Multi-Pass 1.9 µm Tm:YLF Slab Laser Pump Source

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Abstract: A novel multi-pass Tm:YLF laser was demonstrated with an improvement in efficiency, footprint and cost over a two diode stack pumped, single pass systems. We report 100 W of output power from 261 W of incident diode pump power with a slope efficiency of 44%.

1. Introduction

High-power 1.9 µm Thulium doped lasers are most frequently used to pump Ho doped materials to generate high energy 2 µm pulses [1]. This is because Ho doped lasers can not be pumped with readily available diode lasers. Thulium doped lasers can be pumped with ~793 nm diode lasers and have the advantage that Thulium exhibits a cross-relaxation process which creates two ions in the upper laser level for each pump photon absorbed. YLF is an attractive host material since it has a relatively weak thermal lens. Resonators can therefore be designed which have robust outputs over a wide range of pump powers. However YLF has a relatively low fracture limit which restricts the allowable pump power. The low fracture limit can be compensated for by using a slab crystal geometry. A record breaking dual-end-pumped Tm:YLF slab laser pumped by two 300-W diode stacks which delivered over 200 W output power [3] was recently demonstrated. However, a large percentage of pump power (25 to 30%) was not absorbed in the crystal and was therefore wasted. A novel multi-pass Tm:YLF laser pumped by a single 300 W diode stack is proposed as an alternative to this design. The new multi-pass pump design effectively feeds the pump beam from a 300 W *nLight* diode stack into its own quasi-resonant cavity (Figure 1 without the left-most mirror). Polarisation techniques are used to keep the pump light inside this cavity for a maximum of four pump passes, after which nearly all the diode power is absorbed. Two different slab laser crystals were tested, one was 19 mm and the other 16 mm long in the pump/laser direction, at first in a single-pass configuration. In the double pass setup, only the 16 mm crystal was tested, since it had sufficient pump absorption and a longer crystal would have the disadvantage of a higher threshold due to the quasi-three-level nature of Tm:YLF.

2. Results

Figure 2 plots the results of four different configurations. Three different single pass setups were tested using different crystals and pump polarizations. Changing the pump polarization did not make a significant difference in the output power. However, changing to a shorter crystal delivered the same output power with less absorbed pump power (86% vs. 78% at full pump power). By re-imaging this transmitted power back into the crystal, the slope efficiency increased from 39% to 44% and the amount of absorbed pump power increased to 97% (Figure 2).

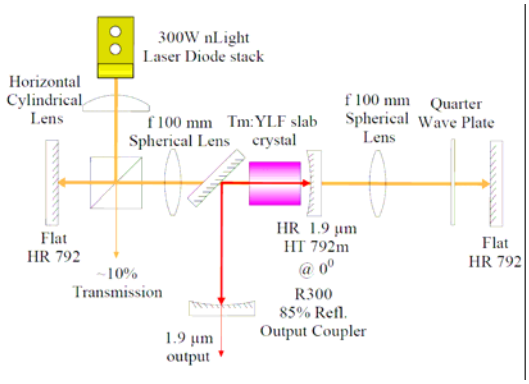

Fig. 1: Experimental setup of the multi pump pass slab laser

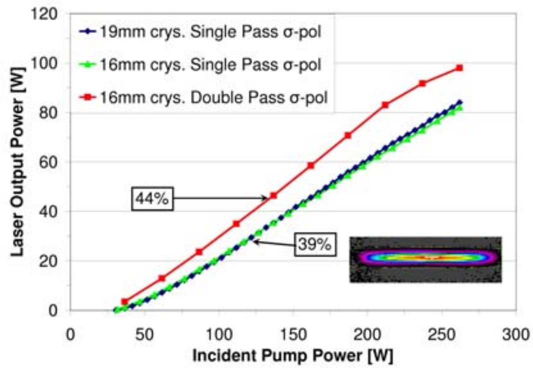

Fig. 2: Output powers of various Tm:YLF slab lasers.

The efficiency can potentially be improved further by using an even shorter crystal and inserting a second flat high reflector to re-image the remaining pump power in a four pass setup (Figure 1). The multi-pass architecture is therefore an energy efficient, less expensive and more compact replacement for single pump pass Tm:YLF lasers currently in use.

3. References

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