Photoluminescence study of interlayer exciton in van der Waals $MoS_2/WSe_2/MoS_2$ trilayer heterostructures

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Abstract

Atomically thin heterostructures made of van der Waals (vdWs) exhibit a type-II band alignment. In this structure, the staggered potential assists efficient separation of photo-excited electrons and holes in the opposite layer. Prior studies have confirmed that electrons are transferred to the MoS_2 layer while holes to the WS_2 layer within 50 fs.[1] Due to the Coulomb interaction of spatially separated electron-hole pairs, long-lived interlayer excitons can be generated.[2] Recent investigations are further directed to exploit the discrete excitonic states, i.e. atom-like sharp resonance, such as exciton quantum coherence or quantum beats of excitons.[3,4] Here, we implemented trilayer vdWs configuration by stacking three hetero-monolayer, in which the WSe_2 layer is embedded between two MoS_2 layers. This, so called "V-type" configuration is expected to provide another degree of freedom to investigate the solid-state version of atomic quantum coherence. We further show that the energy levels of the interlayer excitons can be controlled by applying vertical electric field.[2]

References

[1] J. Kim et al., Nat. Nanotech. 9 (2014) 682-686.
[2] P. Rivera et al., Nat. Commun. 6 (2015) 6242
[3] J. Kim et al., Sci. adv. 3 (2017) e1700518
[4] S. Sim et al., Nat. Commun. 9 (2018) 351

Figures

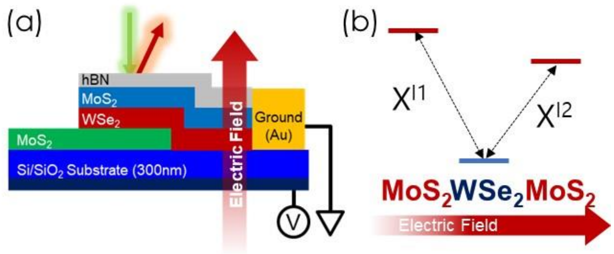

Figure 1: (a) Illustration of the trilayer vdWs heterostructure device. (b) Illustration of the trilayer heterostructure band diagram. External E-field tunes the energy levels of the two interlayer excitons.

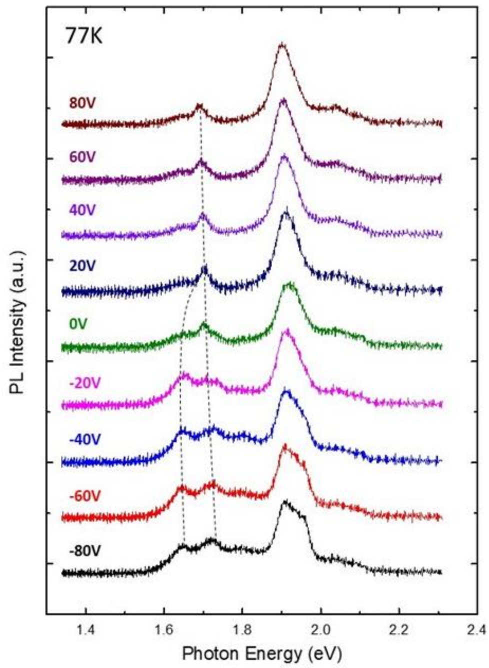

Figure 2: Photoluminescence spectra of trilayer heterostructures with vertical electric field.