The study of a Tm:YbAG laser pumped at 1678 nm

Prokhorov’s General Physics Institute of the Russian Academy of Sciences
GPI RAS
Moscow, Russia
kalachev@kapella.gpi.ru

Abstract—The laser crystal Tm³⁺:Yb³Al₅O₁₂ (Tm:YbAG) was grown by the Czochralski method and was investigated under pumping by a Raman-shifted erbium fiber laser at a wavelength of 1.678 um. Absorbance and luminescence spectra were recorded and the luminescencel lifetime of the upper lasing level 3F4 was measured to be 4.7 ms. Lasing of this crystal at a wavelength of 2.02 um was obtained for the first time. The laser slope efficiency reached 41% at the output power up to 330 mW at room temperature.

Keywords—Tm³⁺, YbAG, Yb³Al₅O₁₂, laser, laser pumping.

The stoichiometric YbAG crystal is analog of YAG crystal, were all Y³⁺ ions are replaced with Yb³⁺ ions [1]. This crystal has a rather simple technology of growth and good thermal property and may be used as host material for thulium – doped lasers. Presence of additional Yb transition 2F5/2->2F7/2 should not cause a large reduction in slope efficiency due to the fact, that 2F5/2 Yb manifold is populated only via up-conversion process when Tm ions are pumped directly to 2F₄ manifold. Energy level diagram of Tm⁺ and Yb⁺ ions is presented in Fig. 1.

The Tm:YbAG crystal was grown by the Czochralski method from an iridium crucible under oxidizing atmosphere (99.5%N₂+0.5%O₂). The gown crystals were annealed for 24 hours at 1200°C. The concentration of Tm³⁺ ions in the active elements was 5.7%. In experiments, we used active elements of a cubic shape with an edge length of 3 mm.

![Fig. 1. Energy level diagram of Tm³⁺ and Yb³⁺ ions. Arrows are marked as follows: 1678 — pumping, 2020 — lasing and luminescence, (1) — energy transfer between Tm ions, (2) — energy transfer between Tm and Yb ions, (3) — Yb luminescence.](image)

Absorption, luminescence and lasing spectra in infrared region are shown in Fig. 1.

![Fig. 2. Absorption, luminescence and lasing spectra.](image)

The pumping wavelength 1678 nm is not match any of absorption peaks, nevertheless, the active element absorbed 60% of pumping energy.

The 2.02 um-luminescence lifetime τ was measured by method of frequency response using Bode plots [2]. Measured value of τ was equal to (4.7±0.2) ms.

The lasing experiments were carried out in the cavity of length of 50 mm formed by a flat mirror (high reflective at 2 um) and concave one (as output coupler with 96% reflectivity). Pumping radiation was focused by means of 80 mm lens into beam of 80 um in diameter and 15 mm in confocal length. Crystal faces were uncoated.

Lasing at a wavelength of ~2.02 um is obtained in pulsed (5% duty time) and CW regimes at room temperature. The total and slope efficiencies reach 33% and 41% at an output power up to 330 mW. Maximal value of absorbed power was 1 W.

REFERENCES


This work was supported by the program "Fundamental Problems of Photonics and Physics of New Optical Materials" of the Department of Physical Sciences of RAS.