Electronic Supplementary Information

A Rationally Assembled Graphene Nanoribbon/Graphene Framework for High Volumetric Energy and Power Density Li-Ion Batteries

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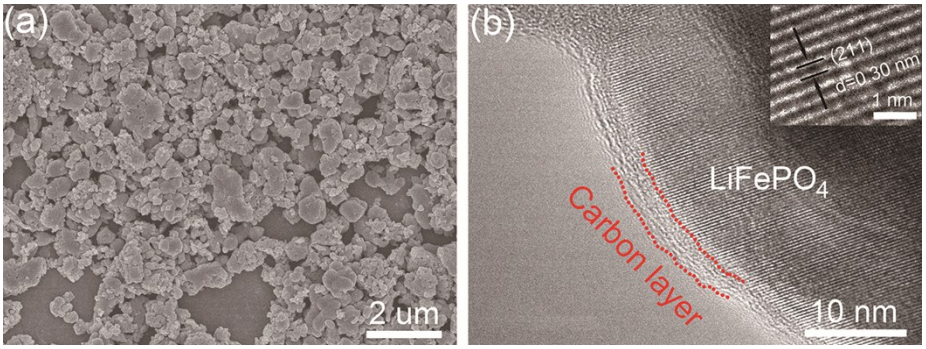

Fig. S1 (a) SEM and（b) TEM images of commercial $LiFePO_4$ used in this work.

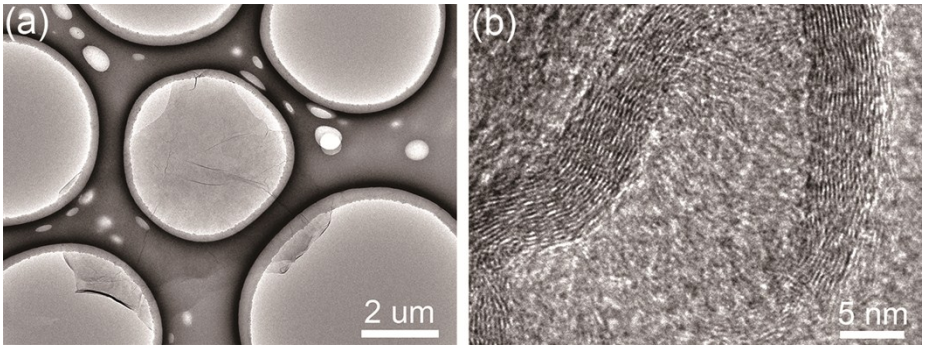

Fig. S2 (a) TEM image of a single piece of GO; (b) HRTEM image of the edges of reduced graphene oxide (rGO) showing 15~20 layers of graphene.

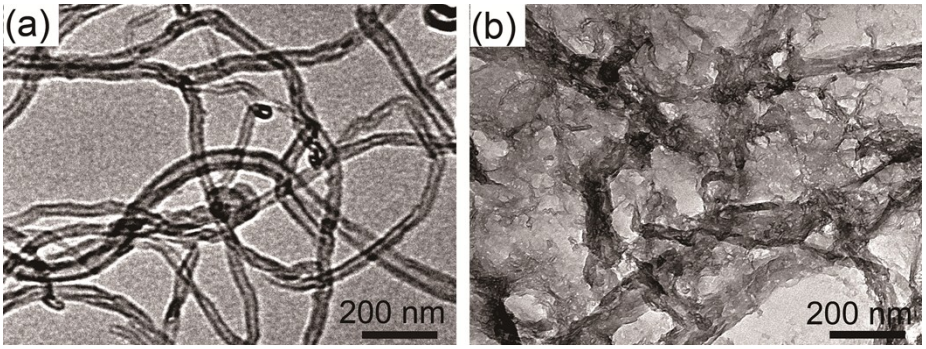

Fig. S3 TEM images of (a) CNT precursor (diameter ~50 nm) as well as resultant (b) GONR (width ~150 nm) obtained by a chemical oxidation method.[1]

