Supplementary information for:

Construction of multi-dimensional flexible MnS based paper electrode with ultra-stable and high-rate capability towards efficient sodium storage

Zehang Sun,[a] Yang Liu,[a] Dongxu Wu, Ke Tan, Linrui Hou and Changzhou Yuan*

School of Materials Science & Engineering, University of Jinan, Jinan, 250022, P. R. China

E-mail: mse_yuancz@ujn.edu.cn; ayuancz@163.com

[a] The authors contributed equally to this work.

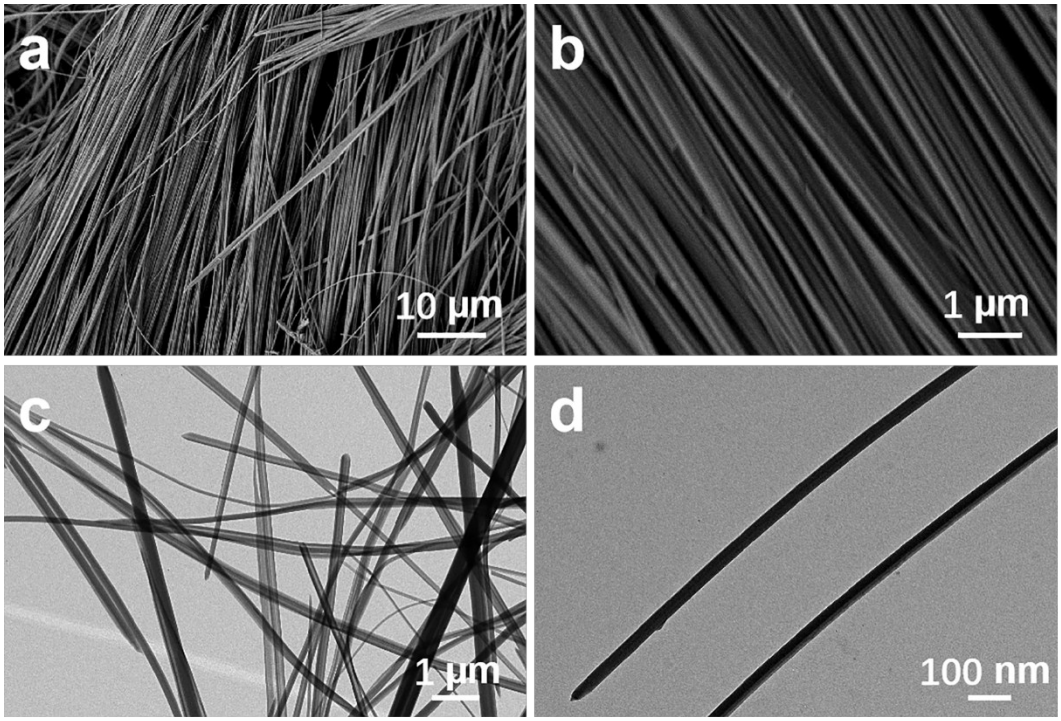

Fig. S1 (a, b) FESEM and (c, d) TEM images of the Mn-NTA precursor

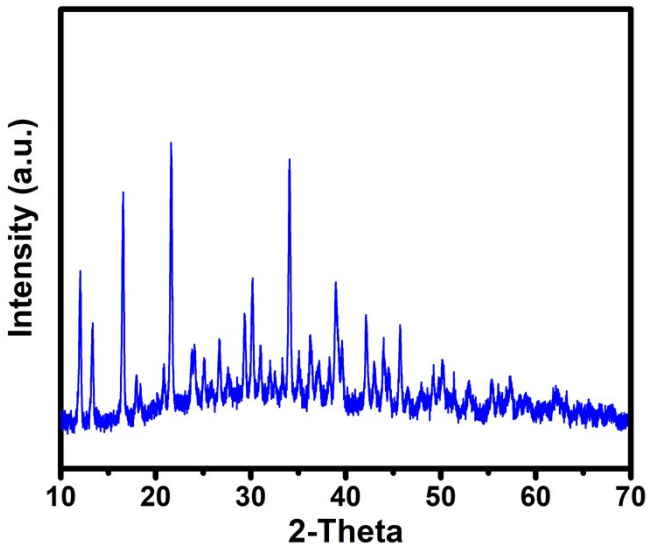

