High power Yb:CALGO multi-crystal oscillator

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High energy lasers are important for many applications ranging from micro-machining to surgery to non-linear optics. In regenerative amplifiers reaching mJ energies, the intracavity non-linearities become important. To minimize those, high stretching factor and increased spot sizes are needed in the crystal, the latter reducing gain at fixed pump power. To keep up the gain and increase the extractable energy, the pump power is increased, leading to higher thermal load in the laser medium. The host CALGO, with a thermal conductivity of 6.3 W/m/K [1], and a lifetime of 420µs, is better qualified for an amplifier crystal than KYW or YAG. The emission spectrum is broadband and lasing was demonstrated between 1018nm and 1052nm [2]. High power with good beam quality, as well as 192fs short pulses and 1.3µJ energy, were obtained from a thin-disk oscillator [3], and 12.5W with sub-100fs pulses have been extracted out of a single-crystal cavity at 80MHz repetition rate [4].

We report here what is, to our knowledge, the highest power generated by a bulk Yb:CaAlGdO4 oscillator, to be later used for a regenerative amplifier aiming at the multi-mJ level. To overcome the thermal effects in a single crystal, the thermal load is distributed between two shorter crystals in a symmetric resonator, as demonstrated in [5]. The cavity is designed so that the spot sizes in the crystals and on the end-mirrors are insensitive to a change of the thermal lens, evaluated experimentally to be 320mm during lasing operation.

The laser is based on two 2% doped Yb:CALGO crystals pumped by a 120 W, fiber-coupled diode laser. The pump laser output is split into two beams for symmetric pumping of both crystals. The spot sizes were increased up to 300 µm radius to later decrease the non-linearities in the regenerative amplifier. The short cavity, consisting of both crystals, dichroic mirrors, identical curved mirrors and output couplers, is extended on one arm with a 4f telescope, imaging the beam parameters onto the end mirror of the long cavity.

From 44W absorbed in both crystals for an incident pump power of 114W, we extracted 22.8W at a wavelength of 1042nm in the short cavity. The slope efficiency was measured to be 35%.

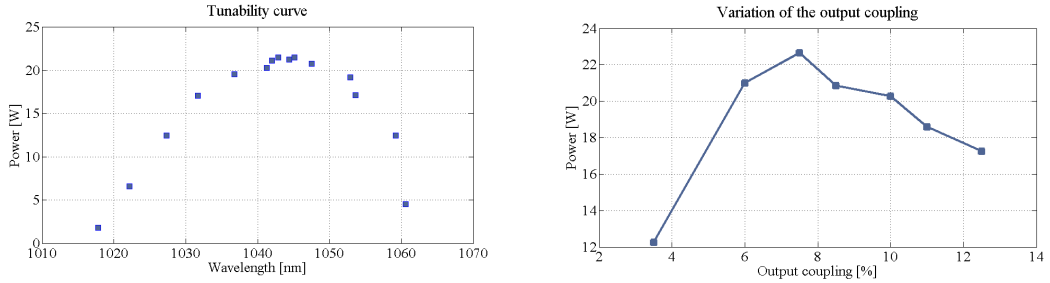

Fig. 1 The left-hand figure represents the tuning curve and the right-hand one the output power versus output coupling.

Figure 1 shows the tuning curve, i.e. output power versus wavelength, using a birefringent intracavity filter. The output power is greater than 15 W for wavelengths between 1030 nm and 1055 nm. At a wavelength of 1052.9 nm, the output power of 19W exceeds previously demonstrated from [2]. The laser was tunable from 1018 nm to 1060.6 nm, which is the largest tuning range demonstrated with this laser crystal. At optimum output coupling of 7.5% the laser emits 22.8W of power, similar to the output power demonstrated with a Yb:CALGO thin-disk laser. The measured beam quality in both axis was M=1.2, measured with second-moment algorithm.

In conclusion, we demonstrated experimentally an Yb:$CaAlGdO_4$ oscillator in dual crystal configuration delivering nearly 23W of output power with good beam quality, tunable between 1018nm and 1060nm.

References

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