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Authors: Renping Cao, Jijun Huang, Xiangfeng Ceng, Zuofu Hu, Ting Chen, Wen Hu, Xinqin Zhang



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Synthesis and emission properties of $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor and the emission improvement by Li^+ ion

Renping Cao*, Jijun Huang, Xiangfeng Ceng, Zuofu Hu, Ting Chen, Wen Hu, Xinqin Zhang
College of Mathematics and Physics, Jinggangshan University, Ji'an 343009, China

*corresponding author: E-mail: jxcrp@163.com; Tel/fax: +86 796 8124959

Abstract: $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor is synthesized by solid-state reaction method in air. Host $\text{Ca}_3\text{Nb}_2\text{O}_8$ emits blue light with excitation 260 and 314 nm, and its emission band peaking at ~ 460 nm is attributed to the ${}^3\text{T}_{1,2} \rightarrow {}^1\text{A}_1$ transitions in $[\text{Nb}_2\text{O}_8^{6-}]$ group. $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor with excitation 314 nm shows a systematically tunable emission by adjusting Sm^{3+} ion concentration, and only emits reddish-orange light with excitation 407 nm. Excitation band indicates that $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor may be effectively excited by (~ 407 nm) near ultraviolet light-emitting diode chip. The optimal Sm^{3+} ion concentration is ~ 5 mol% in $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor. Emission intensity of $\text{Ca}_3\text{Nb}_2\text{O}_8:\text{Sm}^{3+}$ phosphor may be increased ~ 1.4 times by co-doping Li^+ ions as charge compensator and fluxing agent roles. The experimental results will contribute to studying novel Sm^{3+} -doped luminescent materials.

Keywords: Phosphors; Perovskite; Sm^{3+} ion; Optical properties; Energy transfer; Tunable emission

1. Introduction

Rare earth (RE) ions-doped luminescent materials have attracted much attention in many fields, such as fluorescent tubes, white light-emitting diodes (LEDs), field emission displays, solid-state laser, and biological labeling [1-4]. The fluorescence properties of Sm^{3+} ($4f^6$) ion as RE ions are widely analyzed. Sm^{3+} -doped materials (e.g., crystals, glasses, and thin films) have been extensively reported because of the applications in color displays, fluorescent devices, and temperature sensors [5-8]. With excitation near ultraviolet (UV) light, Sm^{3+} -doped luminescent materials provide characteristic emission lines due to the peculiar electronic structure and energy levels of Sm^{3+} ion, which are almost independent of the host, however, the emission bandwidth and relative luminous intensities are governed by the characteristic of the host [9,10]. Therefore, it is important to select suitable compound as the host for the luminescent activator Sm^{3+} ion.

Niobate group materials have attracted much attention because of the good piezoelectric, electro-optic, pyroelectric, and non-linear properties and been used in many fields, such as phosphors, optical waveguides, and frequency doublers [11,12]. Niobate group materials containing niobium oxygen complex (NbO_6) with excitation UV light can emit visible light due to the charge transfer band (CTB) from O ligands to central Nb atoms within the complex [13]. In RE ions doped niobate materials, the RE ion activators can be excited by direct excitation or indirect energy transfer (ET) from the host and emit abundant fluorescence based on the $4f - 4f$ or $5d - 4f$ transitions of RE ion. At present, various RE ions doped niobates have been extensively studied and reported, such as $\text{KNbO}_3:\text{Eu}^{3+}$, $\text{BaNb}_2\text{O}_6:\text{Eu}^{3+}$, $\text{CaNb}_2\text{O}_6:\text{Yb}^{3+}$, $\text{YNbO}_4:\text{Eu}^{3+}$, $\text{YNbO}_4:\text{RE}^{3+}$ (RE = Sm, Tb, Er), $\text{Ca}_2\text{AlNbO}_6:\text{Eu}^{3+}$,

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