CHARACTERIZATION OF LITHIUM-MAGNESIUM-TELLURITE DOPED WITH ERBIUM AND NEODYMIUM GLASS

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Physics)

Faculty of Science
Universiti Teknologi Malaysia

MARCH 2013

This thesis is specially dedicated to:

To my beloved daddy (Roslan Bin Paiman)
My mother (Jamiah Binti Supar),
my siblings,
and all my friends.

ACKNOWLEDGEMENT

Alhamdulillah, all praise to Allah SWT, the Almighty, for giving me the courage, strength, and patience to complete this master study. I would like to express my sincerest appreciation to my project supervisors Prof. Dr. Md. Rahim Sahar and Dr. Ramli for advices, guidance and encouragement throughout completing this project. Kindly thanks to the tolerance, commitment and understanding.

I would like to thank all lecturers who have shared their knowledge and effort with me throughout my dissertation. Furthermore, this thesis would not have been possible without the very pleasant and creative working atmosphere at the Phosphor Material Laboratory, Faculty of Science, Universiti Teknologi Malaysia. My great appreciation to all members of the group and laboratory staffs for their help throughout this project.

In addition, my sincere application also extends to all my postgraduate friends and others who are providing assistance at various applications. Their views and suggestions are useful indeed. Grateful thanks to all my beloved family members for their support.

Last but not least, special thanks to the financial support from the Grant FRGS (Vot 78409) and Grant GUP (Vot 00J76), Ministry of Higher Education (MOHE).

ABSTRACT

Tellurite glass based on (78-x)TeO_2-10Li_2O-10MgO-2Nd_2O_3-xEr_2O_3, (where x = 0.4 to 2.0 mol %) has successfully been prepared by melt-quenching technique. The colour of glass is found to vary from light violet to dark violet as the Er_2O_3 content is increased. No definite peaks are found from the X-ray diffraction pattern, which shows that the glass is amorphous in nature. It also found that the densities and the molar volume of the glass increase as the Er_2O_3 content is increased. The glass transition temperature (T_g), crystallization temperature (T_c), melting temperature (T_m) and the temperature difference (T_c-T_g) are determined by means of Differential Thermal Analysis (DTA). It is found that the T_c, T_g and T_m are in the range of (419-430) ^oC, (300-345) ^oC and (885-890) ^oC respectively. Meanwhile, the vibrational study is conducted using the Infrared spectroscopy in the range of (4000-400) cm^{-1}. Two major absorption peaks are observed around (1600-3600) cm^{-1}, and (900-1200) cm^{-1} which are due to the stretching mode vibration of OH peak and Te-OH peak respectively. The optical absorption edge is studied using UV-Vis spectroscopy. The result shows that the optical band gap (E_{opt}) and Urbach Energy (ΔE) are in the range of (3.038-3.130) eV and (0.334-0.321) eV respectively, depending on the Er_2O_3 concentration. The refractive index is evaluated using the Sellmeier's equation and it is found that the value in the visible region is in the range of 1.724-1.781 depending on the Er_2O_3 content. The emission spectrum is recorded using the photoluminescence spectrometer excited at 582 nm at room temperature. The result shows that the emission spectrum of Er^{3+} and Nd^{3+} consist of five emission bands at ~457 nm, ~495 nm, ~556 nm, ~611 nm, and ~ 665 nm which can be assigned as a transition of $^4F_{7/2} \rightarrow {}^4F_{15/2,}$ $^4S_{3/2} \rightarrow {}^4F_{15/2}$, $^4G_{11/2} \rightarrow {}^4I_{9/2}$, $^4G_{11/2} \rightarrow {}^4I_{15/2}$ and $^4G_{7/2} \rightarrow {}^4I_{13/2}$ respectively.

