

Photonics and optoelectronics of two-dimensional materials

By

*Professor Qiaoliang BAO,
Associate Professor, Materials Science and Engineering & ARC Future Fellow,
Monash University, Australia*

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/Bi₂Te₃[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 (CH₃NH₃PbBr₂I) islands.[6] We also demonstrated a broadband photodetector based on graphene-Bi₂Te₃ heterostructure.[7] Furthermore, we developed new methods to grow and transfer large area single crystal WS₂ [8], large area MoS₂/WS₂ heterojunction [9], and monolayer-bilayer WSe₂ heterojunction [10], and demonstrated their applications for photodetectors.

Thirdly, we investigated plasmonic excitation and THz modulation in graphene/Bi₂Te₃[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.

References

- [1] C. D. Sathish, and Qiaoliang Bao*, *et al.*, *Nanoscale*, 2016, 8, 6410 - 6434.
 - [2] C. D. Sathish, and Qiaoliang Bao*, *et al.*, *Advanced Science*, 2017, 10.1002/advs.201600305.
 - [3] Haoran Mu, and Qiaoliang Bao*, *et al.*, *ACS Photonics*, 2015, 2, 832–841.
 - [4] Haoran Mu, and Qiaoliang Bao*, *et al.*, *Advanced Optical Materials*, 2015, 3:1447.
 - [5] Zeke Liu, and Qiaoliang Bao*, *et al.*, *Advanced Materials*, 2016, 28, 3535–3542.
 - [6] Yusheng Wang, Qiaoliang Bao*, *et al.*, *Advanced Optical Materials*, 2015, 3, 1389.
 - [7] Hong Qiao, and Qiaoliang Bao*, *et al.*, *ACS Nano*, 2015, 9 (2):1886–1894.
 - [8] Zaiquan Xu, and Qiaoliang Bao*, *et al.*, *ACS Nano*, 2015, 9 (6), 6178–6187.
 - [9] Yunzhou Xue, Qiaoliang Bao*, *et al.*, *ACS Nano*, 2016, 10: 573-580.
 - [10] Zaiquan Xu, Qiaoliang Bao*, *et al.*, *2D Materials*, 2016, 3 (4), 041001.
 - [11] Yao Lu, Qiaoliang Bao*, *et al.*, *Journal of the Optical Society of America B*, 2016, 33(9):1842-1846.
 - [12] Qingyang Xu, Qiaoliang Bao*, *et al.*, *Light: Science & Applications* (2017) 6, e16204. Cover story.
 - [13] Jingchao Song, and Qiaoliang Bao*, *et al.*, *ACS Photonics*, 2016, DOI: 10.1021/acsp Photonics.6b00566.
 - [14] Ziyu Wang, and Qiaoliang Bao*, *et al.*, *Nanoscale*, 2015, 8, 6258-6264.
 - [15] Jingying Liu, and Qiaoliang Bao*, *et al.*, *ACS Nano*, 2016, 10, 3536–3542.
 - [16] Yupeng Zhang, and Qiaoliang Bao*, *et al.*, *ACS Nano*, 2016, 10 (3): 3536–3542.
 - [17] Yupeng Zhang, and Qiaoliang Bao*, *et al.*, *Chemical Communications*, 2016, DOI:
-