Electronic Supplementary Material (ESI) for CrystEngComm.

Supporting Information

Promoter-free synthesis of monolayer MoS_2 by chemical vapour deposition

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Growth Optimization:

Growth process of monolayer MoS_2 is significant depends on the ratio of precursors, carrier gas flow, distance between the substrate and Mo source. For the growth of MoS_2, all the substrates are cleaned using sonication with double de-ionized water, isopropanol and acetone 10 minutes each and followed by piranha solution treatment for 2 hours at 70°C.

Figure S1, FESEM image of MoS_2 growth carried with Ar carrier gas flow of 100 SCCM. The high carrier gas flow used to transport vapour phase precursors of $MoO_{(3-x)}$ and MoS_2 towards the substrate, the high carrier gas flow leads to low absorption of precursors on the substrate. Figure S1 shows the formation of only very small domains of MoS_2 on the substrate for the sulphurization period of 10 minutes, the average domain size is 50nm only.

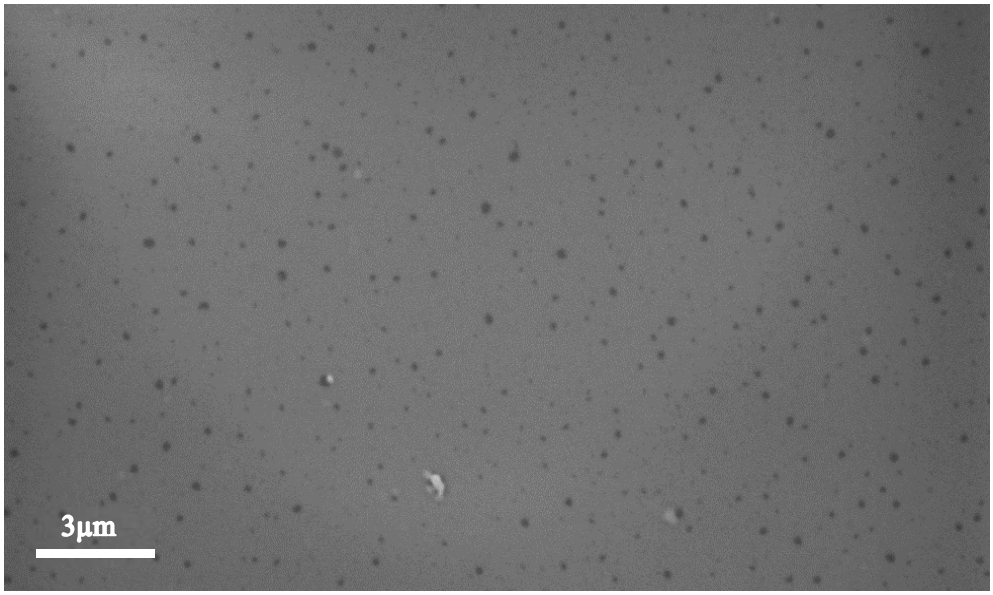
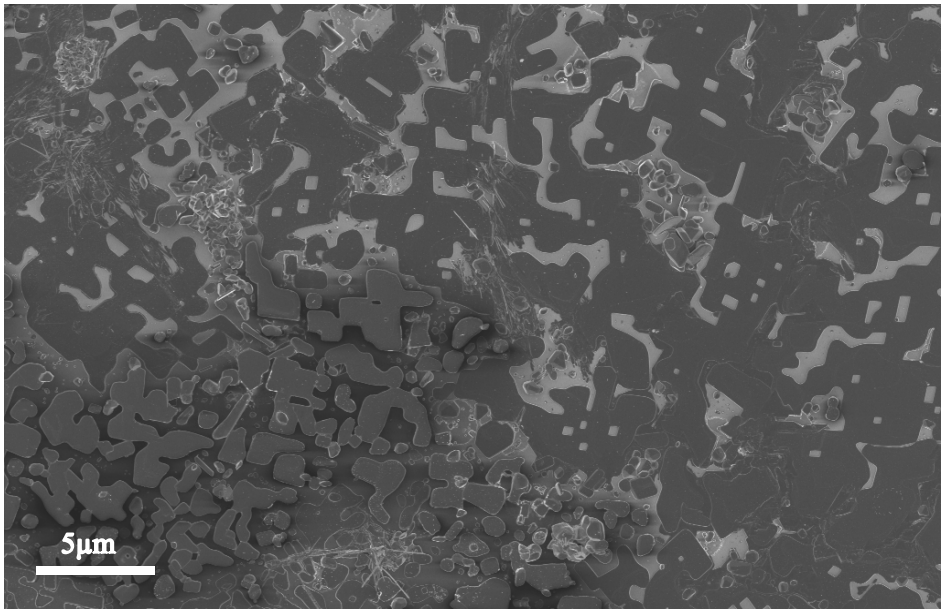


