

Enhanced red up-conversion of β -NaYF₄:Er³⁺,Tm³⁺ microcrystals for bio-imaging applications

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Streszczenie

Pure red fluorescence generated by near infrared (NIR) excitation is desired for bio-imaging with high biological penetration, but without cell damage or multi-photon phototoxicity. In this work, β -NaYF₄:Er³⁺ and β -NaYF₄:Er³⁺,Tm³⁺ microcrystals were synthesized using a novel hydrothermal method. β -NaYF₄:Er³⁺ microcrystals exhibited intense green and red up-conversion emissions under 976 nm laser diode excitation. The introduction of Tm³⁺ ions into β -NaYF₄:Er³⁺ resulted in strong inhibition of green up-conversion emission (Er³⁺:²H_{11/2}/⁴S_{3/2} → ⁴I_{15/2}) and, consequently, red up-conversion emission (Er³⁺:⁴F_{9/2} → ⁴I_{15/2}) was significantly promoted. To simultaneously restrain green up-conversion emissions and enhance red up-conversion emissions, the optimal concentrations of Er³⁺ and Tm³⁺ ions were determined to be 20 mol% and 2.0 mol%, respectively. The red/green up-conversion emission intensity ratio increased from ~1.80 (β -NaYF₄:20Er³⁺, mol%) to ~78 (β -NaYF₄:20Er³⁺,2Tm³⁺, mol%) after the addition of 2 mol% Tm³⁺ ions to β -NaYF₄:20Er³⁺ (mol%). The red up-conversion emission intensity of β -NaYF₄:20Er³⁺,2Tm³⁺ was stronger than that for commercial red up-conversion phosphors (NaYF₄ and ZnF₂) under the same experimental conditions. Based on the results of the emission spectra, luminescence rise, and decay profiles, the mechanism of enhanced red up-conversion emission by Tm³⁺ ion co-doping in β -NaYF₄:20Er³⁺,2Tm³⁺ (mol%) was proposed. The bio-fluorescence experiment under NIR excitation proves that β -NaYF₄:Er³⁺,Tm³⁺ microcrystals have potential applications in bio-imaging.

Słowa kluczowe

β -NaYF₄:Er³⁺ and β -NaYF₄:Er³⁺, Tm³⁺ micro-crystals, Green and red up-conversion emissions, Tm³⁺ energy trapping center, Hydrothermal method, Energy transfer

Adres publiczny

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