ABSTRAK

Kaca Tellurit berasaskan (78-x)TeO_2-10Li_2O-10MgO-2Nd_2O_3-xEr_2O_3, (dengan $0.4 \leq x \leq 2.0$ mol %) telah berjaya disediakan menggunakan teknik pelindapan leburan. Warna kaca didapati berubah dari ungu terang kepada ungu gelap apabila kandungan Er_2O_3 bertambah. Corak pembelauan sinar-X tidak menunjukkan puncak yang pasti dan ini mengesahkan bahawa kaca tersebut adalah amorfus. Didapati juga bahawa ketumpatan dan isipadu molar kaca bertambah apabila kandungan Er_2O_3 bertambah. Suhu peralihan kaca (T_g), suhu penghabluran (T_c), suhu leburan (T_m) dan perbezaan suhu (T_c-T_g) telah ditentukan menggunakan Penganalisis Pembezaan Terma. Didapati bahawa T_c, T_g dan T_m masing-masing berada dalam julat (419-430) ^oC, (300-345) ^oC and (885-890) ^oC. Sementara itu, kajian terhadap getaran telah dilakukan menggunakan spektroskopi inframerah dalam julat (4000-400) cm^{-1}. Dua puncak utama diperolehi disekitar (1600-3600) cm^{-1}, dan (900-1200) cm^{-1} yang masing-masing merujuk kepada puncak mod getaran regangan OH dan Te-OH . Pinggir serapan optik dikaji menggunakan spektroskopi ultraviolet cahaya nampak. Didapati bahawa jurang tenaga, E_g dan tenaga Urbach, ΔE masing-masing adalah di sekitar (3.038-3.130) eV dan (0.334-0.321) eV, bergantung kepada kandungan Er_2O_3. Indek biasan telah ditentukan menggunakan persamaan Sellmeier dan didapati bahawa nilainya dalam julat cahaya nampak adalah 1.724-1.781, bergantung kepada kandungan Er_2O_3. Spektrum pancaran telah direkod menggunakan spektrometer fotoluminesen yang diujakan pada 582 nm pada suhu bilik. Keputusan menunjukkan bahawa spektrum pancaran Er^{3+} dan Nd^{3+} terdiri daripada empat jalur pada ~457 nm, ~495 nm, ~556 nm, ~611 nm, dan ~665 nm dengan masing-masing mewakili transisi dari $^4F_{7/2} \rightarrow {}^4F_{15/2,}$ $^4S_{3/2} \rightarrow {}^4F_{15/2}$, $^4G_{11/2} \rightarrow {}^4I_{9/2}$, $^4G_{11/2} \rightarrow {}^4I_{15/2}$ and $^4G_{7/2} \rightarrow {}^4I_{13/2}$.

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LIST OF SYMBOLS

As_2O_5	-	Arsecin pentoxide
Al_2O_3	-	Aluminium oxide
B_2O_3	-	Boron oxide
Bi_2O_3	-	Bismuth oxide
Ga_2O_3	-	Gallium(III) oxide
GeO_2	-	Germanium dioxide
TeO_2	-	Tellurium oxide
TiO_2	-	Titanium dioxide
Li_2O	-	Lithium Dioxide
MgO	-	Magnesium Oxide
MoO_3	-	Molybdenum trioxide
P_2O_5	-	Phosphorus pentoxide
SeO_2	-	Selenium dioxide
SiO_2	-	Silicon dioxide
V_2O_5	-	Vanadium pentoxide
WO_2	-	Tungsten oxide
WO_3	-	Tungsten trioxide
ZnF_2	-	Zinc fluoride
Li^{3+}	-	Lithium trivalent ion
BOs	-	Bridging oxygen
ESA	-	Excited state absorption
NBO	-	Nob-bridging oxygen
SRO	-	Short range order
tbp	-	Trigonal bipyramid

tp	-	Trigonal pyramid
α-TeO_2	-	Paratellurite
RE	-	Rare earth
Er^{3+}	-	Trivalent erbium ion
Nd^{3+}	-	Trivalent neodymium ion
Yb^{3}	-	Trivalent Ytterbium ion
4f	-	Orbital belong to lanthanide series
$4fn$	-	Shell configuration belong to lanthanide series
DTA	-	Differential Thermal Analyzer
EDFAs	-	Erbium doped fiber amplifiers
FTIR	-	Fourier Transmission Infrared
IR	-	Infrared
NIR	-	Near infrared
UV-Vis	-	Ultraviolet Visible
PL	-	Photoluminescence
WDM	-	Wavelength division multiplexing
XRD	-	X-Ray Diffractometer
T_m	-	Melting temperature
T_c	-	Crystallization temperature
T_g	-	Glass formation temperature
α(ω)	-	Absorption coefficient
A	-	Absorbance
A_j	-	Sellmeier parameter
$A_{1,2,3}$;$B_{1,2,3}$	-	Sellmeier coefficients
c	-	Speed of light
d	-	Distance between each adjacent crystal planes
d_2	-	Thickness sample
D	-	Dispersion
E	-	Energy

E_g	-	Optical energy gap
E_i	-	Energy lower band
E_f	-	Energy upper band
e	-	Electron charge
eV	-	Electron Volt
ΔE	-	Urbach energy
ε_o	-	Electric permittivity
f	-	Vibration frequency
ik	-	Imaginary part
k	-	Extinction coefficient
k	-	Force constant
μ	-	Reduce mass
m	-	Mass of atom
m	-	index transition
M	-	Molar mass
n	-	Refractive index
n^*	-	Complex refractive index
OH	-	Hydroxyl
ρ	-	Density
ρ_l	-	Toluene density
ρ_a	-	Air density
Q	-	Quality factor
q	-	Phonon
R	-	Reflactance
v	-	Speed
ν_{eq}^{s}	-	Symmetric stretching vibration
ν_{ax}^{as}	-	Asymmetric stretching vibration
V	-	Volume

V_m	-	Molar Volume
W_a	-	Weight of sample in air
W_l	-	Weight of sample in immersion fluid
M_i	-	Molar mass of substance mol
Z	-	Atomic number
χ_i	-	Percentage of substance mol
$\hbar\omega$	-	Photon Energy
θ	-	Angle
λ	-	Wavelength
λ_j	-	Resonance wavelengths of the transitions
ΔT	-	Glass stability

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