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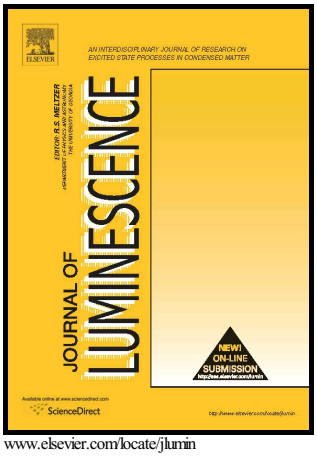

www.elsevier.com/locate/jlumin

PII: S0022-2313(18)30305-3
DOI: https://doi.org/10.1016/j.jlumin.2018.09.032
Reference: LUMIN15915

To appear in: *Journal of Luminescence*

Received date: 14 February 2018
Revised date: 22 August 2018
Accepted date: 14 September 2018

Cite this article as: Irina Sevastianova, Vladimir Aseev, Iuliia Tuzova, Yuriy Fedorov and Nikolay Nikonorov, Spectral and luminescence properties of manganese ions in vitreous lead metaphosphate, *Journal of Luminescence,* https://doi.org/10.1016/j.jlumin.2018.09.032

Spectral and luminescence properties of manganese ions in vitreous lead metaphosphate

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Abstract

Optical materials doped with manganese ions have attracted interest as a red phosphor for warm white light LEDs. Lead-phosphate glasses are chosen for doping with manganese ions due to high refractive index of such material. In this study, new 50 PbO – 50 P_2O_5 – xMnO_2 (x=0.1, 1, 3, 5, 7, 10, 13 mol %) glasses are synthesized. To determine the optimal manganese ion concentration (to be used as the red phosphor) in those glasses, their spectral and luminescent properties are investigated. Mn^{2+} ions in lead-phosphate glasses have intense red luminescence in the wavelength range 620 to 690 nm. The Mn^{3+} ion to the total Mn ions ratio is found less than 0.1 % based on the visible absorption spectroscopy data. Manganese ions in that glass are disposed at non-equivalent positions that results in nonexponential lifetime decay. The maximum absolute quantum yield value of Mn^{2+} ions is 49% in glass with 2.91 mol % MnO_2.

Keywords: red phosphor, manganese, lead phosphate glasses, luminescence

1. Introduction

A combination of 2 phosphors is usually used to obtain warm white light in converted LEDs. The first phosphor is usually a YAG:Ce powder that gives yellow-green light and the second one is a different type of red phosphor. The media activated by Mn^{2+} ions is one of the promising materials for red phosphor [1–5]. In addition, to improve the LED efficiency, it is possible to substitute organic silicone, which is used to fix the phosphor powder on the GaN crystal, with inorganic glasses. A such composite which consists of the crystal YAG:Ce powder distributed in the glass is usually referred to as phosphor-in-glass [6, 7]. Low scattering is one of the main requirements for such composites. To fulfill this requirement, the refractive index close to the YAG one (1.83) glasses is used. The easiest way to obtain the refractive index close to the YAG - 1,83 is to add lead in the glass matrix [8, 9]. The glass doped with manganese ions allows to obtain additional luminescence bands in the red spectral region that shifts LED emission from cool white to warm light [10]. Spectral-luminescent properties of manganese ions in various glass types are described in [11–14]. The highest manganese oxide concentration is obtained in phosphate glass (up to 25 mol %) [15–19, 21]. However, glasses doped with manganese ions with the refractive index higher than 1.7 have not been investigated. Thus, the aim of the research is to determine the optimal MnO_2 concentration in lead-phosphate glasses designed to be used as a phosphor.