High energy amplification of ultrafast pulses in a planar waveguide geometry

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We present an energy-scalable ultrafast Yb:YAG MOPA system for material processing applications. The system consists of a dual-side-pumped Yb:YAG planar waveguide (PWG) amplification stage that is seeded by a commercial laser, pre-amplified by a dual-end-pumped Yb:YAG single crystal fibre (SCF). The SCF is pumped by two 80 W fibre-coupled laser diodes and amplified the seed (344 fs pulses, 10 MHz, 140 nJ to 1.4 µJ) in a single-pass configuration). Thermal lensing, astigmatism and depolarisation within the SCF was analysed and compensated for by careful selection of beam-shaping optics. The PWG crystal consists of a 12 mm long, 150 µm high 2 at. % Yb:YAG core bonded top and bottom to sapphire cladding. The core is side-pumped using two 540 W phase-corrected diode stacks such that a uniformly distributed high gain was achieved. The advanced crystal design suppresses intra-crystal parasitic oscillations and the PWG geometry significantly alleviates thermal lensing for high amplification. The seed is multi-passed through the system and the mirror parameters were carefully chosen to optimise gain extraction was observed. The seed path is scalable up to 7 passes through the crystal for which 8.7 µJ per pulse was achieved at a pump power of 860 W for sub-ps pulses at 10 MHz. Current investigations include suppression of unwanted parasitic oscillations between the multi-pass mirrors to improve the output beam quality. Future work is aimed at the inclusion of kHz burst modes of sub-ps pulses at 1MHz repetition frequency.