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Continuous Heteroepitaxy of Two-Dimensional Heterostructures Based on Layered Chalcogenides

The in-plane connection and layer-by-layer stacking of atomically-thin layered materials are expected to allow the fabrication of two-dimensional (2D) heterostructures with exotic physical properties and future engineering applications. However, it is currently necessary to develop a continuous growth process that allows the assembly of a wide variety of atomic layers without interface degradation, contamination and/or alloying. Herein, we report the continuous heteroepitaxial growth of 2D multi-heterostructures (Fig.1a) and nanoribbons based on layered transition metal dichalcogenide (TMDC) monolayers, employing metal organic liquid precursors with high supply controllability [1]. This versatile process can avoid air exposure during growth process, and enables the formation of in-plane heterostructures with ultra-clean atomically sharp and zigzag-edge straight junctions without defects or alloy formation around the interface (Fig.1b). For the samples grown directly on graphite, we have investigated the local electronic density of states of atomically sharp heterointerface by scanning tunneling microscopy and spectroscopy, together with first principle calculations (Fig.1c). These results demonstrate an approach to realizing diverse nanostructures such as atomic layer-based quantum wires and superlattices, and suggest advanced applications in the fields of electronics and opto-electronics.

Figures

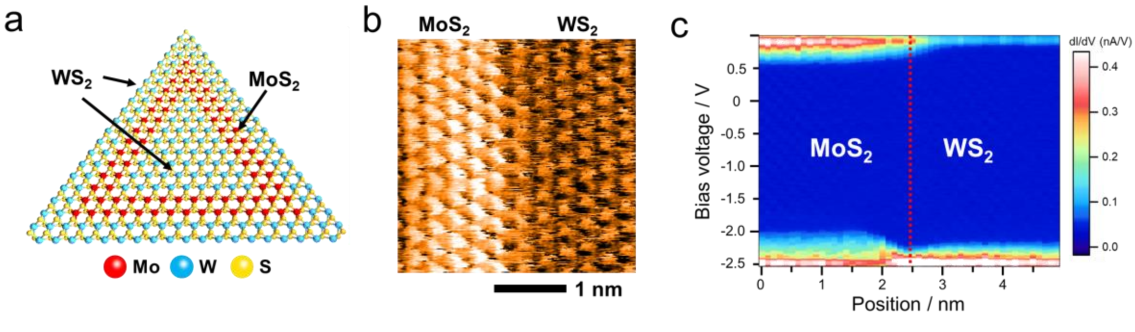

Figure 1: (a) Schematic illustrations of a $WS_2/MoS_2/WS_2$ in-plane multi-heterostructure. (b) STM image and (c) color scale map of the dI/dV spectra of MoS_2/WS_2 heterointerface.