Electronic Supplementary Information for

Rational Design of 3D MoS_2/Dual-channel graphene framework hybrid as a free-standing electrode for Enhanced Lithium Storage

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Supplementary Figures S1 to S10, and Table S1 to S2

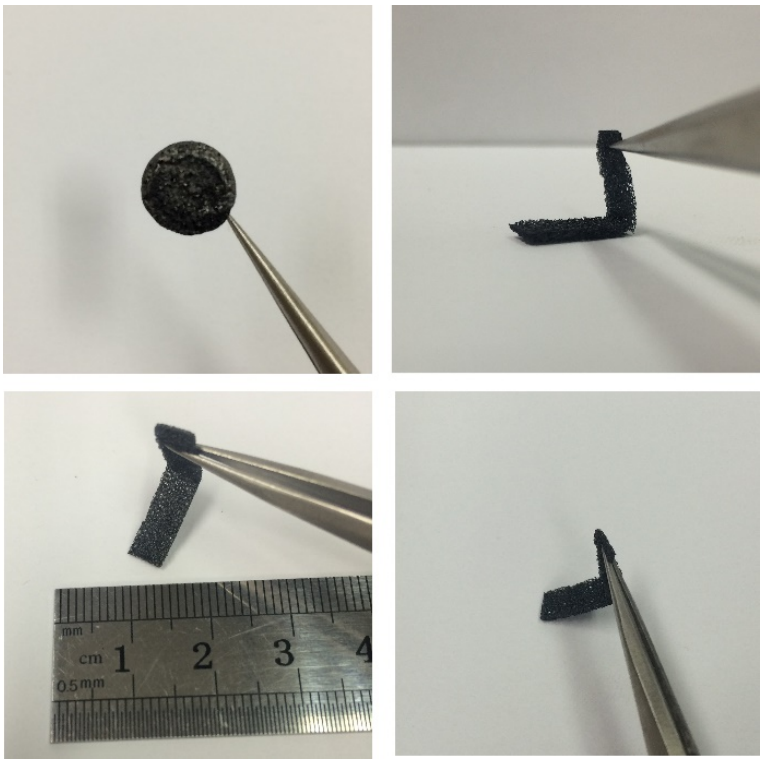

Fig. S1 The photograph of the as-prepared MoS_2/GA-GF free-standing electrode.

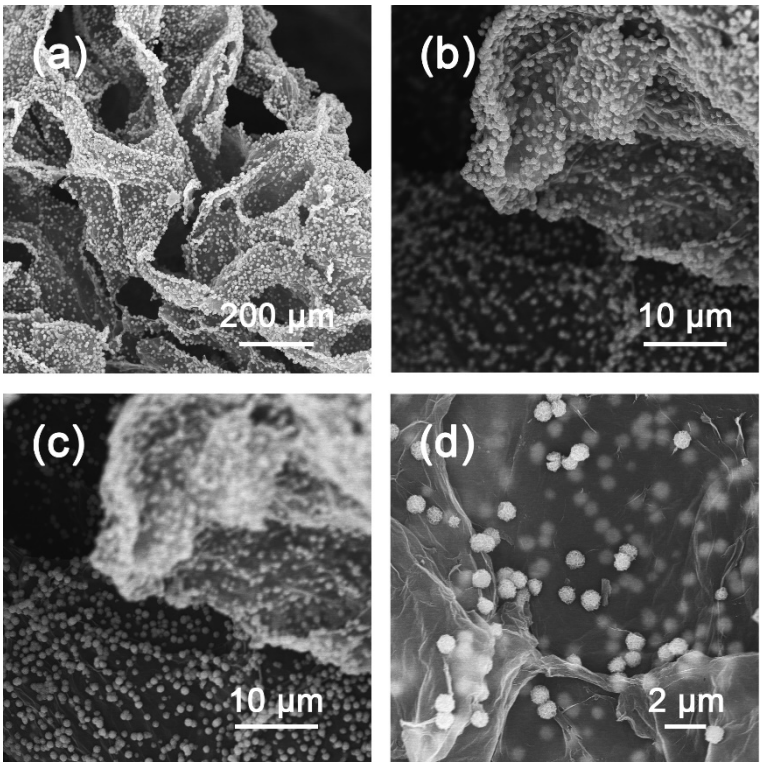

Fig. S2 FE-SEM images of MoS_2/GA-GF.
MoS_2-PHSs are uniformly distributed on GA-GF surface.