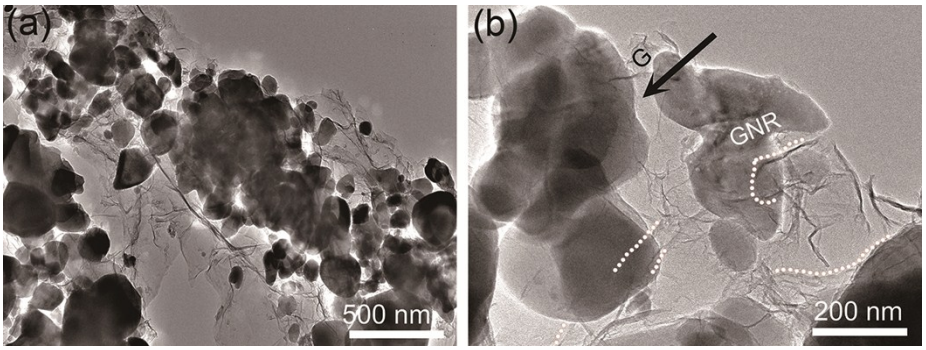

Fig. S4 TEM images of LFP/GNR/G sample. White dot lines in (b) outline some GNRs which bridge LFP particles and G sheets.

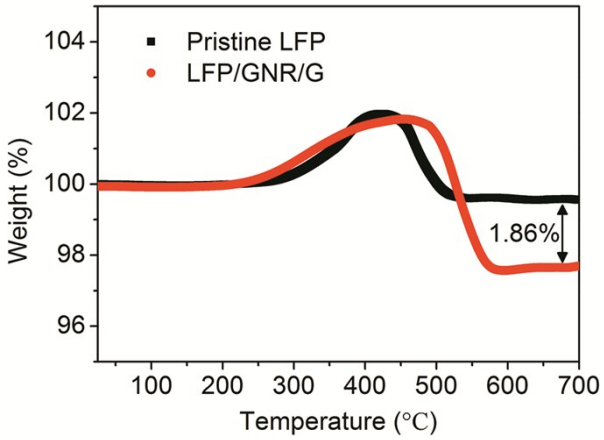

Fig. S5 Thermogravimetric curves of pristine LFP and LFP/GNR/G. The GNR/G content in LFP/GNR/R was 1.86%, which confirmed the result of 2% in Table S2.

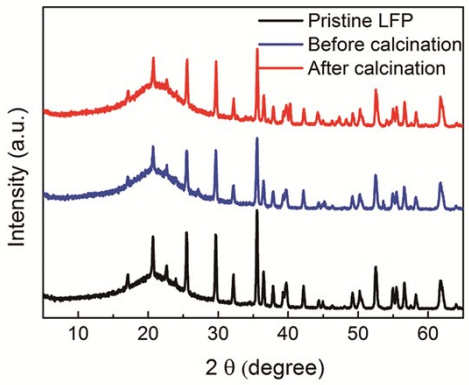

Fig. S6 XRD patterns of commercial LFP, as well as LFP/GNR/G sample before and after a calcination at 600 °C in Ar/H_2 (90/10, V/V) for 5 h.

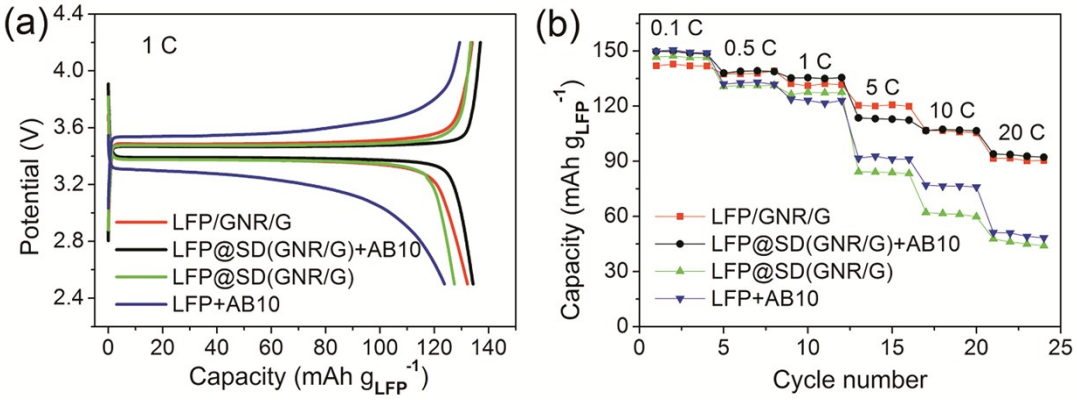

Fig. S7 Comparison of (a) charge/discharge curves at the current rate of 1 C, and (b) rate capabilities of LFP+AB10, LFP@SD(GNR/G), LFP@SD(GNR/G)+AB10 and LFP/GNR/G based on the commercial LFP weight only.

