Supplementary Information

Synthesis of Wafer-Scale Uniform Molybdenum Disulfide Films with Control over the Layer Number Using a Gas Phase Sulfur Precursor

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CVD system of MoS_2 synthesis.

Low pressure CVD (LPCVD) system with tubular quartz, having a diameter over 2 inch, is employed to synthesize MoS_2 films. The Mo deposited wafer or quartz is loaded at the center of heating zone. Ar flow can adjusts chamber pressure with inert atmosphere. H_2S and H_2 gases flow through the inner injection tube to inhibit contamination of quartz tube ahead of heating zone. This can protect the contamination of Mo deposited wafer during temperature rising with Ar flow. After synthesis process at desired temperature, the sample could be cooled down to room temperature with shift of the furnace from heating zone.

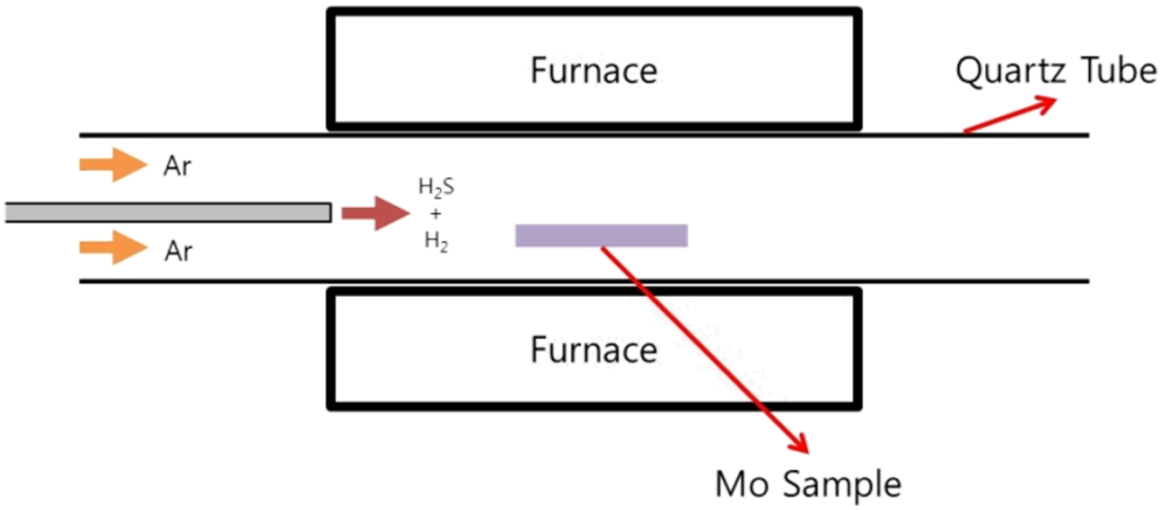

Figure S1. Schematic illustration of LPCVD system for large area MoS_2 synthesis.

Surface morphology with AFM measurement.

Atomic layer microscopy was fulfilled for 2-layered MoS_2 film to estimate surface roughness and thickness. Figure S2 shows the single color distribution along the scanned area, which indicates uniform formation of MoS_2 film with desired thickness. The RMS roughness of 2-layred MoS_2 film is 0.2085 nm that can be inferred by line profile of Figure S2.

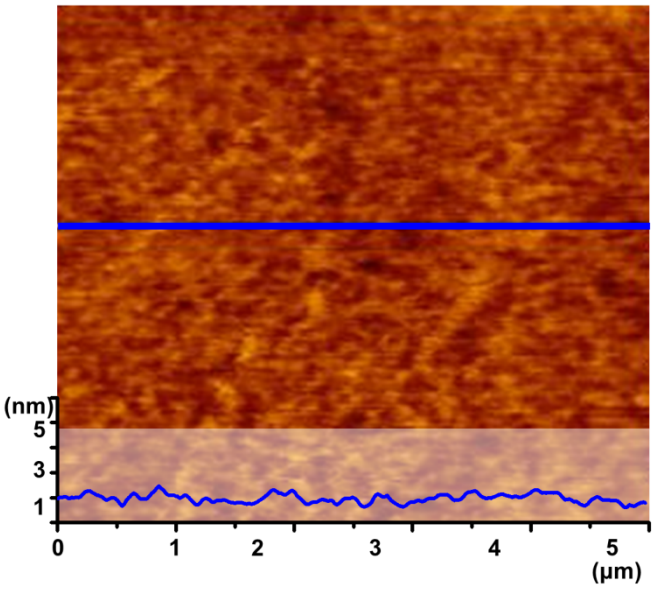

Figure S2. Surface scan image and profile of synthesized MoS_2 film.

