Electronic Supplementary Information (ESI)

Controlled Growth of MoS_2 Nanopetals and Their Hydrogen Evolution Performance

Lin Ling,[1,2] Chan Wang,[1] Kai Zhang,[2] Taotao Li,[2] Lei Tang,[2] Chaowei Li,[2] Liangjie Wang,[2] Yancui Xu,[2] Qijun Song[1] and Yagang Yao*[2]*

[1] Key Laboratory of Food Colloids and Biotechnology, Ministry of Education, School of Chemical and Material Engineering, Jiangnan University, Wuxi 214122, China.

[2] Division of Advanced Nanomaterials, Key Laboratory of Nanodevices and Applications, Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, Suzhou 215123, China.

*Address correspondence to Qijun Song, qsong@jiangnan.edu.cn; Yagang Yao, ygyao2013@sinano.ac.cn

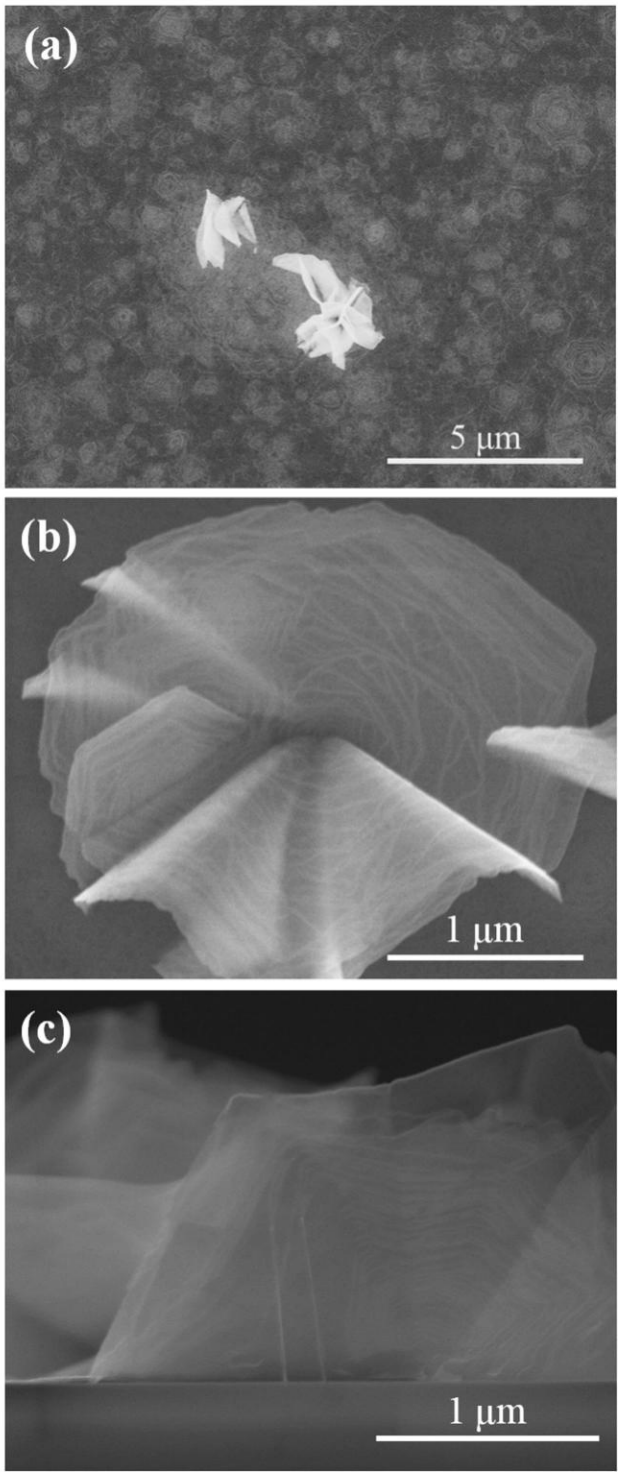

Fig. S1 SEM images show features of spiral growth. (a and b) Top-view SEM images of sample A4. (c) Cross-section SEM image of sample C2.