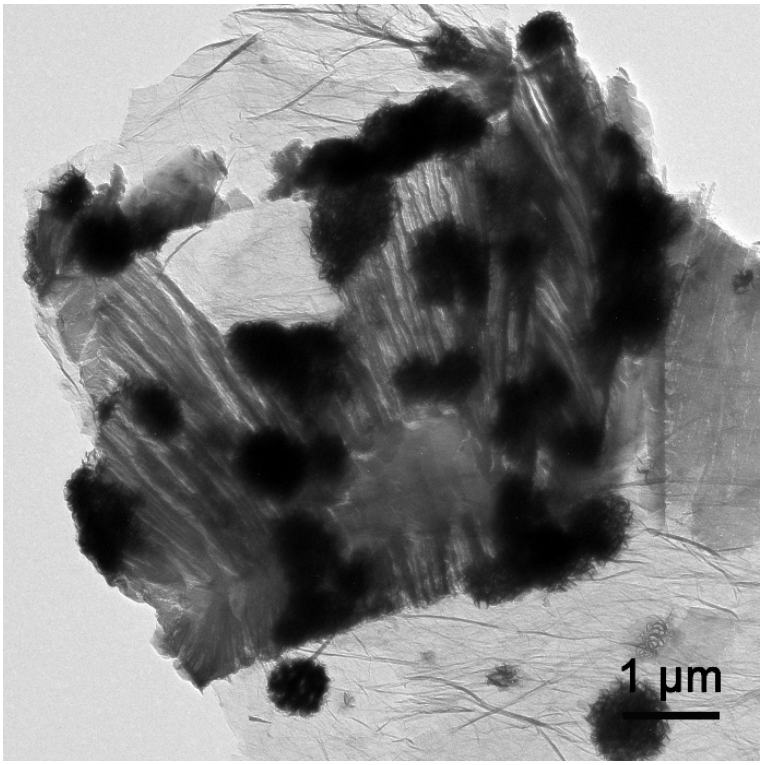

Fig. S3 TEM image of MoS_2/GA-GF.
After 30min sonication, the MoS_2-PHSs are still firmly growth on GA-GF surface.

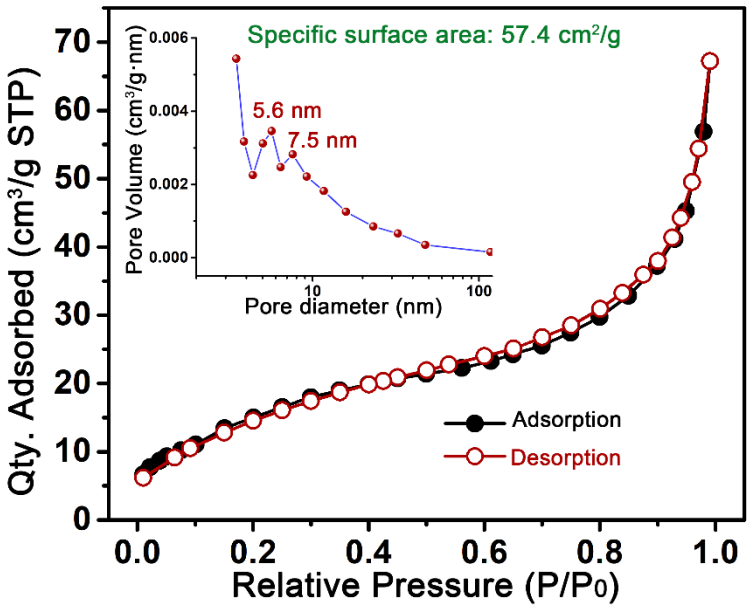

Fig. S4 The Nitrogen adsorption/desorption isotherms and pore size distribution of the MoS_2/GA-G hybrid