Figure S2 & S3, FESEM image of MoS_2 grown on the substrate with distance 0.2cm and 0.5cm from the MoO_3 source at the carrier gas flow of 15SCCM. Placing substrate close to the Mo source leads to formation of MoO_2 crystals on the substrate because of high concentrated vapours of MoO_2. During sulphurization, the out surface of MoO_2 features are sulphurized and leads to formation of core shell like structure of MoS_2/MoO_2. On the substrate placed 0.5cm away from source leads to low dense MoO_2 deposition which is clearly shown in figure S3.



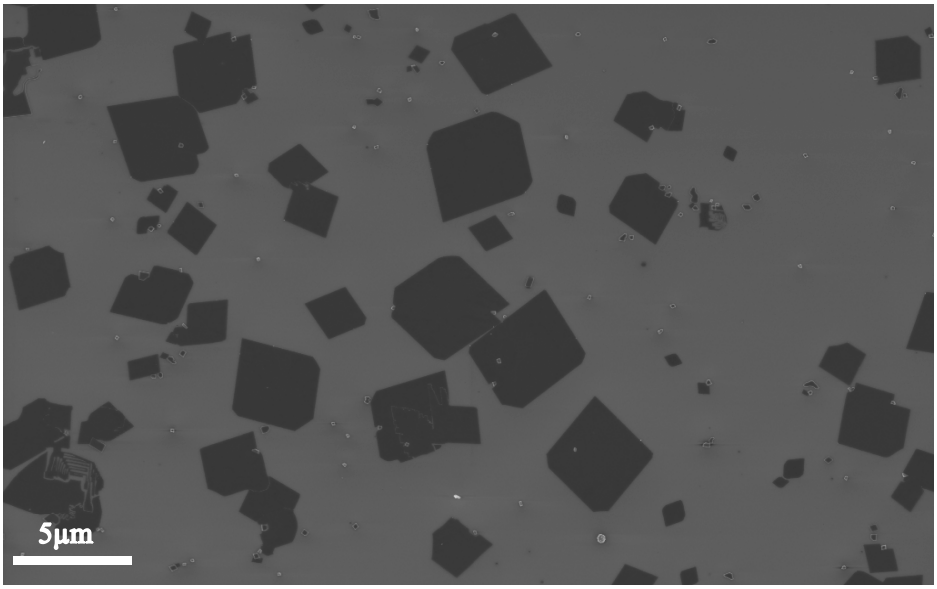
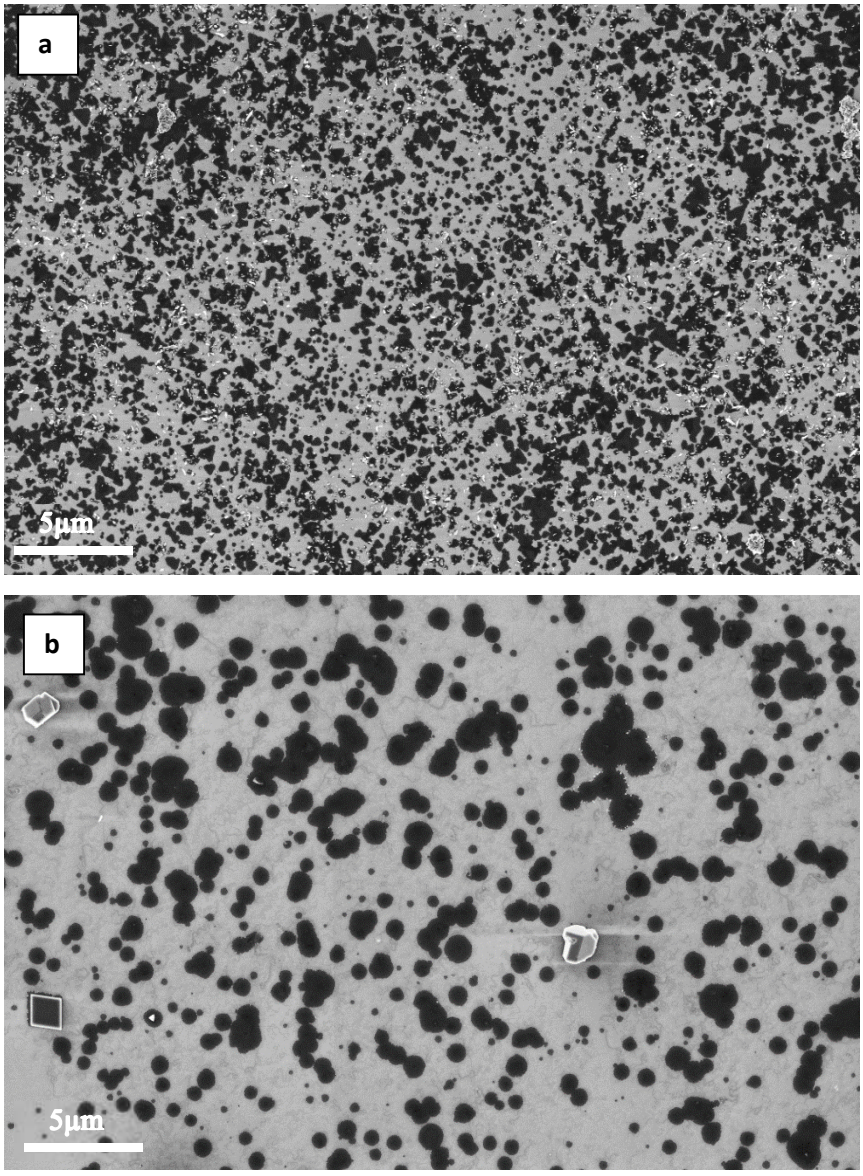


