**Supporting information**

# Large-scale Atomically Thin Monolayer 2H-$MoS_2$ Field Effect Transistors

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***$MoS_2$ growth and characterization***: The $MoS_2$ films were deposited using gas-phase chemical vapor deposition (CVD) (Model: TCVD-100B, Graphene Square, South Korea) technique. The $MoS_2$ films were deposited on $SiO_2$ (300 nm)/Si ($p^{++}$) using Bis(tertbutylimido)bis(dimethylamido) molybdenum, $(N^tBu)_2(NMe_2)_2Mo$, and hydrogen sulfide ($H_2S$) at a growth temperature of 850 $^oC$ and a reactor pressure of 10 Torr. The precursor flow was set as 100 and 3 sccm for Mo and S respectively. The $(N^tBu)_2(NMe_2)_2Mo$ bubbler was maintained at 45 $^oC$. Thickness of the $MoS_2$ films was precisely manipulated from monolayer (1L) to ten layers (10 L) by controlling growth time from 4 min to 40 min. After the growth the films were allowed to cool rapidly in $H_2S$ environment. Room temperature Raman and photoluminescence measurements were carried out using LabRAM HR Evolution (HORIBA France) at an excitation laser wavelength of 532 nm with a power of 5 mW. X-ray photoelectron spectroscopy measurements were carried out using PHI VersaProbe III (ULVAC, Physical Electronics USA). Microstructural analysis was performed using Quanta 200 (FEI, Netherlands) field-emission scanning electron microscope with an accelerating voltage of 5.0 kV and a working distance of 9.3 mm. High-resolution transmission electron microscope images were acquired using Technai 20 (FEI, Netherlands).

***TEM specimen preparation:***

We have used a wet-transfer method to transfer the $MoS_2$ monolayers on to the copper grid. Initially, one edge of the monolayer $MoS_2$ deposited on $SiO_2$/Si substrate was scratched using a sharp knife. Then the scratched side was slowly immersed into the diluted hydrofluoric acid (HF) in DI water (1: 10 ratio). Within 10 to 15 secs, the $MoS_2$ films were floating on the surface of HF solution. Then the films were washed by transferring in to fresh DI water for 3 times and finally scooped using copper grids. The specimens were dried in room temperature (30 oC) for 24 hrs before analyzing using TEM.

***$MoS_2$ FET fabrication and characterization***:

Standard photolithography was employed to fabricate bottom-gated $MoS_2$ monolayer field-effect transistors (FETs) on $SiO_2$(300 nm)/Si ($p^{++}$) with bilayer Au(100 nm)/Ti(5nm) as ohmic contact metals for the source and drain. Electrical performance of the monolayer $MoS_2$ FETs were tested with a fixed channel width (350 µm) and varying channel lengths from 20 to 100 µm using a probe station (Lakeshore PS100, USA) equipped with a semiconductor parameter analyzer (4200 SCS, KEITHLEY).

