HYBRID 1.5 KW USP LASER: FIBER – INNOSLAB – THIN DISK

Task

Increasing the average output power of ultrashort pulse lasers (USP lasers) is one approach to meet the challenge of reaching economical process speeds in ultrashort pulse laser processing. In addition, fundamentally new possibilities are opened up by the combination of USP and high-speed machining.

Method

In an ytterbium-based USP laser, fiber oscillators and low power preamplifiers have been combined together with INNOSLAB amplifiers with high amplification and a thin disk amplifier with high average power.

A commercial USP fiber laser with 7 W output power and 400 fs pulse duration is amplified by two INNOSLAB amplifiers to 630 W output power and M^2 = 1.2. The subsequent disk amplifier makes it possible to increase the power into the multi-kW range. The amplification by the Yb:YAG thin disk – 5 percent per pass – requires a multiple folding of the seed beam to be amplified via the disk. The compact multi-pass arrangement developed allows 18 passages of the disk at a comparatively low overall beam path of 22 m. One rotation of the slightly elliptical (1:1.2) seed beam between each passage ensures that the inversion of the disk is spatially homogeneous.

1 Detailed view of the multi-pass arrangement of the disk amplifier.

Result

With the system described here, an average power of 1.5 kW was achieved in the initial tests; the pulse duration is 710 fs, the beam quality is M^2 = 1.5 x 2.0 – this is the highest average power ever reached in an ultrashort pulse laser. At a pulse repetition rate of 40 MHz, this corresponds to a pulse energy of 37.5 µJ. The overall gain of the disk amplifier is currently 2.4 and is not limited by the pump power but only by the maximum gain per pass. With a double passage through the multi-pass arrangement, the power can theoretically be increased to > 3 kW. Fraunhofer ILT is currently preparing the necessary improvement of the optical insulation in the amplifier stages among each other.

Applications

Laser systems of the power class > 1 kW are suitable for composite materials without causing them great damage, removing dielectrics or blackening of metals and semiconductors by generating surface structures. The disk and the associated pump module were provided by the company TRUMPF Laser GmbH for the experiments.

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