Ultrafast lasers and their applications

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Received December 24, 2016; accepted December 30, 2016; published December 31, 2016

Abstract—The editors introduce the special issue on "Ultrafast lasers and their applications". It covers topics from ultrashort laser pulses generation using nanomaterials-based saturable absorbers to practical applications of such lasers in spectroscopy, supercontinuum generation and laser micromachining. The issue contains nine papers tightly focused on the main topic and two regular papers.

Ultrafast laser sources become a key tool in many practical applications, ranging from advanced scientific like: light-matter interaction investigations, attosecond pulse generation, spectroscopy and exploration of nonlinear effects in gasses and solids; to industry, military and even space. The fast development of mode-locked lasers sources is directly connected with the expansion of: new gain crystals and fibers as well as the special highly nonlinear passive fibers which support existence of laser pulses at visible and mid-infrared spectral ranges, powerful pump diodes, and broadband SAs. The great technical progress in this field is also backed by the theoretical research on soliton dynamics and new regimes of mode-locking e.g. dissipative soliton resonance (DSR), as well as in new concepts in practical applications of ultrashort pulse properties in the time and frequency domains e.g. comb spectroscopy.

Hence, the intention of this issue is to demonstrate the current achievements in this very important for researchers and mankind laser technology. The submitted papers include the topics from new concepts in laser pulse generation, nanomaterials based SA for mode-locked fiber laser, supercontinuum generation and its characterization, to practical application in optical comb spectroscopy and laser micromachining.

The first publication from the Sanchez's group presents current status in the field of generation of high energy square pulses operating in the DSR regime. Such laser pulses with energy up to 10μJ were generated using nonlinear polarization rotation mode-locking mechanism and a figure-of-eight laser cavity with two amplifiers.

The next three publications are focused on nanomaterials based saturable absorbers for pulse generation in fibers lasers. The work of Zuikafly *et al.* presents dual-wavelength Q-switch operation of the Er-doped fiber laser using the multi-walled carbon nanotubes (MWCNTs) slurry as a SA. The Q-switched operation in 2μm spectral range with the pulse energies up to 1μJ using SA based on Bismuth Telluride (Bi_2Te_3) embedded in Polyvinyl Alcohol is demonstrated by Apandi *et al*. In turn, the mode-locked operation in this spectral range using the graphene based SA and Thulium/Ytterbium co-doped silica fibers is presented by Babar *et al.*

The application of ultrashort laser pulses in the 1μm spectral range for supercontinuum generation was presented by Szczepanek *et al*. The group delay of the up to 900nm broadband supercontinuum was carefully instigated using the Cross-correlation Frequency Resolved Optical Gating (XFROG) technique.

The potential of the frequency comb was used by Rutkowski *et al.* for detection of OH in a premixed CH_4/air flat flame at atmospheric pressure using cavity-enhanced absorption spectroscopy. The comb-like structure generated from 8.5μm Fabry-Pérot mid-infrared quantum cascade laser was investigated by Sterczewski *et al.* Its application in multiheterodyne spectroscopy is presented.

The laser micromachining process based on the femtosecond laser system was presented by Stepak *et al.* The 450fs laser pulses at 515nm were used for effective processing of biodegradable poly(L-lactide), which is frequently used in biomedical applications.

As it has been highlighted above the progress in ultrafast laser sources strongly depends on a pump laser development. Power scaling of such diodes is conditioned by development by the diffractive optical components for beam combination. The theoretical and experimental research in this filed was presented by Sobczyk *et al.*

The editors of this issue would like to kindly thank all the authors for their contribution. We would also like to thank all the referees for providing reliable reviews, and Dr. Katarzyna Rutkowska from PLP editorial office for her technical support in elaboration of this issue.

