Preparation of CaAlSiN₃:Eu²⁺ Phosphor Ceramics

As a blue-light excitable and efficient red phosphor, CaAlSiN₃:Eu²⁺ plays a major role in high color rendering white light-emitting diodes (wLEDs) or wide color gamut LED backlights, but it cannot be used in high-power blue laser diode-driven displays and lighting due to the low thermal performance of the phosphor/silicone resin mixture. To apply CaAlSiN₃:Eu²⁺ in solid state laser lighting devices, a bulk ceramic form is thus required to suffer from thermal attacks and high-flux density irradiation. However, the preparation of highly dense CaAlSiN₃:Eu²⁺ luminescent ceramics still remains an unsolved great challenge due to the intrinsic low diffusion rate and high vapor pressure of the nitride host. Here, for the first time, optically translucent CaAlSiN₃:Eu²⁺ ceramics with an interesting composite microstructure, where red-emitting phosphor particles with a core-shell structure are uniformly embedded in a non-luminescent α-Sialon matrix, are successfully synthesized by using Si₃N₄ and SiO₂ as sintering additives. The luminescence ceramic is superior to the corresponding powder phosphor in terms of enhanced thermal stability (15% increase at 300°C) and thermal conductivity (4 Wm⁻¹K⁻¹). It has a high external quantum efficiency of 60% (87% of the powder phosphor) upon 450 nm excitation, and a luminous efficiency of 10.6 lmW⁻¹ when irradiated under a blue laser flux density of 0.75 Wmm⁻². The red-emitting translucent CaAlSiN₃:Eu²⁺ ceramic is thus supposed to be a potential color converter for use in emerging laser lighting and display technologies.

Figure 1 SEM images of CaAlSiN₃:Eu²⁺ samples with varying sintering additives, where (a) S1 (no additives), (b) S2 (SiO₂), and (c) S3 (Si₃N₄ +SiO₂), show obvious differences in levels of densification. The backscattered electron (BSE) image (d) of S3 reveals that CaAlSiN₃:Eu²⁺ particles with a high contrast are homogenously distributed in a matrix.