Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Manipulating nickel oxides in naturally-derived cellulose nanofiber networks as robust cathodes for high-performance Ni–Zn batteries

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Supplementary Information

Calculations:

The specific capacity (C) were calculated from the galvanostatic curve using the following equations:

$$C = \frac{\int_0^{\Delta t} I dt}{m}$$

Where C is the specific capacity (mAh/g), I (mA) is the applied discharging current, Δt(h) is the discharging time, m (g) is the mass loading of active materils on cathode.

Energy density and power density were estimated by the following equations:

$$E = \int_0^{\Delta t} \frac{V \times i}{m} dt$$

$$P = \frac{E}{1000 \times \Delta t}$$

Where E (Wh/kg) is the energy density, P is the power density (kW/kg), V (V) is the working potential, i (mA) is the discharging current, m (g) is the mass loading of active materils on cathode, and Δt(h) is the discharging time.

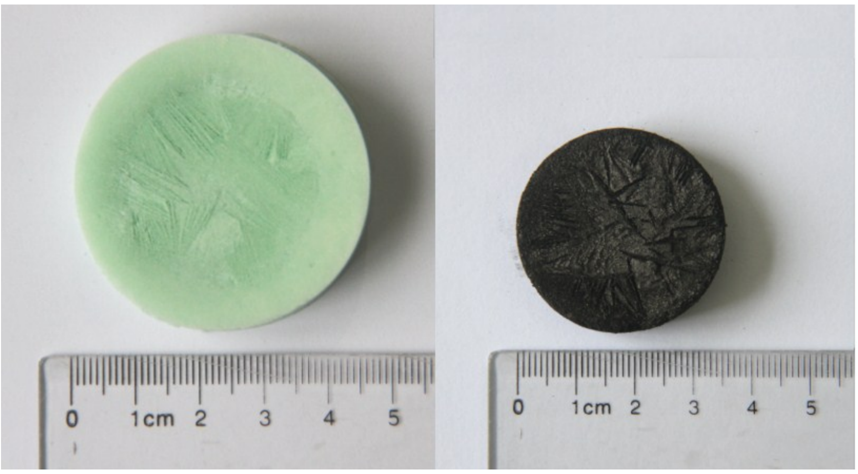

Figure S1. Digital pictures of the Ni/CC-8 composite before calcination (left) and Ni/CC-8 after calcination (right).

Figure S2. Digital pictures of the Ni-8 c before calcination (left) and Ni-8 after calcination (right).

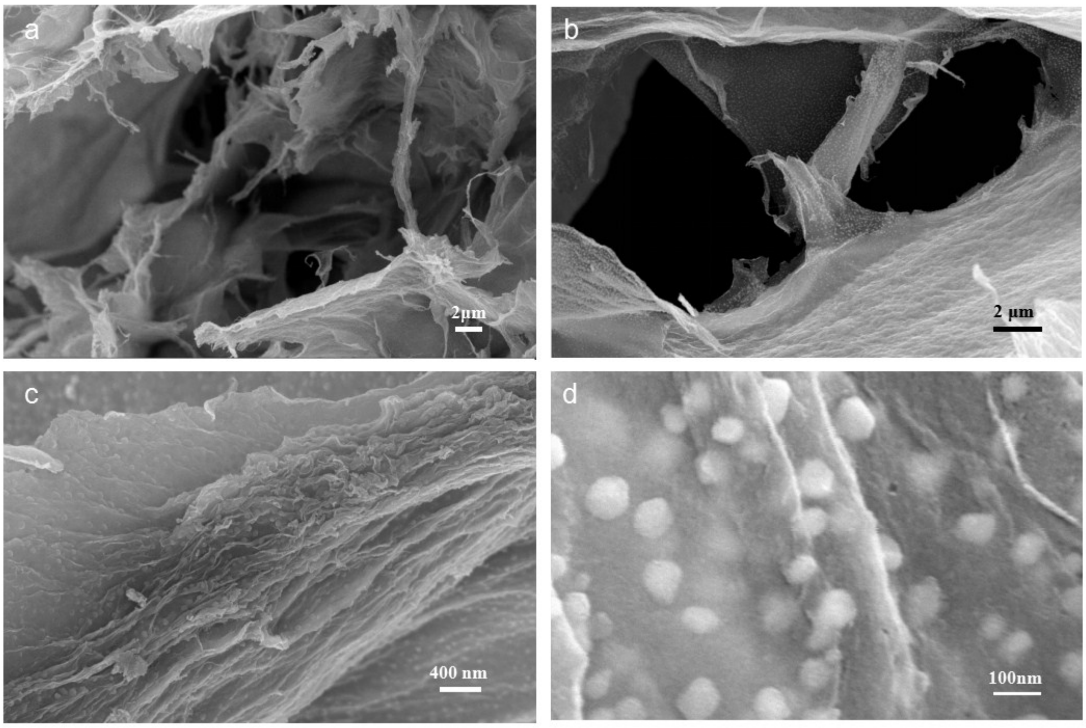

Figure S3. SEM images of Ni/CC-8 composites in different magnitude.