Fig. S2 XRD pattern of the Mn-CPNWs

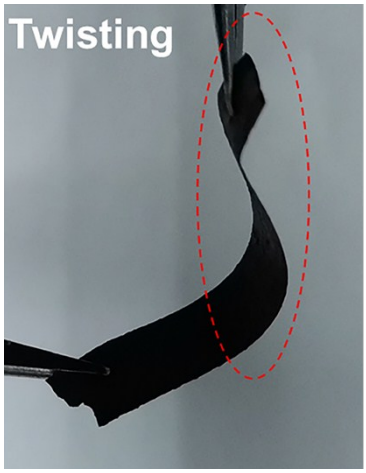

Fig. S3 Digital images for the twisting of MnS@CNWs/rGO paper

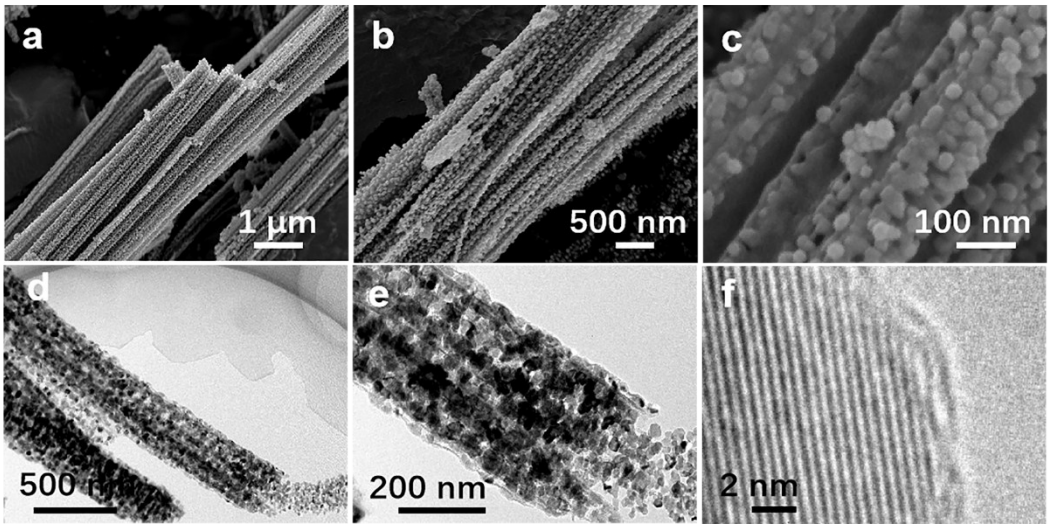

Fig. S4 (a – c) FESEM, (d, e) TEM and (f) HRTEM images of the MnS@CNWs

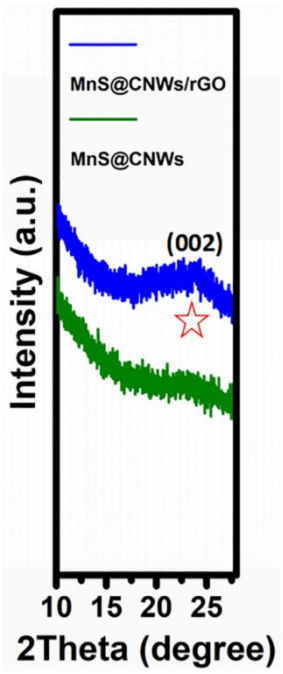

Fig. S5 Enlarged XRD pattern (2θ = 10 – 27.5 °) of the MnS@CNWs/rGO and MnS@CNWs

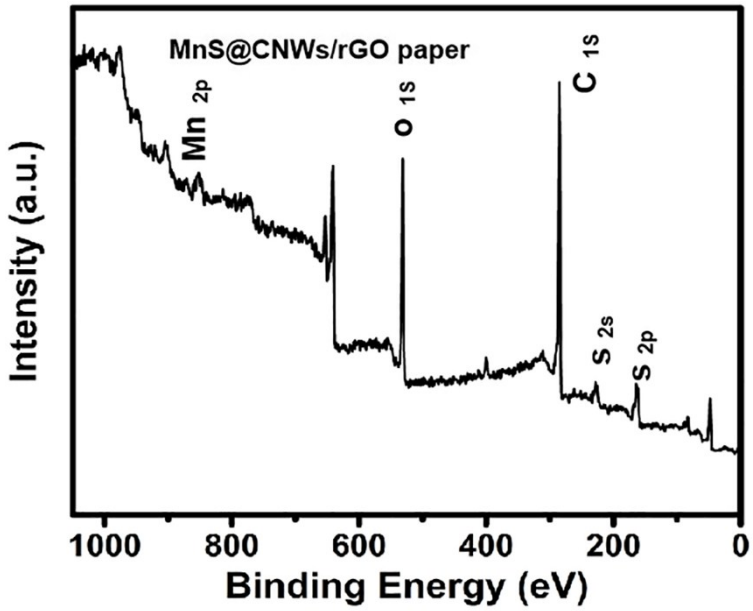

Fig. S6 XPS survey spectrum of the MnS@CNWs/rGO

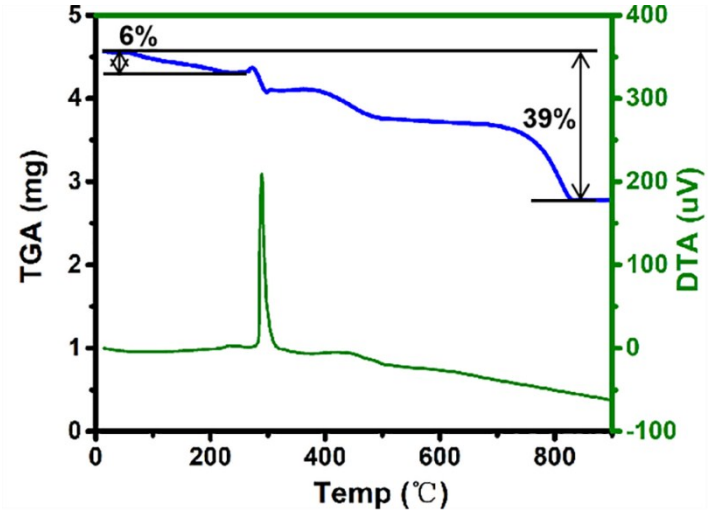

Fig. S7 TG and DTA curves of the MnS@CNWs/rGO

In the TG curve of MnS@CNWs/rGO, a small weight loss of about 6 wt% first occurred below 100 °C because of the removal of adsorbed water on the surface of the MnS@C/rGO. Subsequently, another weight loss took place between 280 and 500 °C. It is believed that both carbon burning and MnS oxidation (transform into $MnSO_3$ and Mn_3O_4) occurred between 280 and 500 °C, which is consistent with previous reports.[1] After a plateau region, sharp weight loss was observed as the temperature increase from 700 °C to 850 °C owing to further oxidation of $MnSO_3$ and Mn_3O_4 to Mn_2O_3. Based on the TGA results, the weight contents of MnS and carbon were calculated to be 71.8 wt.% and 28.2 wt.%.