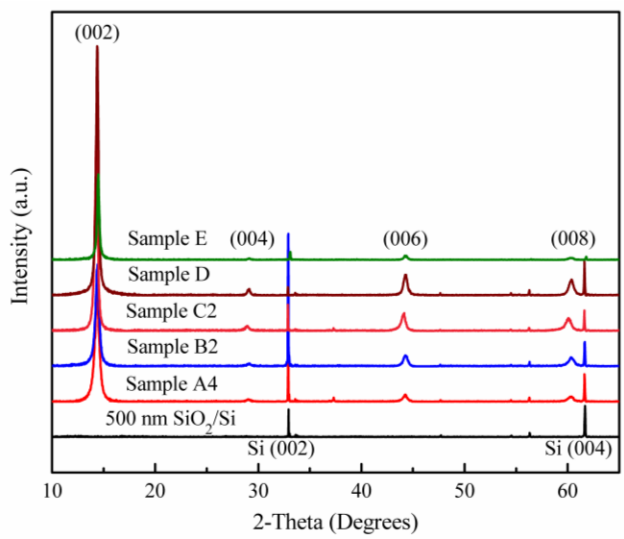

Fig. S2 XRD of Sample A4, B2, C2, D, E and 500 nm SiO_2/Si substrate.

XRD measurements confirm the complete chemical conversion from MoO_3 to MoS_2. High resolution X-ray scans of the five investigated samples A4, B2, C2, D, E and 500 nm SiO_2/Si substrates are compared in Fig. S2. A strong sharp (002) diffraction peak is observed at 2θ = 14.5°, corresponding to the MoS_2 films along the basel plane. Higher order peaks (004), (006) and (008) are observed, confirming that MoS_2 thin films are highly basal-oriented. All peaks are indexed to the MoS_2 according to JCPDS card No. 37-1942.

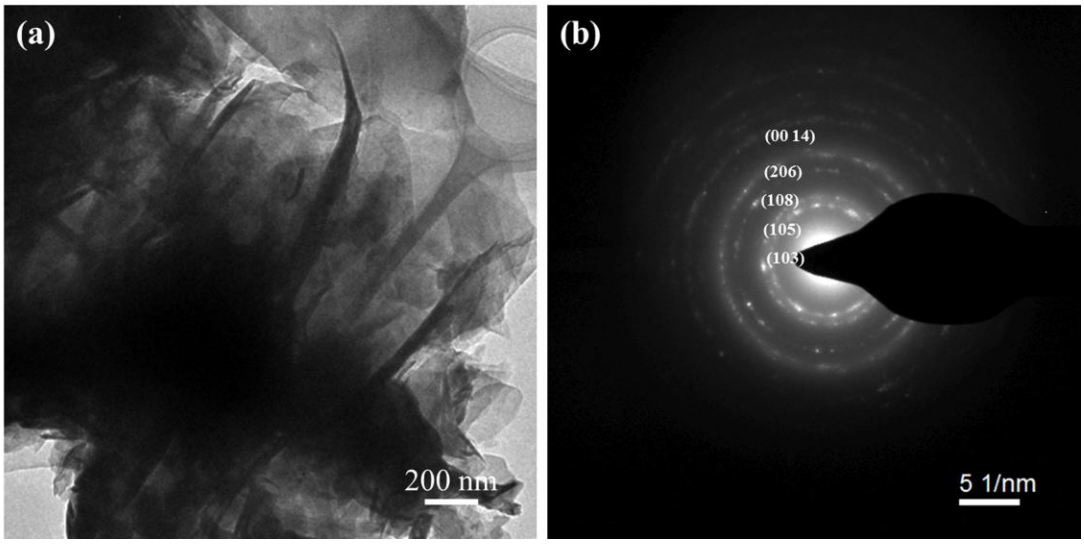

Fig. S3 (a) TEM image of sample B2. (b) Corresponding SAED pattern.

