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Synthesis and Characterizations of Two-Dimensional Atomic Layers and Their Heterostructures

YI-HSIEN LEE, National Tsing Hua University

Monolayers of van der Waals (vdw) materials, including graphene, h-BN, and MoS_2, have been highlighted regarding both scientific and industrial aspects due to novel physical phenomenon inherited from the reduced dimensionality. Layered transition metal dichalcogenides (TMD) atomic layers, being considered as the thinnest semiconductor, exhibit great potential for advanced nano-devices. Monolayer in the class of offered a burgeoning field in fundamental physics, energy harvesting, electronics and optoelectronics. Recently, atomically thin heterostructures of TMD monolayer with various geometrical and energy band alignments are expected to be the key materials for next generation flexible optoelectronics. The individual TMD monolayers can be adjoined vertically or laterally to construct diverse heterostructures which are difficult to reach with the laborious pick up-and-transfer method of the exfoliated flakes. The ability to produce copious amounts of high quality layered heterostructures on diverse surfaces is highly desirable but it has remained a challenging issue. Here, we have achieved a direct synthesis of various heterostructures of monolayer TMDs. The synthesis was performed using ambient-pressure CVD with aromatic molecules as seeding promoters. We discuss possible growth behaviors, and we examine the symmetry and the interface of these heterostructures using optical analysis and atomic-resolution scanning TEM. Our method offers a controllable synthesis of to obtain high-quality heterostructures of TMD atomic layers with diverse interface geometry.

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