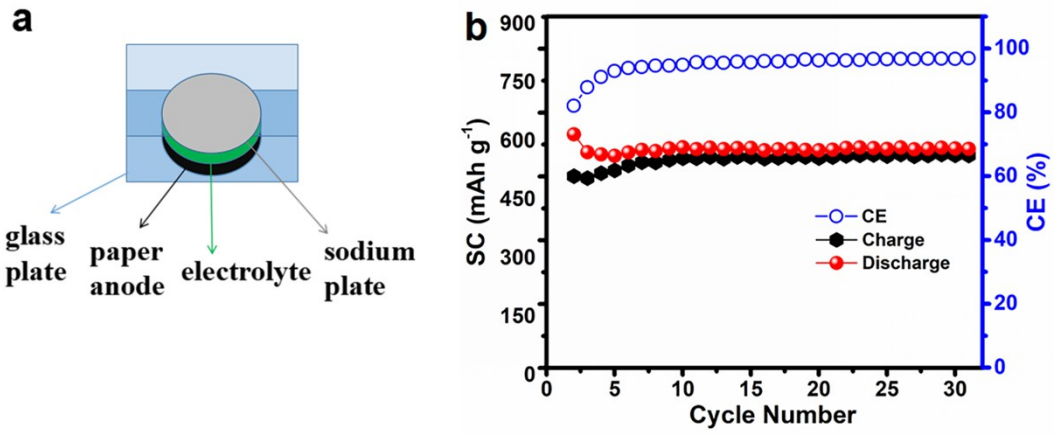

Fig. S8 (a) Schematic illustration and (b) cycling performance (100 mA g^{-1}) for the pre-sodiation of MnS@CNWs/rGO paper

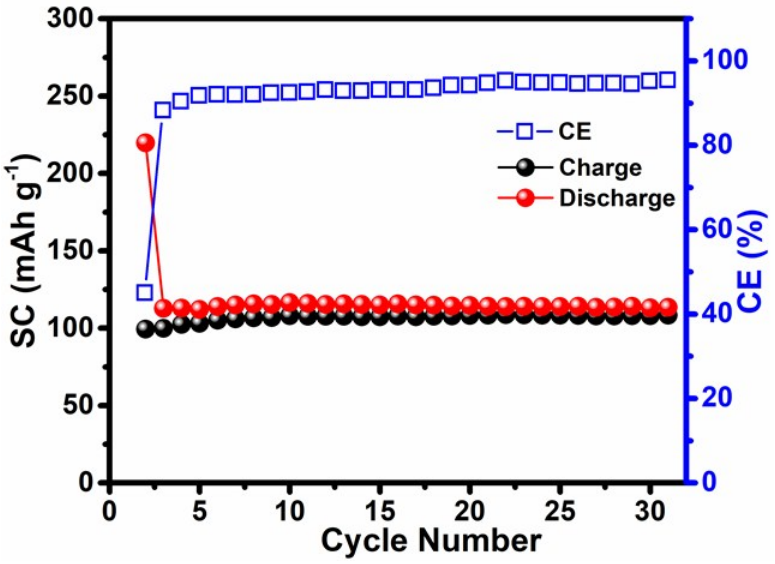

Fig. S9 Cycling performance for the pure rGO paper at a current density of 100 mA g-1

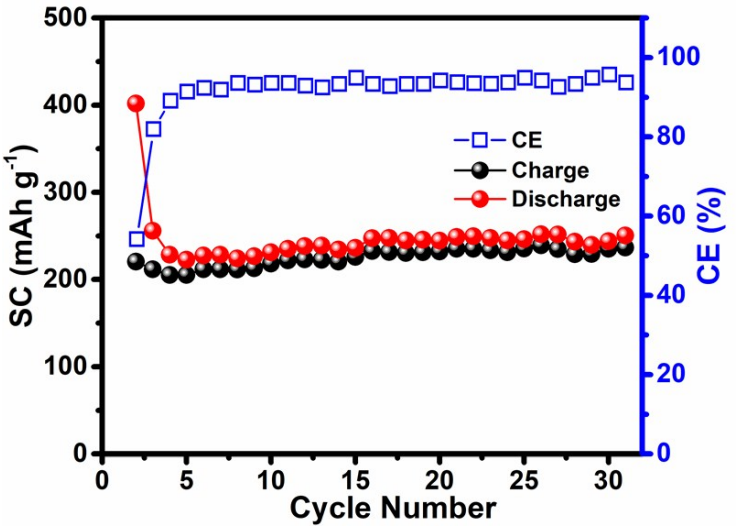

Fig. S10 Cycling performance for the MnS@CNWs/4rGO paper at a current density of 100 mA g^{-1}

