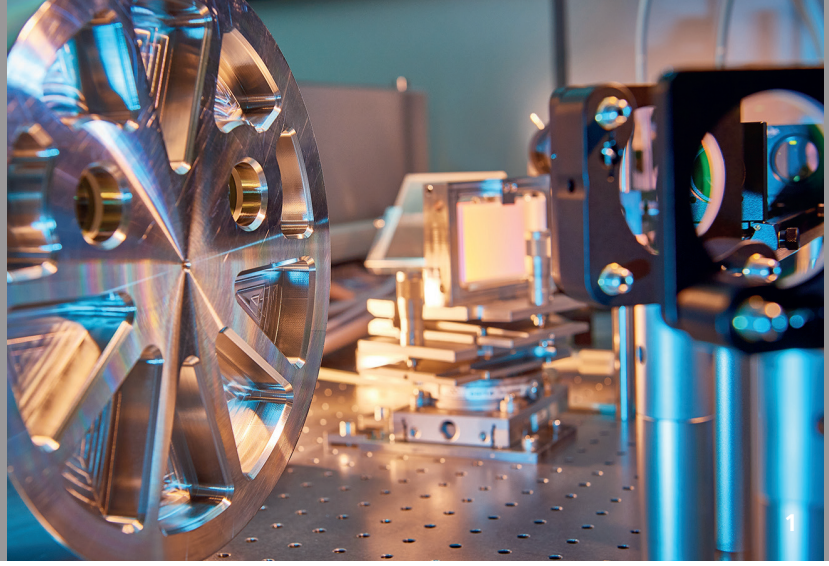

SCALABLE ULTRASHORT PULSE LASER WITH < 30 FS PULSE DURATION AND > 500 W OUTPUT POWER

Task

Based on ytterbium-doped laser media, ultrashort pulse lasers with pulse durations < 1 ps have become well established in many scientific and industrial applications. Since their power can be scaled up to the kW range at repetition rates of several 100 kHz, they offer high throughput and short measurement times in industry and science at reduced costs per watt. Within the Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS, this potential shall be tapped for applications requiring significantly shorter pulse durations below 100 fs.

Method

Although pulse durations < 100 fs can be directly addressed by other laser materials such as Ti:sapphire, their power is limited to values below 100 W. Therefore, nonlinear pulse compression of powerful ytterbium-based ultrashort pulse lasers offers a clear advantage, which can be implemented by spectral broadening in a gas-filled multi-pass cell with subsequent compression by dispersive mirrors. Compared to other compression schemes, this method is particularly well suited for high powers due to its high efficiency > 90 percent and the absence of limiting apertures.

Results

To demonstrate the scalability of the approach, Fraunhofer ILT developed and built a laser system based on a commercial ultrashort pulse laser, a 2-stage Yb:INNOSLAB amplifier and nonlinear pulse compression. This system consists of a gas-filled (4 bar argon) multi-pass cell (800 mm long, 22 roundtrips) and a compressor with 9 dispersive mirrors. The pulses of the laser system – at 590 fs pulse duration and 1.1 mJ pulse energy – are hereby compressed to 30 fs at 1.06 mJ pulse energy (26 GW pulse peak power). At a repetition rate of 500 kHz, the output power is 530 W with an almost unchanged beam quality M^2 < 1.2.

Applications

The laser system presented here can be used profitably if particularly short or broadband pulses with high average power are required. This is especially true for nonlinear processes such as frequency conversion to MIR, EUV or the generation of THz radiation. A further scaling of the average power to ~ 2 kW at similar repetition rates is planned.

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1 Pulse compression unit.