Investigation of advanced radiation source technologies in the Solid state laser laboratory

Aleksėj Rodin, Paulius Mackonis, Augustinas Petrulėnas and Augustė Černeckytė

Department of Laser Technology, Center for Physical Sciences and Technology

Few-cycle, TW-class laser sources in the wavelengths range ~1.3 – 3.5 µm [1–3] are in demand for highly efficient generation of THz and attosecond X-ray pulses, particle acceleration and remote detection of gases using filamentation of chirped pulses in air. To achieve maximum efficiency of modern solar cells, studies of hot carrier excitation in this spectral range are also important. Low throughput and high sensitivity of functional surfaces to environmental influences after laser micro- and nanotexturing [4–6] encourage the search for promising methods for generating and amplifying laser radiation [7], in order to bridge the gap between scientific laboratories and industry. Such a wide range of fundamental [1–3] and applied [4–7] problems has led to the search for promising technologies of radiation sources in the Solid State Laser laboratory, which is reflected in scientific papers published last year [1–7].

Using a Lithuanian-invented Optical Parametric Chirped Pulse Amplification (OPCPA), we have demonstrated a compact, highly efficient ~27% mid-IR laser [1] with a pulse width of <25 fs (Fig. 1) and an energy of ~2.5 mJ, corresponding to ~3 optical cycles and intensity ~0.1 TW. The system is based on a Yb:YAG pump laser, BiBO crystals and supercontinuum generation. To further extend the spectrum above ~3 µm, stimulated rotational Raman scattering (SRRS) in gaseous media is used [2] (LMT project "TERRA: Towards advanced high-intensity mid-IR laser architectures"). This method, upgraded in our laboratory for broadband femtosecond pulses, not only provides coverage of hard-to-reach spectral ranges [2] with further compression to tens of femtoseconds, but also improves the efficiency of OPCPA [3], which is especially important in the mid-IR spectral range and is used in LIDARs (Lithuanian – Spanish – Finnish NATO-SPS project "Tuned optical sensors for detection and identification of airborne hostile agents").

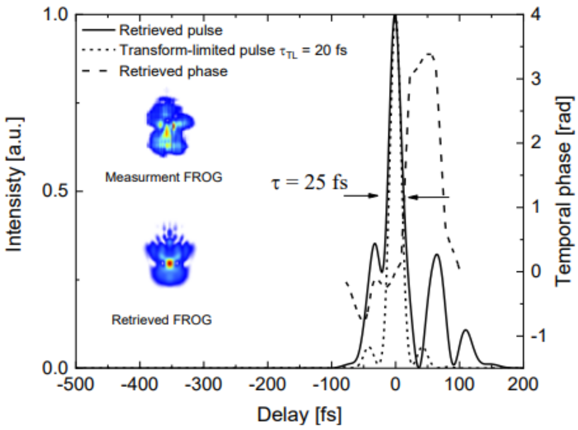

Fig. 1. Temporal envelope of femtosecond laser pulses at ~2.2 µm wavelength using SHG-FROG measurement.

The insufficient resistance of self-hydrophobic surfaces to UV exposure after laser micro- and nanotexturing is overcome by chemical treatment [4–6] (LMT Lithuanian – Ukrainian project: "Stability studies of femtosecond laser-formed and organically coated super hydrophobic surfaces in UV environment"). Without this, it is impossible to sterilize surgical instruments and use functional surfaces outdoors [5,6]. Finally, the SBS pulse compression combined with phase conjugation allows one to obtain pulses with an energy >25 mJ and a duration of ~90 ps with a smooth beam distribution [7]. This makes it possible to increase the thruput and reduce the cost of laser interference texturing of large-area surfaces.

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