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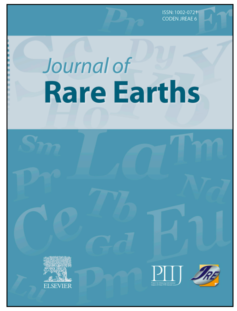

Energy transfer and 2 μm emission in Tm^{3+}/Ho^{3+} co-doped $(Y_{0.87}La_{0.1}Zr_{0.03})_2O_3$ nanopowders

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Energy transfer and 2 m emission in Tm^{3+}/Ho^{3+} co-doped $(Y_{0.87}La_{0.1}Zr_{0.03})_2O_3$ nanopowders

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Abstract: $(Y_{0.87}La_{0.1}Zr_{0.03})_2O_3$ **nanopowders** doped with various concentrations of Tm^{3+} and Ho^{3+} were prepared by the citrate method. The standard cubic Y_2O_3 phase can be matched in the Tm^{3+}/Ho^{3+} co-doped $(Y_{0.87}La_{0.1}Zr_{0.03})_2O_3$ **nanopowders**. The **nanopowders exhibit** average particle sizes of 40, 60, 80 and 100 nm after calcinated at 900, 1000, 1100 and 1200 ^oC, respectively. The energy transfer from $\mathbf{Tm^{3+}}$ to Ho^{3+} and the optimum fluorescence emission around 2 μm were investigated. Results indicate that the emission bands at around 1.86 and 1.95 μm correspond to $^3F_4 \rightarrow ^3H_6$ transition of Tm^{3+} and $^5I_7 \rightarrow ^5I_8$ transition of Ho^{3+}, respectively. Better spectral properties were achieved in Tm^{3+}/Ho^{3+} co-doped $(Y_{0.87}La_{0.1}Zr_{0.03})_2O_3$ nanopowders with the average size of 100 nm obtained at the conditions of the treatment of precursors calcinated at 1200 ^oC for 2 h doped with 1.5 mol% $\mathbf{Tm^{3+}}$ and 1 mol% Ho^{3+}.

Keywords: Emission spectral; $\mathbf{Tm^{3+}}$/Ho^{3+}**;** Y_2O_3**;** La_2O_3-ZrO_2**; Nanopowders; Rare earths**

1. Introduction

Benefiting from eye-safe nature and high atmospheric transmission, Ho-doped solid-state lasers working in the 2 μm spectral region have attracted considerable attention in recent years. It is useful for a number of advanced applications, such as wind shear detection, coherent laser lidar and remote sensing [1, 2, 3]. As the wavelength of Ho lasers is beneficial to avoiding two-photon absorption in non-oxide nonlinear crystals, it is a more preferable pump source for optical parametric oscillators to generate mid-infrared lasers [4]. The use of crystalline materials doped with Tm^{3+} and Ho^{3+} ions in 2 μm lasers is based on the $^3F_4 \rightarrow ^3H_6$ optical transition of Tm^{3+} and the $^5I_7 \rightarrow ^5I_8$ transition of Ho^{3+}. Tm^{3+} ions can also be used as sensitizers to transfer absorbed pump energy to Ho^{3+} ions, which allows one to pump Tm^{3+}/Ho^{3+} co-doped systems by high-power commercial laser diodes emitting at 808 nm. The laser oscillation at ~2 μm in the co-doped crystals was successfully demonstrated in LuAG [5], YAG [6], $YLiF_4$ [7], $LuLiF_4$ [8], $GdVO_4$ [9], $KLu(WO_4)_2$ [10], $LiGd(MoO_4)_2$ [11] and $Gd_2(MoO_4)_3$ [12] crystals.

In recent years, Y_2O_3 has been considered as a promising laser host material in contrast to the traditional laser host materials. For example, Y_2O_3 possesses higher thermal conductivity (27 W/(m·K)) and lower phonon energy compared with YAG, which can ensure the stable laser operations [13]. In addition, the broad transparent region from UV to IR makes Y_2O_3 suitable for laser oscillation. A few papers reported the crystal growth of Y_2O_3, but the high melting point of 2430 ^oC and the high-temperature phase transition at approximately 2280 ^oC make the growth of Y_2O_3 single crystal difficult and seriously constrict the sizes of as-obtained crystals by conventional methods [13, 14]. On the contrary, it is much easier to produce transparent ceramics than single crystals because of the numerous easy fabrication methods and much lower

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