Optik 160 (2018) 340–347

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Luminescence emission of Tm-Dy ions codoped tellurite glasses under visible light excitation

H. Algarni[a,b], M. Reben[c], Sharefah Almoeed[d], Ramzi Maâlej[e], El Sayed Yousef[a,b,*]

[a] Research Center for Advanced Materials Science (RCAMS), King Khalid University, Abha 61413, P. O. Box 9004, Saudi Arabia
[b] Physics Dept., Faculty of Science, King Khalid University, P. O. Box 9004, Abha, Saudi Arabia
[c] Faculty of Materials Science and Ceramics, AGH – University of Science and Technology, al. Mickiewicza 30, 30-059 Cracow, Poland
[d] Physics Dept., Faculty of College of Arts & Sciences, King Khalid University, Muhail Asir, Saudi Arabia
[e] Laboratoire Géoressources, Matériaux, Environnement et Changements Globaux, Faculty of Sciences of Sfax, University of Sfax, 3018 Sfax, Tunisia

ARTICLE INFO

Article history:
Received 16 January 2018
Received in revised form 30 January 2018
Accepted 1 February 2018

Keywords:
Oxide glasses
Rare earth
Spectroscopic properties
Absorption
Emission cross section
Internal gain
CIE

ABSTRACT

Tellurite glass with composition $90TeO_2$-$10Nb_2O_5$-10ZnO in mol% codoped with $x(Tm_2O_3/Dy_2O_3)$, where x = 10,000, 20,000 and 30,000 ppm were prepared by quenching melting technique. The optical density and photoluminescence properties of this glass were studied. Spectroscopic parameters such as the absorption cross section, $\sigma_{ab}(\lambda)$, emission cross section, $\sigma_{em}(\lambda)$, effective band width, $(\Delta\lambda)$, internal gain coefficient, $g_R(\lambda)$, and the chromaticity coordinates CIE of the emitted light for this glass were computed. The, (σ_{em}), $(\Delta\lambda)$, and $\sigma_g(\lambda)$ parameters increase from 5.95×10^{-21} to 8.86×10^{-21} cm^2, from 123 to 127 nm and from 4.2 to 6.3 dB/cm, respectively when increasing Tm^{3+}/Dy^{3+} ions from 10,000 to 30,000 ppm in the host glass matrix. Compared the luminescence intensity and spectroscopic parameters in these glasses are greatly enhanced. From CIE results indicate that the emission color varied from blue to white can be achieved by tuning Tm^{3+}/Dy^{3+} ratio under excitation at 466 nm. The present glasses are found to be a suitable candidate for solid state laser material.

1. Introduction

From our knowledge, a few researchers studied and concerned on the tellurite glass used as the white light emitting diode (W-LEDs). Knowing that tellurite glasses are important materials used in active optical device application because of their high thermal stability, corrosion resistance, low melting temperature, high refractive index and high light transmission. In addition, TeO_2 based glass are considered as promising materials for hosting lasing rare earth ions because they possess very low phonon energies which are advantageous in order to minimize nonradiative losses [1,2].

Recently, much attention has been paid especially on glasses, which emit multi- colors/white light to replace the phosphors in light emitting diodes (W-LEDs). Nowadays, W-LEDs are considered as potential candidates for lighting source due to their long lifetime, high efficiency and eco-friendly compared with fluorescence lamps [3–6].

* Corresponding author at: Research Center for Advanced Materials Science (RCAMS), King Khalid University, Abha 61413, P. O. Box 9004, Saudi Arabia.
E-mail address: omn_yousef2000@yahoo.come (E.S. Yousef).

https://doi.org/10.1016/j.ijleo.2018.02.001
0030-4026/

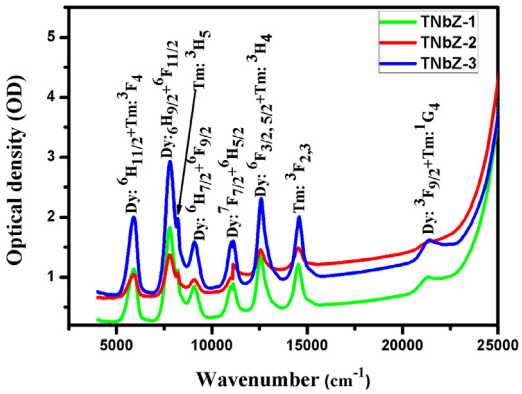

Fig. 1. Optical density of present glasses (TNbZ-1), (TNbZ-2) and (TNbZ-3).

