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Synthesis and photoluminescence properties of Er^{3+} and Dy^{3+} doped Na_2NbAlO_5 phosphors

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Abstract: A series of Ln^{3+} (Ln^{3+} = Er^{3+}/Dy^{3+}) ions doped Na_2NbAlO_5 (NNAO) phosphors were synthesized by solid-state method. The Er^{3+} and Dy^{3+} ions doped phosphors were characterized by XRD, photoluminescence (PL) and decay profiles. The Ln^{3+}-doped samples are consistent with the pure NNAO phase which is analyzed by the X-ray diffraction result. The PL graphs show that the intensity of luminescence increases with the increasing doping concentrations up to their critical certain values and then decreases at higher concentrations due to the concentration quenching effect of Er^{3+}/Dy^{3+} ions. The energy level diagrams containing the positions of 4f and 5d energy levels of Er^{3+} and Dy^{3+} ions have been established and studied. In addition, under the ultraviolet light, the prepared NNAO: $x$$Ln^{3+}$ (Ln^{3+} = Er^{3+}/Dy^{3+}) phosphors show the characteristic green (Er^{3+}), cyan (Dy^{3+}) emission, respectively. Under the excitation of 365 nm, the quantum efficiencies of NNAO:0.01Er^{3+} and NNAO:0.03Dy^{3+} phosphors are measured to be 61.7% and 72.2%, respectively. The obtained results indicate that the new NNAO: $x$$Ln^{3+}$ (Ln^{3+} = Er^{3+}/Dy^{3+}) phosphors are promising applications in white -light emitting diodes field.

Keywords: Photoluminescence; Na_2NbAlO_5; Energy transfer; White LEDs; Rare earths

1. Introduction

During the last few decades, the luminescent materials for diverse applications in modern technologies have been retrieved actively[1]. There into, lanthanides compounds can be used in lasers, light emitting diodes, displays devices, biomedical labels, etc [2–5]. Among them, white-light emitting diodes (w-LEDs) have been regarded as the new generation of illumination source for their superior merits, such as energy saving, long lasting, compactness and environment friendliness [6,7]. The first commercial w-LED was developed in 1997 after the blue-emitting GaN LED had been fabricated by Nakamura et al. (in 1993)[8]. After that, w-LED has been raising more and more attention. The white light can be produced by combining blue InGaN with a broadband yellow-emitting phosphor, and can also be obtained by the group of ultraviolet (UV) LED with blue, green and red phosphors. Currently, the dominate way to fabricate white light is combining the InGaN blue ships with $Y_3Al_5O_{12}$:Ce^{3+} yellow phosphor, meanwhile, with the disadvantages of low color-rendering index and high color temperature due to lack of red emission[9]. Therefore, more attention has been paid to discovery of the original phosphor materials for new applications.

Since the 4f electrons of lanthanide ions are shielded by the outer 5s and 5d electrons, the energy levels of low energy states are less affected by outfield and basically stable. The intra 4f emission spectra of lanthanide ions are characterized by narrow lines with high color purity[10]. Therefore, lanthanide ions have been widely used in w-LEDs.

Niobates have attracted much attention in several materials owing to their commendable electro-optical, photo-elastic, piezo-electric, and nonlinear properties together with chemical stability

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