Figure S4, for the growth temperature of 650 ˚C and 800 ˚C carried with gas flow of 15SCCM and substrate distance of 1cm from MoO_3. For the growth temperature of 650 ˚C, we observe many unreacted species on the top of grown perfect MoS_2 triangle and some vertical MoS_2 formations are also observed as shown in figure S4a. As compare to the MoS_2 grown at temperature of 800 ˚C shown hexagonal formation of MoS_2 with very low amount of impurities, however it exhibits structural deformation form unique triangle to hexagonal (Figure S4b).



Contact Angle Measurements:

Figure S5 is the water contact angle measurements for piranha treated and bare SiO_2 substrate. As expected, the super acidic piranha treated substrate shows very low contact angle of $\theta=34^{\circ}$ (figure S5a) and non-treated substrate exhibits $\theta=132^{\circ}$ (figure S5b) which is nearly 5 times higher than the piranha treated substrate.

Figure S5, Water contact measurement of SiO_2 substrate a) with piranha b) without piranha treatment.

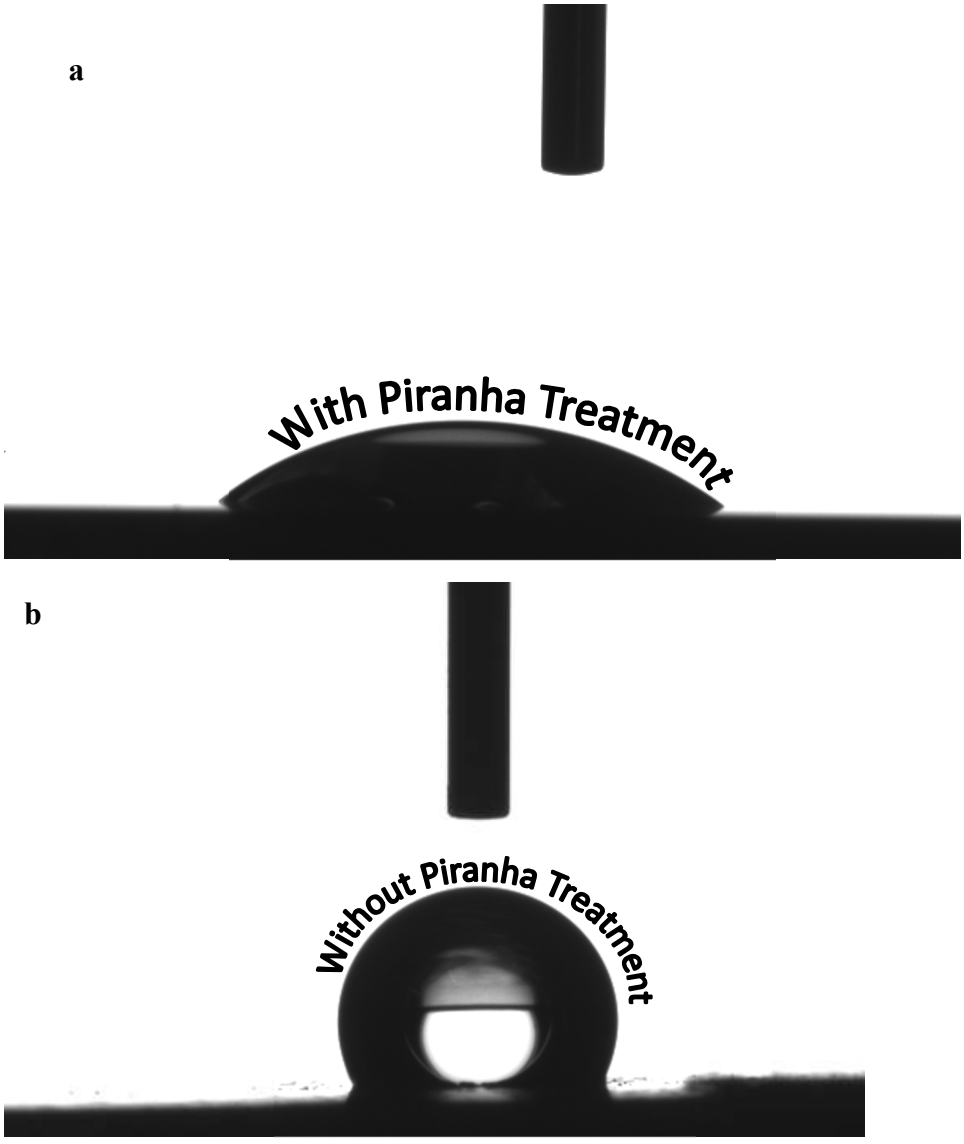


Figure S6, Formation of grain boundaries due to merging of triangle MoS_2.

