Twisted $MoSe_2$ Homobilayer Behaving as a *Heterobilayer*

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Heterostructures (HSs) formed by the transition-metal dichalcogenides (TMDCs) materials have shown great promise in next-generation optoelectronic and photonic applications. In these HSs, the interlayer charge (CT) and energy transfer (ET) processes are the main photocarrier relaxation pathways. Traditionally, at atomically closed proximity the CT process dominates due to its fast timescale (< 50 fs) as compared to the ET process (hundreds of fs to few ps). In this talk, I introduce our latest work [1] on the understanding of the complex dominating ET process over the CT process in a twisted molybdenum diselenide ($MoSe_2$) homobilayer *without* any charge-blocking interlayer, *i.e.*, in atomically closed proximity. We fabricated an unconventional homobilayer (*i.e.*, HS) with a large twist angle (~57°) by combining the chemical vapor deposition (CVD) and mechanical exfoliation (Exf.) techniques to fully exploit the lattice parameters mismatch and indirect/direct (CVD/Exf.) bandgap nature. These result in weakening the CT process and allowing the ET process to take over the carrier recombination channels. We employ a series of optical and electron spectroscopy techniques at cryogenic and room temperature, complementing by the density functional theory (DFT) calculations, to describe a massive room temperature photoluminescence enhancement from the HS area due to an efficient ET process. Our results show that the electronically decoupled $MoSe_2$ homobilayer is coupled by the ET process, mimicking a 'true' *heterobilayer* nature.

Reference

[1] "*Twisted $MoSe_2$ Homobilayer Behaving as a Heterobilayer*", A. Karmakar, A. Al-Mahboob, N. Zawadzka, M. Raczyński, W. Yang, M. Arfaoui, Gayatri, J. Kucharek, J. T. Sadowski, H. S. Shin, A. Babiński, W. Pacuski, T. Kazimierczuk, M. R. Molas, *Nano Lett. 2024, 24, 31, 9459–9467*.

Graphical Abstract

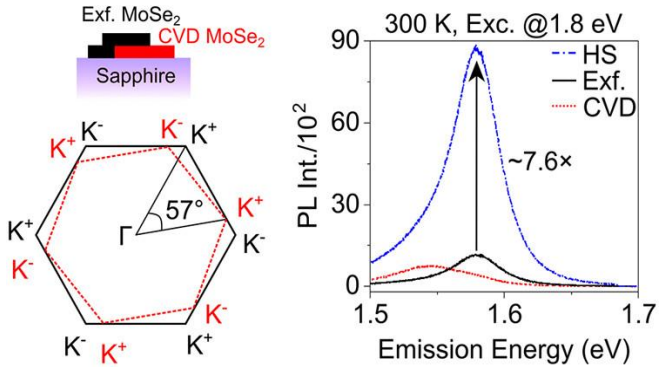

Figure 1: Schematic illustration of the sample's cross-section and 57° rotated Brillouin zone (BZ). Room temperature PL spectra from the sample shows ~8× enhancement from the HS area as compared to the Exf. region. Image taken from *ref.*[1].