ability was determined using Differential Thermal Analysis (DTA) curve. Magnetic measurement has been performed at room temperature using vibrating sample magnetometer (VSM). The dielectric properties of the samples were also measured using Novocontrol Novotherm High Dielectric Resolution Analyser. The density of the FT series decreases from 5.26 gcm^{-3} to 5.09 gcm^{-3} while FTN series decrease from 5.37 gcm^{-3} to 5.06 gcm^{-3} with the addition of Fe_2O_3 due to the replacement of high density TeO_2 with Fe_2O_3. The molar volume of the glass samples shows a reverse trend compared to the density which increases with increasing Fe_2O_3 where FT series increase from 30.28 cm^3 mol^{-1} to 31.18 cm^3 mol^{-1} and FTN series increase from 29.71 cm^3 mol^{-1} to 31.35 cm^3 mol^{-1}. The magnetization analysis shows that all samples have soft magnetic properties. FT glass series were found to exhibit paramagnetic behavior. Binary samples using nano material with x=0.30 has paramagnetic behavior with contribution of superparamagnetic behaviour. The results show that the dielectric permittivity and dielectric loss decrease with frequency and increase with temperature. The behavior of dielectric curves was modeled using equivalent RC circuit consisting combinations of dispersion barrier $C^*_{A,}$ quasi – dc, $C^*_{B,}$ resistance R, and non dispersive capacitance C_∞. The conductivity plot shows two regions, dispersive and flat. This is due to the DC conduction and hopping mechanism. The hopping will take place between the Fe^{2+} and Fe^{3+} ions ($Fe^{2+} \rightarrow Fe^{3+} + e^-$) among the different factors, which influence the conductivity

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

SIFAT STRUKTUR, MAGNET DAN DIELEKTRIK BAGI KACA Fe_2O_3-TeO_2 DENGAN BAHAN PERMULAAN YANG MEMPUNYAI SAIZ ZARAH BERBEZA

Oleh

ZARIFAH BT HJ NADAKKAVIL ALASSAN

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Kaca Tellurit mempunyai sifat fizikal yang penting bagi kedua-dua aplikasi asas dan praktikal iaitu suhu lebur yang rendah, pemalar dielektrik yang tinggi, indeks biasan tinggi, penghantaran inframerah yang baik dan ketahanan kimia yang tinggi manakala oksida kaca bersama logam oksida penting kerana sifat magnet, optik dan elektrik yang dipunyainya. Oleh itu, kami mencadangkan untuk mengkaji sifat struktur, magnet, dan dielektrik bagi sistem kaca Fe_2O_3-TeO_2 dengan saiz zarah bahan permulaan yang berbeza. Kaca dalam satu julat komposisi diantara sistem binari $(Fe_2O_3)_x$-$(TeO_2)_{1-x}$ dimana x dalam julat 0.10 hinga 0.30 dengan sela 0.05 telah dihasilkan menggunakan saiz bahan permulaan berbeza melalui teknik sepuh lindap dengan Fe_2O_3 dan TeO_2 sebagai bahan asas permulaan. Semua sampel dalam kajian ini telah disahkan amorfus melalui analisis Pembelauan sinar-X (XRD). Struktur tertib julat pendek bagi kaca binari ini dikaji oleh spektroskopi infra merah (FTIR). Ketumpatan kaca telah

ditentukan menggunakan prinsip Archimedes. Dari nilai empirikal yang diukur, isipadu molar telah dikira. Kestabilan kaca dan keupayaan membentuk kaca telah ditentukan menggunakan parameter dari analisis pembezaan terma (DTA). Pengukuran magnetik telah dijalankan pada suhu bilik menggunakan getaran sampel magnetometer (VSM). Sifat dielektrik bahan kaca juga diukur dengan menggunakan Penganalisis Dielektrik Resolusi Tinggi Novocontrol Novotherm. Ketumpatan bagi siri FT berkurangan dari 5.26 gcm^{-3} ke 5.09 gcm^{-3} sementara siri FTN berkurangan dari 5.37 gcm^{-3} ke 5.06 gcm^{-3} dengan penambahan Fe_2O_3 disebabkan penggantian TeO_2 yang berketumpatan tinggi dengan Fe_2O_3. Isipadu molar kaca ini menunjukkan corak yang berlawananan dari ketumpatan yang mana ia meningkat dengan penambahan Fe_2O_3 dimana siri FT meningkat 30.28 cm^3 mol^{-1} ke 31.18 cm^3 mol^{-1} dan siri FTN meningkat dari 29.71 cm^3 mol^{-1} ke 31.35 cm^3 mol^{-1}. Kajian pemagnetan menunjukkan bahawa semua sampel mempunyai sifat magnet lembut. Kaca dari siri FT didapati mempunyai sifat paramagnet. Sampel binari menggunakan bahan berzarah nano dengan x = 0.30 mempunyai sifat paramagnet dengan sedikit sumbangan sifat superparamagnet. Keputusan menunjukkan ketelusan dielektrik dan kehilangan dielektrik menurun dengan frekuensi dan meningkat dengan peningkatan suhu. Sifat daripada lengkuk dielektrik dimodelkan menggunakan litar RC setara yang terdiri daripada kombinasi halangan penyebaran $C^*_{A,}$ kuasi – dc, C^*_B , rintangan R, dan kapasitan tak terserak C_∞. plot kekonduksian menunjukkan dua rantau, serakan dan rata. Ini adalah kerana konduksi DC dan mekanisma lompatan. Lompatan ini berlaku diantara Fe^{2+} and Fe^{3+} ion ($Fe^{2+} \rightarrow Fe^{3+} + e^-$) antara factor berbeza yang mempengaruhi kekonduksian

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DECLARATION

I declare that the thesis is my original 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 degree at Universiti Putra Malaysia or other institutions.

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