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Preparation, structure, luminescence propertiesof europium doped zinc spinel structure green-emitting phosphor $ZnAl_2O_4:Eu^{2+}$

Can He, Haipeng Ji, Zhaohui Huang*, Xiaoguang Zhang, Yang′ai Liu, Minghao Fang, Xiaowen Wu, Xin Min*

Beijing Key Laboratory of Materials Utilization of Nonmetallic Minerals and Solid Wastes, National Laboratory of Mineral Materials, School of Materials Science and Technology, China University of Geosciences, Beijing 100083, China

**Corresponding author Tel: +86-10-82322186, Fax: +86-10-82322186*

E-mail:huang118@cugb.edu.cn (Zhaohui huang), *minxin4686@126.com* (Xin Min)

Abstract: The $Zn_{1-x}Al_2O_4:xEu^{2+}$ phosphor powders were synthesized by the solid-state reaction method. The synthesis temperature for $ZnAl_2O_4$ was optimized, whereas the phase structure, TEM images, photoluminescence (PL) properties, the concentration quenching mechanism, the fluorescence decay curves, as well as the CIE chromaticity coordinates of the samples were investigated in details. Under the excitation at 379 nm, the phosphor exhibits an asymmetric broad-band green emission with a peak at 532 nm, which is ascribed to the 5d–4f transition of Eu^{2+}. When the doping concentration of Eu^{2+} ions is 0.01, the luminescence intensity of the sample reaches the maximum value. It is further proved that the exchange interaction results in the concentration quenching of Eu^{2+} in the $Zn_{1-x}Al_2O_4:xEu^{2+}$ phosphor powders. The thermal quenching property of $ZnAl_2O_4:Eu^{2+}$ phosphor was investigated and the quantum efficiency (QE) values of the selected $Zn_{0.99}Al_2O_4:0.01Eu^{2+}$ phosphor was measured and determined as 54.85%. The lifetime of the optimized sample $Zn_{0.99}Al_2O_4:0.01Eu^{2+}$ is 3.0852 μs and the CIE coordinate of the sample was calculated as (0.3323, 0.5538) with high-color-purity green emission. All properties indicate that the green-emitting $ZnAl_2O_4:Eu^{2+}$ phosphor powder has potential application in white LEDs.

Keywords: Zinc spinel; Europium; Luminescence properties; Green-emitting; Rare earths

1. Introduction

In recent years, the white light-emitting diodes (WLEDs), due to the corresponding high efficiency, low power consumption and long life properties, as well as the pollution-free and other excellent capabilities, have become a substitute for incandescent and fluorescent lamps, as a candidate for new generation of solid-state lighting[1]. At present, three main types of white LEDs exist: the light conversion type, the multi-color combination andthe multi-quantum dot type. The light conversion type of white LEDs is also called the phosphor-converted white light-emitting diode (pc-WLEDs)[2]. It functions through other luminescent materials excitation by the LED, which are mixed to form white light. The commercial pc-WLEDs applied nowadays are obtained through two methods. One method is using the blue LED to excite the yellow phosphor LED, consequently producing white light[3]. Commercially, the commonly utilized is GaN the blue LED and the $Y_3Al_5O_{12}:Ce^{3+}$ (YAG:Ce), the yellow phosphor LED[4]. Another way is using the violet or ultraviolet light LED to stimulate all red, green and blue types of phosphor to produce white light[5].In contrast, compared to the pc-WLEDs obtained through the second method, the pc-WLEDs obtained through the first method have the disadvantages of poor color reproduction, low color rendering index and high color temperature, due to the absence of red light component[6]. The multi-color combination type combines the arrangement of red, green and blue colors (or additional colors) in a certain way to form a white LED template[7]. This method has high efficiency and good color rendering, and it can also dynamically adjust the color temperature. By contrast, the tri-color LED forward voltage and light output differ. In addition, the corresponding temperature and light-keeping characteristics are not the same. The system must have

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