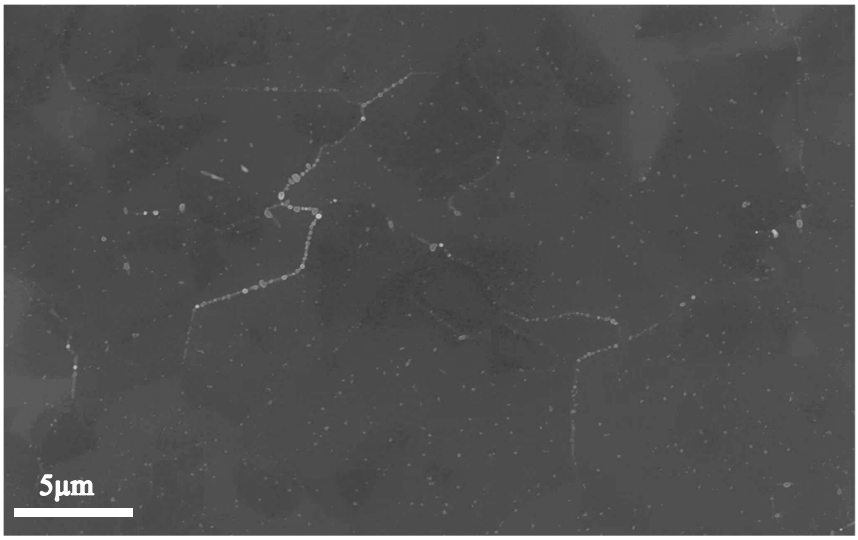


Figure S7, Interconnection of MoS_2 domains

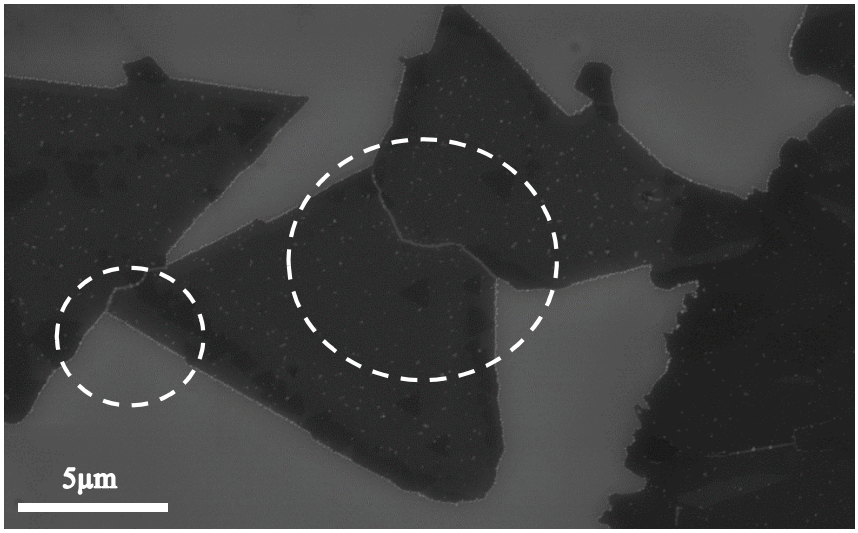


Figure S8, Overlap of MoS_2 sheets.

