High efficiency diode-side-pumped Nd^{3+}:$YLiF_4$ laser at 1053nm

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Diode pumped lasers operating in fundamental mode have applications such as material processing, medical and LIDAR. Good beam quality is achieved with the longitudinal pumping configuration that permits good overlap between the laser and the pump mode. On the other hand, this pump scheme is limited with respect to power scaling due to thermal effects. This difficulty can be solved using a side pumped configuration at the expense of beam quality. Only few configurations exist that permit good beam quality and high efficiency with side-pumping. Dergachev et al. have demonstrated a side pumped Nd:YLF laser operating at 1053nm with 20W of cw output power at 64W of pump power, resulting in 31% optical efficiency [1]. The emission at 1053nm has the advantage of a weaker thermal lens compared to 1047nm, resulting in a 2.3x smaller dioptric power [2]. In this work, we describe a very compact cavity with two total internal reflections inside the crystal and demonstrate 6.9W of output power in fundamental mode, which results in 33% optical-to-optical efficiency and 42% slope efficiency.

The laser crystal used was a home-grown Nd:YLF with 0.8mol% Nd^{3+} doping and dimensions of 14mm x 13mm x 3mm. A Brewster angle at the entrance of the beam into the crystal creates an efficient selection mechanism for the 1053nm transition. The pump source was a cw 20W TM polarized diode bar operating at 792nm. The crystal c-axis was parallel to the diode's polarization in order to access the higher absorption cross-section. Operation was cw up to a pump power of 16 W above which we used qcw pumping with parameters of 7% duty cycle and 2ms pump pulse duration to prevent crystal fracture (refrigeration was only from the bottom crystal facet). The diode beam was focused into the crystal by a f = 2.5 cm spherical lens.

The crystal was side pumped with two different configurations. In the first experiment, a compact plano-convex cavity with a 30cm ROC high reflector mirror and a flat output coupler with 7% transmission were used in a single pass configuration (Fig. 1a). Fundamental mode was achieved in a double pass configuration using an additional flat high reflector mirror (M3) and a 3m ROC folding mirror (Fig. 1b).

With a single pass inside the gain media, an output power of 9.5W, resulting in 45% optical-to-optical efficiency and 49% slope efficiency was achieved. The beam quality was multimode with a M^2 of 61 × 1.65 in the horizontal and vertical, respectively. An output power of 6.9W in fundamental mode, M^2 of 1.16 × 1.05, was obtained the double bounce configuration. In summery, in both cases the obtained efficiencies correspond, to the best of our knowledge, to the highest efficiencies reported in the literature for diode side-pumped Nd:YLF lasers operating at 1053 nm.

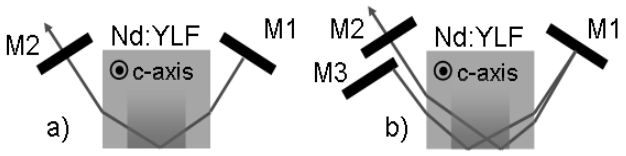

Fig. 1 : Scheme of the single (a) and double (b) bounce configuration.

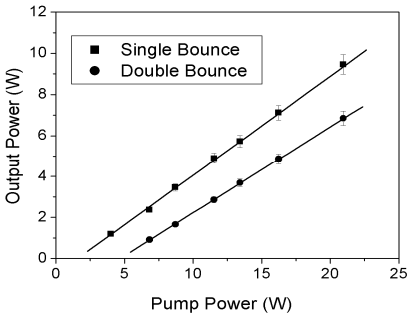

Fig. 2: Output power versus pump power for single and double bounce configurations.

References

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978-1-4244-4080-1/09/$25.00 ©2009 IEEE