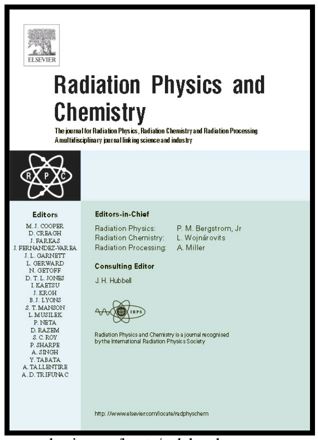
Author’s Accepted Manuscript



www.elsevier.com/locate/radphyschem

Scintillation properties of phosphate-borate-fluoride glass doped with Tb^{3+}/Pr^{3+}

D. Valiev, S. Stepanov, E. Polisadova, G. Yao

PII: S0969-806X(17)31264-1
DOI: https://doi.org/10.1016/j.radphyschem.2018.02.007
Reference: RPC7766

To appear in: *Radiation Physics and Chemistry*

Received date: 11 December 2017
Revised date: 3 February 2018
Accepted date: 8 February 2018

Cite this article as: D. Valiev, S. Stepanov, E. Polisadova and G. Yao, Scintillation properties of phosphate-borate-fluoride glass doped with Tb^{3+}/Pr^{3+}, *Radiation Physics and Chemistry,* https://doi.org/10.1016/j.radphyschem.2018.02.007

Scintillation properties of phosphate-borate-fluoride glass doped with Tb^{3+}/Pr^{3+}

D. Valiev[a*], S. Stepanov[a], E. Polisadova[a] and G. Yao[b]

[a]National Research Tomsk Polytechnic University, 30 Lenin Avenue, 634050, Tomsk, Russia

[b]School of Materials Science and Engineering, Changchun University of Science and technology, Changchun 130022, China

[*]Corresponding author at: National Research Tomsk Polytechnic University, Tomsk, Russia. dtdamirka@gmail.com

Abstract

Scintillation glass doped with Tb^{3+} and Pr^{3+} ions with different concentrations were prepared by the melt-quenching method. Optical, photoluminescence and decay kinetic characteristics of the pulse cathodoluminescence (PCL) were investigated. It was shown that the absorption coefficient of the induced absorption in the visible range of the spectrum decreases significantly with the increase of the Pr_2O_3 content starting from 0.2 to 1 wt%. There was the difference in the luminescence spectra of the glass at a selective and non-selective type of excitation. The "green" emission (λ_{em}=542 nm, $^5D_4 \rightarrow {}^7F_5$ radiative transition of Tb^{3+} ions) was excited an electron beam. The "red" emission (λ_{em}=600 nm, $^3P_0 \rightarrow {}^3H_6$ radiative transition of Pr^{3+} ion) was observed under selective excitation action (λ_{exc}=450 nm). It was demonstrated that decreasing of intensity the main bands of Tb^{3+} ions at 487, 544, 622 nm connected with increases of concentration Pr^{3+} ions. The luminescence decay time of terbium ions at 487, 544, 622 nm emission bands depend on Pr^{3+} concentration. The tendency of reducing the luminescence decay time in the main luminescence bands of Tb^{3+} ions at increasing the Pr^{3+} concentration was presented. The results showed that Tb^{3+}/ Pr^{3+} co-doped phosphate-borate-fluoride glasses are promising non-crystalline scintillation materials.

Keywords

cathodoluminescence, scintillation glass, rare earth ions, luminescence decay kinetics, color centers

1. Introduction

The glasses doped with rare-earth ions (REI) are widely used as active media in optoelectronics [1]; as scintillation materials for imaging radiation fluxes [2-6]; UV-Vis radiation converters [7-9], as dosimeters in radiotherapy [10]. The simplicity of synthesis the glassy materials, the ability to manufacture optical elements of any shape and size, relatively low cost, possibility to incorporate impurities, a variation of the host composition, and high optical homogeneity makes them an alternative to single crystals.

Glass-based on phosphate/borate host can be used as a luminescent material. Phosphate glass has good physical properties such as low melting point, high transparency in UV spectral region, good thermo-optic properties and low refractive index [11-15]. Borate glass is mechanical, thermally and chemically stable [16, 17]. Borophosphate glass is a good candidate for photonic materials due to its physical and optical properties such as high REI solubility and high transparency in the UV region [18, 19].

The choice of the dopants connected with several factors: 1) a high light yield; 2) spectral matching between the scintillator emission spectrum and photodetector; 3) the possibility of sensitization of luminescence by co-doped pairs of REI [20]. Tb^{3+} doped phosphate glass can emit strong "green" (480–570 nm) luminescence originated from $^5D_4 \rightarrow {}^7F_j$ (j=3, 4, 5, 6) transition of Tb^{3+} ions [21], which matches with the sensitivity wavelength (500–750 nm) of CCD detectors. Pr^{3+} ions have strong absorption bands in the visible region at the expense of the rich energy structure emitting in the visible and infrared spectral region [22]. Crystals and glass materials doped with Pr^{3+} and Tb^{3+} ions under certain conditions give the "white" emission, which allows to use it as transmitters of radiation "blue" and the UV-LED chip [23].