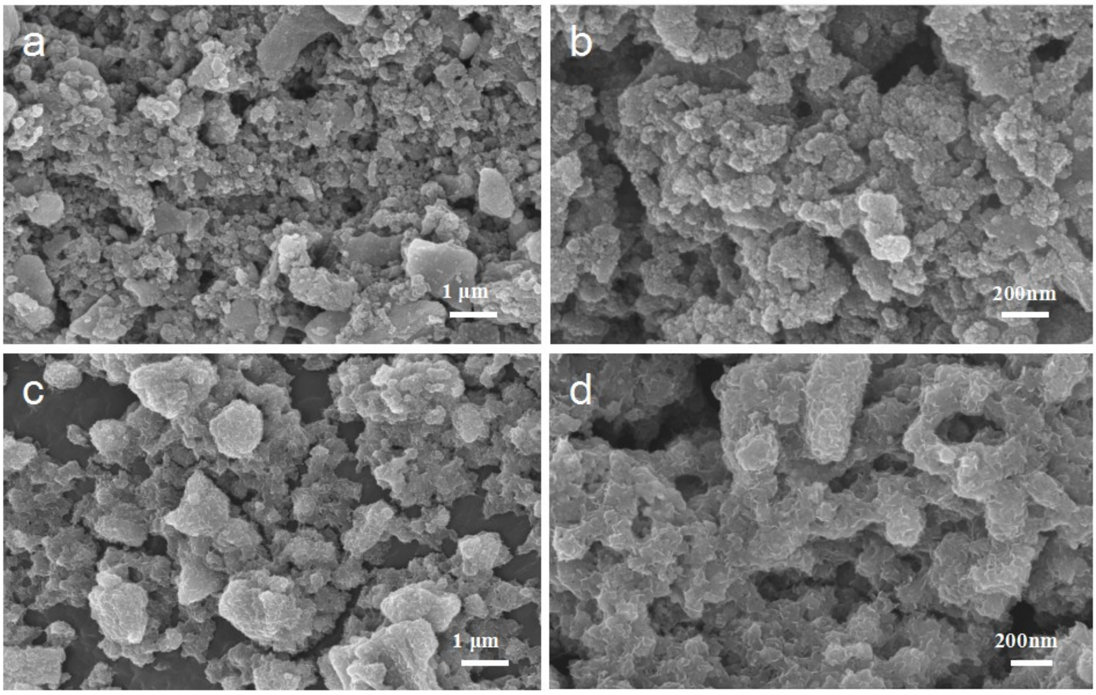

Figure S4. SEM images of (a-b) Ni/CC-8 electrode and (c-d) Ni─NiO/CC-8 electrode in different magnitude.

Table 1. EDS mapping spectrum of Ni/CC-8 electrode.

Element	Weight	Atomic
	Percentage	Percentage
C	40.11	74.65
O	2.51	3.50
Ni	57.38	21.85
Total	100.00	

Table 2. EDS mapping spectrum of Ni─NiO/CC-8 electrode.

Element	Weight	Atomic
	Percentage	Percentage
C	49.63	69.23
O	21.52	22.54
Ni	28.85	8.23
Total	100.00	

