Introduction to the Photonics Based on Two-dimensional Materials feature issue

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We are pleased to introduce a feature issue on photonics based on two-dimensional (2D) materials. Enlightened by the unique optical and electronic properties of graphene, 2D layered materials have been extensively studied in recent years driven by their promising applications for a large range of novel photonic and optoelectronic devices, ranging from saturable absorbers for ultrafast lasers, to optical modulators, to photodetectors. The emergence of these 2D materials not only offers unique insights on light–matter interaction at the atomic layer level but also provides unprecedented opportunities for researchers to fabricate photonic devices based on 2D materials with superior performance: (1) They display strong interaction with light despite being only one atom thick; for instance, a single layer of molybdenum disulfide (MoS_2) absorbs around 10% at excitonic resonances. Owing to their unique electronic properties, 2D materials (e.g., graphene) can extend over a wide range of the electromagnetic spectrum. (2) They possess versatile bandgap properties from wideband insulator, to narrowband semiconductor, to semimetal or metal (depending on their thickness and composition), rendering them attractive candidates for diverse photonic functions. (3) They have tunable optoelectronic properties (bandgap, absorption, etc.) with variable approaches, such as defects, doping, strain, and electric field. These grant the convenient and effective control of their optoelectronic response, leading to new conceptual photonics devices (such as 2D materials–based optical modulators, optomechanical sensors, and biooptical sensors), fundamentally different from these based on traditional bulk materials. (4) Atomically thin 2D heterostructures can be readily assembled by stacking different types of 2D materials, offering a flexible and easy approach to designing desired properties of photonic devices. (5) The surfaces of 2D materials are naturally passivated without any dangling bonds, making their integration simple, cost effective, and compatible with different photonic devices such as waveguides and cavities. It is therefore envisaged that 2D materials and their heterostructures—combined with other available approaches to control the light–matter interaction—offer a great opportunity to the optics community in creating new functional photonics devices across a wide range of the electromagnetic spectrum.

Photonics based on 2D materials, as a continuously advancing research area, is a field that investigates the light–matter interaction in 2D materials and the related applications for light generation, propagation, modulation, and detection. The intention of this feature issue is to introduce the fundamental and applied research progress in the optics and photonics of 2D materials. This feature issue presents 16 papers, including 5 invited papers produced by internationally recognized research teams. Papers in the feature issue cover a wide range of the recent advances in photonics based on 2D materials, including internal carrier dynamics, saturable absorbers, single-longitude-mode generation, ultrashort pulse generation, and nonlinear refractive index tunability by using different kinds of 2D materials ranging from graphene, to topological insulators, to transition metal dichalcogenides (i.e., MoS_2, WS_2, $MoSe_2$).

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