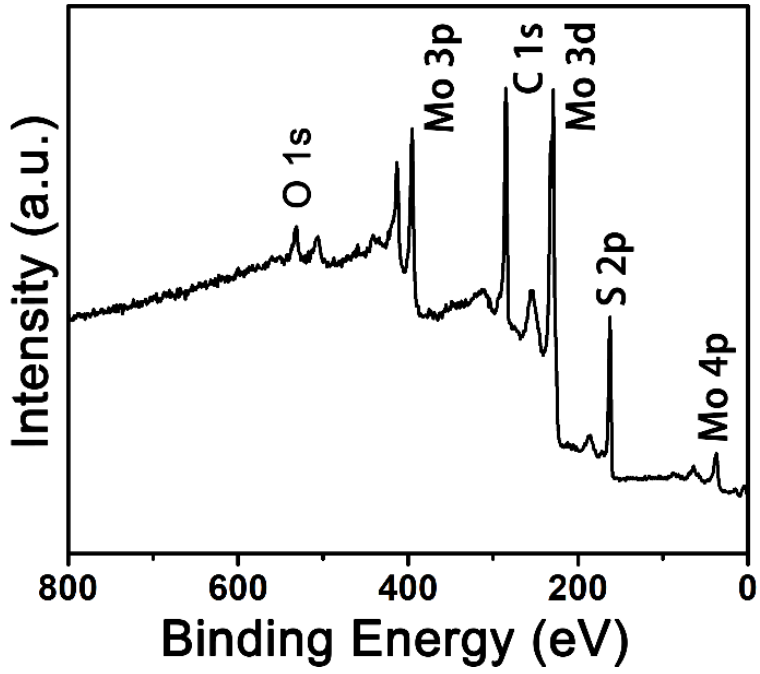

Fig. S5 The XPS survey spectrum of MoS_2/GA-GF hybrid

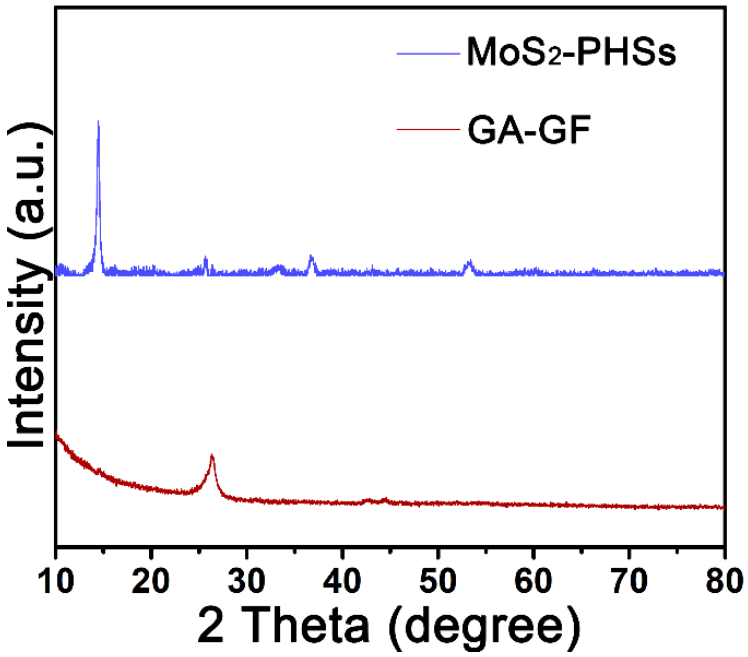

Fig. S6 XRD pattern of MoS_2-PHSs and GA-GF.

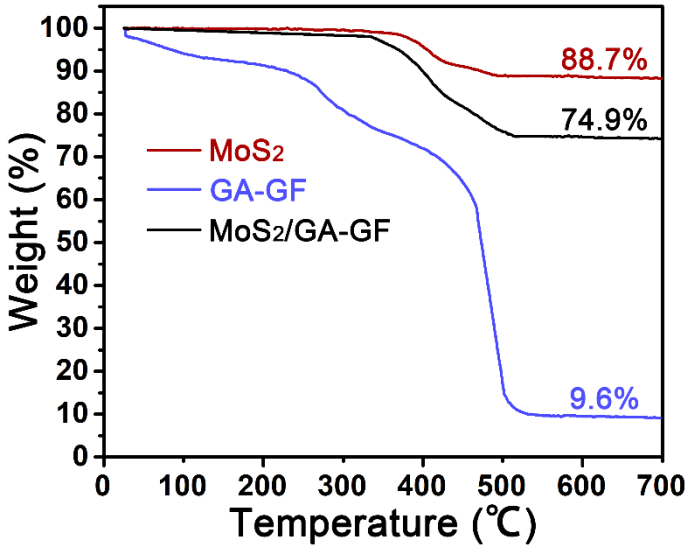

Fig. S7 Thermogravimetric analysis (TGA) of MoS_2/GA-GF hybrid, GA-GF, and MoS_2 sample. The TGA were carried out from room temperature to 700 ℃ with the heating rate of 10 ℃ min^{-1} in air. It is indicated that the MoS_2 weight content in the MoS_2/GA-GF hybrid is nearly 82.6%.

