Diode side-pumped, high efficiency Nd:YVO_4 laser and improvement in beam quality

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Diode pumped solid state laser are developing at a very fast rate. At the same time, materials that in some aspects have better characteristics than Nd:YAG are on the market such as Nd:YVO_4, Nd:$GdVO_4$, Yb:YAG and others. Within the existing variety of geometries and gain materials there is one combination that is particularly interesting because of its reduced complexity and high efficiency: the edge-pumped slab-laser using grazing-incidence geometry and a gain media with a very high pump absorption cross-section. Previously, we demonstrated high efficiency in multimode with a side-pumped Nd:YVO_4 laser using a grazing incidence geometry [1]. In this work, we describe a compact cavity with high slope efficiency with one pass inside the gain media and a significant improvement in beam quality with a novel cavity with only three mirrors and a second pass inside the gain media. Moreover, this cavity uses joint stability zones, giving therefore almost constant beam parameters throughout a wide range of pump powers.

The laser crystal is a Nd:YVO_4 with 1.1 at.% neodymium doping with dimensions 22×5×2 mm^3. The end faces (5×2 mm^2) have AR coating for the 1064 nm laser. The crystal is pumped on the 22×5mm^2 edge face, which has AR coating for the 808 nm wavelength. The pump source is a 48 watts TM-polarized diode bar operating at 808 nm with the TM polarization parallel to the c-axis of the crystal.

In a first experiment we used two mirrors, one flat mirror with 36% transmission and other of 50cm radius of curvature. We did one single pass through the gain media with one total internal reflection (figure 1). This cavity was very compact with less than 8 cm. In a second experiment we used a double pass configuration with a second total internal reflection at the pump face. We used a novel configuration with only three mirrors (figure 1). A 6.4 mm cylindrical lens was used in front of the diode bar in order to focus the pump radiation into the crystal in both configurations.

Fig. 1: Cavities configuration: **a)** Single bounce: 1) end mirror (R=50cm); 2) plane output mirror with 36% transmission; **b)** Double bounce: 1) folding mirror (R=50cm); 2) high reflector (plane mirror); 3) plane output mirror with 36% transmission.

In the first experiment we achieve 21.9 watts output power in multimode to a pump power of 45 watts (figure 2). A high slope efficiency of 69% was achieved. The value of the M^2 was 24.6 × 10.4 (HxV). Using a second pass we achieved 17 watts of output power. The beam quality was improved and almost spherically symmetric, with a M^2 of 3.4 x 3.8. In figure 2 we see input-output curves of both cavities and the joint stability zones of the second cavity. This double bounce cavity is very compact, with only three mirrors, and can be compared with the cavity used by Damzen et al. [2] that used four mirrors.

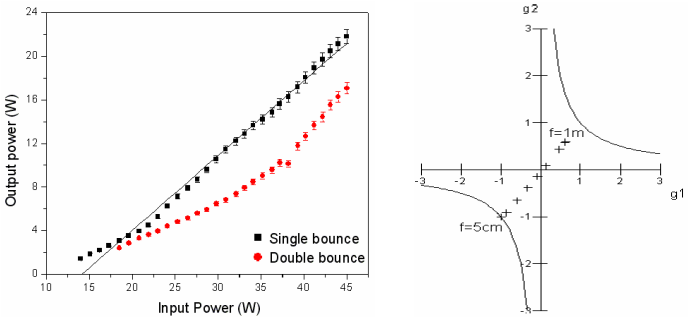

Fig. 2: Output power versus diode pump power for a single bounce configuration (■) and double bounce configuration (●) and stability diagram and zones (I and II). 1/f is the dioptric power of the thermal lens.

We conclude that this compact three-mirror cavity improves the beam quality and the beam stability while achieving very high efficiency.

Reference

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[2] A. Minassian, B. Thompson, M. J. Damzen, "High power TEM_{00} grazing-incidence Nd:YVO_4 oscillators in single and multiple bounce configurations", Opt. Comm. **245**, 295-300 (2005).

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