TEM samples are prepared via a following procedure: some products are stripped off and dispersed in alcohol with the aid of ultrasonic vibration for 1 h, and then a drop of the solution is transferred onto a standard holey carbon covered copper TEM microgrid.

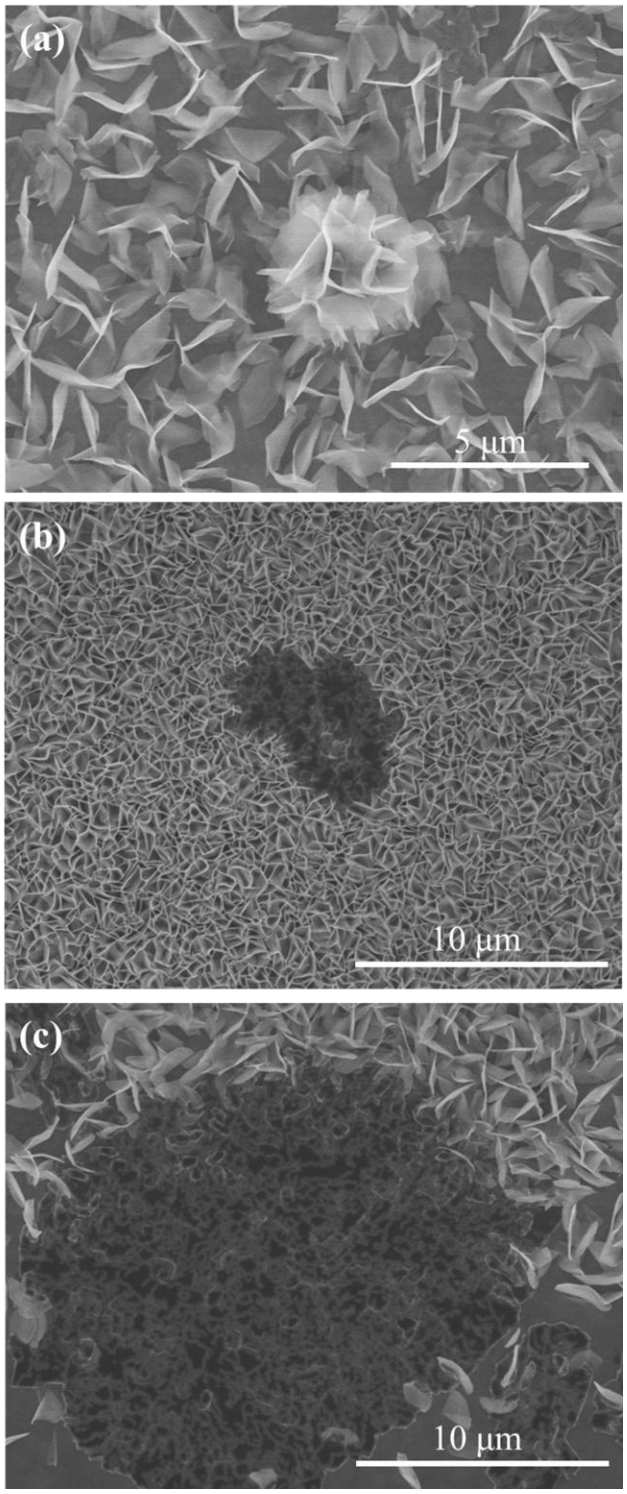

Fig. S4 (a) SEM image of sample B2. (b and c) SEM images of sample C2.

Some particles and sheets which arised from the incomplete sulfuration were sometimes observed either at the roots or among the MoS_2 nanopetals (Fig. S4a). Influenced by dense sulphur atmosphere, large layers sometimes formed on the top of MoS_2 nanopetals. The edges were hided (Fig. S4b and S4c).

