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Controllable optical properties between Ho^{3+}: $^5I_7 \rightarrow ^5I_8$ and Tm^{3+}: $^3F_4 \rightarrow ^3H_6$ transitions in germanosilicate glasses

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ABSTRACT: Diode-pumped solid-state 2 μm lasers have seen rapid development for their efficient operation, compact size, and stable performance. In this work, doped germanosilicate (SiO_2-GeO_2-Ga_2O_3-Lu_2O_3) glasses with varying Tm^{3+}/Ho^{3+} concentrations exhibiting excellent physical and optical characteristics were successfully prepared. Thermal and structural properties were analyzed by the measured DSC and Raman spectra. An evident efficient wide absorption band near 770–830 nm demonstrated the feasible energy transfer between Tm^{3+}: $^3F_4 \rightarrow ^3H_6$ and Ho^{3+}: $^5I_7 \rightarrow ^5I_8$ transitions. Meanwhile, combining with Judd-Ofelt theory, super predicted spontaneous emission probabilities were obtained, which are beneficial to obtain fine laser action for solid-state lasers. This is a first study to demonstrate that a tunable fluorescence peak (1.8–2.05 μm) can be obtained by modulating the combined effects between two luminous activation centers. Therefore, the results indicate a promising rare-earth doped glass host for solid-state 2 μm lasers.

Keywords: Germanosilicate glasses; 2 μm laser; Energy transfer; Judd-Ofelt theory.

1. Introduction

As well known, abundant attention has been poured into 2 μm laser materials owing to wide applications in remote sensing, optical communication and military equipment for recent years. It is especially worth to point out the important role for medical applications owing to its strong absorption in water and biological tissues[1-3]. Among various luminous active ions, two irreplaceable rare-earth (RE) ions, Ho^{3+} and Tm^{3+} must be emphasized for providing 2 μm emission because of $^5I_7 \rightarrow ^5I_8$ and $^3F_4 \rightarrow ^3H_6$ transitions respectively[4-7]. From 1999, great interest have been poured to investigate the potential applications in the field of medical laser therapy through the cw mode at 2 μm[8]. For the past few years, persistent concern has been focused on Tm^{3+} doped laser glass materials because of its high quantum efficiency (200%) resulting from the energy transfer (ET: $^3H_6 + ^3H_4 \rightarrow ^3F_4 + ^3F_4$) process between