Transition Metal Dichalcogenide Heterojunctions: Synthesis, spin-valley physics and fundamental properties

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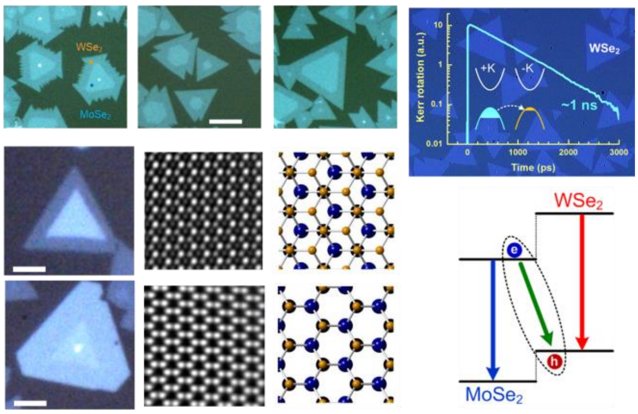
Semiconductor heterojunctions (HJs) have played a central role in both fundamental physics and modern device applications. Recent advances in HJs formed by vertical stacking or lateral connecting of different 2D semiconductors, i.e., transition metal dichalcogenide (TMD) monolayers, further push semiconductor HJs down to atomically-thin thickness with atomically sharp interface, opening up new opportunity for novel device applications. TMD HJs also feature their type-II band alignment, which can separate photoexcited electrons and holes in different materials through efficient interlayer charge transfer, making them very promising for optoelectronic and photovoltaic applications. In this talk, I will demonstrate various TMD lateral and vertical HJs synthesized by chemical vapor deposition (CVD). In particular, domain shape evolutions of $MoSe_2$-WSe_2 lateral HJs induced by termination dependent growth kinetics will be discussed. The local strain inhomogeneity exhibited in WSe_2-MoS_2 and $MoSe_2$-WSe_2 lateral HJs further provide a unique platform to study the strain modulation of electronic and optical properties of monolayer MoS_2 and WSe_2. In vertically stacked HJs, such as WSe_2/$MoSe_2$ and WS_2/MoS_2, the different stacking configurations combined with the coupled spin-valley physics in monolayer TMDs further enrich the interplay of electron spin, valley pseudospin, and layer pseudospin. We found that the valley polarization in vertical HJs can be further stabilized by interlayer carrier transfer and the formation of interlayer exciton. We show that the stacking symmetry play a critical role in not only the interlayer spin transfer, but also the helicity of circularly polarized emissions from interlayer excitons. The symmetry-dependent spin-valley properties of TMD heterobilayer would shed light on developing future valley-based electronic and optoelectronic devices.



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