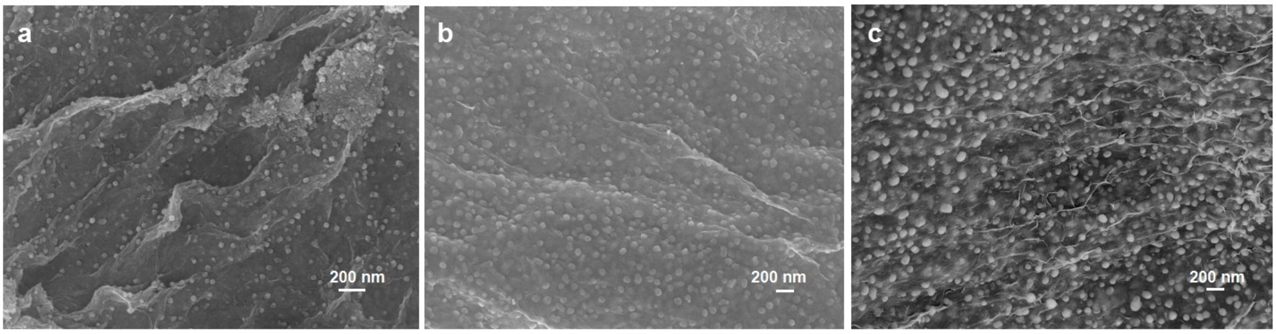

Figure S5. SEM images of (a) Ni/CC-4 composite, (b) Ni/CC-8 and (c) Ni─NiO/CC-10 composites.

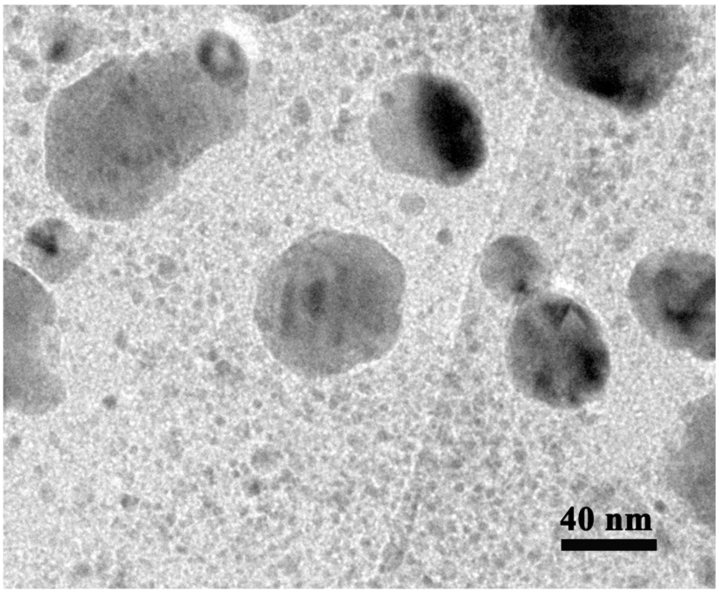

Figure S6. TEM images of Ni/CC-8 composite.

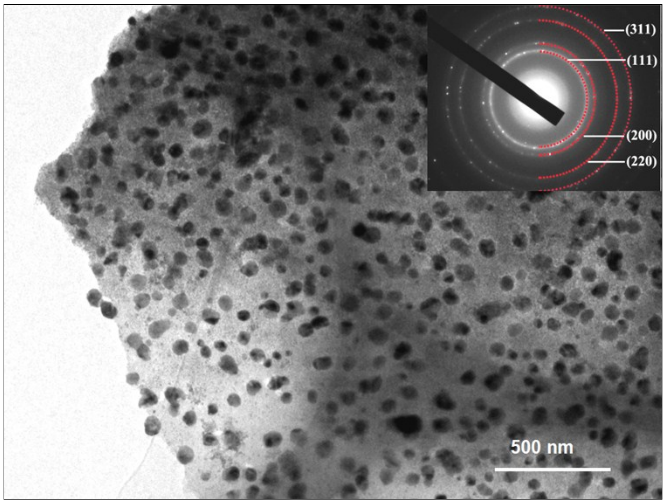

Figure S7. SAED pattern of Ni/CC-8 composite.

