Filtering the photoluminescence spectra of atomically-thin semiconductors with Graphene

Luis Enrique Parra Lopez[1]
Etienne Lorchat[1], Cédric Robert[2], Delphine Lagarde[2], Guillaume Froehlicher[1], Takashi Taniguchi[3], Kenji Watanabe[3], Xavier Marie[2,4] and Stéphane Berciaud[1,4]
[1]*Université de Strasbourg, CNRS, Institut de Physique et Chimie des Materiaux de Strasbourg, UMR 7504, F-67000 Strasbourg, France.*
[2]*Université de Toulouse, INSA-CNRS-UPS, LPCNO, 135 Avenue de Rangueil, 31077, Toulouse, France.*
[3] *National Institute for Materials Science, Tsukuba, Ibaraki 305-0044, Japan.*
[4]*Institut Universitaire de France, 1 rue Descartes, 75231 Paris cedex 05, France.*
luis.parralopez@ipcms.unistra.fr

Atomically thin semiconductors made from transition metal dichalcogenides are appealing material systems for the investigation of strong light-matter interactions and are ideal building blocks for an increasing number of applications in nanophotonics, opto-electronics and valley-tronics [1]. However, atomically-thin TMDs exhibit quite complex excitonic manifolds and their emission spectra are often composed of a large number of features that are challenging to decipher [2-4]. On a practical level, implementations in photonic devices would profit from the existence of a prominent single emission line. Here we demonstrate that an atomically thin-semiconductor stacked onto a graphene monolayer enables single narrow-line photoluminescence (1.7 meV) arising solely from neutral excitons [5]. This filtering effect comes from a neutralization of the TMD combined to selective energy transfer of long-lived excitonic species to graphene. Interestingly our observations are valid both on bright (Mo-based) and dark (W-based) TMDs monolayers. Our results establish TMD/Graphene heterostructures as a suitable building block for opto-electronics.

References

[1] K. F. Mak, J. Shan. Nature Nanotech. 10, 216 (2016).
[2] M. Barbone et al. Nature Communications, 9, 3721 (2018).
[3]D. Vaclavkova et al. Nanotechnology 29 (2018) 325705.
[4]E. Courtade et al. Phys. Rev. B 96, 085302 (2017)
[5]**L. Parra Lopez** et al. arXiv:1908.10690 (Accepted for publication in Nature Nanotech.)

Figures

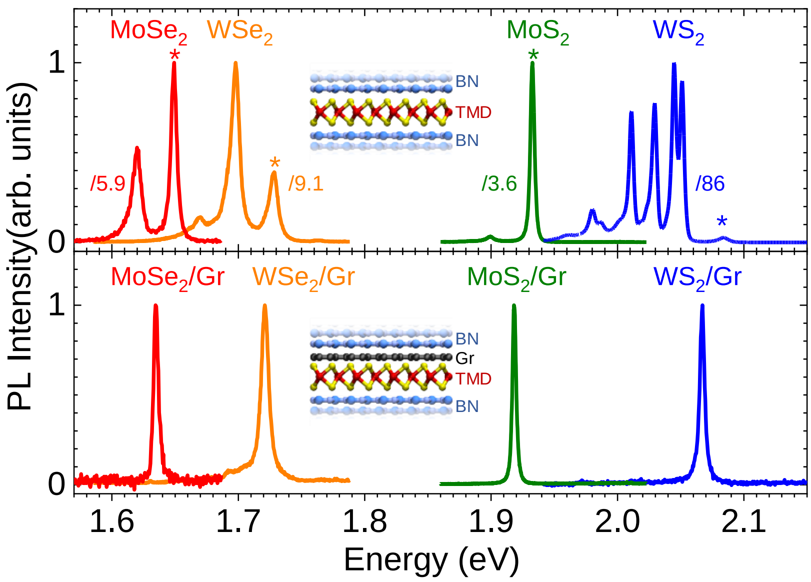

Figure 1: Bright, single narrow-line photoluminescence spectra of BN-Capped monolayer TMD/Graphene heterostructures (bottom). The PL of the BN-Capped TMD regions are shown on the upper pannel for comparison.