Photonics of two-dimensional materials: graphene and beyond

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Here we would like to review our recent progresses on the photonic applications of graphene and other two-dimensional (2D) layered materials.[1,2]

Firstly, we report the development of new saturable absorbers based on graphene heterostructures and other 2D materials, including graphene/Bi_2Te_3[3], black phosphorus[4] and self-doped plasmonic 2D $Cu_{3-x}P$ nanosheets[5]. Depending on their nonlinear optical properties, both high energy Q-switched laser and ultrafast mode-locked pulse generation were demonstrated.

Secondly, we fabricated a highly efficient hybrid photodetector that consists of graphene covered with dispersive organolead halide perovskite ($CH_3NH_3PbBr_2I$) islands.[6] We also demonstrated a broadband photodetector based on graphene-Bi_2Te_3 heterostructure.[7] Furthermore, we developed new methods to grow and transfer large area single crystal WS_2 [8], large area MoS_2/WS_2 heterojunction [9], and monolayer-bilayer WSe_2 heterojunction [10], and demonstrated their applications for photodetectors.

Thirdly, we investigated plasmonic excitation and THz modulation in graphene/Bi_2Te_3[11], graphene nanoribbon [12] and 3D graphene [13] using either spectroscopic or real space imaging techniques. The important discoveries include the plasmonic coupling of two Dirac materials [11], excitation of high-order mode [13] and edge chirality-related plasmonic broadening [12].

Last, we report our recent progress on the synthesis of 2D organic-inorganic hybrid perovskite nanosheets as well as their optoelectronic applications.[14-17]

In summary, the advances of photonics of 2D materials may pave the way for the integration of next generation hybrid silicon photonic circuit.

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