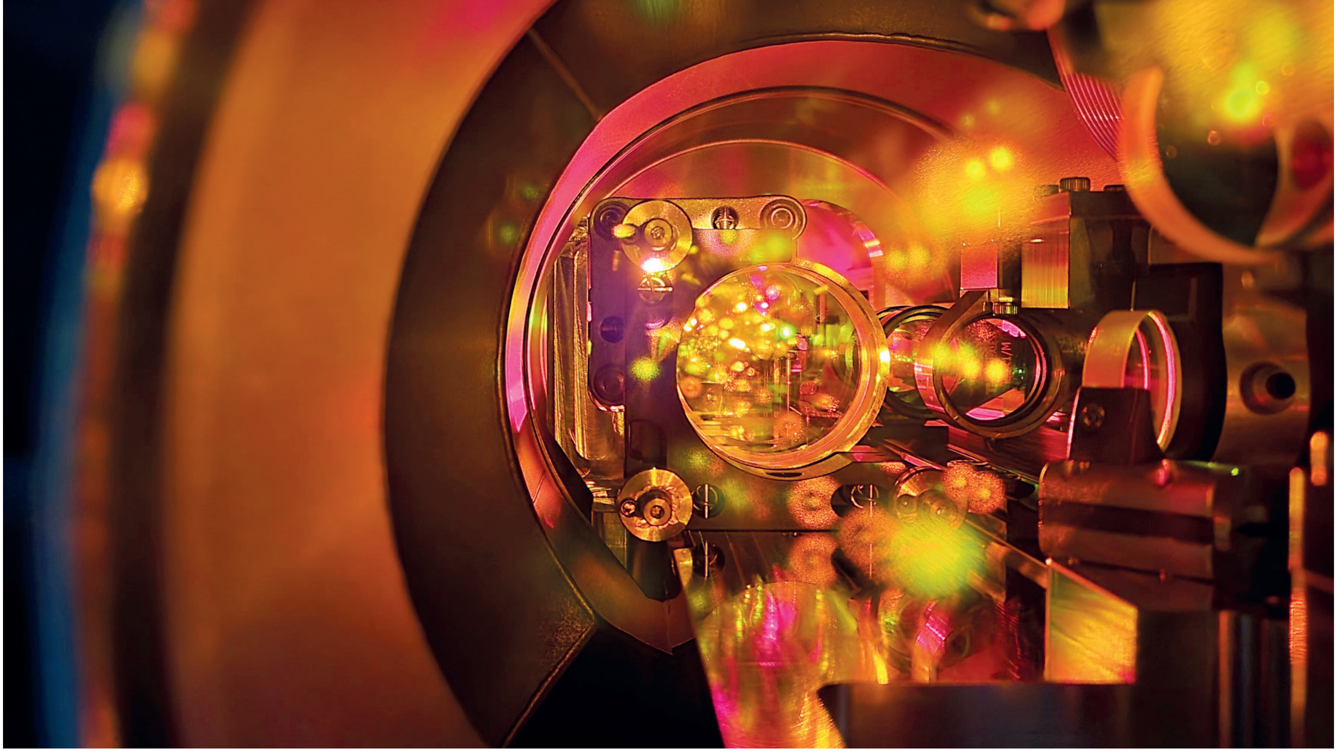

View through an observation window during MPC operation.

Development of a multipass cell for pulse compression in the near infrared range

In recent years, there has been an increasing interest in laser sources with a high pulse energy and high repetition rate in the shortwave infrared range (1.4–3 µm) for scientific and industrial applications. Compared to the 1 µm wavelength of established radiation sources, the longer wavelength offers fundamental advantages for some nonlinear conversion processes such as THz or soft X-ray generation. Moreover, pulse durations of only a few cycles per pulse are required for efficient frequency conversion, e.g., by generation of high harmonics (HHG). However, lasers based on thulium (Tm)-doped fibers or crystals emitting at 2 µm cannot directly generate these short pulse durations.

Shortening the pulse duration with a multipass cell

Besides spectral broadening in gas-filled capillaries, multipass cells (MPC) have emerged as an approach for subsequent pulse duration shortening. They preserve the beam quality of the input beam and offer the highest overall transmission of all pulse shortening techniques. Fraunhofer ILT already showed this, at 1 µm wavelength, during the first demonstration of this technique in 2016. However, as things stand today, neither more than 1 mJ pulse energy nor more than 100 W average power was spectrally broadened at 2 µm wavelength in an MPC and subsequently compressed.

Great potential of MPC technology

With a Tm fiber laser from Fraunhofer IOF, it was possible to spectrally broaden pulse energies of 1.6 mJ at a repetition rate of 100 kHz at a wavelength of 1.9 µm in a krypton-filled MPC. With subsequent temporal compression, an overall transmission of 95 percent with pulse durations of 25 fs was achieved, corresponding to four optical cycles. These unique results demonstrate that the MPC technology can be transferred and has enormous potential in the short-wavelength infrared range. Furthermore, these results represent an important milestone on the path to efficiently generating soft X-rays in the water window. The R&D project underlying this report was carried out on behalf of the German Federal Ministry of Education and Research (BMBF) under the grant number 01DR20009A.

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