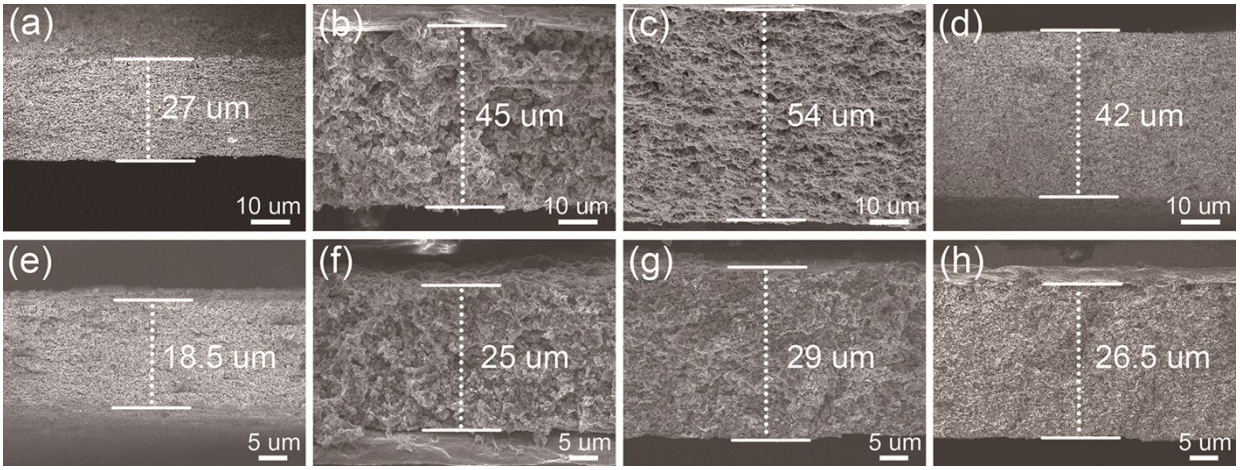

Fig. S8 Cross-sectional SEM images of four electrode samples with electrode weight of 5 mg cm^{-2} (including active material, conductive additive and binder) before and after compression under a pressure of 50 MPa: (a, e) LFP/GNR/G; (b, f) LFP@SD(GNR/G); (c, g) LFP@SD(GNR/G)+AB10; (d, h) LFP+AB10.

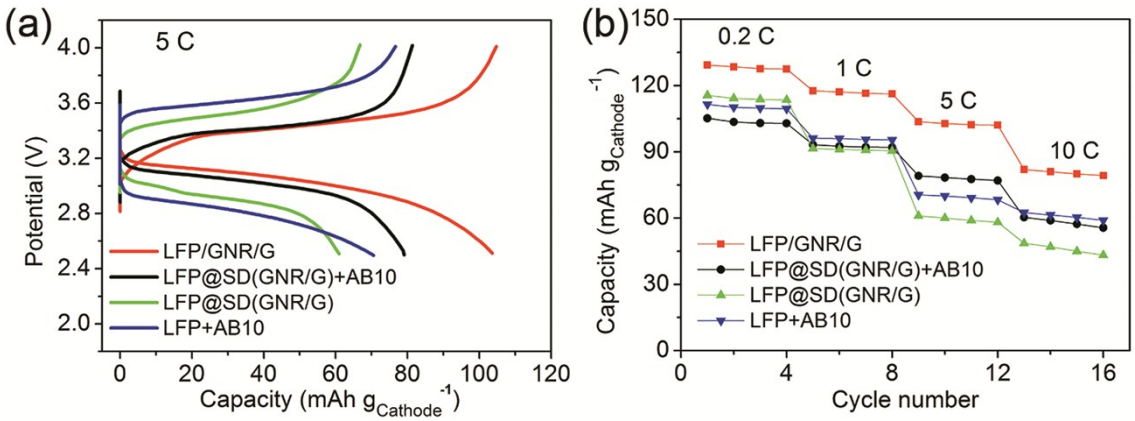

Fig. S9 Comparison of electrodes LFP+AB10, LFP@SD(GNR/G)+AB10, LFP@SD(GNR/G) and LFP/GNR/G based on the cathode weight in full cells with grphite as the anode material. (a) Charge/discharge curves at the current rate of 5 C and (b) rate capabilities.

