NTA2022

2nd International Conference on
Nanotechnology: Theory and Applications,
Cairo, 19 – 21 Dec., 2022

Ref. 063

Effects of structural disorder and Urbach's rule in borate glasses doped with Erbium oxide

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KEYWORDS
Borate glass, Erbium oxide, optical absorption edge, Urbach's rule

SHORT SUMMARY

A comparative analysis of temperature effect on the optical absorption edge is performed for lead borate glass with chemical composition B_2O_3 +Pb_3O_4 +ZnO, and with deviations from the Urbach behavior by doping with Erbium oxide Er_2O_3. the Urbach behavior of the absorption edge in temperature range is limited was explained according to viewpoint of both components of structural disordering (static and dynamic). It can conclude that the spectral and temperature parameters are strongly dependent on the doping concentration and the temperature rang which reflect on the type of medium-range order in the atomic arrangement in the presence of short-range order in the glassy matrix.

EXTENDED ABSTRACT

In recent years, oxide glasses principally borate glass is vastly used as optical media, radiation-resistant dielectrics, storage materials and electro-optical devices [1]. Boron oxide glass is working as a good glass former due to its ability to make a homogenous formation during the interaction of different oxides ratio through the glass matrix [2]. Heavy metal oxides, such as PbO and ZnO, act as network exchangers to decline the phonon energy of borate glasses [3]. Rare earth (RE) cation at low levels can be successfully inserted into most glass systems [4].

In order to verify the absorption edge in glass material, the modified Urbach rule (MUR) is used [3]. MUR is verified when the slope of spectral characteristics of glasses is unchanged as temperature increases but shifted towards lower energies [2].

In this present work, we aimed to do an analysis of the temperature dependence of the optical absorption (OA) spectra of glass samples with composition (40-x)B_2O_3 +40Pb_3O_4 +20ZnO + xEr_2O3 with different additive ratios of Er_2O_3 (x = 0, 1, 2, 3, 4, 5) measured in a broad temperature range of T = 7–340 K.

Experimental

The conventional method of solid-state is applied to prepare a group of glasses that consist of six different samples. The temperature dependence of the (OA) of all glass samples is determined for a polished parallel plane plates with thickness of 0.7 mm. The (OA) spectra at a broad temperature region (T = 7–340 K) are measured in a setup comprising of the Shimadzu UV-2450 spectrophotometer, a closed-cycle refrigerator system (Janis Model CCS-100/204N) with DT-670-CU temperature sensor and a HiCube 80 Eco-turbomolecular pumping station ensuring a residual pressure of 7 × 10–5 mbar.

Results and discussion

The UV–Vis absorbance spectra of the investigated (BPZE) glass are carried out at different temperature range (7 – 340 K) to detect and describe the alteration of the bandgap structure due to the optical induced electronic transitions. It depicts a variation of the absorption edge energy and Urbach tail for the samples. It is observed that the optical absorption for each sample shifts to a higher wavelength as the temperature increases. Moreover, it is also shifted to a higher wavelength with increasing Er content. By using MUR analysis , the characteristic parameter (Eu-Urbach energy) can be determined which characterizes the degree of disorder in the system.

When the photon energy (hv) depends on the temperature (T), the absorption coefficient can verify the glassy Urbach's rule [4].

$$\alpha(h\nu,T) = \alpha_0 \ * \exp\left[\frac{h\nu - E_0}{E_u(T)}\right] \qquad (1)$$

where (E_U) is the Urbach energy (reciprocal of the absorption edge), α_0 and E_0 are the convergence point coordinates of the Urbach bundle .

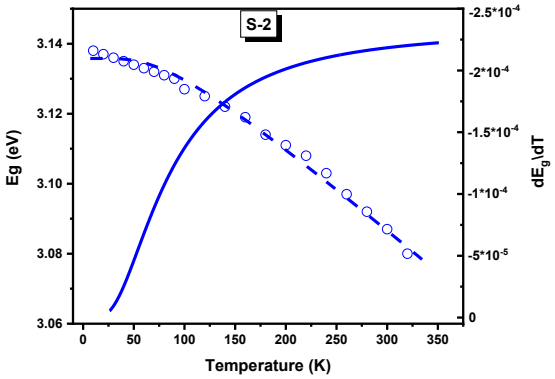

Figure 1 Temperature dependence of the position of Urbach edge for (BPZE) glasses.

Fig. 1 shows that the plot of (dE/dT) which, characterizes variation of temperature coefficient (β) which have values around (2.2 eV/K). All the obtained and approximated parameters were given in Table 1.

Table 1 Parameters of modified Urbach's rule in (BPZE) glasses.

Er Content %	Eu (eV)	β *10-4	T/ (K)	ω (cm-1) Ephonon	A (eV)
0	0.161	2.24	175	123	0.045
1	0.179	1.94	196	156	0.055
2	0.152	1.96	214	173	0.061
3	0.184	2.32	209	90	0.032
4	0.175	2.67	221	286	0.188
5	0.174	2.29	184	177	0.072

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