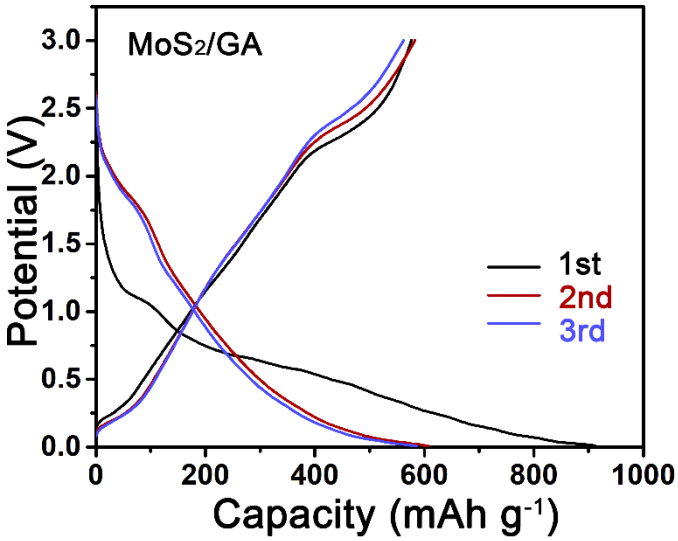

Fig. S8 The galvanostatic charge/discharge curves at 0.2 A g^{-1} of the first three cycles for the MoS_2/GA electrode.

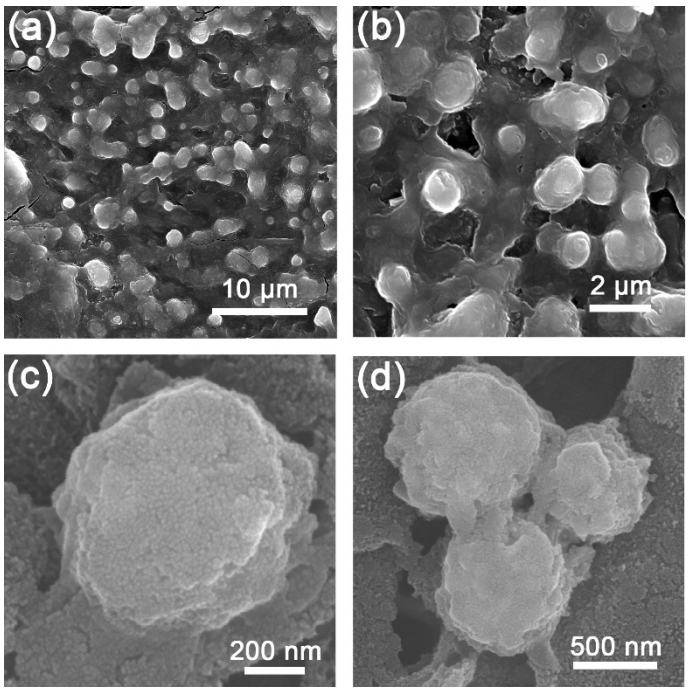

Fig. S9 SEM image of the MoS_2/GA-GF after 200 cycles at 0.2 A g^{-1}.

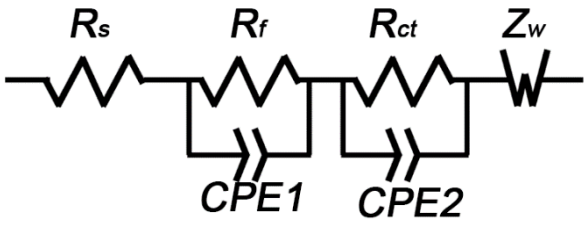

Fig. S10 Equivalent circuit used for simulating the experimental impedance data.

Table S1 The impedance value of MoS_2/GA-GF and MoS_2/GA electrodes after 50th and 500th cycles.

Impedance*	Cycles	R_s(Ω)	R_f(Ω)	R_{ct}(Ω)
MoS_2/GA-GF	50^{th}	2.8	34.5	15.6
	500^{th}	1.5	29.0	13.2
MoS_2/GA	50^{th}	6.1	146.7	55.2
	500^{th}	4.0	69.5	38.2

Table S2 Comparison of electrochemical performance for MoS_2 composite anodes reported previously.