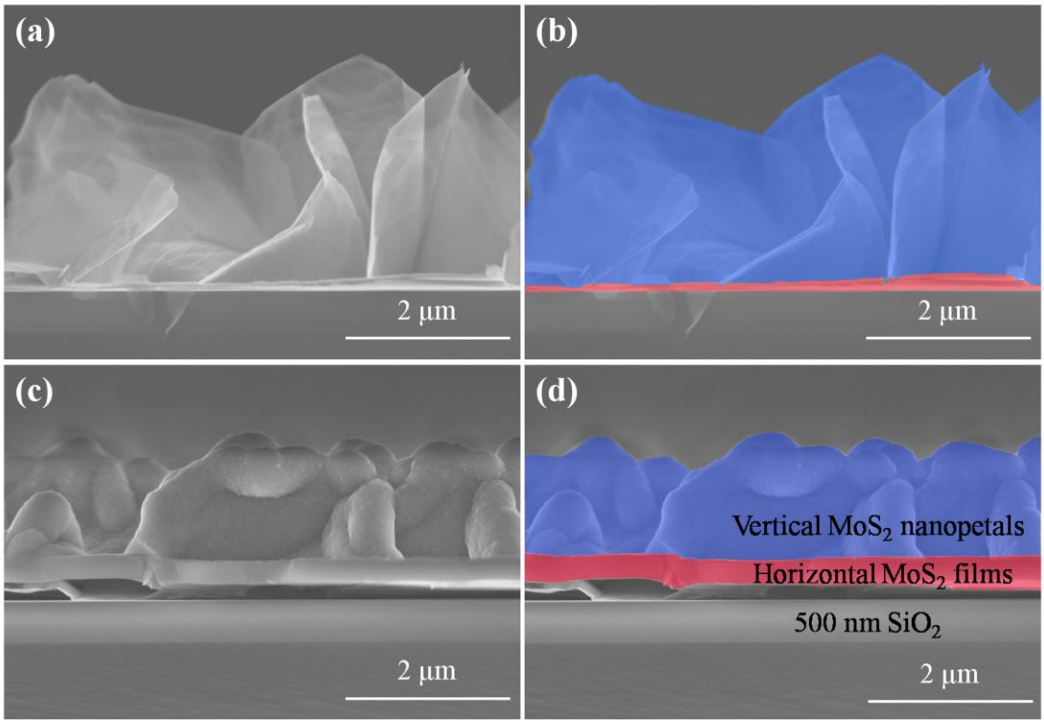

Fig. S5 (a and b) Cross-section SEM images of sample D. (c and d) Cross-section SEM images of sample E. Compared regions are shown with blue (vertical MoS_2 nanopetals) and red (horizontal MoS_2 films) in this two samples (b and d).

According to cross-section SEM images of sample D and E, we can clearly see the boundary between vertical MoS_2 nanopetals, horizontal MoS_2 films and 500 nm SiO_2 layer. Different areas can be derived by image software to calculate the ratio of vertically aligned MoS_2 nanopetals / total MoS_2 (F).[1] We calculated it as the ratio between the area of vertically aligned MoS_2 nanopetals (S_v, blue) and horizontal MoS_2 films (S_h, red) according to:

$$F = \frac{S_v}{S_v + S_h} \times 100\%$$

This type of calculation requires the sheets to be aligned and close-packed in 3D space. With the increase of the growth temperature from 900 to 950 ^{o}C, vertically aligned MoS_2 nanopetals and horizontal MoS_2 films both become thicker. The value of F decreased from 82.1% to 79.5%.

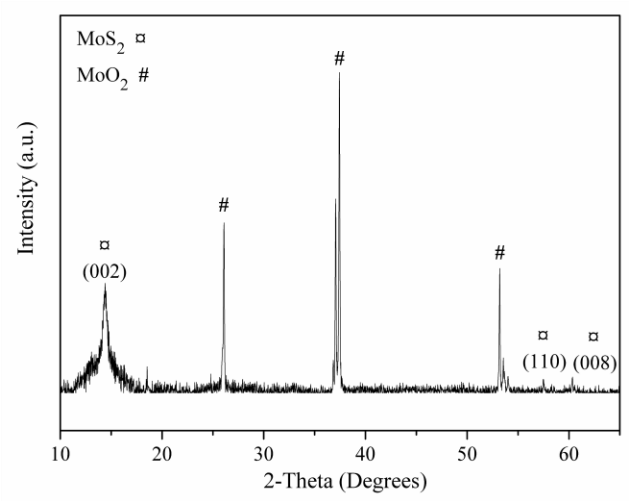

Fig. S6 XRD data of products synthesised with S/MoO_3 mass ratio less than 10:1.