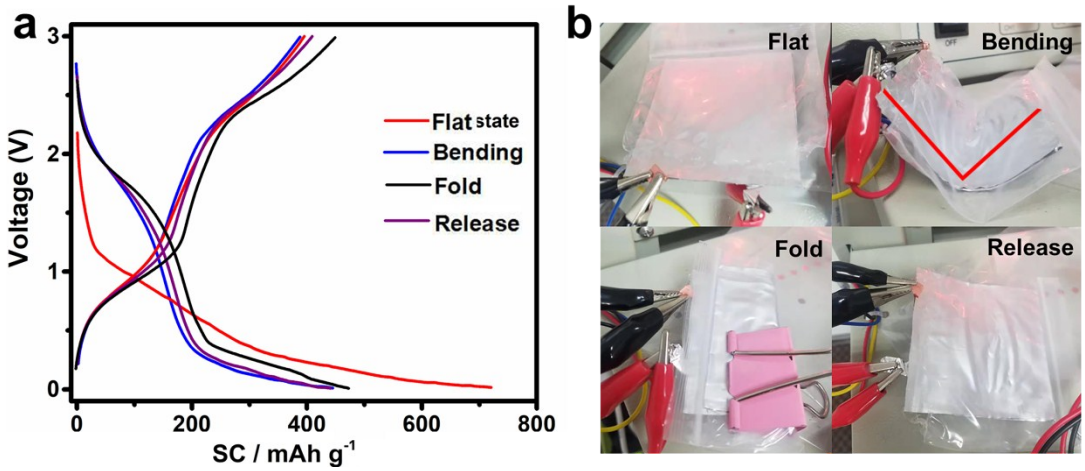

Fig. S11 (a) Typical galvanostatic discharge-charge plots (100 mA g^{-1}) for (b) the soft package of half sodium ion cells in different flexible modes. The area of the MnS@CNWs/4rGO paper is ~ 4 cm^2

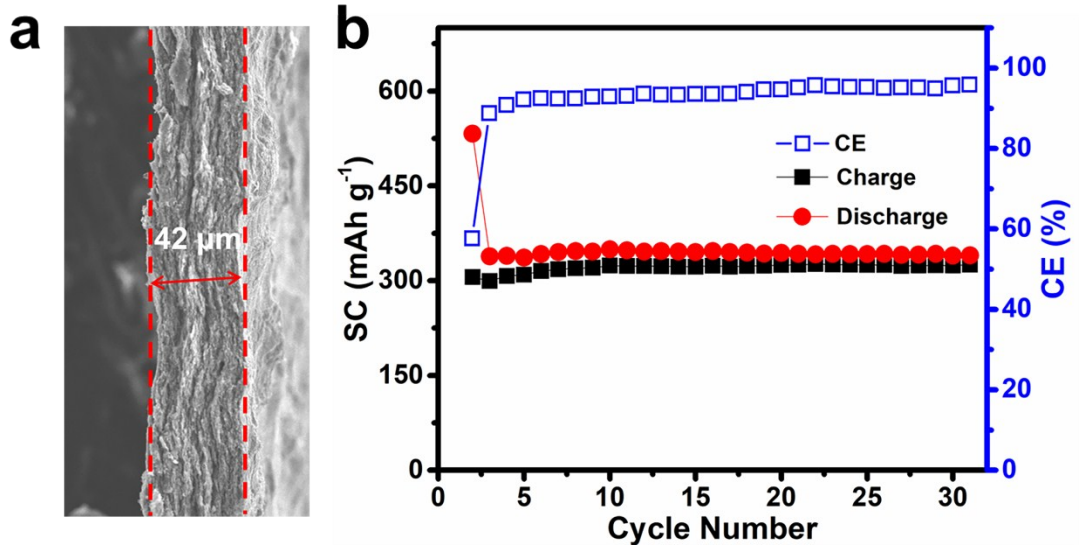

Fig. S12 (a, b) The thickness and cycling performance (100 mA g^{-1}) for the MnS@CNWs/rGO paper of 3.8 mg cm^{-2}

Table S1 The comparison between this work and other sulfide self-supporting anodes for SIBs

