PHOTOLUMINESCENCE OF PARTIALLY REDUCED Eu^{2+}/Eu^{3+} ACTIVE CENTERS IN $NaF–Al_2O_3–P_2O_5$ GLASSY MATRIX

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Over the past years, the unprecedented progress in technology has shaken many industries including lighting industry. Energy-inefficient conventional lamps has been rapidly replaced by the energy efficient and prolonged lifetime LEDs. However, spectra of most of today's commercial white LEDs substantially deviate from natural light. In particular, they have a strong blue component, which is unhealthy for human vision and can even lead to serious irreversible health damages [1]. These shortcomings leave a room for considerable improvements and development of new phosphor materials with photoluminescence resembling natural light.

The most common materials used as phosphors are based on matrices doped with different rare-earth elements (REE) and, especially, lanthanides ions which have remarkable optical properties. They are characterized by [Xe] core, partially filled 4*f* shell and outer shells that screen 4*f* shell from the external field. Such an electronic structure leads, in most cases, to optical spectra of those elements consisting of sharp lines characteristic for transitions within the 4*f* shell, which basically are forbidden [2]. One should, however, be aware that the actual emission spectrum of a given REE center can also depend on a matrix composition.

Recently, the research carried out by our group [3] has proven that it is possible to synthesize REE-doped glassy materials whose photoluminescence is much more continuous, smoother and better resembling white light in visual impression. What is more, it has been shown that the synthesis conditions have a strong effect on photoluminescence spectrum. Additionally, one can control the relative Eu^{3+} and Eu^{2+} ions concentration and therefore manipulate photoluminescence spectrum.

In this research, $Na_3Al_2(PO_4)_2F_3$ glassy matrix doped with 1 wt% of Eu_2O_3 was successfully synthesized by a melt-quenching process and additional use of a double crucible method [4] in order to provide reducing atmosphere during melting. Three obtained samples with different synthesis parameters (see Fig. 1) were carefully investigated using X-ray diffractometry (XRD), differential thermal analysis (DTA), photoluminescence spectroscopy (PL), X-ray photoemission spectroscopy (XPS), absorption spectroscopy and time-resolved photoluminescence.

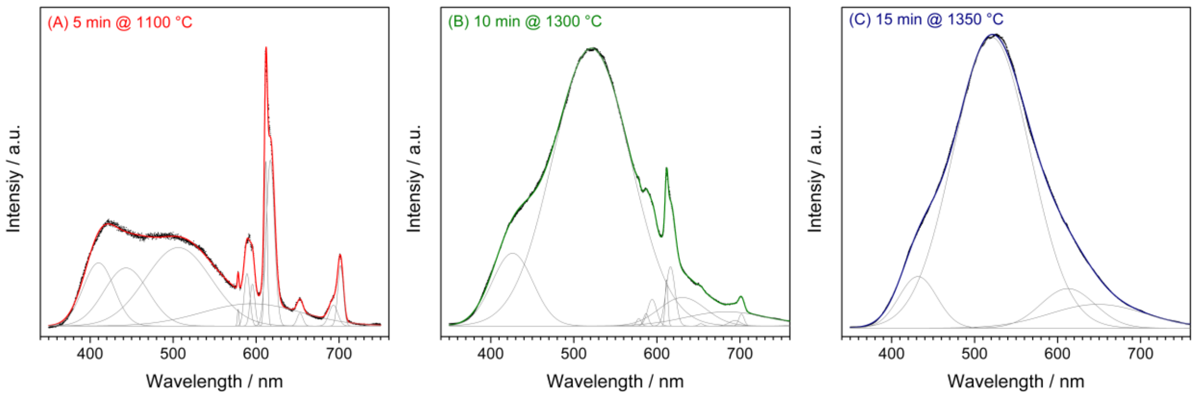

Fig. 1. Room temperature photoluminescence spectra for 3 glassy samples $Na_3Al_2(PO_4)_2F_3$ doped with Eu_2O_3 excited with 325 nm laser. Different synthesis parameters (time and temperature) are given in the plots [3].

[1] E. Chamorro, C. Bonnin-Arias, M.J. Pérez-Carrasco, J. Muñoz de Luna, D. Vázquez, C. Sánchez-Ramos: *Effects of Light-emitting Diode Radiations on Human Retinal Pigment Epithelial Cells In Vitro.* Photochemistry and Photobiology, 89 (2013) 468–473.

[2] B. M. Walsh: *Advances in Spectroscopy for Lasers and Sensing. Judd-ofelt theory: principles and practices.* [red.] Baldassare Di Bartolo, Ottavio Forte. Erice Italy, Springer, 2005.

[3] T.K. Pietrzak, A. Gołębiewska, J. Płachta, M. Jarczewski, J. Ryl, M. Wasiucionek, J.E. Garbarczyk: *Photoluminescence of partially reduced Eu^{2+}/Eu^{3+} active centers in a $NaF–Al_2O_3–P_2O_5$ glassy matrix with tunable smooth spectra.* Journal of Luminescence 208 (2019) 322–326.

[4] K. Hirose, T. Honma, Y. Benino, T. Komatsu: *Glass-ceramics with $LiFePO_4$ crystals and crystal line patterning in glass by YAG laser irradiation,* Solid State Ionics, 178 (2007) 801–807.