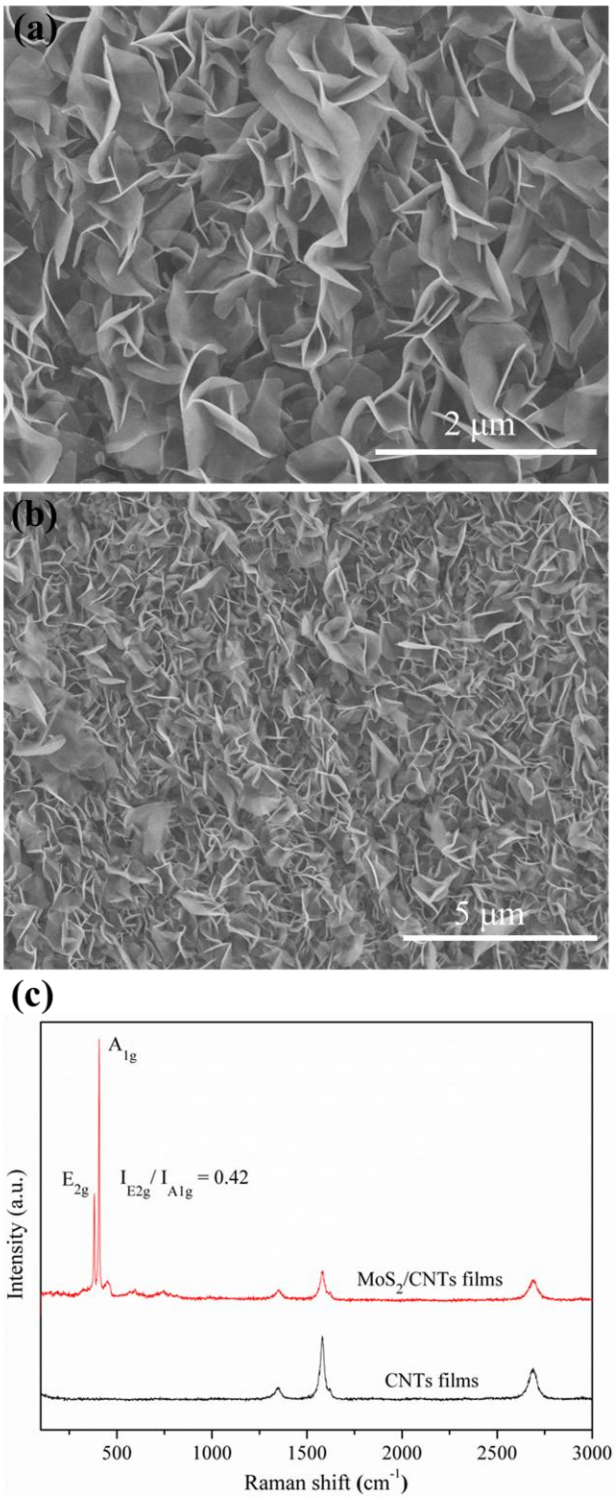

Fig. S7. (a and b) SEM images of MoS_2 nanopetals grown on the CNT films at 800 ℃ for 1 h. (b) Raman spectra of the CNT films and MoS_2/ CNT films.

