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Spectroscopic properties analyses and laser characterization simulation of $\text{Er}^{3+}, \text{Eu}^{3+}:\text{YAP}$ single crystal

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Abstract: Er,Eu:YAlO₃ (abbr. as Er,Eu:YAP) crystal was grown by the Czochralski technique for the first time. Its absorption and fluorescence spectra as well as the fluorescence decay curves were measured and investigated. The spectral parameters including absorption cross-section and emission cross-section were calculated. It is found that the crystal has short lifetimes at ⁴I_{13/2} and ⁴I_{11/2} levels, large absorption cross-section at 974 nm and 790 nm, and large stimulated emission cross-section at 2704 nm. The co-dopant Eu³⁺ decreases the fluorescence lifetime of ⁴I_{11/2} level from 400 μs to 59.35 μs, and thus inhibits the self-termination effect of ~2.7 μm in some degree. We develop a theoretical model that simulates the laser characteristics of Er,Eu:YAP crystal numerically. Based on Er³⁺-Eu³⁺ energy level diagrams, the rate equation model was built and discussed. It was found that: when the pump rate increases gradually, the laser quantum efficiency reaches to its upper limit with a fixed value $2-p^2$, and this value is 1.35 for Er,Eu:YAP crystal. The results show that Er,Eu:YAP crystal is an excellent material candidate for ~2.7 μm laser.

Keywords: Er,Eu:YAP crystal; Er³⁺ ions; Energy transfer; Spectroscopic properties; Laser characterization simulation

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