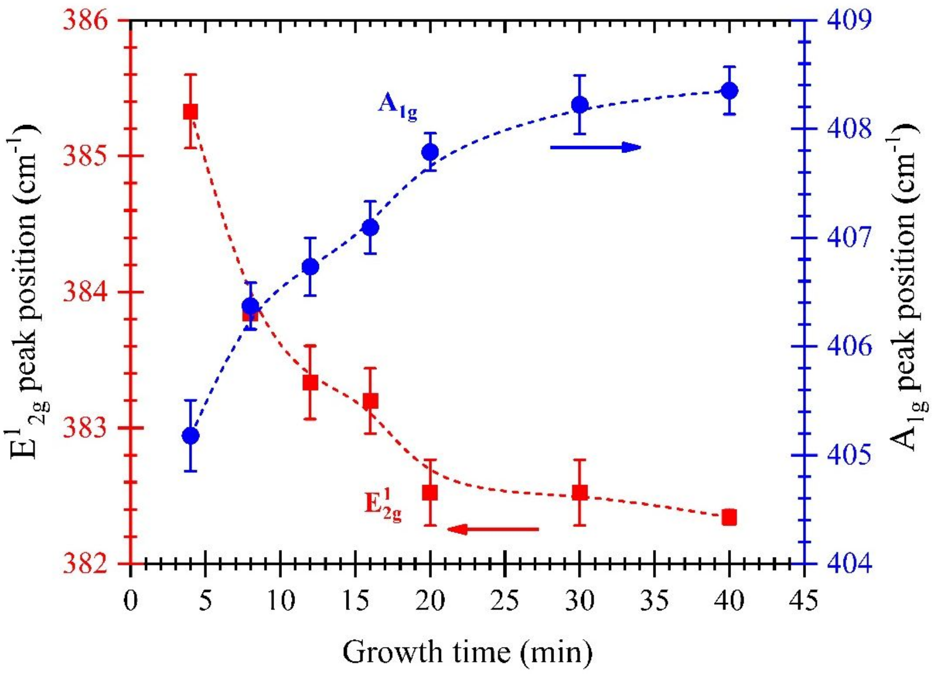


Figure S1. Dependence of the Raman vibrational mode positions ($E^1_{2g}$ and $A_{1g}$) of the $MoS_2$ films deposited on $SiO_2$/Si with a growth time varying from 4 to 40 min. The trend qualitatively explains increase in layer thickness with increase in growth time.

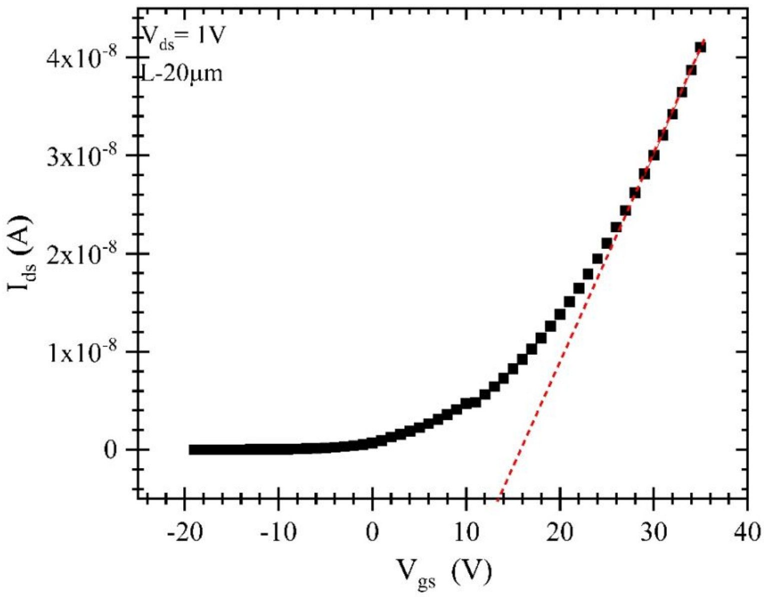


Figure S2. Transfer curve ($I_{ds}$-$V_{gs}$) obtained for $V_{ds}$= 1V for the FET device with channel length L=20 μm. The threshold voltage ($V_{th}$) is extracted from the intercept of the linear fit to the voltage axis.

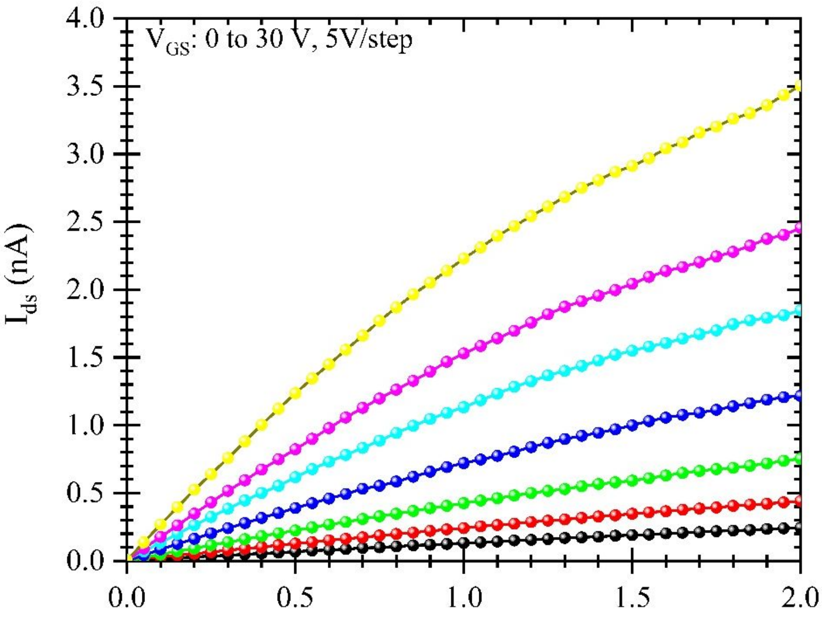


Figure S3. Out put characteristics of the $MoS_2$ FET with channel length L=20 μm displaying saturation behavior of the current ($I_{ds}$) above $V_{ds}$ = 1 V.