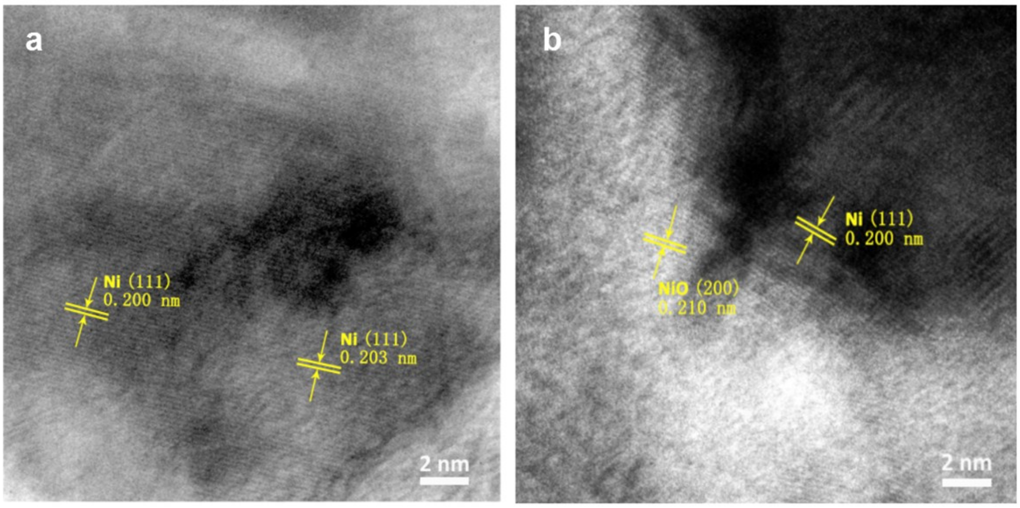

Figure S8. HRTEM of (a) Ni/CC-8 composite and (b) Ni–NiO/CC-8 composite.

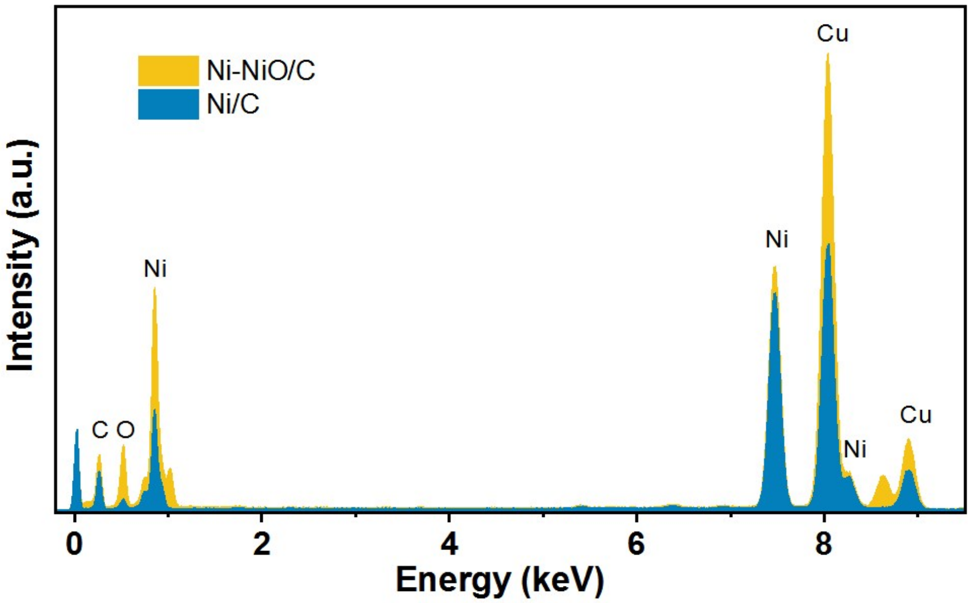

Figure S9. EDS of Ni/CC-8 composite and Ni─NiO/CC-8 composite

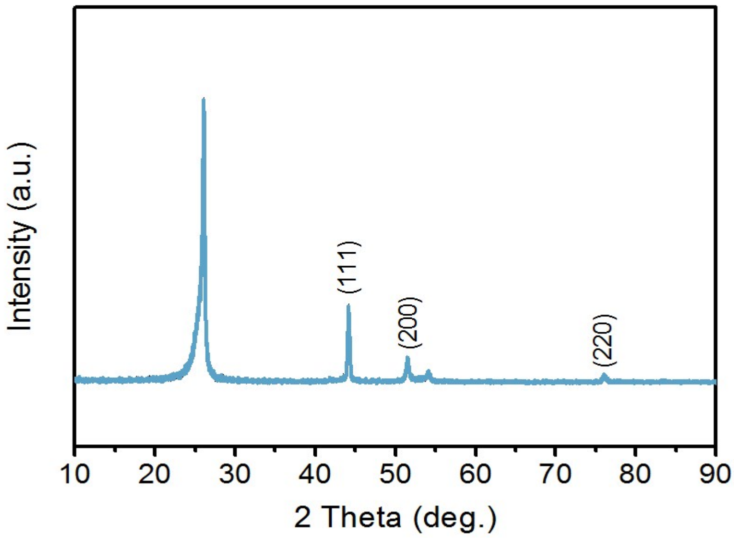

Figure S10. XRD spectrum of Ni─NiO-8 electrode.

