Editorial for special issue on extraordinary 2D-materials-based nanophotonics

The emergence of new materials can push scientific development and even lead to a new industrial revolution. The discovery of graphene has attracted more and more attention from society due to their excellent optics and electricity properties. Graphene has been widely used in optoelectronic devices, such as an optical modulator, polarizer, photoelectric detector, and ultrafast laser. In addition, there is a remarkable transition towards other nanomaterials in recent years. Apart from topological insulators (TIs), transition metal dichalcogenides (TMDs), and monoelemental two-dimensional (2D) materials, composites and heterogenous layered materials are also worthy of mention.

This special issue of *Chinese Optics Letters* entitled "Extraordinary 2D-materials-based nanophotonics" includes the exploration of the nanophotonics of 2D materials and showcases recent works in photonics based on 2D materials, i.e., plasmons, lasers, and photodetectors.

The Goos–Hänchen (GH) shift is a classical optical phenomenon that occurs when the light beam is reflected at the interface. Graphene shows advantages in realizing an enhanced and tunable GH shift due to its dynamic control of electrical conductivity and zero band gap. Jiang *et al.* achieve a giant GH shift of light beams reflected at terahertz frequencies by using a composite structure, where monolayer graphene is coated on a one-dimensional photonic crystal. The composite structure is a good candidate for a dynamic tunable optical shift device in the terahertz regime. In addition, Dai *et al.* demonstrate the physical mechanism of the optical Tamm state (OTS) at the interface between graphene and a dielectric Bragg mirror in the terahertz frequency range, which can precisely generate and control OTS at a desired angle and frequency.

By taking advantage of plasmonic near field enhancement to largely increase the interaction of molecules and the infrared light, surface enhanced infrared spectroscopy provides a sensitive method to identify nanoscale proteins as well as protein adsorption processes. Excition-polaritons are an exceptional platform for photoelectronic and quantum information applications. Zhang *et al.* investigate the influence of the optical Stark effect on excition-polaritons in a microcavity embodied with a monolayer WS_2. The proposed model proves that an outside polarized optical Stark pulse can control the strongly coupled excition-polariton dispersion and fraction ratios, both in time dependent and time independent analysis.

Transient reflectivity measurements can be employed to investigate the photoexcited carrier dynamics of 2D materials. Jiang *et al.* measure the optics properties of the Bi_2Se_3 thin film with various substrates via a 400 nm pump–white-light probe setup. They verify the existence of a second Dirac surface state in Bi_2Se_3. Experimental results show a rise of the transient reflection signal at the time scale of several picoseconds.

To investigate unique physical properties for electronic and optoelectronic devices, van der Waals heterostructures assembled with different 2D materials are considered to be a promising way. The existing experimental and theoretical results show that most atomically thin 2D heterostructures exhibit an obvious photovoltaic effect and improvements in optical characteristics as a result of the weak interaction between the different layers. Zhang *et al.* design a graphene/$MoSe_2$ heterostructure photodetector with the photoresponse ranging from the visible to near infrared and an ultrahigh photoresponsivity up to $1.3 \times 10^4\ \mathrm{A \cdot W^{-1}}$ at 550 nm. Electrons shift to graphene while holes remain in the $MoSe_2$, which creates a photogating effect. Wen *et al.* investigate the electronic and optical properties of the ZrS_2/SnS_2 van der Waals heterostructure. The characteristics of optical absorption in a heterostructure can be enhanced to the amount of 10^6 in the ultraviolet light region. The tuning electronic properties of a ZrS_2/SnS_2 heterostructure are studied.

In terms of laser applications, there are six articles using graphene, graphene oxide (GO), gold nanobipyramids (G-NBPs), WTe_2, WSe_2, and black phosphorus (BP) as saturable absorbers (SAs) for Q-switching or mode-locking of lasers. Vector solitons are a type of stable-state wave containing two orthogonal polarization components, which keep polarization fixed or periodic evolution when propagating in a single mode fiber that holds birefringence. Mou *et al.* demonstrate an all-fiber mode-locked erbium fiber laser based on graphene polyvinylalcohol film. Two types of polarization attractors can be obtained by carefully adjusting the polarization controller. The work may help readers in understanding nonlinear optical dynamics in nanomaterial-based ultrafast lasers.

The Langmuir–Blodgett (LB) technique, a convenient and low-cost technique, can keep the uniformity distribution of the nanomaterials under normal conditions. Wang *et al.* demonstrate a Q-switched Nd:$GdVO_4$ laser with reflective GO LB films. The shortest pulse duration is 115 ns, and the output power is 2.11 W when the pump power is 10.9 W. To the best of the author's knowledge, it is the highest output power in a Q-switched laser with 2D materials.

The doubly Q-switched (DQS) technique can compress pulse width, improve the peak power, and obtain a single symmetric pulse compared with the single active or passive Q-switched techniques. Liu *et al.* realize an active–passive pulse laser by using an acousto-optic modulator and a G-NBPs absorber. The shortest pulse duration is measured to be 150.5 ns. The compressed ratio and enhancement time for the pulse width and peak power are 82.6% and 16, respectively.

As new functional materials for optoelectronic application, TMDs, denoted as MX_2 (M: Mo or W and X: S, Se or Te), have recently been extensively studied with superb nonlinear optical properties, such as strong light–material interaction, broad optical response, ultrafast recovery time, and controllable optoelectronic properties. Liu *et al.* investigate the Q-switched fiber laser operating at 1.5 μm by incorporating the WTe_2 absorbers into the ring cavity. The stable laser pulses with pulse duration of 583 ns are obtained. To the best of the author's knowledge, this is the first attempt of WTe_2 in a Q-switched fiber laser at 1.5 μm. In addition, Chen *et al.* report on a multi-gigahertz Q-switched mode-locked waveguide laser based on WSe_2 saturable absorber. The mode-locked waveguide laser operates at fundamental repetition frequency of 6.5 GHz, and the pulse width is measured to be as short as 47 ps.

Mao *et al.* demonstrate an all-fiber Q-switched cylindrical vector laser based on a BP SA and a transverse mode converter. By enhancing the pump power from 64.68 to 174.82 mW, the pulse width of the Q-switched azimuthally/radially polarized laser varies from 1.77/1.73 μs to 4.23/4.44 μs, while the repetition rate of the Q-switched azimuthally/radially polarized laser increases from 16.72/19.25 kHz to 30.71/37.82 kHz.

Finally, Ye *et al.* discuss recent advances in the mastering single photoemitters in 2D materials, electrical generation pathways, detuning, and resonator coupling towards use as quantum light sources. In addition, the remaining challenges and the outlooks for materials-based quantum photonic sources are also summarized.

We thank the authors for their contributions, and all of the reviewers for their constructive criticism, as well as the editorial office staff for their constant support. Lastly, we hope that our readers can enjoy this special issue, and that it will trigger more exciting discoveries in the future.

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