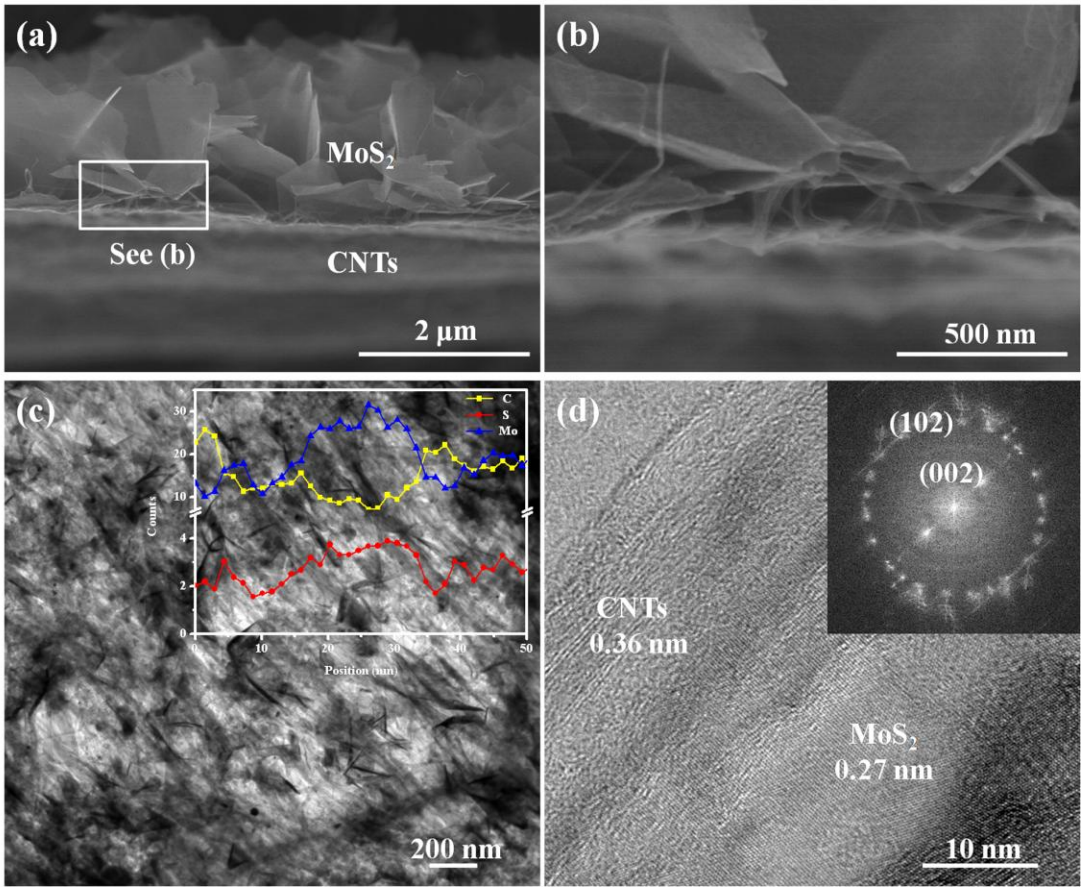

Fig. S8 (a and b) Cross-section SEM images of MoS_2 nanopetals on the CNT films. (c) TEM image of MoS_2 nanopetals on the CNT films (Inset: Line-scan EDS spectra). (d) HRTEM image (Inset: corresponding FFT patterns).

Fig. S8a and S8b show the interfacial structure of MoS_2 on the CNT films, assuring that there is a robust atomic connection between the interface through which efficient electron transfer may occur. Fig. S8c suggests that strong adhesion between MoS_2 nanopetals and the CNT film is still maintained after ultrasonic vibration for 1 h. Fig. S8d clearly shows different regions of MoS_2 and CNTs with crystal lattice. In addition, the FFT pattern clearly identifies diffraction rings corresponding to the planes of hexagonal-phase MoS_2 (Inset of Fig. S3d)

References

1 S. Esconjauregui, R. Xie, M. Fouquet, R. Cartwright, D. Hardeman, J. Yang and J. Robertson, *J. Appl. Phys.*, 2013, **113**, 144309.