High-power qcw-side-pumped Nd:$YLiF_4$ laser with over 50% efficiency using mode-controlling

A. M. Deana[1], *N. U. Wetter*[2]

1. *University Nove de Julho, 109 Dr. Adolpho Pinto, São Paulo - SP, Brazil*

2. *Institute for Nuclear and Energetic Research, CNEN-IPEN/SP, 2242 Av. Prof. Lineu Prestes, São Paulo - SP, Brazil*

The development of high-power Q-switched lasers with short pulse duration of less than ten nanoseconds showing a high degree of power scalability whilst maintaining diffraction limited beam quality and high repetition rates is still a major field of research among laser developers. Among the most common resonator designs are the longitudinally diode-pumped laser, which shows some restrictions with respect to power scaling of the TEM_{00} mode due limited access of the pump beam to the resonator mode, and the diode-side-pumped laser that usually suffers from small overlap between the fundamental mode and the pump laser and therefore, generally has poor beam quality and/or low efficiency during fundamental mode operation. There are only a few designs that allow for efficiency and power scalability of the TEM_{00} mode employing a side-pumping configuration, the most successful design being de grazing incidence laser developed by Damzen et al [1].

In this letter we present a new laser design based on a side pumping configurations that employs a 1 mol% doped Nd:$YLiF_4$ slab in a double-pass configuration. The design allows power scalability of the fundamental mode without the insertion of any additional mode-selective devices into the resonator. The resonator achieves single transversal mode by well calculated screening of the inverted population inside the crystal by the two passes of the fundamental mode in such a manner that any higher order mode encounters insufficient gain to oscillate without insertion of additional losses inside the resonator. The schematic of the laser cavity, including the 40 W - 797 nm diode, is seen in figure 1a. Figure 1b shows the input-output curve for this cavity. Figure 1c shows the dependence of fundamental mode operation with beam separation inside the crystal for a 792 nm pump diode.

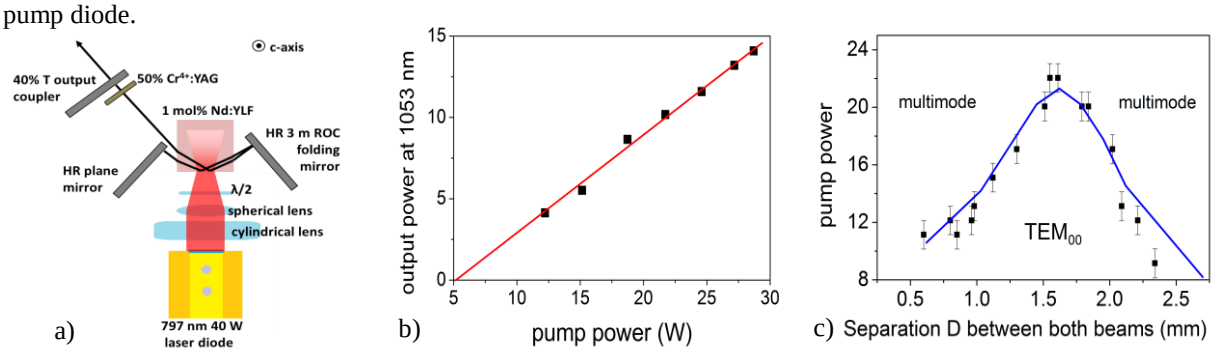

Fig. 1 a) Schematic diagram of the resonator. b) Input-output power curve. c) TEM_{00} mode operation as a function of pump power.

In this work we report record qcw-efficiency in excess of 50% using a 20% output coupler. In earlier works we already showed good results under cw operation and Q-switched operation: By using a Cr^{4+}:YAG saturable absorber of 50% initial transmission inside the laser cavity and a 40% output coupler we were able to obtain Q-switched laser pulses of the order of 10 ns with up to 2.5 mJ at 1053 nm [3]. Changing the saturable absorber to 70% initial transmission, the repetition rate could be increased to 1 kHz while pulse energy and duration were 1.1 mJ and 14 ns, respectively [4].

In conclusion, this is a very robust and simple cavity with a small footprint (10 cm x 13.5 cm are possible), which is based on a new resonator design and that permits the highest efficiency, to our knowledge, reported in either longitudinal or transversal pumping of Nd:$YLiF_4$ [5,6].

References

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