Analele Universităţii de Vest din Timişoara
Vol. XLIX, 2006
Seria Fizică

SPECTROSCOPIC AND MAGNETIC PROPERTIES OF $xGd_2O_3(1-x)[0.15Bi_2O_3 – 0.85TeO_2]$ GLASSES

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Abstract
Glasses with gadolinium ions $xGd_2O_3(1-x)[0,15Bi_2O_3-0,85TeO_2]$, where $0.01 \leq x \leq 0.25$, were prepared and characterized by IR spectroscopy and susceptibility measurements. IR spectroscopic data permitted to identify some of the structural units characteristic of this glasses and to follow their evolution with increasing the rare earth oxide content of the samples. Magnetic susceptibility data permitted to observe the localization of rare earth ions and the evolution of their interactions with increasing their content in the samples.
Keywords: glasses, spectroscopy, magnetism.

1. Introduction

TeO_2-based multicomponent glasses have attracted much interest because of their high refractive index, dielectric constants, low dispersion, wide infrared transmittance and high thermal expansion coefficients. Because of their promising optical and electrical properties, they became interesting materials for optical switching devices, laser hosts and semiconductive devices. Much attention has been focused on practical applications using non-linear properties such as optical modulators and memories in the shape of bulk or under fiber waveguide form. [1-3].

In order to extend the available information concerning the interesting class of tellurium glasses, in this work we investigated the $[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses with gadolinium ions in the range of concentration $0.01 \leq x \leq 0.25$ by IR spectroscopy and magnetic susceptibility measurements.

2. Method and samples

Samples of the $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glass system, were prepared by mixing Bi_2O_3, TeO_2 and Gd_2O_3 reagent grade purity. The mentioned oxides were mixed in suitable proportions to obtain the desired compositions. The mixtures were milled in an agate

ball mill for 30 minutes and then were melted at 1200^{o}C for 15 minutes. The glass samples were obtained by pouring the melts on a stainless steel block.

The IR absorption spectra of the glasses were recorded using an Equinox 55 spectrometer in the 400-1300 cm^{-1} wave number range at room temperature. Sample pellets were prepared by mixing and grinding a small quantity of glass powder with spectroscopic grade dry KBr powder and then compressing the mixtures to form thin pellets for testing.

Magnetic susceptibility measurements were performed on a Faraday type balance in the 80 to 300 K temperature range. The sensitivity of the equipment was 10^{-8} emu/g.

3. Results and Discussions

IR spectroscopic data permitted to identify some of the structural units characteristic of the studied glasses and to follow their evolution with increasing the rare earth oxide content of the samples. The assignment of the IR absorption bands is discussed by comparing the experimental data obtained for $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glass system with the absorption spectra of the Bi_2O_3 and TeO_2 crystalline compounds represented in fig. 1.

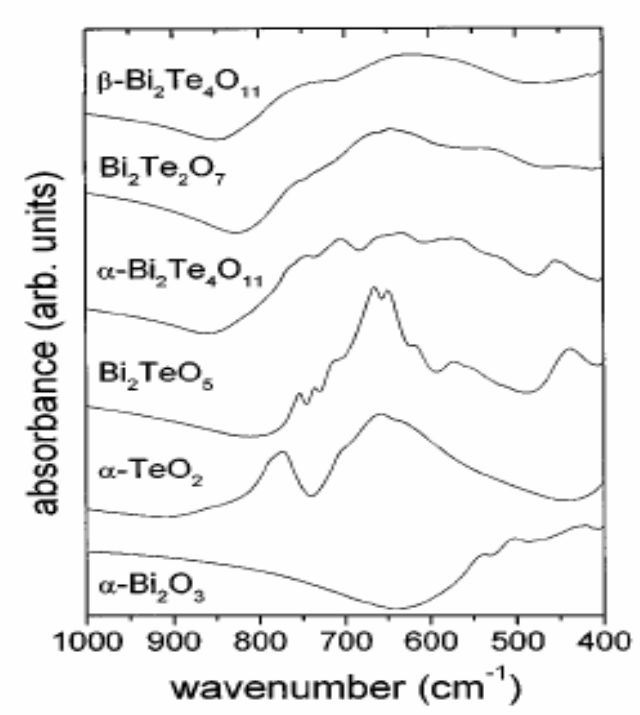

Fig. 1 IR absorption spectra of the Bi_2O_3 and TeO_2 crystalline

In table 1 are presented the most important IR absorption bands obtained from the IR spectra of $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses.

Table 1. *IR bands and there assigned in case of $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses*

Wavenumber [cm^{-1}]	Assignment
~ 450	Bi-O bending vibrations in BiO_6 units
~ 575	Bi-O stretching vibrations in BiO_6 units
~ 630	Te-O vibrations in TeO_3 degenerate units
~ 704	Te-O bonds vibrations from TeO_3 units
~ 780	Te-O-Te symmetric vibration Bi-O stretching vibrations in BiO_3 units

The structural changes observed by varying the Gd_2O_3 content of $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses and evidenced by the IR investigation suggests that the gadolinium ions play a network modifier role in these glasses.

Dependence by the composition of the paramagnetic Curie temperature θ_p, Curie molar constant and effective magnetic moment per gadolinium ion μ_{eff} from $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses it can be see in table 2.

Table 2. *Magnetic susceptibility characteristics for $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses*

x [mol Gd_2O_3]	$-\theta_p$ [K]	C_M [emu/mol]	μ_{eff} [μ_B/atom]
0.01	0	0.1562	7.9
0.05	2	0.7711	7.85
0.10	7	1.5147	7.78
0.15	11	2.2430	7.73
0.20	16	2.9444	7.67
0.25	20	3.6613	7.65

Magnetic susceptibility data show a Curie type magnetic behaviour for low rare earth oxide contents ($x < 0.05$) and a Curie –Weiss type one for higher contents. The magnetic moment values for the free Gd^{3+} ion is $\mu_{eff} = 7.98\mu_B$ [5]. The values of μeff obtained for the Gd^{3+} ions in $[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glasses as well as their evolution with respect to x support the assumption of the presence of weak antiferromagnetic interaction between the Gd^{3+} ions in the samples with $x > 0.05$.

4. Conclusions

Spectroscopic data suggest that the gadolinium ions play a network modifier role in the host glass matrix. Based on the IR spectra obtained for the $xGd_2O_3(1-x)[0.15Bi_2O_3 \cdot 0.85TeO_2]$

glasses, we assumed that the structure of these glasses is built up of BiO_3, BiO_6 and TeO_3 structural units.

The magnetic susceptibility data evidence that for low gadolinium oxide contents, $x<0.05$, the Gd^{3+} ions appear as isolated species randomly distributed in the $[0.15Bi_2O_3 \cdot 0.85TeO_2]$ glass matrix. For higher x values the gadolinium ions are submitted to antiferromagnetic interactions and appear also as coupled species.

Acknowledgements

This work was supported by CEEX – MATNANTECH 47/2006 program.

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