Technology Offer

Hybrid Thin-Disk Amplifier

Ref.-No.: 1202-4510-WT

Ultrafast amplifier systems providing high average powers (>10W) at repetition rates in the kHz regime suffer from severe accumulation of nonlinear phase inside the laser gain medium and other optical components within the amplifier. Implementation of chirped pulse amplification (CPA) constitutes a well-established method to reduce the peak intensity of the laser pulse during the amplification process [1, 2]. However, state of the art laser materials supporting high average output powers such as Yb:YAG deliver output pulses in the picosecond regime. Implementation of CPA in these systems is expensive due to the costs of the highly dispersive optics required for stretching and compressing the picosecond pulses. The thin-disk technology in combination with a regenerative amplifier reduces the accumulation of nonlinear effects in the laser gain medium to a minimum. However, the indispensable electro-optical switch (Pockels cell) still requires the large and complex dispersive delay lines for amplification to the multimillijoule level [3, 4, 5, 6]. Multipass amplifiers allow amplification without this switch but rely on geometric displacement to guide the beam several times (10-40) through the gain medium. These amplifiers provide exceptional performance [7], but are very limited in the overall gain needed to boost oscillator pulses from nano/micro-joule energies to the multimillijoule level.

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The patented hybrid technology overcomes this limitation exploiting the advantages of a thin-disk regenerative amplifier in combination with a multipass system. The system amplifies pulses within the cavity of the regenerative amplifier. Before accumulating destructive nonlinear phase distortions, a multipass system using the same active amplification volume as the regenerative amplifier boosts the pulse energy to a level inaccessible inside the regenerative amplifier. The absent electro-optical switch in the high-energy amplification process allows amplification without the need for CPA. Thus, this concept permits renouncing chirped pulse amplification leading to a compact setup including advantages in costs, stability and complexity of the system by abandoning stretcher and compressor units.

Figure 1 shows a schematic picture of the laser amplifier. The amplification process starts with a seed oscillator (red). Such laser oscillators deliver pulse energies from a few nanojoules (fiber oscillators) up to a few microjoules (thin-disk oscillators). An optical isolation stage and an optical switch couple the seed oscillator to the cavity of the regenerative amplifier. The Pockels cell then traps the pulses inside the resonator and the pulses remain in the resonator (figure 1, blue) until they reach energies of ~100µJ-1mJ. Once the pulses leave the regenerative amplifier, the optical isolator separates input and output beam paths and sends the pulses to the multipass amplifier (figure 1, green). Within several passes (2-40, depending on the needs) the remaining stored energy of the thin-disk is extracted boosting the pulse energy up to the multimillijoule level.

A prototype has successfully been tested showing amplification up to 6.5 mJ pulse energy at 5-10 kHz repetition rates within a simple multipass geometry incorporating up to 40 passes through the gain medium [8]. These energy levels are competitive to standard systems based on CPA proving the validity of the concept and paving the way to compact powerful laser sources.

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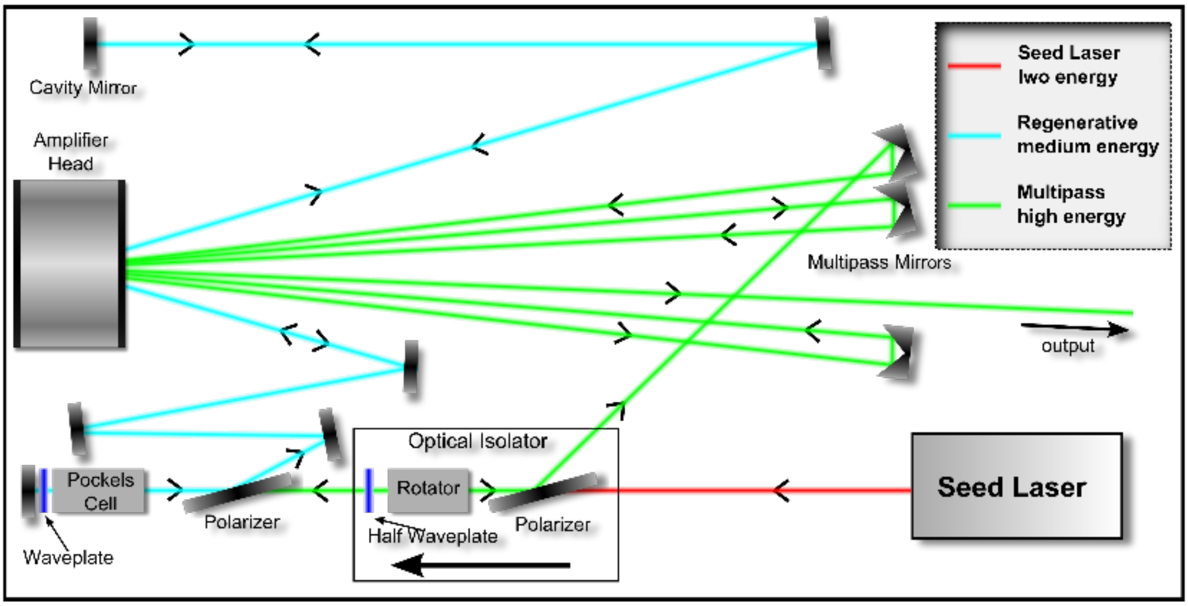

Figure 1: Schematic picture of the invention. The different sections are marked in red, blue and green. Red: Seed beam with low energy. Blue: Amplification in the regenerative amplifier. Green: High-energy multipass amplification.

Patent Information

Granted patents EP 2873123 (validated in CH, CZE, DE, FR, GB, HU); US 9450367; patent application in KR.

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