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

Baotong Zhang[1,2], Yan Wang[1,*], Wei Zhang[1,3], Jianfu Li[1], Zhaojie Zhu[1], Zhenyu You[1] and Chaoyang Tu[1]

[1] Key Laboratory of Optoelectronic Materials Chemistry and Physics, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou City, Fujian Province, 350002 P. R. China

[2] College of Materials Science and Engineering, Fujian Normal University, Fuzhou City, Fujian Province, 350007 P. R. China

[3] College of Chemistry, Fuzhou University, Fuzhou City, Fujian Province, 350116 P. R. China

*Corresponding authors: wy@fjirsm.ac.cn

Abstract: Er,Eu:$YAlO_3$ (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 Eu^{3+} 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 Er^{3+}-Eu^{3+} 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; Er^{3+} ions; Energy transfer; Spectroscopic properties; Laser characterization simulation