Anode	Volumetric (areal) capacities	Mass loading (mg cm^{-2})	Rate capability	Cycling stability	Ref.
FeS/SPAN-HNF	–	1.5- 2.0	782.8 at 0.2 A g^{-1}	327.5 at 5.0 A g^{-1} after 500 cycles	2
$Fe_{1-x}S$@PCNWs/rGO	424 mAh cm^{-3} at 0.2 A g^{-1}	0.9-11.2	180 mAh cm^{-3} at 5 A g^{-1}	573 at 100 mA g^{-1} after 100 cycles	3
3D carbon-networks/ Fe_7S_8/graphene	2.12 mAh cm^{-2} at 0.25 mA cm^{-2}	–	1.12 mAh cm^{-2} at 10.0 mA cm^{-2}	1.064 mAh cm^{-2} at 10.0 mA cm^{-2} after 500 cycles	4
MWCNT and In_2S_3 nanohybrid paper	–	1.8	280 at 1.0 A g^{-1}	410 at 100 mA g^{-1} after 100 cycles	5
SnS/C NFs	–	–	230 at 2.0 A g^{-1}	349 at 200 mA g^{-1} after 500 cycles	6
MoS_2−F	–	1.0-1.2	186 at 2.0 A g^{-1}	243 at 1000 mA g^{-1} after 1100 cycles	7
MnS@CNF	–	1.25	87 at 1.0 A g^{-1}	220 at 20 mAg^{-1} after 200 cycles	8
α -MnS@N,S-NTC	–	1.5	188 at 1.0 A g^{-1}	291 at 250 mA g^{-1} after 200 cycles	9
MnS@CNWs/rGO	362.3 mAh cm^{-3} at 0.1 A g^{-1}	1.0-3.8	147 at 2.0A g^{-1}	≈150mA h g^{-1} at 1000 mA g^{-1} after 10000 cycles;	This work

Note: – : not provided; MoS_2−F: MoS_2 and CNFs overall composite electrode

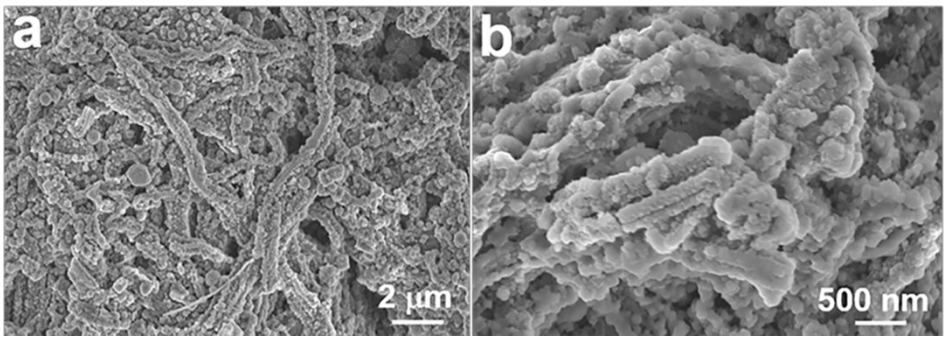

Fig. S13 (a, b) FESEM images of the MnS@CNWs/rGO paper electrode after 50 cycle at current density of 0.1 A g^{-1}