Materials	Cycling stability ($mAh\ g^{-1}$)	Rate capability ($mAh\ g^{-1}$)	Ref.
MoS_2/GA-GF	1183 mAh g^{-1} at 0.2 A g^{-1} after 200 cycles	843 mAh g^{-1} at 1 A g^{-1}after 500 cycles	This work
MoS_2/graphene	1077 mAh g^{-1} at 0.1 A g^{-1} after 150 cycles	907 mAh g^{-1} at 1 A g^{-1}after 400 cycles	1
graphene-like MoS_2 nanowall/graphene	700 mA h g^{-1} at 0.5 A g^{-1} after 100 cycles	590 mAh g^{-1} 3 A g^{-1}	2
layered MoS_2/graphene nanoribbons	1009.4 mA h g^{-1}at 0.2 A g^{-1} after 80 cycles	606.8 mA h g^{-1} at 3 A g^{-1}	3
MoS_2/reduced graphene oxide	1180 mA h g^{-1} at 0.1 A g^{-1} after 80 cycles	750 mAh g^{-1} at 3 A g^{-1}	4
MoS_2-coated vertical graphene	1060 mA h g^{-1} at 0.2 A g^{-1} after 100 cycles	818 mAh g^{-1} at 3 A g^{-1}	5
N-doped graphene/MoS_2	1205 mA h g^{-1} at 0.1 A g^{-1} after 200 cycles	980 mA h g^{-1} at 1 A g^{-1}after 400 cycles	6
Mesoporous-carbon/MoS_2/ carbon	~1400 mA h g^{-1} at 0.1 A g^{-1} after 300 cycles	400 mA h g^{-1} at 10 A g^{-1}	7
N-doped graphene/MoS_2	~1000 mA h g^{-1} at 0.1 A g^{-1} after 120 cycles	~460 mAh g^{-1} at 5 A g^{-1}	8
8.4 % MoS_2-C composite	~970 mA h g^{-1} at 0.1 A g^{-1} after 100 cycles	730 mAh g^{-1} at 1 A g^{-1}	9
C@MoS_2@C	857 mA h g^{-1} at 0.067 A g^{-1} after 100 cycles	382 mA h g^{-1} at 3.35 A g^{-1}	10
NDG/MoS_2/NDG	750 mAh g^{-1} at 0.1 A g^{-1} after 100 cycles	552 mAh g^{-1} at 1 A g^{-1} after 600 cycles	11
G/MoS_2	931 mAh g^{-1} at 0.1 A g^{-1} after 100 cycles	400 mAh g^{-1} at 2 A g^{-1}	12

Reference

1 Y. Teng, H. Zhao, Z. Zhang, Z. Li, Q. Xia, Y. Zhang, L. Zhao, X. Du, Z. Du, P. Lv, K. Wierczek, *ACS Nano*, 2016, 10,8526-8535.

2 J. Guo, X. Chen, S. Jin, M. Zhang, C. Liang, *Catal. Today*, 2015, 246, 165-171.

3 R. Tian, W. Wang, Y. Huang, H. Duan, Y. Guo, H. Kang, H. Li, H. Liu, *Journal of Materials Chemistry A*, 2016, 4, 13148-13154.

4 G. Liu, Y. Feng, Y. Li, M. Qin, H. An, W. Hu, W. Feng, *Particle and Particle Systems Characterization*, 2015, 32, 489-497.

5 Y. Wang, B. Chen, D.H. Seo, Z.J. Han, J.I. Wong, K. Ostrikov, H. Zhang, H.Y. Yang, *NPG Asia Materials*, 2016, 8, e268

6 T. T. Shan, S. Xin, Y. You, H. P. Cong, S. H. Yu, A. Manthiram, *Angewandte Chemie-International Edition*, 2016, 55, 12783-12788.

7 Y. Fang, Y. Lv, F. Gong, A. A. Elzatahry, G. Zheng, D. Zhao, *Advanced Materials*, 2016, 28, 9385-9390.

8 C. Zhao, X. Wang, J. Kong, J.M. Ang, P.S. Lee, Z. Liu, X. Lu, *Acs Applied Materials & Interfaces*, 2016, 8, 2372-2379.

9 W. Sun, Z. Hu, C. Wang, Z. Tao, S.-L. Chou, Y. M. Kang, H. K. Liu, *Acs Applied Materials & Interfaces*, 2016, 8, 22168-22174.

10 Z. Li, A. Ottmann, T. Zhang, Q. Sun, H. P. Meyer, Y. Vaynzof, J. Xiang, R. Klingeler, *Journal of Materials Chemistry A*, 2017, 5, 3987-3994.

11 B. Chen, Y. H. Meng, F. He, E. Z. Liu, C. S. Shi, C. N. He, L. Y. Ma, Q. Y. Li, J. J. Li and N. Q. Zhao, *Nano Energy*, 2017, 41, 154-163.

12 T. L. Wang, G. Zhao, C. L. Sun, L. Zhang, Y. Z. Wu, X. P. Hao and Y. L. Shao, *Advanced Materials Interfaces*, 2017, 4, 1601187.