



# Optical properties of zinc borotellurite glass doped with trivalent dysprosium ion



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## ABSTRACT

The zinc borotellurite doped with dysprosium oxide glass samples with chemical formula  $\{[(\text{TeO}_2)_{0.7}(\text{B}_2\text{O}_3)_{0.3}]_{0.7}(\text{ZnO})_{0.3}\}_{1-x}(\text{Dy}_2\text{O}_3)_x$  (where  $x=0.01, 0.02, 0.03, 0.04$  and  $0.05$  M fraction) were prepared by using conventional melt quenching technique. The structural and optical properties of the proposed glass systems were characterized by using X-ray diffraction (XRD) spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, and UV–VIS spectroscopy. The amorphous nature of the glass systems is confirmed by using XRD technique. The infrared spectra of the glass systems indicate three obvious absorption bands which are assigned to  $\text{BO}_3$  and  $\text{TeO}_4$  vibrational groups. Based on the absorption spectra obtained, the direct and indirect optical band gaps, as well as the Urbach energy were calculated. It is observed that both the direct and indirect optical band gaps increase with the concentration of  $\text{Dy}^{3+}$  ions. On the other hand, the Urbach energy is observed to decrease as the concentration of  $\text{Dy}^{3+}$  ions increases.

## 1. Introduction

Recently, optical properties of the rare earth oxide doped glass systems have been thoroughly studied due to their various applications, e.g. lasers, sensors, telecommunications, display devices, fiber amplifiers and waveguide amplifiers for optical transmission network [1,2]. Among all the glasses, borate and tellurite glasses have been widely used as the host matrix due to their outstanding characteristics which are attractive for specific applications. Borate is one of the most important glass formers which is assimilated into various kinds of glass systems as a flux material with specific physical and chemical properties suitable for technological applications [3]. Borate glasses with desirable properties such as low refractive index, high melting point, large phonon energy ( $\sim 1300 - 1500 \text{ cm}^{-1}$ ), high rare earth solubility, easy preparation on bulky amount and low cost preparation are highly attractive and suitable for noble optical devices [4]. On the other hand, tellurite glasses which also have been considered as promising hosts to develop rare earth composites possess high refractive index ( $> 2$ ), high rare earth solubility, wide transparent range, low loss phonon energy and low melting point [5,6]. Moreover, the addition of ZnO into the borotellurite glass matrix will produce a low rate of crystallization and improve the forming ability of the glass systems [7].

Generally, lanthanide elements are referred to the consecutive

series of elements in the periodic table from lanthanum to lutetium. All the trivalent lanthanide ions have unfilled electron shell structure of  $4f^N$  ( $N=1-14$ ) [8]. In general, the  $4f$  electrons are responsible for optical transitions [9]. Among the trivalent lanthanide ions,  $\text{Dy}^{3+}$  ion is the most suitable for investigating the dependence of its optical behavior and glass compositions [10].  $\text{Dy}^{3+}$  ion is identified as  $f$ -localized trap-creating ion and forms some electron trapping level in the intra-band gap of the host materials [11].

By taking into consideration of the advantages of zinc borotellurite glasses as well as the industrial importance of  $\text{Dy}^{3+}$  ion, the aim of this study is to investigate the effect of doping the  $\text{Dy}^{3+}$  ion into the optical properties of zinc borotellurite glass systems. To the best of authors' knowledge, this is the first report of the optical properties zinc borotellurite glass doped with  $\text{Dy}^{3+}$  ions with varying concentrations of dopant.

## 2. Experimental

In this research, the zinc borotellurite doped with dysprosium oxide glass samples with chemical formula  $\{[(\text{TeO}_2)_{0.7}(\text{B}_2\text{O}_3)_{0.3}]_{0.7}(\text{ZnO})_{0.3}\}_{1-x}(\text{Dy}_2\text{O}_3)_x$  (where  $x = 0.01, 0.02, 0.03, 0.04$  and  $0.05$  molar fraction) were prepared by using conventional melt quenching technique.  $\text{Dy}^{3+}$  ions doped zinc borotellurite glass systems were fabricated from the high purity chemicals of tellurium (IV) oxide,  $\text{TeO}_2$

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