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Ultrafast phenomena and terahertz waves: introduction

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In this introduction, we provide an overview of the papers that were accepted for publication in the feature issue on ultrafast phenomena and terahertz (THz) waves. This feature issue presents cutting-edge research on ultrafast phenomena and highlights recent developments in THz technology.

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In the past twenty years, the correlated fields of ultrafast phenomena and terahertz (THz) waves have moved steadily forward, owing partially to the development of new table-top ultra-intense lasers and laser-/accelerator-based THz sources. The new ultrafast/ultra-intense laser/THz sources not only unveil new ultrafast phenomena covering physics, chemistry, and biology, but also enable new diagnostic methodologies (spectroscopy and imaging) ranging from far-infrared to ultraviolet and X-ray. Meanwhile, the flexibility in methodologies of ultrafast and THz science and technology opens perspectives for many applications in the fields, such as solar energy, quantum information, and optoelectronic devices. To strengthen the collaboration among researchers worldwide and promote the development in science and technology of ultrafast phenomena and THz waves, the International Symposium on Ultrafast Phenomena and Terahertz Waves (ISUPTW) was initiated in 2002 by Prof. Xi-Cheng Zhang of Rensselaer Polytechnic Institute at the time (now at University of Rochester). The 10th ISUPTW was held in Chengdu, China, and was organized by the China Academy of Engineering Physics, University of Rochester, and Shanghai Institute of Optics and Fine Mechanics, CAS. Following the 10th ISUPTW, the current special issue of *Journal of the Optical Society of America B* (JOSA B) is focused on ultrafast phenomena and THz waves. It contains thirteen papers, with five papers devoted to the topic of novel ultrafast phenomena and eight papers to the cutting-edge research on THz waves.

The topic of ultrafast phenomena covers broad areas of research, including the development of ultrafast light sources typically from picosecond to attosecond, related ultrafast techniques, and their applications in resolving ultrafast processes found in various matters at the atomic and molecular levels. There are five papers on this topic in this special issue. Generation of high-intensity few-cycle laser pulses with duration down to 10 fs is attractive, as such pulses can be the drivers for many applications including the generation of attosecond pulses. Self-compression of ultrashort pulses from a Ti:sapphire laser system in a hollow core waveguide filled with noble gas provides a simple approach to generate such pulses, as reported in the paper by Ran *et al.*, in which they experimentally demonstrate the stable compression of 3 mJ pulses down to about 10 fs by optimizing the group delay dispersion and third-order dispersion [1]. Generation of isolated attosecond pulses sensitively depends upon various driver laser parameters. Yang *et al.* discuss how to optimize the generation of isolated attosecond pulses with the two- or three-color gating scheme towards shorter pulse duration by using a genetic algorithm, which may provide useful guidance for future experiments [2]. Photonic crystals are known for their unique photonic bandgap and rich dispersive properties. The propagation of femtosecond pulses in photonic crystals is associated with these linear dispersion properties and some nonlinear effects. Shi *et al.* investigate theoretically and numerically ultrafast dynamic nonlinear phenomena and mechanisms in photonic crystal over photonic gap and band regions, which can be useful in designing new ultrafast all-optical devices [3].

The emission from plasma is widely applied as a diagnostic of plasma states. Pang *et al.* report a new approach for non-destructive and highly sensitive plasma diagnosis based on third-harmonic generation of an ultrashort laser in a direct-current pulsed discharge plasma [4]. The lifetime, electron density distribution, refractive index, and flow velocity of the discharge plasma can be determined by scanning the laser through the plasma. Yi *et al*. report a high-resolution dual-energy sixteen-channel Kirkpatrick–Baez microscope for ultrafast laser plasma diagnosis [5]. Such diagnosis based upon either backlighting or self-emission X-rays can be applied in inertial confinement fusion and high-energy density physics, where detailed information related to plasma density and temperature can be measured simultaneously.

The other topic of this feature issue is focused on the developments and applications in THz science and technology, including novel sources, modulation, and detection. One of the special sub-topics of THz technology is the generation of THz radiation by using laser fields. E *et al*. review recent progress, challenges, and opportunities of THz emission from liquids, and their summary offers insights into the exploration of THz liquid photonics [6]. Tu *et al*. demonstrate the enhancement of THz radiation from filament by using circularly polarized two-color laser fields [7]. Wang *et al*. propose the generation of broadband THz radiation from a liquid crystal with large birefringence in the THz frequency range, pumped by 800 nm femtosecond laser pulses based on optical rectification [8]. Another sub-topic of this special issue is the effective manipulation of THz waves, which plays an important role in THz science and technology. In this sub-topic, Wang *et al*. report a method to realize frequency tuning of THz emission from two-color laser induced air plasmas [9]. In another paper, Zhang and Xu report a dynamically switchable and tunable bi-functional THz metamaterial absorber based on vanadium dioxide (VO_2) and graphene [10], which provides a new pathway for further development of the multi-functional integrated metamaterial devices in the THz regime.

THz technology represents a competitive approach for non-destructive testing of materials and identification of chemicals based on their distinctive spectral response. The third sub-topic of THz technology addresses the applications of THz spectroscopy for non-destructive detecting. Wang *et al*. propose a method to qualitatively detect amino acids from a mixture at room temperature and humid air, based on a THz time-domain spectrometer which scans tablets of amino-acid mixtures laid out on a PE plate in transmission mode [11]. Yan and Shi focus on the detection of aging in the common explosive cyclotrimethylene-trinitramine (RDX) using THz time-domain spectroscopy [12]. Another important application of THz wave technology is demonstrated for measuring the deflagration rate of polymer-bonded explosive (PBX) under high pressures in a closed burner, based on a noninvasive THz Doppler velocimetry (TDV) method [13].

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