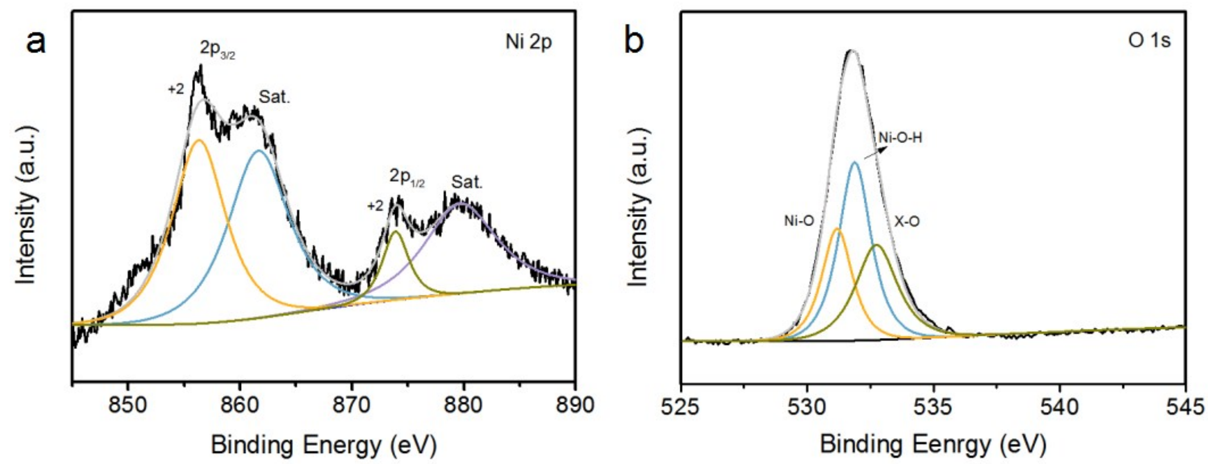

Figure S11. XPS spectrum of Ni–NiO-8 electrode.

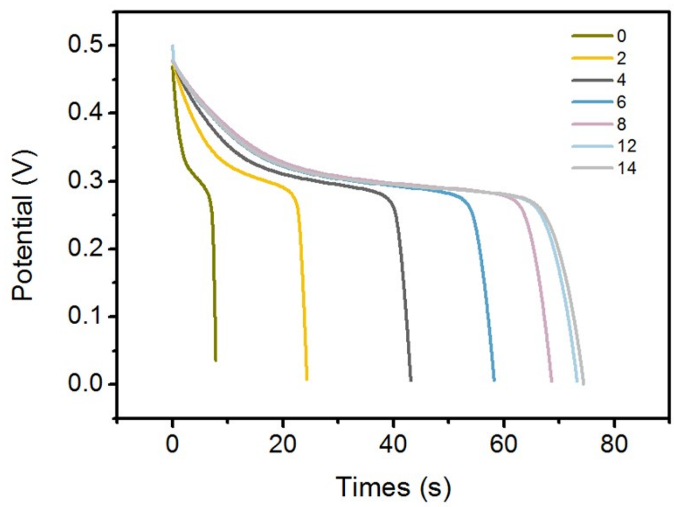

Figure S12. GCD curves of Ni–NiO/CC electrode in different electrochemical oxidation times.

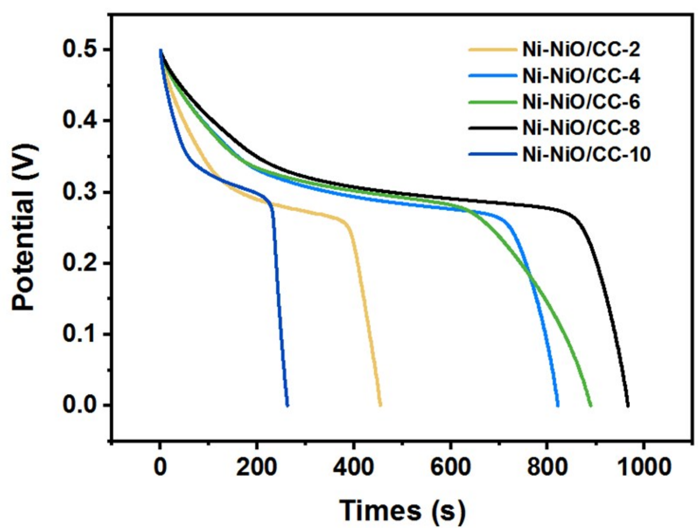

Figure S13. GCD curves of Ni–NiO/CC-x electrode.

