Excitons in $MoS_2/MoSe_2/MoS_2$ trilayer metal dichalcogenides

P. Plochocka
Laboratoire National des Champs Magnétiques Intenses, UPR 3228, CNRS-UGA-UPS-INSA, 143 Av. de Rangueil 31 400 Toulouse, France.

Monolayer transition metal dichalcogenides (TMDC) are rapidly emerging as potential building blocks for novel electronic and optoelectronic devices. In this talk I will discuss the optical properties of excitons in tri – layer transitions metal dichalcogenides (TMDC).

First, I will demonstrate a novel approach to neutralize the intrinsic defects of CVD-grown TMDCs, using transfer tools routinely employed in the fabrication of van-der-Waals heterostructures. We investigate the optical properties of trilayer stacks composed of external CVD-grown MoS_2 flakes as capping layers and an internal CVD-grown $MoSe_2$ flake which has a smaller band gap (Fig 1(a)). Remarkably, this fabrication approach strongly suppresses the localized exciton emission in $MoSe_2$ yielding a low temperature PL comparable to that observed in mechanically exfoliated samples (as shown in Fig 1(c)) [1]. Our results pave the way for the production of large area high quality TMDCs. Furthermore, I will demonstrate that tuning the excitation laser to the A-exciton resonance of the larger band gap MoS_2 leads to a considerable charge transfer towards lower band gap $MoSe_2$ as schematically presented in Fig 1(b). The conservation of the spin during the charge transfer opens new possibilities for spintronics and spin injection. In addition, the investigation of the charge transfer between the $MoS_2/MoSe_2$ layers allows us to demonstrate a novel way to introduce the valley polarization in $MoSe_2$, which is difficult to achieve in non resonant excitation conditions [2].

Finally, I will discuss optical properties of the long lived inter-layer exciton formed between the $MoSe_2$ and MoS_2 monolayers (schematically presented in Fig.1(b)). Under circularly polarized excitation, the inter-layer exciton emission is intriguingly counter polarized. Such an effect has never been observed previously. Our results show that a careful choice of the TMDs forming the van der Waals heterostructure makes it possible to control the circular polarization of inter-layer exciton emission. This unexpected phenomenon gives an additional degree of freedom for tailoring the properties of van der Waals heterostructures [3].

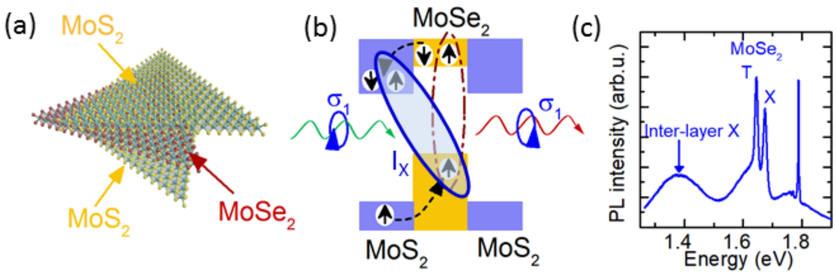

Fig. 1 (a) Ball and stick model of $MoSe_2$ layer sandwiched between two MoS_2 flakes (b) scheme of the charge transfer and indirect exciton formation (c) typical μ-PL spectra of the trilayer

[1] A. Surrente, PP et al Nano Letters 17, 4130 (2017)
[2] M. Baranowski, PP et al 2D materials 4, 025016 , (2017)
[3] M. Baranowski, PP et al Nano Letters in press DOI: 10.1021/acs.nanolett.7b03184
+ Author for correspondence: paulina.plochocka@lncmi.cnrs.fr