Synthesis of $A_3B_8X_{15}$-type new oxynitride phosphors starting from a single crystal composition

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Recently, we reported a simple and rapid approach to discover novel phosphors. This approach is based on characterizing a single luminescent crystalline particle distinguished from a complex powder mixture by using single-crystal X-ray diffraction together with single-particle fluorescence imaging and spectroscopy techniques. Using this approach, a blue single crystal with the composition of $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:Eu$^{2+}$ was discovered. Starting from the composition of the single crystal, we successfully prepared the phase-pure blue $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:Eu$^{2+}$ powder phosphor by using gas-pressure sintering.

Figure 1. (a) Normalized excitation and emission spectra, and (b) thermal stabilities of $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$: 2%Eu$^{2+}$ and $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$: 3%Ce$^{3+}$ phosphors.

The emission spectrum of the $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:2%Eu$^{2+}$ powder phosphor measured under the 355 nm, is shown in Fig.1(a). It shows a band emission with a peak maximum at 465 nm. The excitation spectrum monitored at 465 nm covers a broad range of 220-450 nm, which enables the phosphor to be used in UV-LEDs (Fig. 1a). The thermal stability of the $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:2%Eu$^{2+}$ phosphor is given in Fig. 1(b). The thermal quenching temperature is about 150 °C. The quantum efficiency of the blue phosphor is 42% under the 355 nm excitation. In addition, we also applied Ce$^{3+}$ as an activator for $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$. Under the 350 nm excitation, the $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:3%Ce$^{3+}$ phosphor exhibits a blue-violet band emission peaked at 410 nm (Fig. 1a). The excitation spectrum monitored at 410 nm also shows a broadband extending from ultraviolet part to 390 nm, which matches well with the emission of UV-LEDs. The $\text{Sr}_3\text{Si}_{8-x}\text{Al}_x\text{O}_{7+x}\text{N}_{8-x}$:3%Ce$^{3+}$ phosphor possess a better thermal stability, retaining its emission intensity of 85% at 150 °C, as shown in Fig. 1(b). Moreover, the phosphor has a higher quantum efficiency, which is 63% under the 350 nm excitation.