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Color tunability and white light generation through up-conversion energy transfer in Yb^{3+} sensitized Ho^{3+}/Tm^{3+} doped tellurite glasses

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ABSTRACT

In this study, tellurite glasses in the (50-*x*)TeO_2-25WO_3-25Li_2O-*x*RE (RE: Ho^{3+}, Tm^{3+}, Yb^{3+}) system were synthesized to investigate white light generation through up-conversion energy transfer. Thermal properties of glasses were studied, and optical absorption spectra were collected. Energy transfer mechanisms between RE ions and effect of RE concentrations on up-conversion emission and color tunability were investigated through photoluminescence analysis under 980 nm excitation. Additionally, effect of excitation power on up-conversion emission intensities were investigated. Colorimetric properties such as CIE color coordinates, correlated color temperature, color rendering index and color purity were calculated. The obtained colorimetric results under 2 watt pump power were comparable or better than other reported glass systems. H005T025Y2 sample was found to show the closest color coordinates (x = 0.32 and y = 0.33) to pure white light and suitable colorimetric properties indicating that studied glasses have high potentiality to be used as luminescent materials for white light generation.

1. Introduction

In post-modern era, people tend to spend most of their time indoors. Therefore, artificial lighting plays an important role in human life due to its vital effects such as circadian phase shift, melatonin suppression [1]. It is possible to overcome these problems by the incorporation of smart lighting that can imitate the variations of daylight. Therefore, tunable luminescent materials that simulates all phases of daylight from 3500 K to 6500 K is the key point [2]. At this point, development of smart lighting systems highly depends on the advancement of so-called state-of-the-art white light emitting diode (WLED) technology.

The groundbreaking WLED technology is currently based on a combination of blue led chip with red, green and yellow phosphors so called the phosphor converted LEDs (PC-LEDs). However, radiant efficiency of PC-LEDs cannot exceed 30% due to the phosphor conversion and epoxy resin encapsulation, low performance values of blue LED [3]. For this reason, studies have been concentrated on development of phosphor and epoxy free WLEDs. Therefore, lanthanide-doped glasses have taken center stage as alternative luminescent materials for WLEDs instead of phosphor and epoxy combination due to their favorable properties such as better heat resistance and transparency, simple manufacture technique, [4–6].

Lanthanides are exceptional luminescent materials due to their shielded vast number of 4f-4f and 5d-4f emission transitions. Thus, they offer promising properties for SSL applications particularly for white [7,8]. Among lanthanide ions, Dy^{3+} ion is renowned for white light generation due to its intense emission bands at blue and yellow regions upon UV excitation. Nonetheless, low absorption cross-section and parity forbidden f-f transitions of Dy^{3+} ion causes poor [9]. Additionally, inhomogeneous spectral power distribution is obtained due to weak red emission and hypersensitive yellow emission that suppress other colors which ultimately results color coordinates close to yellow region of the International Commission on Illumination (CIE) chromaticity diagram.

Apart from Dy^{3+} ion, lanthanide ions such as Pr^{3+}, Er^{3+}, Ho^{3+} and Tm^{3+} have been commonly used to generate white light emission through combination of three primary colors (red, green and blue) [10–13]. However, to achieve pure white light, relative intensities of red, green and blue colors should be tuned precisely by controlling lanthanide ions concentration. Yb^{3+} ion with its large infrared zone absorption cross-section and high radiation capability is widely used as sensitizer in up-conversion processes. Due to relatively high absorption cross-section corresponding to $^2F_{7/2} \rightarrow {}^2F_{5/2}$ transition, Yb^{3+} ions effi-

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