Table-top all-diode-pumped MOPA laser for generation of high-energy, high-frequency picosecond pulse trains

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Laser systems providing hundred or thousand nanosecond-long macro-pulses containing trains of intense (10-100 μJ) picosecond pulses can be very interesting for many scientific, industrial and medical applications. Incidentally, this kind of performance is most usually provided by complex and expensive Free Electron Laser (FEL) facilities. In this work we describe a different solution based on a master-oscillator power-amplifier (MOPA) all-solid-state modular laser system [1].
The basic concept is the high-energy amplification of a macro-pulse ($\approx 10^3$) of picosecond pulses, obtained with fast acousto-optic modulation from a low-power cw diode-pumped oscillator at 1064 nm. Compact diode-pumped SESAM passively mode-locked Nd:YVO_4 based picosecond oscillators operating either at 450 MHz, 1 or 5 GHz repetition rate have been developed and tested as seeders. It is worth noticing that the modular architecture approach typical of MOPA systems easily allows MO substitution without affecting the subsequent stages behavior. Furthermore, low-average-power rugged picosecond fiber-lasers can be employed whenever system robustness become an issue. A computer-programmable electronic control of the acousto-optic pulse-picker has been developed to enable selection of self-shaping of macro-pulse trains with length > 100 ns and typical energy of 100 nJ at 1 μs duration at 100-Hz repetition rate, for compensation of amplifier distortions. Macro-pulse amplification relies on high-gain side-pumped Nd:YVO_4 or Nd:YAG grazing-incidence bounce amplifiers. Such amplifiers yield very high gain per pass $>10^3$ and offer excellent beam quality preservation owing to the total internal reflection leading to left-right beam symmetrization. This technology allows the realisation of compact, efficient and modular amplifiers, significantly simpler than, for example, cavity-based regenerative schemes. Employing three slab amplifiers each pumped by a quasi-cw 150-W peak power diode array, we amplified macro-pulses up to 2 mJ, preserving both near diffraction limited beam quality and pulse duration < 10 ps at 5 GHz. Further amplification, from tens up to few hundreds mJ, are obtained employing properly up-scaled diode-stack pumped bounce amplifiers. Both experimental results and numerical simulations will be reported.
Such pulse trains are very effective for synchronous pumping of optical parametric oscillators in the mid-infrared at 6.5 μm, as requested by novel promising surgical techniques [2], first demonstrated through experiments with a FEL. Laser system performances are also suitable for photocathode RF gun injection [3], for instance to seed intense electron beams for subsequent generation of short-pulse X-ray beams by Thomson scattering.

References

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