J Mater Sci: Mater Electron (2017) 28:4318–4327
DOI 10.1007/s10854-016-6056-2

# Optical properties of zinc borotellurite glass system doped with erbium and erbium nanoparticles for photonic applications

**M. N. Azlan[1] · M. K. Halimah[1] · R. El-Mallawany[2] · M. F. Faznny[1] · C. Eevon[1]**

Received: 15 July 2016 / Accepted: 8 November 2016 / Published online: 23 November 2016


**Abstract** Comparative analysis on optical properties between two glass series (a—ordinary glass, b—glass with nanoparticles) have been estimated. The two glass series (a—ordinary glass, b—glass with nanoparticles) with compositions $\{[(TeO_2)_{0.70}\ (B_2O_3)_{0.30}]_{0.70}\ (ZnO)_{0.30}\}_{1-y}$ $(Er_2O_3/Er_2O_3$ nanoparticles$)_y$; y = 0.005, 0.01, 0.02, 0.03, 0.04, 0.05 mol% were successfully prepared by using melt-quenching method. The TEM, EDX and XRD have been used to confirm the existence of nanoparticles and all elements in the glass system. The density of b—glass with nanoparticles are found greater than a—ordinary glass. The optical properties of the glass series were characterized by using Ellipsometer and UV–Vis spectrophotometer. There is a linear increasing trend in refractive index of the glass series along with concentration of erbium and erbium nanoparticles oxide. The refractive index of b—glass with nanoparticles is greater than a—ordinary glass. Moreover, the absorption peaks of a—ordinary glass are more intense than b—glass with nanoparticles. The glass with nanoparticles will offer a potential materials for nanophotonic devices.

✉ M. K. Halimah
halimahmk@upm.edu.my

[1] Physics Department, Faculty of Science, University Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia

[2] Department of Physics, Faculty of Science, Menofia University, Menofia, Egypt

## 1 Introduction

Tellurite oxide, $TeO_2$ is the most stable oxide among the heavy metal oxide groups with a melting point of 733 °C. The stability of tellurite oxide had attracted researchers of its potential usefulness for optical and photonic applications. The recent study by Peng et al. [1] stated that tellurite oxide is a prospective candidate applied for a visible-band upconversion fiber laser. Moreover, tellurite oxide is transferrable to the other glass derivatives which allow the addition of multiple compositions in tellurite glass system. Fares et al. [2] stated that tellurite oxide, $TeO_2$ consists of a lone pair of electrons at the equatorial position of $TeO_4$ units. This effect will result in the limitation of structural rearrangement of these units which gives a disadvantage to the glass formation. It is very important to mention that tellurite glasses have an interesting physical properties [3–8].

Borate oxide is known as the best candidate to be used as glass modifier in the tellurite-based glass. The presence of $TeO_2$ in borate glasses reduces the hygroscopic nature and widen the infrared transmittance. Meera et al. [9] found that borate glasses consist of two structural units, which are tetrahedral ($BO_4$) and trigonal boron ($BO_3$). The combination of both units will form diborate, triborate, tetraborate and pentaborate groups. Moreover, Manara et al. [10] proposed that the incorporation of borate oxide and tellurite oxide in borotellurite glasses leads to the formation of mixed structural units as in borosilicate glass system. Tellurite glasses with a low concentration of borate oxide consist of $TeO_4$, $BO_4$, and $BO_3$ groups. These properties lead to a very stable of tellurite glass formation and enhance their optical and electrical properties.

Zinc oxide, ZnO has been widely used to improve the mechanical strength, chemical durability and lowering