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

Supporting Information

Binder-free Co-CoO_x nanowire array for lithium ion battery with excellent rate capability and ultra-long cycle life

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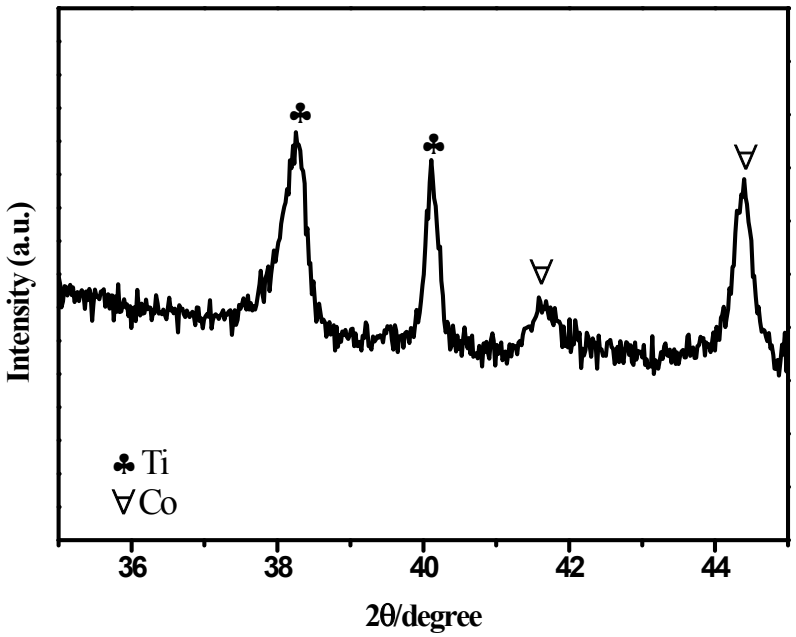

Fig. S1 XRD patterns of the as-prepared Co-CoO_x NWAs with Ti foil with the scan rate of 0.01 s^{-1}. Metallic Co has two peaks at 41.6 ° and 44.5°. Diffraction peaks of CoO and Co_3O_4 are not observed.

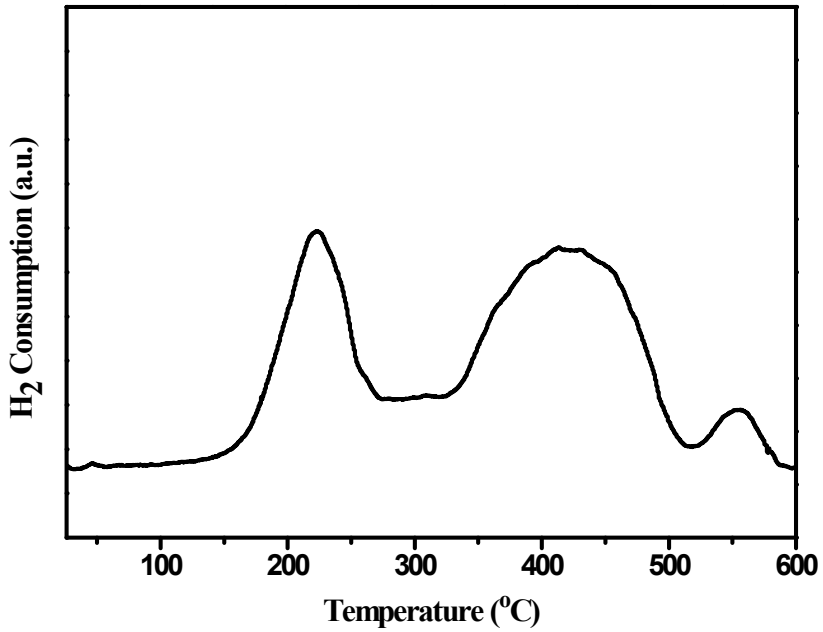

Fig. S2 H_2-TPR profile of the obtained Co-CoO_x NWAs. Two main reduction peaks were observed, which belongs to CoO_x. [1, 2]

