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Scanning Tunneling Spectroscopy of Transition Metal Dichalcogenides: Quasiparticle Gap, Critical Point Energies and Heterojunction Band Offsets

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As an emergent atomically thin electronic and photonic materials material, transition metal dichalcogenides (TMDs) has triggered intensive research activities toward understanding of their electronic structures. Here I will introduce a comprehensive form of scanning tunneling spectroscopy (STS) which allows us to probe details quasi-particle electronic structures of TMDs. More specifically, we show that not only the quasi-particle band gaps but also the critical point energy locations and their origins in the Brillouin Zone (BZ) can be revealed using this comprehensive form of STS. By using this new method, we unravel the systematic trend of the critical point energies for TMDs due to atomic orbital couplings, spin-orbital coupling and the interlayer coupling. Moreover, by combining the micro-beam X-ray photoelectron spectroscopy (micro-XPS) and STS, we determine the band offsets in planar heterostructures formed between dissimilar single layer TMDs (MoS2, WSe2, and WS2). We show that both commutativity and transitivity of heterojunction band offset hold within the experimental uncertainty.

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