$Ca_3(Ta,Ga)_5O_{12}:Pr^{3+}$ as potential laser crystal emitting in the blue and red spectral domains

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Pr^{3+}-doped $Ca_3(Ta,Ga)_5O_{12}$ (CTGG) - CTGG:Pr single crystal was grown by the Czochralski method, for the first time to our knowledge, from a melt (starting composition) containing 5 at.% Pr^{3+} ions - CTGG:Pr (5 at.%). The starting melt composition, crystal growth direction, and rotation and pulling rates were optimized. The best quality grown crystal is shown in Fig. 1a. Spectroscopic characteristics of CTGG:Pr (5 at.%) single crystal were investigated in order to assess its potential as laser material emitting in the visible spectral range. The absorption and emission spectra at low (10K) and room temperature were measured and analyzed to determine the energy levels of Pr^{3+} ions in the crystal field of the CTGG host (Figs. 1b and 1c). The Judd-Ofelt (JO) theory was applied to determine JO intensity parameters and other spectroscopic parameters such as spontaneous emission probabilities ($A_{JJ'}$), branching ratios (β), and radiative lifetimes (τ_r). The temperature dependence of the absorption spectrum corresponding to the $^3H_4 \rightarrow {}^3P_0$ transition (Fig. 1c) was used to highlight the multicenter structure, different Stark levels, hot bands, and also the connection between the vibronic and electronic lines. The dynamics of the $^3P_0$ and $^1D_2$ excited levels have been also investigated at different temperatures and excitation wavelengths. The emission cross-sections (σ_{em}) corresponding to the $^3P_0 \rightarrow {}^3H_4$ and $^3P_0 \rightarrow {}^3F_2$ transitions were determined to be 19×10^{-20} cm^2 (488 nm) and 15.9×10^{-20} cm^2 (650 nm), respectively. The obtained values are much higher than the values for other oxide hosts and comparable to those of the YLF:Pr fluoride single crystal of 19×10^{-20} cm^2 and 22×10^{-20} cm^2, respectively [1]. These results show that the CTGG:Pr (5 at.%) crystal is a promising laser crystal for laser emission in the blue (~ 488 nm) and red (~ 650) domains.

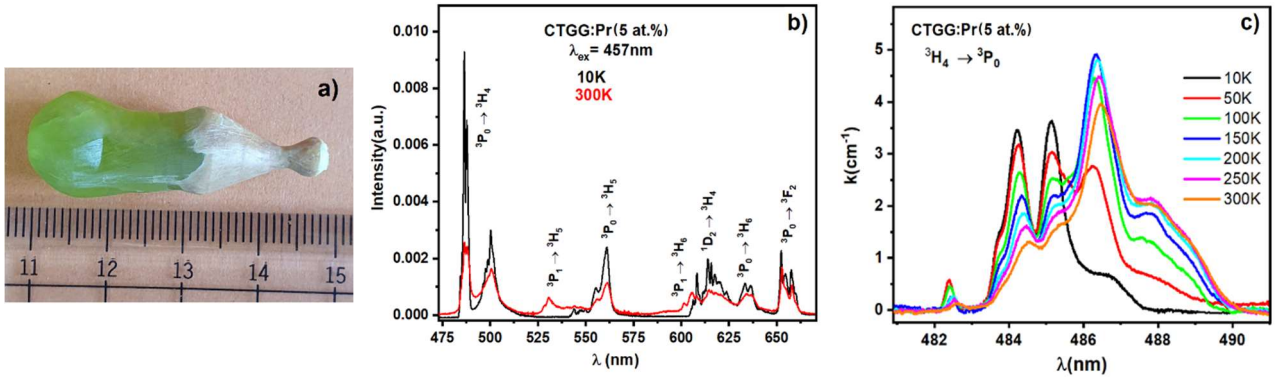

Fig.1. Czochralski-grown CTGG:Pr (5 at.%) single crystal (a). Emission spectra at 10 and 300K (b) and temperature dependence of the absorption spectrum corresponding to the $^3H_4 \rightarrow {}^3P_0$ transition (c) of the CTGG:Pr (5 at.%) single crystal.

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References

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