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A full-color emitting phosphor Ca₉Ce(PO₄)₇:Mn²⁺, Tb³⁺: Efficient energy transfer, stable thermal stability and high quantum efficiency

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Abstract:

Herein, we report a series of phosphate phosphors Ca₉Ce(PO₄)₇:xTb³⁺/yMn²⁺, exhibiting much efficient energy transfer, stable thermal stability and high quantum efficiency. First of all, Ca₉Ce(PO₄)₇ host is full of sensitizers (Ce³⁺) and the maximum energy transfer efficiency from Ce³⁺ to Mn²⁺ and Tb³⁺ reaches 91% and 72%, respectively. In Ca₉Ce(PO₄)₇:xTb³⁺/yMn²⁺ system, white light can be obtained by mixing the tricolor composition at a suitable ratio. Energy transfer from Ce³⁺ to Mn²⁺/Tb³⁺ is confirmed via an electronic dipole-dipole (d-d) interaction. We found that the Mn²⁺ emission intensity of Ca₉Ce(PO₄)₇:Mn²⁺ keeps unchanged during the rising temperature and the Tb emission lines of Ca₉Ce(PO₄)₇:0.15Tb³⁺ are not affected by the increasing temperature. Meanwhile, quantum efficiency (QE > 60%) of Ca₉Ce(PO₄)₇:xTb³⁺/yMn²⁺ presents a stable output until the temperature rises to 150 ℃. We also report the luminescence quenching temperature (T > 300 ℃) and the activation energy for thermal quenching (ΔE > 0.2 eV). To prove the potential application, a proof-of-concept white LEDs is fabricated by combining the single-component phosphor Ca₉Ce(PO₄)₇:Mn²⁺, Tb³⁺ with a UV LED chip, which has a CIE chromaticity coordinate (0.347, 0.344), color temperature (4770 K), color rendering index (Ra=80.4) and R₉=92.3.

Keywords: phosphate phosphors; efficient energy transfer; high quantum efficiency; stable thermal stability; white LEDs

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