High performance photodetectors based on graphene and other 2D materials

Xuechao Yu[1], **Qi Jie Wang[1,2],**

1. OPTIMUS, Photonics Centre of Excellence, School of Electrical and Electronic Engineering , Nanyang Technological University, 50 Nanyang Avenue, 639798, Singapore

2. Centre for Disruptive Photonic Technologies, Nanyang Technological University, 21 Nanyang Link, 63737, Singapore

qjwang@ntu.edu.sg

Abstract

Graphene and other 2D materials have attracted tremendous attention thanks to their extraordinary electronic and optical properties, accommodating a large potential in modern optoelectronic applications such as photodetection. Graphene is considered as a suitable candidate for ultrafast and broadband photodetector, however, suffering from low light absorption and photoresponsivity. In our group, nanostructured graphene (graphene quantum dots and nanoribbons) were employed to enhance the photoresponsivity of graphene based photodetector. The low detectivity of graphene photodetector based on photoconductive mode operation remains big challenges in further applications. Here, we demonstrated the photovoltaic mode operation in graphene p-n junctions fabricated by a simple but effective electron irradiation method that induces n-type doping in the intrinsic p-type graphene and exhibit a high detectivity of ~ 3×10^{10} Jones.

On the other hand, metal dichalcogenides and black phosphorene with strong in-plane and weak out-of-plane interactions open up new opportunities for 2D materials for optoelectronic applications. Single crystal 1T phase Tin Diselenide ($SnSe_2$) was synthesized and exfoliated into single and few layers. Atomically layered $SnSe_2$ field-effect transistors displayed a high responsivity (0.5 A/W) and response time (~2 ms) in the visible range. Few layer black phosphorene p-n junction formed by chemical doping was also demonstrated as a promising material for IR photodetector and filled the gap between graphene and metal dichalcogenides.

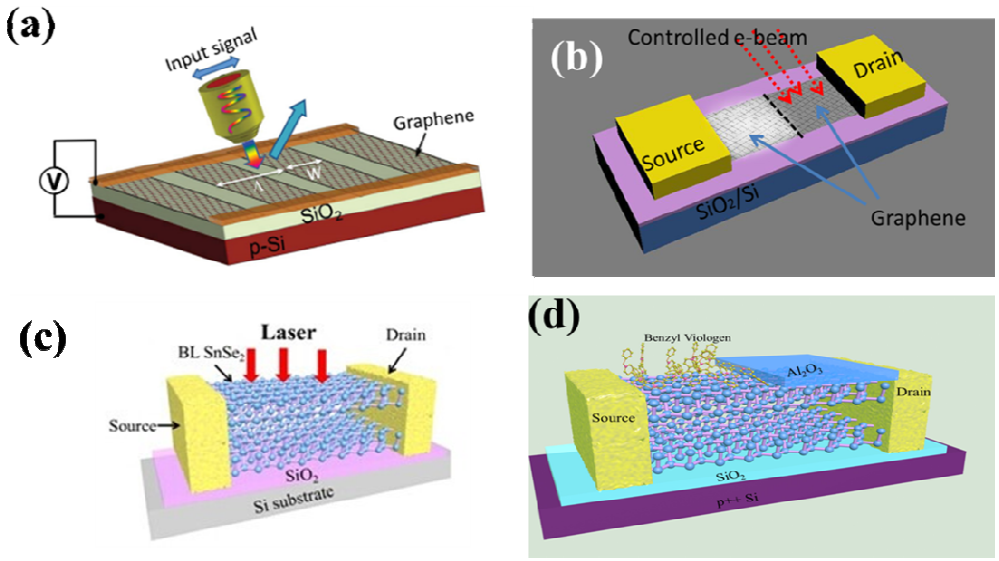

Figure 1. Photodetector based on graphene nanoribbon (a), graphene p-n junction, bilayer SnSes (c) and few layer black phosphorene (d).