Oral PhD

Photocurrent spectroscopy in TMDC-based van der Waals heterostructures

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Two-dimensional (2D) materials such as graphene and transition metal dichalcogenides (TMDCs) can be assembled on top of one another to create the so called van der Waals (vdW) heterostructures [1]. The properties of these artificial materials can be tailored by combining the various 2D crystals, thus making them promising candidate for multi-functional, high performance optoelectronic applications.

Recently, photodetectors with high efficiencies have been demonstrated using graphene /MoS_2/graphene [2] and graphene/WS_2/graphene heterostructures [3]. However, many questions concerning photoconduction processes occuring in these TMDC-based heterostructure remain unanswered, in particular the role the excitons generation and separation.

Here we present a detailed study of the photocurrent generated in graphene /WSe_2/graphene heterostructure encapsulated in hBN. By performing photocurrent spectroscopy, we demonstrate that the photoresponse of the heterostructure is strongly dominated by the excitons generated in the TMDC. The electon-hole pairs can be efficiently separated by creating a potential difference between the top and bottom graphene, which also act as electrodes. The sign of the photocurrent can therefore be changed by tuning the Fermi level one of the graphene layer via an external gate. Our results also demonstrate the potential of these heterostructures as photodetectors, with a responsivity of up to 0.1 A/W at 575 nm.

References

[1] Geim et al., Van der Waals Heterostructures, Nature, 2013.

[2] Yu et al., Highly efficient gate-tunable photocurrent generation in vertical heterostructures of layered materials, Nature nanotechnology, 2013.

[3] Britnell et al., Strong light-matter interactions in heterostructures of atomically thin films, Science, 2013.