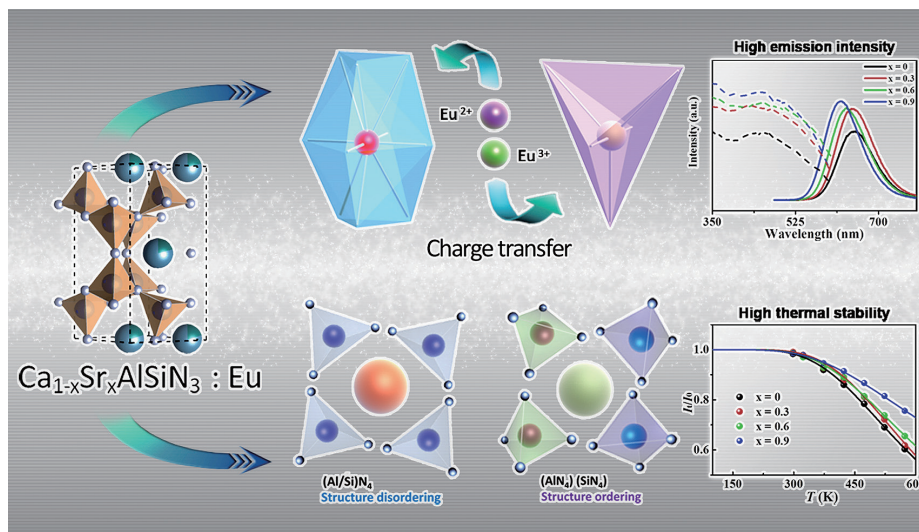


Inorganic phosphor materials for application in light-emitting diodes

Structural ordering and charge variation induced by cation substitution in (Sr,Ca)AlSiN₃:Eu Phosphor

Red-emitting phosphor materials have been extensively developed to increase the color rendering index and stability in white light-emitting diodes (LEDs). Nitridosilicate phosphors, such as MAISiN₃:Eu²⁺ (M = Ca, Sr), exhibit high chemical and thermal stabilities because of their rigid structures. In the present study, disordering of Si/Al in (Si/Al)N₄ clusters is introduced in the framework via cation substitution to induce charge variation from Eu³⁺ to Eu²⁺ and simultaneously improve the thermal stability and luminescent properties of the phosphor.

The structure of the phosphor has been modified through cation substitution to induce charge variation and a rearrangement of neighboring nitride clusters and, consequently, enhance its luminescent behavior. Substitution of Ca²⁺ by Sr²⁺ cations expanded the lattice volume and the b-c plane but shortened the distance between the layers along the a axis. Lattice distortion of the framework introduced high-coordination sites in the Sr/Eu centers and adequate space, thereby facilitating charge variation of activators under reduced atmosphere, as detected through X-ray absorption near-edge



structure spectroscopy. As such, the photoluminescent intensity of the phosphors increased by more than 10%, and a blueshift occurred. Cation substitution induced a special change in the anion environment, as indicated in the solid-state Raman spectra. Moreover, typical ordering variations in the SiN₄ and AlN₄ clusters are generated in the lattice. Meanwhile, neighbor sequences of (Si/Al)N₄ around the divalent centers were observed through solid-state nuclear magnetic resonance spectroscopy. The modified ordering distribution resulted in a rigid structure and improved the thermal quenching behavior. This study promotes the research into neighbor sequences for selective tetrahedral sites, such as Li, Mg, Al, and Si coordinated by N atoms in contact with cation sites.

In conclusion, these results not only confirm the local structure through a subtle analysis technology but also improve the phosphor properties for LED applications.

Reference

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