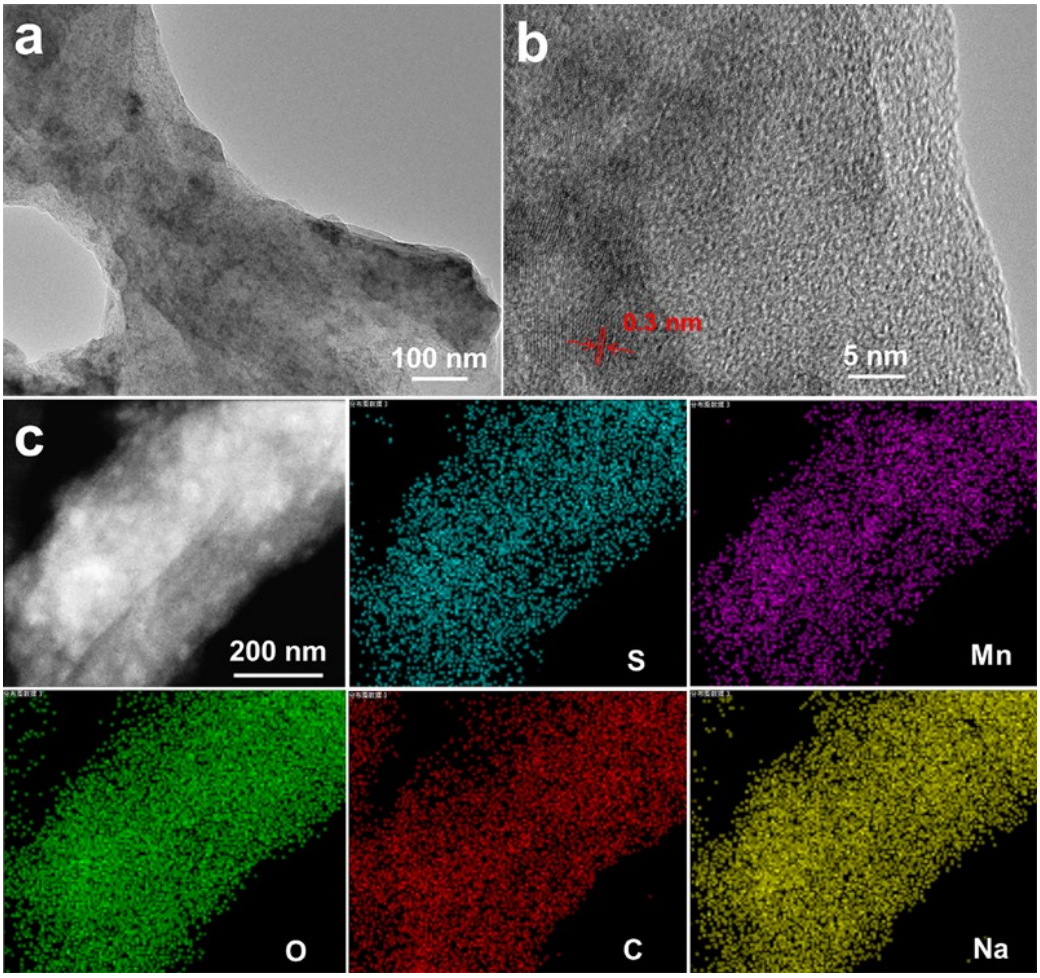

Fig. S14 (a, b) TEM and (c) STEM images of the MnS@CNWs/rGO paper electrode after 50 cycle at current density of 100 mA g^{-1}

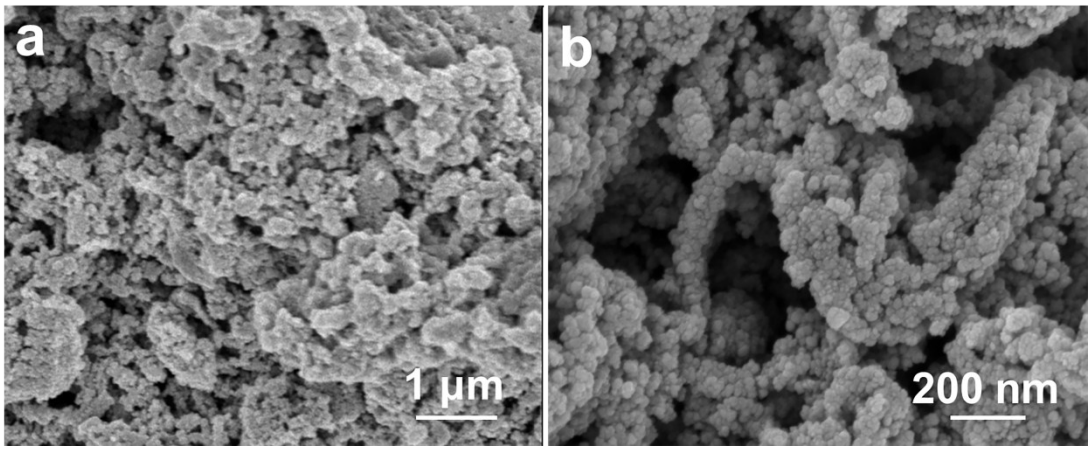

Fig. S15 (a, b) FESEM images of the MnS@CNWs electrode after 50 cycle at current density of 0.1 A g^{-1}

