CONTINUOUS WAVE DIODE-PUMPED TM:HO:YLF LASER

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Introduction

Solid-state lasers emitting at 2 μm have various applications in a wide range of fields[1,2]. These eye-safe sources are useful in wind sensing, dental caries prevention and medical applications. Tm:Ho lasers are suitable to use diode laser as the pump source with high efficiency [3,4].

The Tm:Ho:YLF is a three-level system with a thermal population at the lower laser level that leads to a considerable reabsorption at room temperature and higher threshold for lasing. This system has also upconversion processes, which reduce the population of the upper laser level [5]. These effects can be decreased by cooling the crystal. The low temperature increases the gain and the efficiency, which enables the continuous operation of this laser.

We report the development of a continuous wave diode-pumped Tm:Ho:YLF laser at temperature of −25°C. The behavior of cw and quasi cw laser is analyzed as well as the laser efficiency for different pumped wavelength near 792 nm.

Experimental Setup

We used a 5 mm long Tm:Ho:YLF crystal with 6 mol% of Tm and 0.5 mol% of Ho. The laser was end pumped by a 20W diode bar emitting at 792 nm, whose beam was reconfigured into three columns using a two-mirror beam shaper (fig.1).

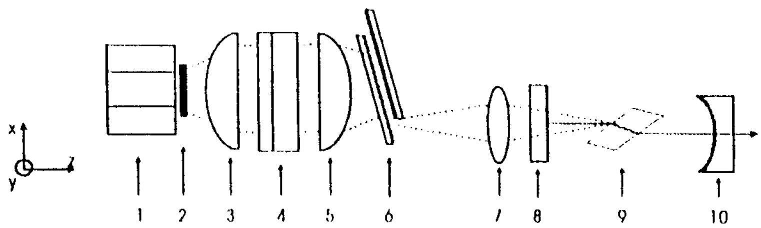

Fig. 1: Setup of the Tm,Ho:YLF laser. (1) diode, (2) cylindrical micro-lens, (3) f_x=2.5cm, (4) f_y=2.5cm, (5) f_x=2.5cm, (6) beam shaper, (7) f_{xy}=2.5cm, (8) plane mirror, (9) crystal, (10) output coupler R=10cm and T=9%.

The 38 mm focal length spherical lens generates a beam waist of w_x = 402 μm and w_y = 309 μm and quality factor of M_x^2=139 and M_y^2=86. The laser resonator consisted of a flat high reflector mirror and a 10 cm radius of curvature output coupling mirror with a transmission of 9 % at 2 μm. The pump power incident on the crystal was 15 W due to losses in the collimating optics, beam shaper and the back mirror of the resonator.

The crystal and the diode temperatures were controlled by Peltier elements. The crystal was placed in a sealed box with nitrogen which allowed the temperature of −28°C. The diode has a temperature range between 12°C and 32°C, which tranlates into a wavelength between 787 and 794 nm.

Experimental Results

The temperature sensitivity of the Tm:Ho:YLF becomes clear when the crystals temperature is lowered from 10°C to −25°C (fig 2), accompanied by an output power increase of 70%. By lowering the crystal temperature, higher duty cycle is achieved until a maximum of 60 % (fig. 3).

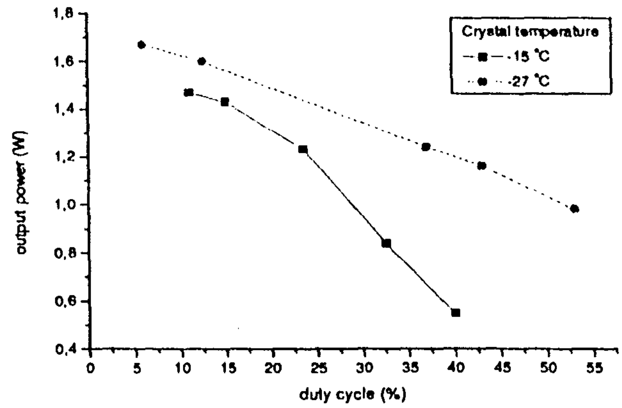

Fig 2: Output power as a function of crystal heatsink temperature. The laser duty cycle is 10 %.

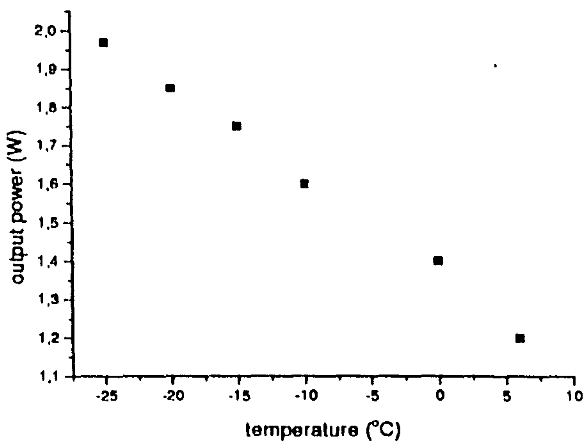

Fig 3: Output power as a function of laser duty cycle for two crystal heatsink temperatures.

Detuning the diode from the Tm absorption peak permitted us to increase the duty cycles. With the diode at 32°, we achieved continuous operation, with output power of 300mW.

We also verified the influence of volume pumping in the crystal. A 25 mm focal length biconvex spherical lens in the place of the 38 m generate a smaller beam waist (w_x=250 w_y=144). However, it was not possible to reach higher duty cycle than 60%.

Our next step is to pump the laser crystal from both sides in order to decrease the crystal's temperature. Our goal is thus to achieve 1 watt of cw output power as expected from figure 2.

Conclusion

We report on pure cw operation of a 2 μm Tm:Ho:YLF laser pumped by a 20 watts diode bar. Our projections show that, if we pump the laser from both side, the temperature rise to small enough to permit a compact system with watt-level continuous operation at 2 μm.

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