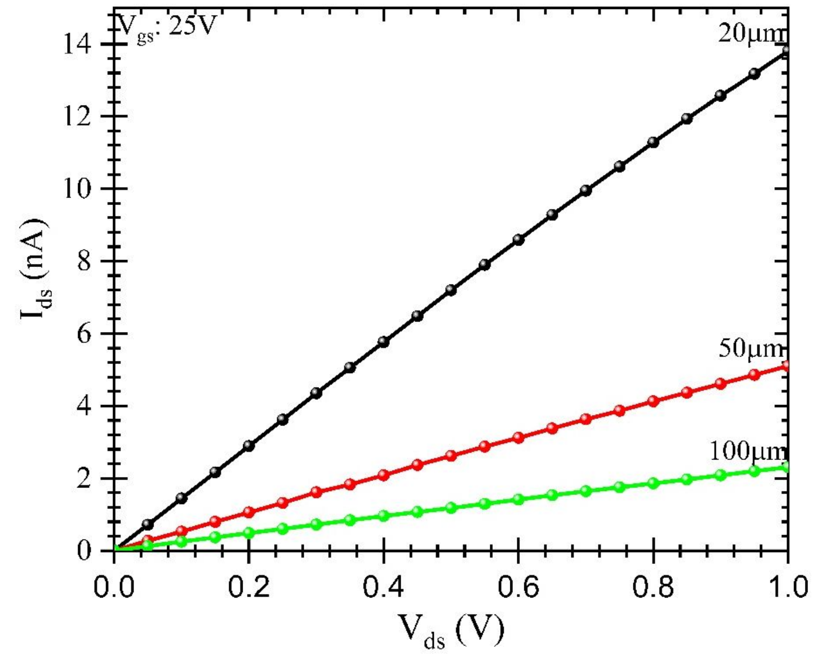


Figure S4. Out put characteristics ($I_{ds}$-$V_{ds}$) of the $MoS_2$ FET with various channel lengths (L=20, 50 and 100 μm) at $V_{GS}$= 25V. It is evident that the current decreases with increase in channel length.

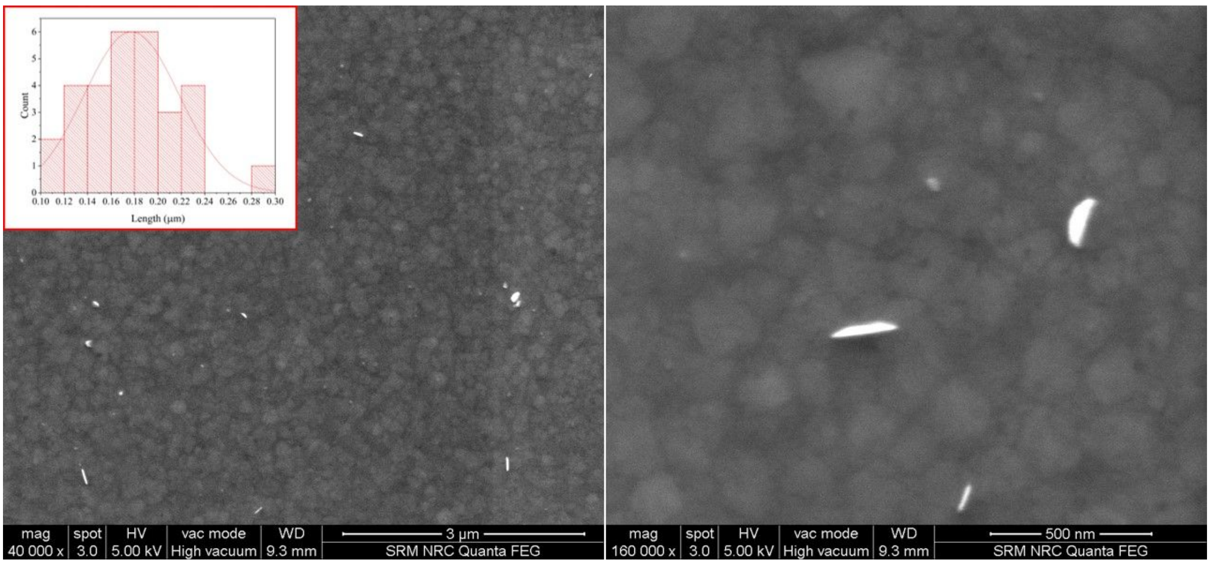


Figure S5. Field emission scanning electron microscope (FESEM) images of few layer $MoS_2$ grown on $SiO_2$/Si substrate. The inset shows the histogram of grain size variation (100 nm to 200 nm) with average grain size ~180 nm.