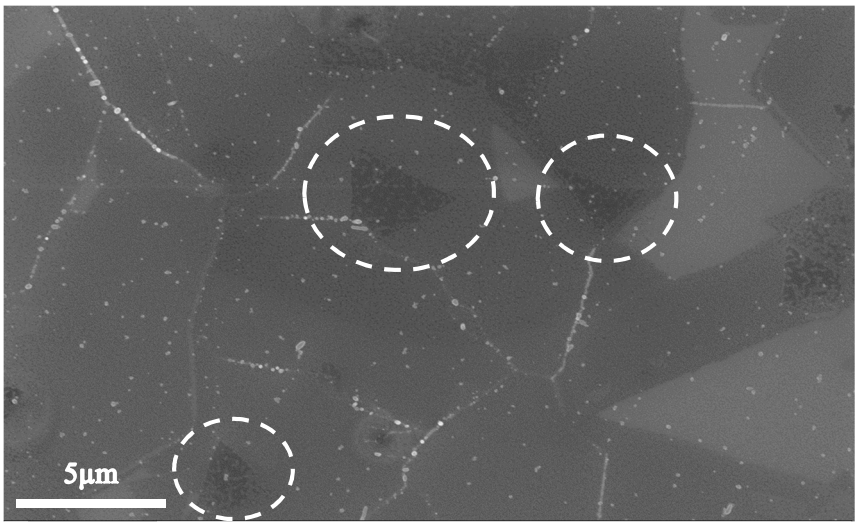
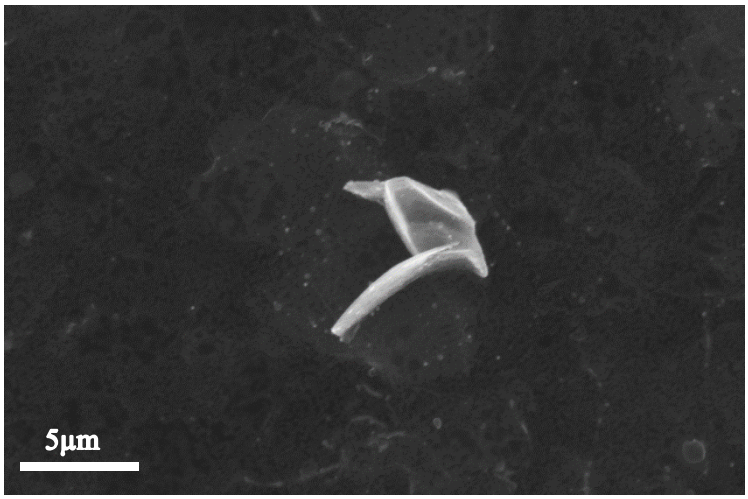


Figure S9, MoS_2 grown on graphene transferred SiO_2 substrate.