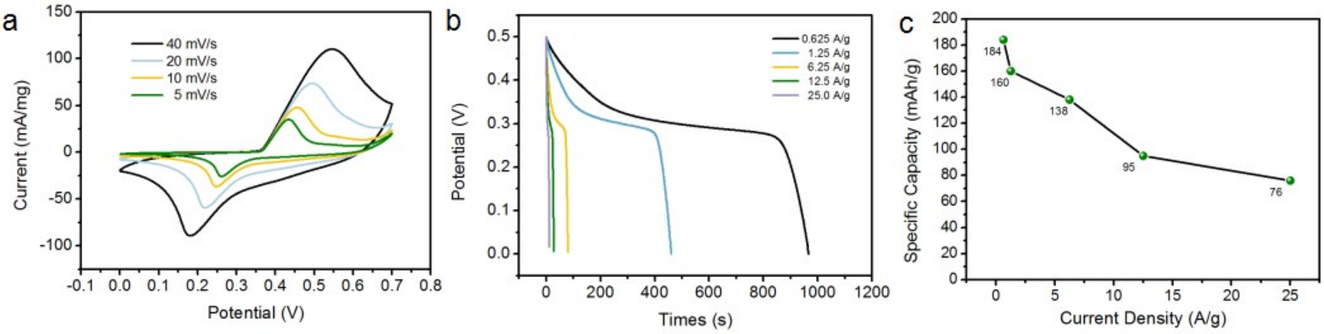

Figure S14. (a) CV curves, (b) GCD and (c) rate capacity of Ni─NiO/CC-8 electrode.

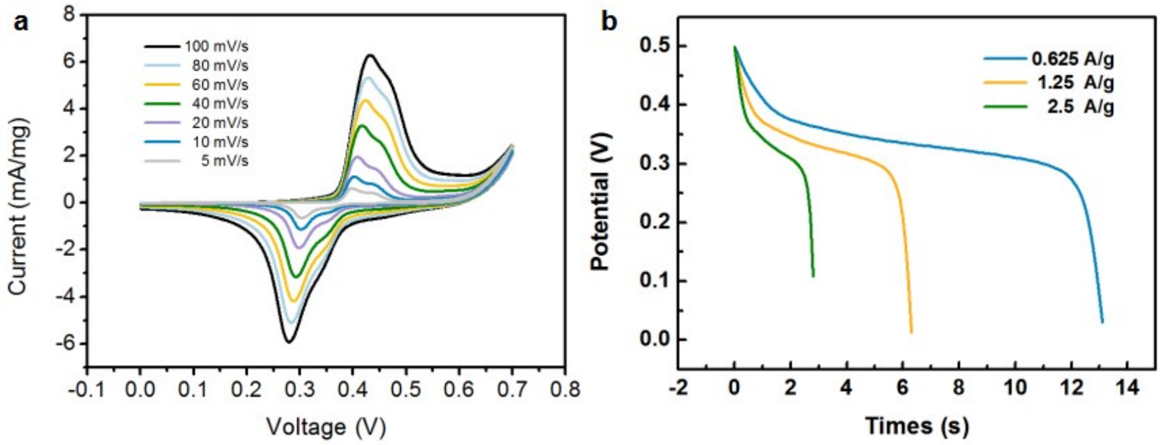

Figure S15. (a) CV curves, (b) GCD of Ni─NiO-8 electrode.

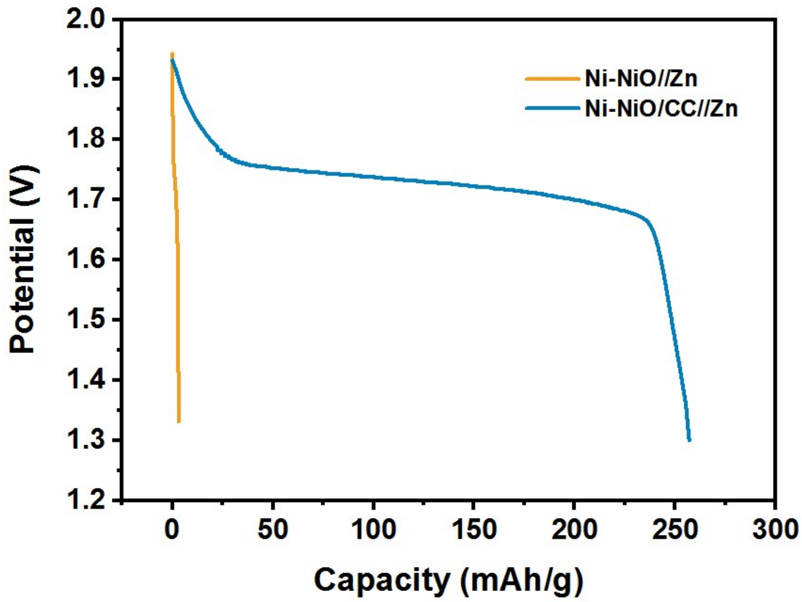

Figure S16. GCD curves of Ni─NiO//Zn and Ni─NiO/CC//Zn.

