Photonics of two-dimensional materials beyond graphene

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The success in graphene with fascinating and technologically useful properties[1] has stimulated the study of two-dimensional (2D) atomic-layer materials other than graphene, such as single layers of transition metal dichalcogenides (TMDCs, e.g., MoS_2, WS_2, WSe_2, etc)[2] and a few quintuple layers of topological insulators (TIs, e.g., Bi_2Se_3, Bi_2Te_3, Sb_2Te_3 etc)[3]. The rapid pace of progress in graphene, TMDCs and TIs and some demonstrated applications have led to the exploration of new type of electric and optoelectronic devices constructed by vertically stacking different layered materials. [4-9]

Here we would like to review our recent progresses on the photonic applications of 2D layered materials other than graphene. A few photonics devices based on these 2D materials or their heterostructures have been successfully fabricated, including pulse laser, photodetector, solar cell, modulator and ring filter. Firstly, we use graphene as template to grow graphene/topological insulator heterostructure and investigate the linear and nonlinear optical properties as well as the application for pulse laser generation.[4] Broadband photodetection was also demonstrated on this heterostructure. [5] Ultrahigh responsivity and gain was proved in hybrid graphene-perovskite phototransistors.[6] Secondly, we develop new approach to grow and transfer large area TMDCs,[7-8] which is the basis for fabrication of new type of flexible thin film photodetectors and solar cell devices. Last, based on the good CMOS-compatibility of 2D materials [9], we fabricate chip-integrated modulator and resonator devices and incorporate graphene/TMDCs heterostructure for the signal modulation and processing. The advances of photonics of these new 2D materials may pave the way for the integration of next generation hybrid silicon photonic circuit.

[1]Bao, Q.L. & Loh, K.P. ACS Nano 6, 3677-3694 (2012).

[2]Chhowalla, M. et al. Nat. Chem. 5, 263-275 (2013).

[3]Zhang, H. et al. Nature physics 5, 438-442 (2009).

[4] Haoran Mu, et al., ACS Photonics, 2015, accepted.

[5]Hong Qiao, et al., ACS Nano, 2015, 9 (2):1886–1894.

[6] Yusheng Wang, et al., Advanced Optical Materials, 2015, DOI: 10.1002/adom.201500150.

[7] Zaiquan Xu, et al., ACS Nano, 2015, DOI: 10.1021/acsnano.5b01480

[8] Changxi Zheng, et al., Nano Letters, 2015, DOI: 10.1021/acs.nanolett.5b00098.

[9] Sheng Gan, et al., Advanced Optical Materials, 2015, submitted.