Graphene growth by CVD and its characterization:

Graphene layers were grown on Cu foil by self-limiting mediated growth by atmospheric pressure CVD and transferred onto SiO_2 substrate. The FESEM image of transferred graphene on SiO_2 is shown in Figure S10 (a & b). Raman spectrum of graphene recorded using 532nm laser excitation source is illustrated in Figure S10 c. The characteristics peaks of D, G and 2D are observed at 1349, 1645 and 2699cm^{-1}**.** The thickness of graphene layer was calculated to be bilayers from Raman intensity ratio of I_D/I_G. Ti/Au (10/80 nm) Ohmic contacts were formed by e-gun deposition process for the electrical measurements. A strong linear I-V characteristic is observed from the transport measurements which witnesses that graphene is highly conductive over large scale (0.5 cm) (Figure S10 d).

Figure S10, a&b) FESEM images of graphene transferred on SiO_2, c) Raman spectrum of graphene recorded after transfer onto SiO_2 substrate and d) I-V curve of graphene transferred onto SiO_2 substrate with channel length of 0.5cm

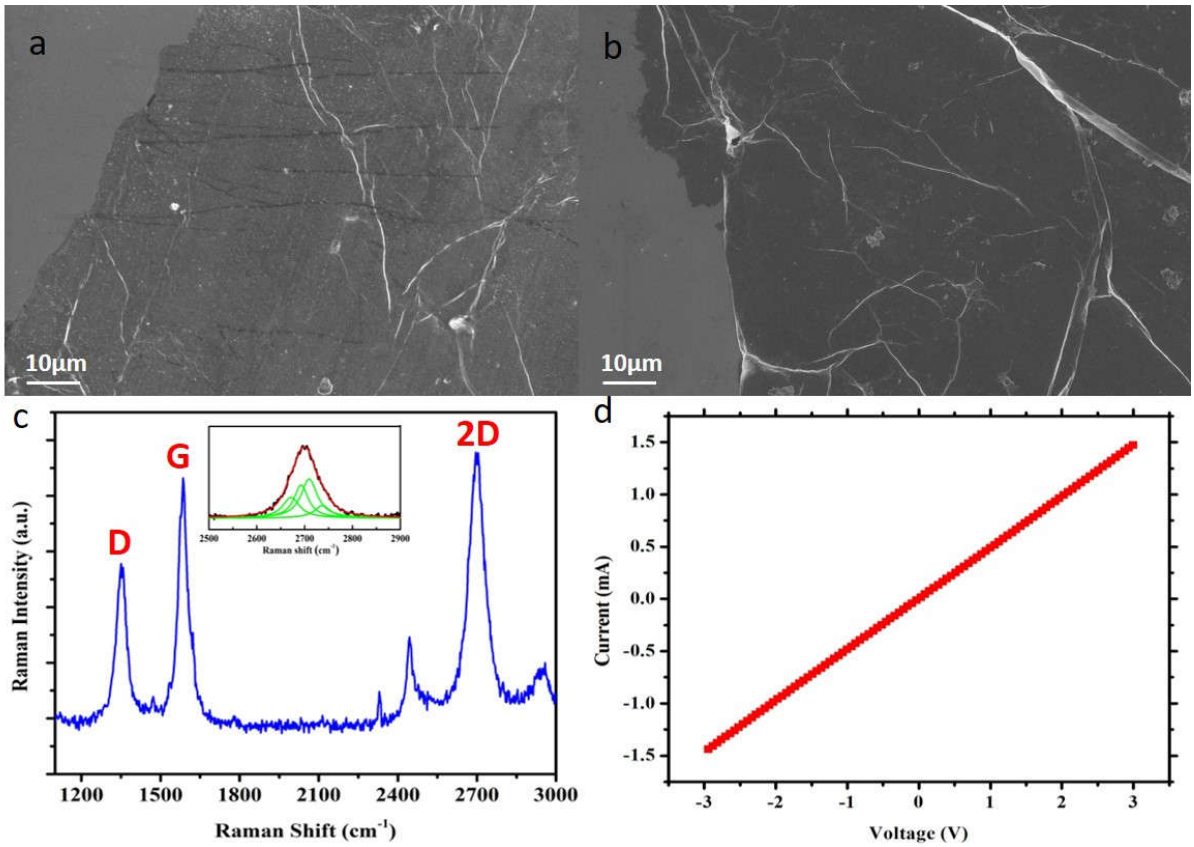


Figure S11, Digital image of centimetre scale grown monolayer MoS_2 on SiO_2

References:

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