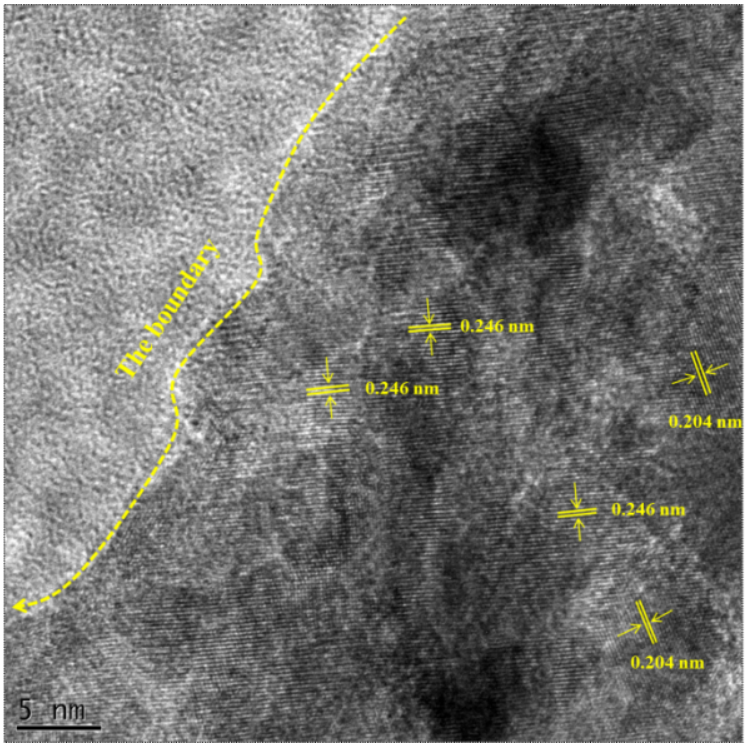

Fig. S3 HRTEM image of the Co-CoO_x NWAs.

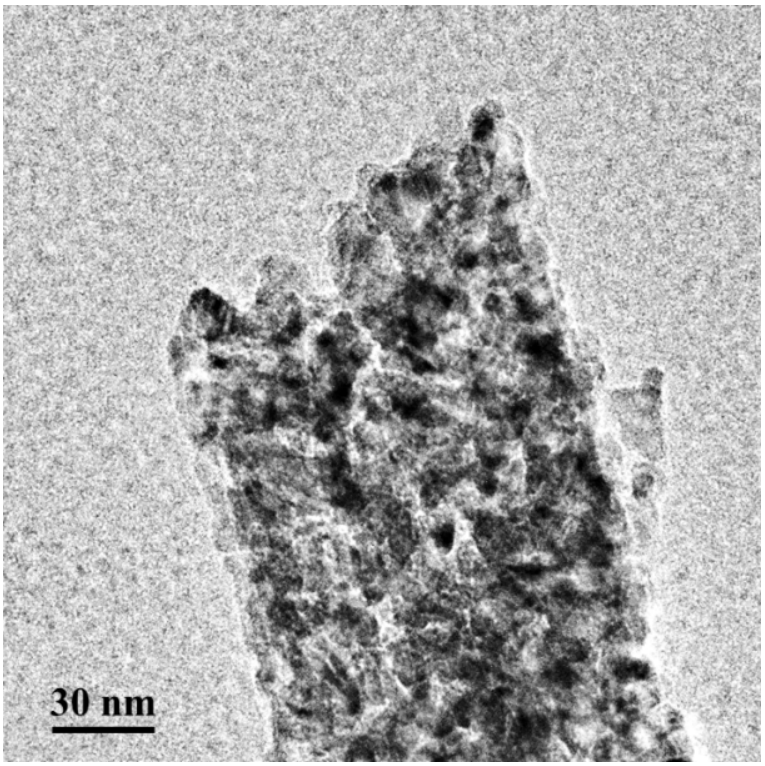

Fig. S4 TEM image of the Co-CoO_x nanowire.

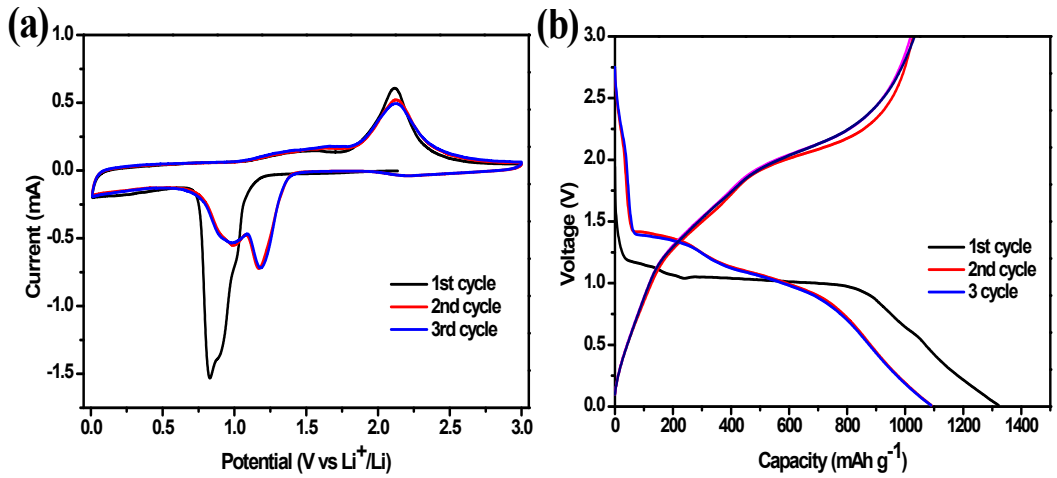

Fig. S5 (a) The first three cyclic voltammograms of the Co_3O_4 NWAs electrode, (b) Typical charge and discharge curves of first three cycles at a current density of 0.5 A g^{-1} of Co_3O_4 NWAs. These data are in accord with the performance of grass-like Co_3O_4 NWAs in our previous work.[3]