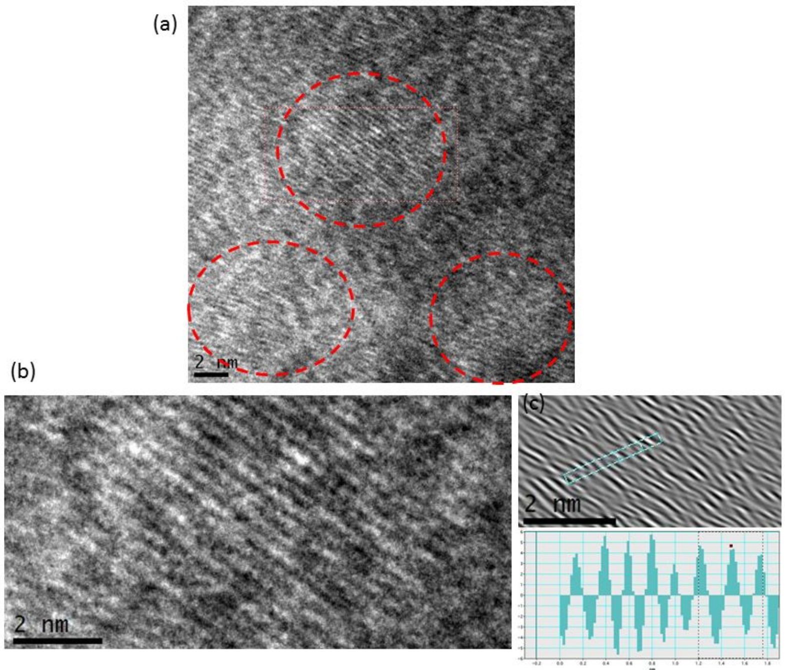


Figure S6. High-resolution transmission electron microscope (HRTEM) images of the monolayer $MoS_2$. The d-spacing of the monolayer $MoS_2$ is estimated as ~ 0.324 nm, using GATAN DM software.

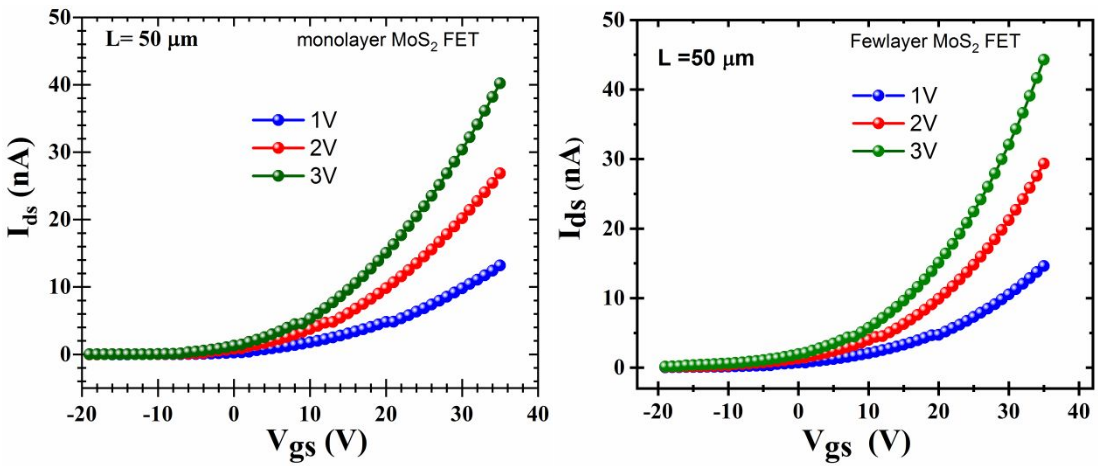


Figure S7. Transfer characteristics of the monolayer $MoS_2$ and few layer $MoS_2$ FETs for a fixed channel length of 50 μm. It can be seen that both the devices show nearly same current values indicating the similar scattering mechanism in both monolayer and few layered samples.