

Modulating optical properties through cation substitution: composition-property relationships in $M^I3M^{III}P_3O_9N:Eu^{2+}$ ($M^I = Na, K$; $M^{III} = Al, Ga, In$)

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Streszczenie

Developing phosphors with narrow photoluminescence emission peaks and high chromatic stability holds significant importance in light-emitting diode (LED) display technologies, where a wide color gamut is essential to achieve the Rec. 2020 specifications. This research focuses on the optical properties of a solid solution: $M^I_{2.97}Eu_{0.015}M^{III}P_3O_9N$ [$M^I = Na, K$; $M^{III} = Al, (Al_{0.75}Ga_{0.25}), (Al_{0.5}Ga_{0.5}), (Al_{0.25}Ga_{0.75}), Ga, (Ga_{0.75}In_{0.25}), (Ga_{0.5}In_{0.5})$] to understand how the narrow-emitting photoluminescence in $K_3AlP_3O_9N:Eu^{2+}$ can evolve during host structure cation substitution. Photoluminescence measurements at low temperature (15 K) support that Eu^{2+} replaces three crystallographically independent Na^+ sites in $Na_{2.97}Eu_{0.015}AlP_3O_9N$, similar to the parent K^+ phosphor, but substituting Ga^{3+} and In^{3+} for Al^{3+} leads to a change in Eu^{2+} site preference, narrowing the full-width-at-half-maximum (fwhm) of the emission peak. The chromatic stability and photoluminescence quantum yield are also enhanced with higher Ga^{3+} content in the host but not with In^{3+} . Thermoluminescence analysis indicates the relationship between trap states and the enhanced quantum yield with Ga^{3+} leads to the series' best performance. The analysis of the $M^I_{2.97}Eu_{0.015}M^{III}P_3O_9N$ series offers insight into the potential method for modulating optical properties with cation substitution in the host structure.

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