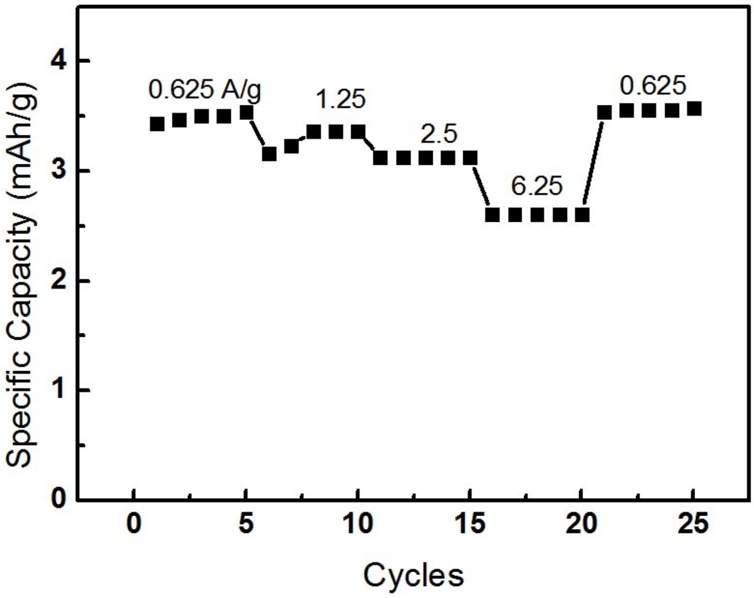

Figure S17. Rate performance of Ni–NiO-8//Zn battery.

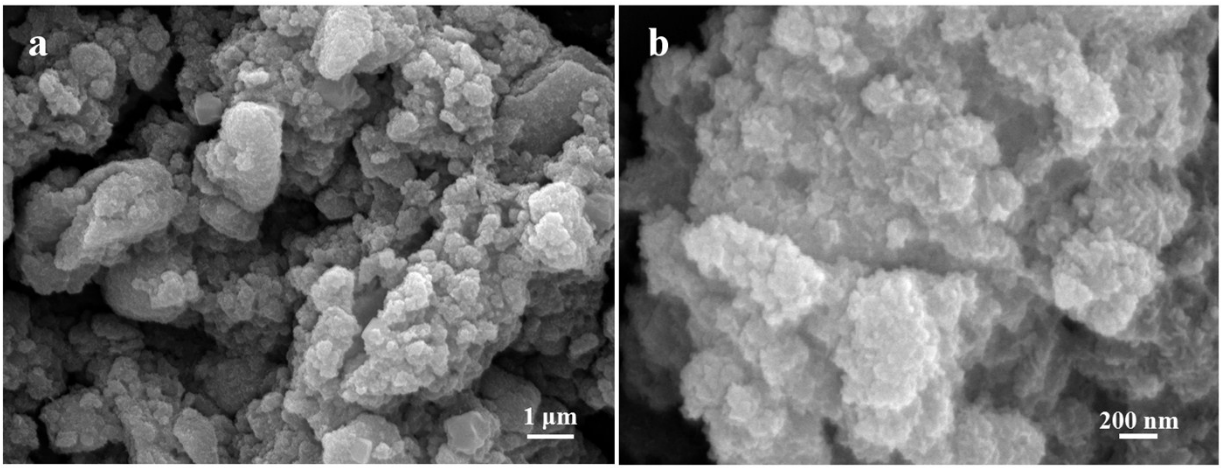

Figure S18. SEM (TESCAN MIRA3 LMU) images in different magnitude of cycled Ni–NiO/CC electrode after 2000 charge-discharge cycles.

Table 3. Electrochemical performances of different zinc ion batteries

Types of materials	Specific capacity	Cycling stability	Reference
Ni_3S_2/Ni//Zn	148 mAh/g at 0.2 A/g	~100% after 100 cycles	1
NiO/CNTs//Zn	155 mAh/g at 1 A/g	65% after 500 cycles	2
Co_3O_4//Zn	173.6 mAh/g at 1 A/g	84.1% after 1000 cycles	3
Ni_2P/C//Zn	176 mAh/g at 1 A/g	93.8% after 1500 cycles	4
Solid-state Co_3O_4//Zn	200 mAh/g at 0.5 A/g	94.6% after 2000 cycles	5
$NiCo_2O_4$//Zn	230.1 mAh/g at 0.5 A/g	63.23% after 1000 cycles	6
NiAlCo/CNT//Zn	354 mAh/g at 6.7 A/g	85% after 600 cycles	7
MnO_2//Zn	150 mAh/g at 1.86 A/g	77.7% after 300 cycles	8
This work	237.1 mAh/g at 2.5 A/g	87.5% after 2000 cycles	This work

Refernces:

[1] P. Hu, T. Wang, J. Zhao, C. Zhang, J. Ma, H. Du, X. Wang and G. Cui, Acs Applied Materials & Interfaces, 2015, 7, 26396-26399.

