Compact High-Power Ho:YAG MOPA in-Band Pumped by Laser Diode Stacks at 1.9 µm

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Laser systems that operate around 2 µm offer exceptional advantages for various applications, e.g. high-resolution spectroscopy, medicine and pumping of optical parametric oscillators (OPO). Many of these applications require compact table-top solutions with high output powers and high overall efficiencies. Ho:YAG lasers are attractive candidates because of the high emission cross-section of the Ho $^5I_7$ manifold and its long lifetime of ~ 8 ms. Recently developed GaSb laser diodes in the wavelength range around 1.9 µm offer the possibility for direct in-band pumping which is an attractive route to compact high-power 2 µm lasers with high lasing efficiencies. In our first experiments we demonstrated 46 W of cw output power and 6 mJ of pulse energy at a repetition rate of 500 Hz [1].

The main goal of this investigation is to increase the output power of our Ho:YAG laser system. The most promising candidate to achieve higher output powers and higher damage thresholds of the optical components is a master oscillator power amplifier (MOPA) system based on direct in-band pumped Ho:YAG rods by laser diode stacks at 1.9 µm. The experimental setup is shown in Fig. 1.

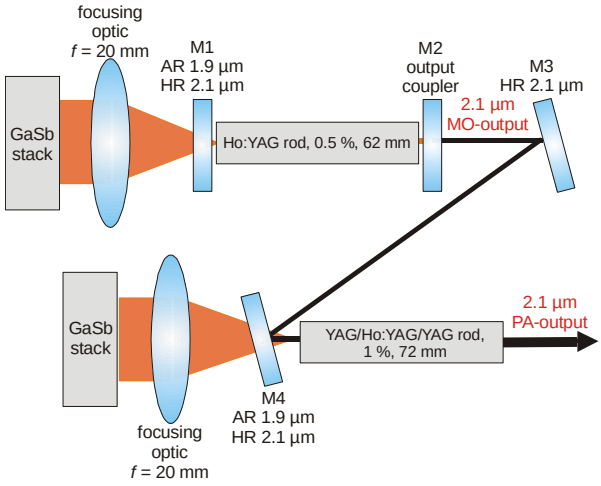

Fig. 1 Experimental setup of the MOPA system

The master oscillator was formed by a compact plane-plane resonator with a 62 mm long 0.5 % doped Ho:YAG rod which was water cooled to 15 °C. Both sides of the laser crystal were anti reflection (AR) coated for laser and pump wavelengths. An acousto-optic modulator (AOM) was used for the q-switched operation. The 2.1 µm laser beam was deflected with mirror M4 to mirror M5 and passed the amplifier stage. The 72 mm long 1 % doped YAG/Ho:YAG/YAG rod of the power amplifier was also water cooled to 15 °C and AR-coated for laser and pump wavelengths. Both Ho:YAG rods were in-band pumped by GaSb-based diode stacks whose pump light (P_{max} = 160 W) was focused onto the crystals (f = 20 mm).

The average single pass absorbed power of the oscillator rod was 55 % and the amplifier rod absorbed 75 % of the incident pump power. Before the amplifier stage, the maximum output power was 55 W with a corresponding slope-efficiency of 48 % using a plane output coupler with 7 % transmission. For q-switched operation, this mirror was replaced by a plane output coupler with a transmission of 30 % in order to avoid damage of the optical components. The maximum pulse energy was 3.5 mJ at 1 kHz pulse repetition rate and was amplified to 6.2 mJ. Thus, compared to former experiments, the average power could be increased by a factor of 2. The amplification of the presented MOPA system was nearly 2 and decreased for high output powers due to saturation effects.

In the near future we will optimize the q-switched Ho:YAG MOPA system by testing different Ho doping concentrations and rod lengths for the amplifier stage and by optimizing the laser resonator geometry for high q-switch pulse energies.

References

[1] S. Lamrini, P. Koopmann, K. Scholle, P. Fuhrberg, and M. Hofmann, "High-Power Ho:YAG Laser in-Band Pumped by Laser Diodes at 1.9 µm and Wavelength-Stabilized by a Volume Bragg Grating," in Proceedings of ASSP 2010, paper AMB13 (2010).