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Continuous wave diode pumped Yb:LLF and Yb:NYF lasers

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ABSTRACT

Experimental and theoretical results of investigation of CW Yb:$LiLuF_4$ (Yb:LLF) and Yb:$Na_4Y_6F_{22}$ (Yb:NYF) lasers under longitudinal diode laser pump are reported. Slope efficiencies of 41%, 58% with 0.21, 0.53 W of output powers were obtained for the Yb:LLF and Yb:NYF lasers, correspondingly. The Yb:NYF laser demonstrated tunability in the region from 1005 to 1061 nm. The mathematical modelling of CW laser operation predicts under optimized laser parameters optical to optical efficiencies of about 55% and 51% for Yb:LLF and Yb:NYF lasers, respectively.

1. Introduction

Solid-state lasers operating in the spectral range around 1 μm based on diode pumped Yb-doped materials demonstrate high efficiency in continuous wave (CW), Q-switched and mode locking regimes. These properties directly derive from the simple electronic energy level structure of Yb ions which sufficiently reduces excited state absorption and up-conversion processes [1], moreover vibronic broadening of luminescence leads to tunability of such lasers and to femtosecond pulse generation. A number of fluoride Yb-doped crystals demonstrate high laser performance. The most remarkable results are obtained for Yb-doped CaF_2. This material combines a rather high thermal conductivity and a broad gain bandwidth. All of this makes it possible to design diode pumped lasers oscillating ultra short light pulses with a high average power. In [2,3] it was reported on Yb^{3+}:CaF_2 high power (up to 5.8 W) tunable (60 nm) CW oscillation under laser diode pumping. A passively mode-locked diode pumped femtosecond laser based on an Yb^{3+}:CaF_2 single crystal demonstrated light pulses with duration of 150–230 fs and 0.88–1.74 mW of average power [4]. A considerable attention is paid to mixed fluoride crystals. Though their thermal conductivities are lower than that of Yb^{3+}:CaF_2, they potentially have more broad and smooth gain bands. The last circumstance is important for obtaining short light pulses. A number of papers are devoted to Yb:$YLiF_4$ (Yb:YLF) [5–7], Yb:KYF_4 (Yb:KYF) [7,8], Yb:KY_3F_{10} [9], and Yb:$LuLiF_4$ (Yb:LLF) [6,10] as laser materials and laser performance. A rather wide tunability region (1.01–1.07 μm) was demonstrated for Yb:YLF and Yb:KYF along with optical slope efficiencies of 33% and 52% for these materials correspondingly [7]. A single longitudinal CW mode of operation in 1020–1045 nm spectral region was reported in [8] for a laser based on Yb:KYF crystal. Spectroscopic properties of Yb:LLF were reported in [6,10]. In [10] were reported also spectroscopic and thermal properties of a new Yb-doped crystal of Yb^{3+}:$Na_4Y_6F_{22}$ (Yb:NYF).

Here we report what is believed to be the first demonstration of efficient CW laser operation of Yb(2 at%):NYF and Yb(1 at%):LLF crystals. Slope efficiencies of 41% and 58% with 0.21 and 0.53 W of output power were obtained under longitudinal laser diode pumping for the lasers based on Yb:LLF and Yb:NYF crystals, correspondingly. The Yb:NYF laser demonstrated tunability in the region from 1005 to 1061 nm. Optimization of laser parameters based on mathematical simulation of CW laser operation was made.

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