Efficient Laser Operation of Ho:Lu_2O_3 at Room Temperature

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High power lasers emitting at around 2 µm have significant potential for a variety of applications including laser surgery, welding of plastic materials, and pumping of nonlinear media to generate mid-infrared radiation in the 3 µm - 12 µm spectral range, e.g. OPOs based on ZGP. Even though ZGP can be pumped by thulium lasers at 2.0 µm its conversion efficiency at 2.1 µm is significantly higher [1]. Thus, holmium based lasers are ideally suited to pump ZGP-OPOs. The sesquioxide Lu_2O_3 is a very promising laser host crystal regarding power scaling because it offers several favourable properties. Sesquioxides exhibit a high thermal conductivity which is higher than the one of YAG and their low phonon energies ensure a large energy storage time while minimizing non-radiative relaxation processes [2].

In this work we report on the spectroscopy and laser performance of Ho:Lu_2O_3 crystals which were grown by the Heat-Exchanger Method. Fig. 1a shows the absorption and emission spectra in the 2 µm spectral range. There are four pronounced absorption peaks which are located between 1928 nm and 1940 nm (see inset graph). It shows two potential emission wavelengths at 2124 nm and 2134 nm leading to a low quantum defect which gives the potential for scaling to high output powers when the crystal is pumped at 1940 nm.

In our experiments a diode pumped master oscillator power amplifier (MOPA) based on Tm fibers served as pump source. The output of a fiber Bragg grating stabilized single mode Tm fiber laser (125 µm/10 µm) at 1940 nm was amplified with one diode pumped Tm fiber (550 µm/50 µm) stage providing 17 W of pump power.

For laser operation a compact folded plano-concave resonator was chosen. The gain medium was a Ho(0.3 %):Lu_2O_3 barrel polished laser rod. It was 20 mm long, had a diameter of 2.5 mm and was water cooled to 18 °C. Both facets were anti reflective (AR) coated for the pump and the laser wavelength. The pump light was focused onto the crystal with an AR coated lens (f = 80 mm). The plane incoupling mirror was AR coated for the pump light and highly reflective (HR) coated for the laser wavelength. The 2.1 µm light was deflected to the curved (R = 200 mm) output coupling mirror by a plane folding mirror (45°). In our initial experiments four output coupling rates were investigated. The input-output curves are shown in Fig. 1b.

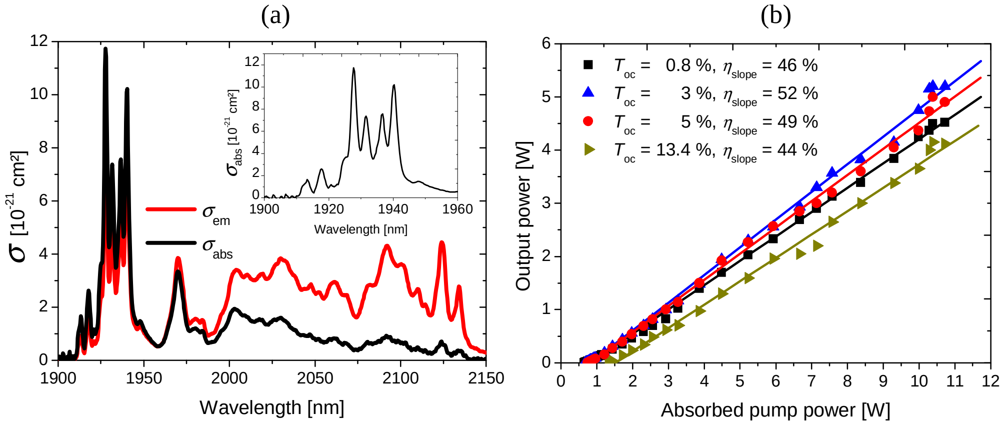

Fig. 1 (a) Absorption and emission spectra of Ho:Lu_2O_3 at room temperature. The inset graph shows the pronounced absorption peaks around 1930 nm. (b) Laser performance of the Ho:Lu_2O_3 oscillator at room temperature.

With the described setup the first laser operation of Ho:Lu_2O_3 could be achieved. The laser threshold was 0.65 W with respect to the absorbed pump power and increased to 1.3 W for 13.4 % of output coupling. A maximum output power of 5.2 W at 2124 nm, limited by the available pump power, and a slope efficiency of 52 % with respect to the absorbed pump power were achieved for 3 % of output coupling. The slope efficiency decreased to 44 % for 13.4 % of output coupling. Nevertheless more than 4 W of output power were obtained. For 0.8 % of output coupling the laser emitted simultaneously at 2124 nm and 2134 nm due to the low output coupling rate.

Further crystal lengths and resonator configurations will be investigated in the near future.

References

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