High Peak Power Sub-Nanosecond MOPA Laser System

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Sub-nanosecond (< 1 ns) high peak power (> 1 MW) laser pulses are interesting for many industrial, scientific and military applications. Instead of scaling up the output power of an oscillator which would cause higher mechanical and optical stress on the intra-cavity components, a reliable solution is an extra-cavity amplification of a seed generated by a low average power and robust oscillator (Master Oscillator Power Amplifier, MOPA). Furthermore, the development of very high gain diode-pumped amplification modules offers new reliable, cost effective and simple solutions for pulse amplification. Owing to the effective gain confinement near the pump side in highly absorbing media with large stimulated emission cross section, grazing-incidence side-pumped slabs offer high gain per pass as well as effective gain averaging in the direction of the pump absorption [1,2]. This approach is straightforward, flexible and power-scalable.

In order to achieve relatively short, high-peak power pulses, we developed the MOPA system shown in Fig. 1(a). The master oscillator (MO) was either an actively Q-switched Nd:YVO_4 laser, longitudinally pumped by a 40-W cw diode laser array, generating 150-µJ, 780-ps long pulses (see Fig. 1(b)) or a Cr^{4+}:YAG passively Q-switched Nd:YAG laser, longitudinally pumped by a pulse-driven 40-W diode laser array, with 55-µJ, 600-ps long pulses (see Fig. 1(c)). Both oscillators worked in the frequency range from 1 kHz to 10 kHz.

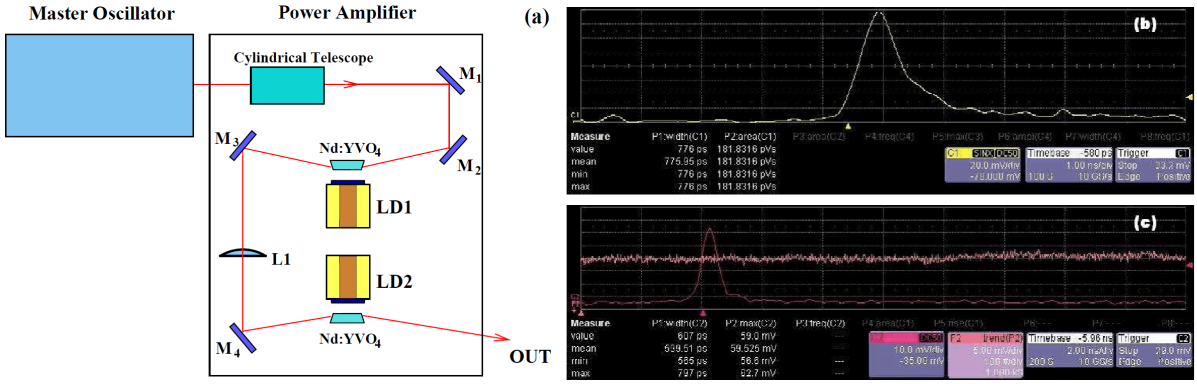

Fig. 1 (a) System setup: M1, M2, M3, M4: turning mirrors; LD1, LD2: laser diodes; L1: focusing lens. Oscilloscope traces of the actively Q-switched laser pulse at 10 kHz (b) and of the passively Q-switched laser pulse at 10 kHz (c).

The power amplifier stage layout was the same in both cases. The amplifier was based on a couple of 4x2x15 mm^3 Nd:YVO_4 slabs, 1%-doped, 5° wedged, in a grazing-incidence configuration. Each slab was pumped by a cw laser diode array polarized parallel to the slab c-axis, tuned at 808 nm. Two different collimation lenses have been used for each amplifier laser diode. In the first module, the goal was to maximize the gain and so a tighter pump sheet was required. In the second module, a larger pump sheet was desirable to better match the larger seed waist required to avoid damages in the gain medium due to the higher pulse energies.

In the case of the actively Q-switched MO, the diodes could provide a cw power up to 40 W. At a maximum energy injection of 115 µJ, we obtained up to 880 µJ pulse energy, corresponding to average power as high as 8.8 W at 10 kHz repetition rate. No distortions in the pulse shape and in the beam quality have been observed. Efficient nearly diffraction-limited second harmonic generation at 532 nm with 4 W has been achieved. The absence of any degradation in the beam quality indicates that power-scaling via the increase of pump power should be easily achievable, obviously being careful to the damage threshold.

Instead, in the case of the passively Q-switched MO, we employed a couple of 60-W cw diode arrays, since the injected seed energy was lower than in the previous experiment. We obtained up to 1-mJ pulse energy at 10-kHz repetition frequency corresponding to an average power of 10 W in a diffraction-limited, single-longitudinal mode operation. The output pulse energy and power were about twice that reported in our previous work [3].

References

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