Dy^{3+} is one of the important rare-earth ions which play a major role in the production of different types of light-emitting materials [7–14]. It is known that the luminescence spectrum of Dy^{3+} consists of two intense emission bands firstly; blue at (486 nm) which corresponding transition $^4F_{9/2} \rightarrow {}^6H_{15/2}$ and secondly yellow at (576 nm corresponding to the $^4F_{9/2} \rightarrow {}^6H_{13/2}$transitions. Knowing that the $^3H_4(Tm^{3+})$ level can absorb efficiently the 800 nm pump light, it is sensitized by Dy^{3+} ions through nonradiative resonance energy transfer [15]. This is can possibly occur because of two energy level matching as follow; Tm^{3+}: $^3H_4/Dy^{3+}$:$^6F_{5/2}$ and Tm^{3+}:$^3F_4/Dy^{3+}$:$^6H_{11/2}$ level. At a suitable environment host glasses with doped Tm^{3+}/Dy^{3+} the intensity ratio of these yellow to blue transition will generate white light.

In addition, many authors [16–18] reported that tellurite glasses within composition TeO_2-Nb_2O_5, TeO_2-ZnO and TeO_2-Nb_2O_5-ZnO have excellent optical and functional properties with low optical loss and high thermal stability compared with other glasses systems. Here in order to enhance the luminescence the hosts with lower phonon energy are usually chosen. The present glasses have high thermal stability, ΔT, in the range from 186 to 212 °C this results tabulated in Ref. [1] by our research group [1], comparing with other glasses system such as ZBLAN glass ($\Delta T = 67$ °C), germanate glass ($\Delta T = 129$ °C) and other system tellurite glass ($\Delta T = 123$ °C) [2–5], this means that strong resist thermal damage with respect to excited laser powers.

Therefore, in the present work, we choose the glasses composition TeO_2- Nb_2O_5- ZnO as a host material for codoped Dy^{3+}/Tm^{3+} because of its low phonon energy in order to enhanced novel light emitting laser diode, high gain emission cross section and high effective band width. From the emission spectra in the visible range, the CIE chromaticity coordinates (x,y) were calculated and the utility of the present glass for white light emission is discussed.

2. Experimental work

The glasses within composition $80TeO_2$-$10Nb_2O_5$-10ZnO- 10,000 ppm Tm_2O_3/Dy_2O_3 (TNbZ-1), $80TeO_2$-$10Nb_2O_5$-10ZnO- 20,000 ppm Tm_2O_3/Dy_2O_3 (TNbZ-2) and $80TeO_2$ -$10Nb_2O_5$- 10ZnO- 30,000 ppm Tm_2O_3/Dy_2O_3 (TNbZ-3) in mol% were prepared and reported in Ref. [1]. These glasses are melted under a special melting program, controlled atmosphere to ensure high-purity and low water content. The density of these glasses determined by using gas pycnometer (Model: UltraPyc 1200e) with accuracy +0.0001 g cm^3.

The absorbance spectra were measured by using (UV (ultraviolet)–visible (Vis)- NIR (near infrared)), by using JASCO V-570 at wavelengths from 200 to 2500 nm. The emission spectra were measured with an FLS980 type spectrometer pumped by the laser diode (LD). Resolution of emission spectra has peaks with line widths less than 5 nm. All the measurements were performed at room temperature.

3. Results and discussion

Fig. 1 shows the UV–vis-NIR absorption spectra of TNbZ-1, TNbZ-2 and TNbZ-3. From this figure the absorption bands appeared at 5882, 7752, 9009, 11,136, 12,500 and 14,925 cm^{-1}, which correspond to the transitions from the ground state $^6H_{15/2}$ to excited states $^6H_{11/2}$, $^6H_{9/2} + {}^6F_{11/2}$, $^6H_{7/2} + {}^6F_{9/2}$, $^6F_{7/2}$, $^6F_{5/2}$ and $^6F_{3/2}$, respectively were attributed to the Dy^{3+} ions. Also, the absorption bands appeared at 5882, 8180, 12,500, 14,493 and 21,186 cm^{-1}, which correspond to the transition from the ground state $^3H_6$ of Tm^{3+} ions to the excited states $^3F_4$, $^3H_5$, $^3H_4$, $^3F_3$ and $^1G_4$ were confirmed. The absorption cross-sections, $\sigma_{abs}(\lambda)$, for transition $^3F_4 \rightarrow {}^3H_6$ of Tm^{3+} ions and combine with the transition of $^4F_{9/2} \rightarrow {}^6H_{11/2}$ of Dy^{3+} ions can be calculated by relation as follow [20]:

$$\sigma_{abs}(\lambda) = \frac{2.303 \log\left[\frac{I_{0(\lambda)}}{I(\lambda)}\right]}{Nd} \quad (1)$$