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Synthesis and luminescent properties of $BaGd_2O_4:Eu^{3+}$ phosphors with highly efficient red-emitting

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Abstract

The $BaGd_{2-2x}Eu_{2x}O_4$ (BG, x=0.01–0.09) phosphors were successfully synthesized via the sol-gel method, and $BaY_{2-2y}Eu_{2y}O_4$ (BY, y=0.005–0.07) phosphors were included for comparison. The pure phase BG phosphors with the ordered $CaFe_2O_4$-type structure were obtained by annealing at 1300 °C for 5 h. The phosphors with uniform particle size of 120 nm and good dispersion display typical Eu^{3+} emission with the strongest peak at 613 nm ($^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+}) under optimal excitation band at 262 nm (CTB band). The presence of Gd^{3+} excitation bands on the PLE spectra monitoring the Eu^{3+} emission directly proves an evidence of Gd^{3+}-Eu^{3+} energy transfer. Owing to the concentration quenching, the optimum content of Eu^{3+} addition is 5 at% (x=0.05), and the quenching mechanism is determined to be the exchange reaction between Eu^{3+}. All the BG samples have similar color coordinates and temperature of (0.64±0.02, 0.36±0.01) and 2000±100 K, respectively. The lifetime value of $BaGd_{1.9}Eu_{0.1}O_4$ for 613 nm is fitted to be 2.19±0.01 ms, and the Eu^{3+} concentration does not change the lifetime significantly. Owing to the Gd^{3+}-Eu^{3+} energy transfer, the luminescent intensity of the $BaGd_{1.9}Eu_{0.1}O_4$ phosphor is better than BY system. The BG system served as a new type of phosphor is expected to be widely used in lighting and display areas.

Keywords: $BaGd_2O_4$ host, Eu^{3+} doped, sol-gel method, luminescent properties, Rare earths

1. Introduction

During the past several years, white light-emitting diodes (*w*-LEDs) have attracted wide interest owing to their advantages such as friendly nature, scientific significance, and great application prospect.[1–3] Phosphors play an important role in the development of LED and are also extensively used in fluorescent lamps, flat panel displays, solid laser and high-energy radiation detection fields.[4-6] Due to the wide charge transfer absorption band in the near ultraviolet region, and the higher energy transfer efficiency between the strong matrix and activator RE^{3+}, inorganic phosphor activated trivalent rare earth ions, such as the use of tungstate,[7] phosphates,[8] molybdate,[9] vanadate,[10] borates[11] and aluminate and other inorganic matrix, have received wide concern. Rare earth oxides are the most stable oxides and are often used in the fields of luminescent devices, optical transmission, biochemical probes, medical diagnose, etc.[12-15] Rare earth ions in inorganic fluorescent powder occupy interstitial or lattice position in the substrate lattice and have the effect of the transition of rare earth ions 4f or 5d electrons to achieve the emission of visible light. Phosphors with different lattice types exhibit different luminescence properties because the lattice environment of different matrix has great influence on the outer electrons of rare earth ions.[16,17]

In recent years, the structural characteristics and luminescent properties of RE^{3+} ions (Eu^{3+}, Tb^{3+}, Dy^{3+}, etc.) activated SrY_2O_4, $SrGd_2O_4$, $SrLu_2O_4$, BaY_2O_4 and $BaGd_2O_4$ with ALn_2O_4 crystal structure get extensive research attention due to their special properties such as interesting magnetic properties and outstanding electronic and ionic conductivity.[18] The ALn_2O_4 (space group: *Pnam*) host is iso-structural to the $CaFe_2O_4$-type structure and crystallizes into an orthorhombic structure which consist of one A site of bicapped trigonal prismatic geometry and two Ln sites.[19] Taking $BaGd_2O_4$ for example, the lattice of them contain a double octahedral Gd_2O_4 frame with Ba ions within the framework, where the Ba site comprises eight coordinates with C_s point symmetry and Gd^{3+} ions have

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