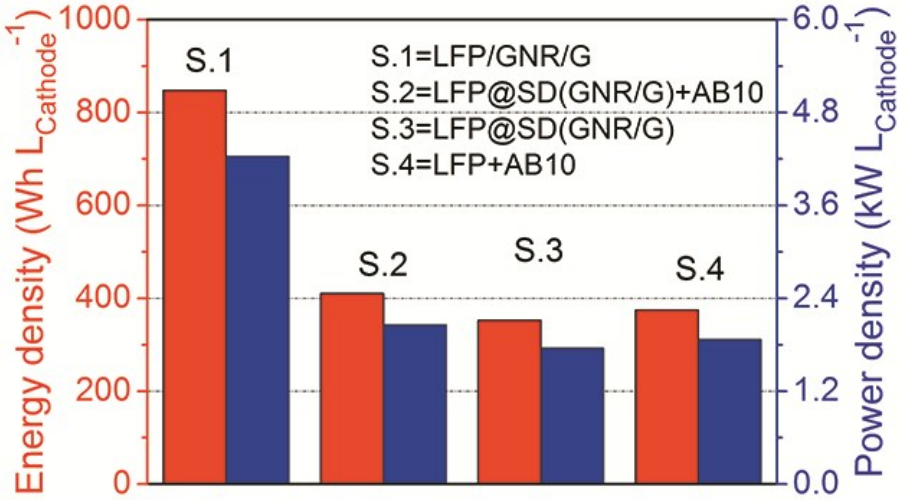

Fig. S10 Energy density and power density comparisons of LFP+AB10, LFP@SD(GNR/G)+AB10, LFP@SD(GNR/G) and LFP/GNR/G samples in full cells at 5 C rate. The discharge median-potentials of 2.81 V, 2.91 V , 3.02 V and 3.03 V were used for LFP+AB10, LFP@SD(GNR/G), LFP@SD(GNR/G)+AB10 and LFP/GNR/G samples, respectively.

Table S1 EDS elemental analysis of commercial $LiFePO_4$.

Element	Mass%	Atomic%
C_K	8.16	14.54
O_K	46.79	62.57
P_K	18.32	12.65
Fe_K	26.73	10.24
Total amount	100.00	100.00

Table S2 The residual contents of freeze-dried GO and GONR after 600 °C treatment in Ar/H_2 (90/10, V/V) for 5 h.

Samples	Freeze-dried GO sponge	Freeze-dried GONR sponge
Mass before calcinations [mg]	28.27	14.53
Mass after calcinations [mg]	11.35	5.98
Residual content [%]	40.1	41.2

Table S3 Specific capacity comparison of reported LFP electrodes.

Size [nm] / morphology of LFP	Resource of LFP	With Polym-eric binder or not	Conductive additives		Specific properties at 5 C rate (current collector excluded)			Ref.
			Material	Content [wt.%]	Gravimetric capacity [mAh g^{-1}]	Volumetric capacity [mAh cm^{-3}]	Volumetric energy density [Wh L^{-1}]	
100 – 2000 (particles)	**Commercial**	**N**	**G, GNR**	**1.0, 1.0**	**118**	**318**	**1020**	**This work**
100 – 800 (particles)	Commercial	N	G	7.5	98.5			2
140 (particles)	Commercial	Y	Carbon black	5	~145	~260	~850	3
3000 – 7000 (porous particles)	Hydrothermal	Y	Carbon black	15	~100	~150	~500	4
D=30 – 100 L=80 – 400 (rods)	Hydrothermal	Y	G, Carbon black	<0.7, 8	~105			5
4000– 6000 (porous particles)	Hydrothermal and chemical lithiation	Y	CNT, Carbon black	~1.2, 10	~95	~150	~500	6
~40 (particles)	Hydrothermal	Y	CNT, Carbon black	~2.2, ~12.8	~95			7
D=20 L=100 (rods)	Hydrothermal	Y	N-dopped carbon, G, Carbon black	~1.6, ~2, 10	~126	~180	~600	8
~50 – 200 (particles)	Precipitation and chemical lithiation	Y	N-doped G	~11.4	~125	<200	~650	9
~100 (particles)	Hydrothermal	Y	G, Carbon black	3.6, 10	~84			10

[a)]Y: Yes; [b)]N: No; [c)]G: Graphene

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