Grain size of MoS_2 film by HRTEM.

Figure S3 represents the grains of MoS_2 film which has different crystalline directions. Each domain has distinct hexagonal lattice structure suggesting that the film is highly crystalline MoS_2. Domain size of each domain is over 10 nm that could be inferred by dashed line in Figure S3.

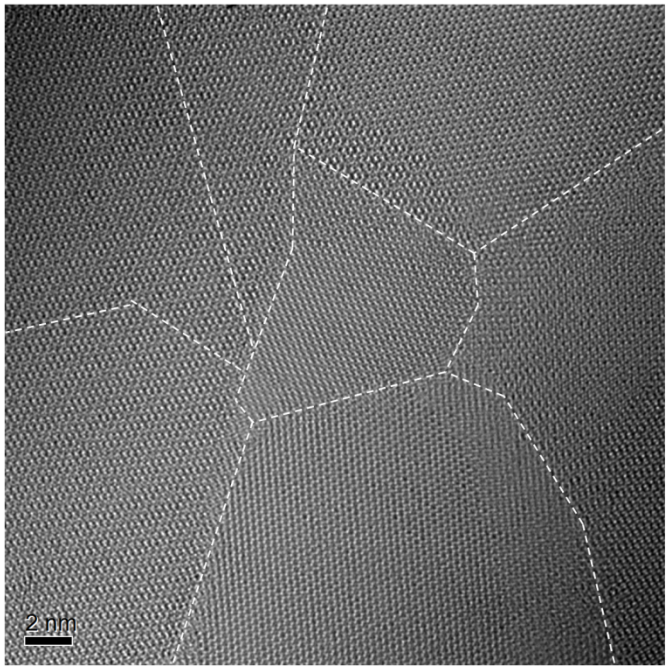

Figure S3. HRTEM image of MoS_2 film with polycrystalline grain boundaries.

Thickness measurement

The thickness could be measured by not only confocal Raman microscopy (Figure 4 c and d) but also step scan profile of AFM. Figure S4 (a-d) show topology image of 2, 4, 8, 12 layers of synthesized MoS2 films. The step patterns are prepared by photolithography. In Figure S4 (e-h), The step heights between film and bottom SiO2 surface are 1.35, 2.62, 5.17, and 7.82 nm, which are in agreement with the result of previous reports for exfoliated MoS_2.

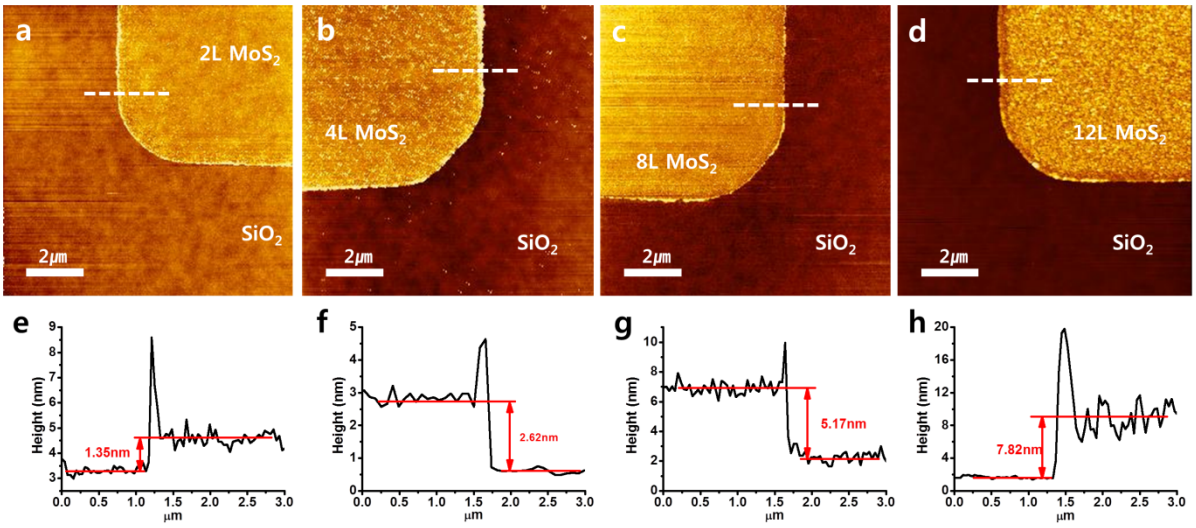

Figure S4. Atomic force microscopy (AFM) image of synthesized MoS_2 film. (a-d) Topology image. (e-h) Line profiles from 2layers to 12layers.