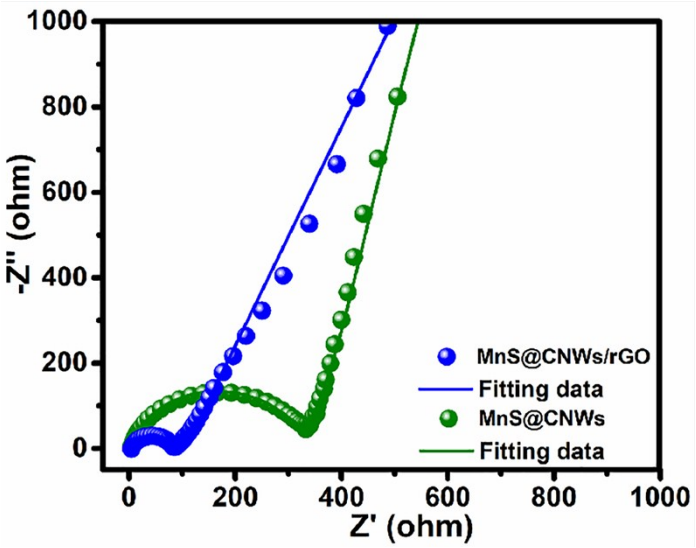

Fig. S16 EIS spectra of the MnS@CNWs/rGO and MnS@CNWs electrodes

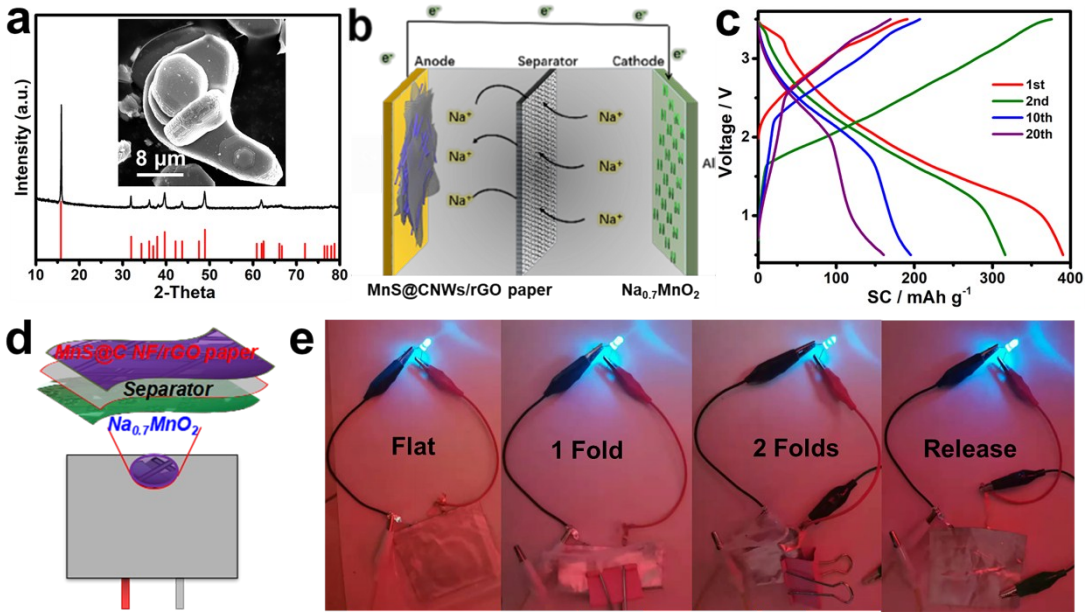

Fig. S17 (a) XRD pattern and FESEM image (the inset) for the cathode $Na_{0.7}MnO_2$; (b) Schematic illustration and (c) galvanostatic discharge-charge plots (100 mA g^{-1}) of the manganese-based full SIB; (d) Schematic demonstration and (e) digital pictures of the pouch-type devices in different flexible modes. The areas of the MnS@CNWs/rGO paper and the cathode $Na_{0.7}MnO_2$ are ~4 and ~6 cm^2, respectively

References

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