Results in Physics 14 (2019) 102457

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

Structural, optical and thermal properties of Er^{3+}-Ag codoped bio-silicate borotellurite glass

A.M. Hamza[a,b], M.K. Halimah[a,*], F.D. Muhammad[a], K.T. Chan[a], A. Usman[a,c], M.F. Faznny[a], I. Zaitizila[a], R.A. Tafida[a,d]

[a] Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 Upm Serdang, Selangor, Malaysia
[b] National Agency for Science and Engineering Infrastructure, Idu, Abuja, Nigeria
[c] Kano State University of Science and Technology Wudil, Kano, Nigeria
[d] Nigerian Defence Academy, Kaduna, Nigeria

ARTICLE INFO

Keywords:
Bio-silicate
Judd-Ofelt
Optical gain
McCumber
Emission cross section
Figure of merit

ABSTRACT

In this paper, thermal, structural and spectroscopic properties of Er^{3+}-Ag^{+} codoped bio-silicate borotellurite $[\{[(TeO_2)_{0.8}\ (B_2O_3)_{0.2}]_{0.8}\ (SiO_2)_{0.2}\}_{0.99}\ (Ag_2O)_{0.01}]_{1\text{-}y}\ (Er_2O_3)_y$ where y = 0.05 glass are studied. The thermal and structural studies have been conducted using differential scanning calorimetry (DSC) and X-ray diffraction (XRD) respectively so as to confirm the nature of the glass sample. The Fourier transform infrared (FTIR) has revealed the basic structural units of the glass system. Ultra violet visible (UV–Vis) spectrometer was used to measure the absorption spectrum and was analysed using Judd-Ofelt (J-O) and McCumber theory. Other important parameters such as radiative lifetime, branching ratio and transition probability are also determined from the analysis. The peak emission cross section discovered from McCumber theory is $4.9 \times 10^{-21}\ cm^2$. This value is larger than that of phosphate, silicate and tellurite glasses. The gain band width and figure of merit are used to evaluate the application of the glass in optical amplification and solid state laser.

Introduction

Recently, Er^{3+} has been identified as one of the important rare earth (RE) ions to be studied in infrared lasers and optical communication [1,2]. The introduction of silver oxide into the bio-silicate borotellurite glass will influence its optical and structural properties [3].

Tellurite glasses doped with rare earth ions are promising in various applications such as non-linear optics, sensors, lasers, solar cells and optical fibers. This is as a results of their low melting point, high refractive index, high thermal stability and low phonon energy [4,5]. Furthermore, the tellurite glasses were been well-known for their efficiency and best laser host material for fixing Er^{3+} ions [6]. The addition of tellurite oxide in borate glass system will reduce the high hygroscopic property of the glass system. Therefore, the borotellurite glass system would be a good choice host glass for optical and laser applications [7].

One of the advantages of the silicate glass doped with Er^{3+} is that it can be simply prepared. Despite its large phonon energy of approximately $1100\ cm^{-1}$, narrow emission bandwidth, high thermal stability and also wide range of glass forming region; silicate-based glass is comprehensively studied. However, the addition of borate (B_2O_3) will lower the phonon energy in the glass system which is capable of improving the radiative transition rate [2].

Usually, erbium silicates give rise to high density of Er^{3+} ions that is normally 100 times higher than that of other materials doped with Er^{3+} [8]. Among rare-earth ions, the Er^{3+} ion is of special interest, because its emission at 1.5 mm ($^4I_{13/2}$-$^4I_{15/2}$ transitions in the internal 4f-shell) corresponds to minimal loses of silica fibre-based optical communication systems [37]. Moreover, silicates glasses are one of the most important hosts materials that have been extensively used for fiber amplifiers and lasers [9]. Conventional rare earth doped silicates glasses were used for some of optical application in respect to their excellent thermal and optical properties with a very strong chemical resistance [10,11]. Many researches have been going on worldwide to produce a new erbium doped silicate material for solid state lasers with enhanced performances. The existence of Ag^{+} in the present glass is mainly in the forms of isolated Ag^{+} ions.

This research contributes towards a good knowledge between the thermal and structural, and also provides a better understanding of the spectroscopic properties of bio-silicate borotellurite glass. Lastly, a modified bio-silicate glass codoped with about 0.05 and 0.01 M fraction of Er_2O_3 and Ag_2O respectively was fabricated. A brief study of thermal

* Corresponding author.
E-mail address: halimahmk@upm.edu.my (M.K. Halimah).

https://doi.org/10.1016/j.rinp.2019.102457
Received 19 March 2019; Received in revised form 17 June 2019; Accepted 17 June 2019
Available online 21 June 2019