[2] X. Wang, M. Li, Y. Wang, B. Chen, Y. Zhu and Y. Wu, Journal of Materials Chemistry A, 2015, 3, 8280-8283.

[3] T. Peng, C. Bin, X. Haoran, C. Weizi, H. Wei and N. Meng, Applied Catalysis B: Environmental.

[4] J. Li and C. Chen, Materials Research Express, 2018, 5, 015502.

[5] L. Ma, S. Chen, H. Li, Z. Ruan, Z. Tang, Z. Liu, Z. Wang, Y. Huang, Z. Pei, J. A. Zapien and C. Zhi, Energy & Environmental Science, 2018, 11, 2521-2530.

[6] W. Shang, W. Yu, P. Tan, B. Chen, H. Xu and M. Ni, Journal of Power Sources.

[7] M. Gong, Y. Li, H. Zhang, B. Zhang, W. Zhou, J. Feng, H. Wang, Y. Liang, Z. Fan and J. Liu, Energy & Environmental Science, 2014, 7, 2025-2032.

[8] Y. Zeng, X. Zhang, Y. Meng, M. Yu, J. Yi, Y. Wu, X. Lu and Y. Tong, Advanced Materials, 2017, 29, 1700274.

Table 4. Energy density with power density of different energy storage devices

Types of materials	Energy density	Power density	Reference
NiAlCo/CNT//Zn	274 Wh/kg	16.6 kW/kg	1
NNA@CNH//NNA@Zn	138 Wh/kg	1.72 kW/kg	2
Co_3O_4@NiO//Zn	215.5 Wh/kg	3.45 kW/k	3
β-$Ni(OH)_2$/CNFs//Zn	325 Wh/kg	11.4 kW/kg	4
Ni//Fe	100.7 Wh/kg	0.287 kW/kg	5
$V_3O_7.H_2O$/rGO//Zn	186 Wh/kg	8.4 kW/kg	6
$NiCo_2O_4$//Bi	55.4 Wh/kg	21.2 kW/kg	7
NiS/Carbon aerogel//Carbon aerogel	21.5 Wh/kg	7 kW/kg	8
Nickel Cobaltite/Graphene//Carbon	52.2 Wh/kg	0.187 kW/kg	9
This work	441.7 Wh/kg	1.1 kW/kg	This work

Refernces:

[1] M. Gong, Y. Li, H. Zhang, B. Zhang, W. Zhou, J. Feng, H. Wang, Y. Liang, Z. Fan and J. Liu, Energy & Environmental Science, 2014, 7, 2025-2032.

[2] X. Chao, L. Jie, Y. Cheng, R. Wang and C. P. Wong, Nano Energy, 2016

[3] Z. Lu, X. Wu, X. Lei, Y. Li and X. Sun, Inorganic Chemistry Frontiers, 2015, 2, 184-187.

[4] Y. Jian, D. Wang, M. Huang, H.-L. Jia, J. Sun, X. Song and M. Guan, Acs Sustainable Chemistry & Engineering, 2017, 5, acssuschemeng.7b01048.

[5] J. Liu, M. Chen, L. Zhang, J. Jiang, J. Yan, Y. Huang, J. Lin, H. J. Fan and Z. X. Shen, Nano Letters, 2014, 14, 7180-7187.

[6] S. Chao, L. Xin, L. Nan, X. Keyu, W. Jian-Gan, L. Xing-Rui and W. Bingqing, ACS Applied Materials & Interfaces, 2018, acsami.8b07781-.

[7] H. Xu, X. Hu, H. Yang, Y. Sun, C. Hu and Y. Huang, Advanced Energy Materials, 2015, 5.

[8] L. Zuo, W. Fan, Y. Zhang, Y. Huang, W. Gao and T. Liu, Nanoscale, 2017, 9, 4445-4455.

[9] Y. Lv, H. Wang, X. Xu, J. Shi, W. Liu and X. Wang, Chemical Engineering Journal, 2017, 326, 401-410.