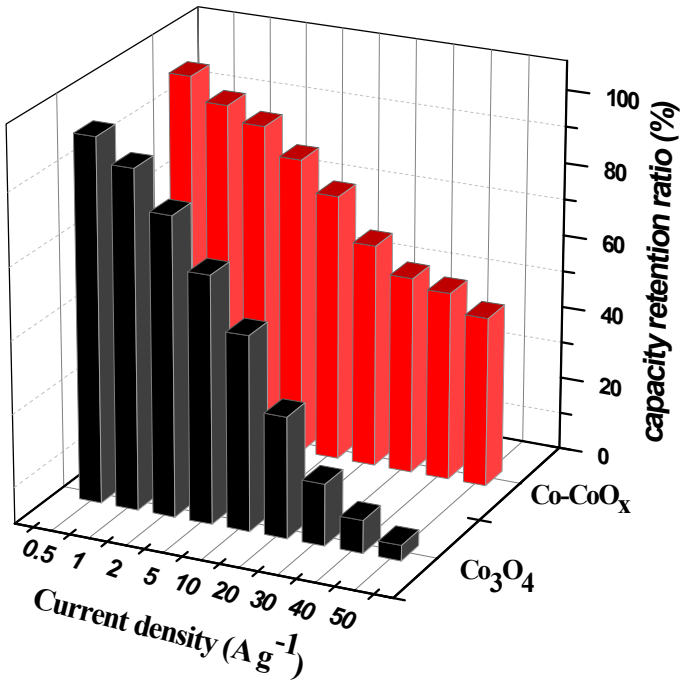

Fig. S6 Capacity retention ratios of Co_3O_4 and Co-CoO_x NWAs at various current densities. Capacity retention ratio is the ratio of the discharge capacity at an assigned rate to the discharge capacity at 0.5A g^{-1}. Obviously, Co-CoO_x NWAs maintain higher capacity retention ratio than Co_3O_4 NWAs at the same rate. Along with the increasing of the rate, the gap between Co-CoO_x NWAs and Co_3O_4 NWAs is widened. Even at 50 A g^{-1}, the capacity retention ratio of Co-CoO_x NWAs also keep at 46.6%, while that of Co_3O_4 NWAs is only 4.2%.

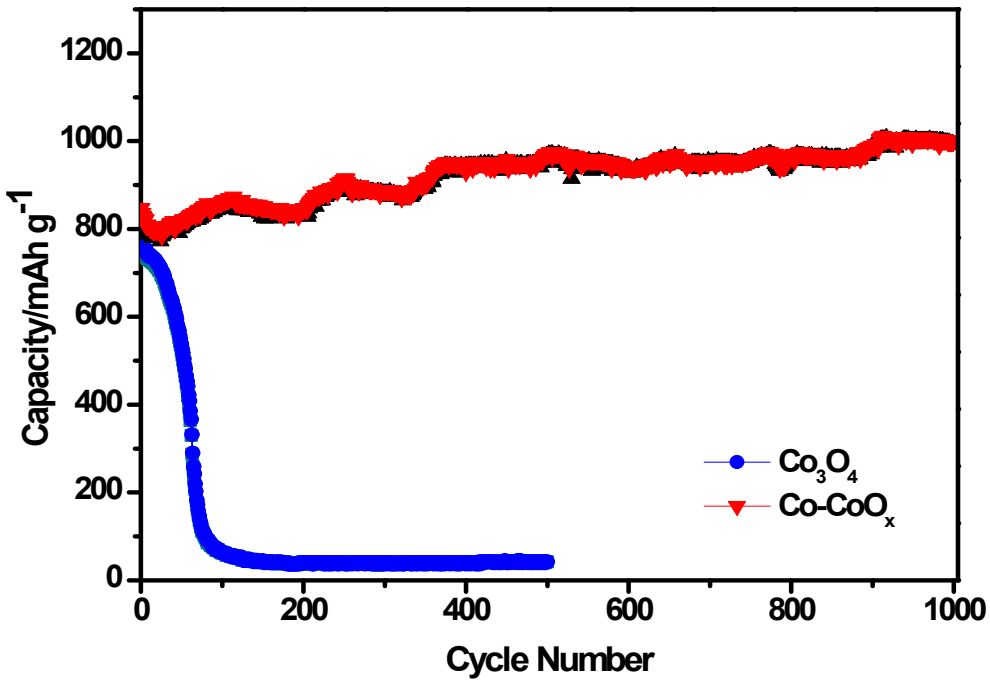

Fig. S7 Cycling performance of Co_3O_4 and Co-CoO_x at a current density of 10 A g^{-1}. The capacity data are based on the mass of CoO_x. Co-CoO_x NWAs show a high reversible capacity of 990 mAh g^{-1} at 10A g^{-1} after 1000 cycles, while Co_3O_4 NWAs exhibit a rapid capacity fading in the first 100 cycles at 10 A g^{-1}.

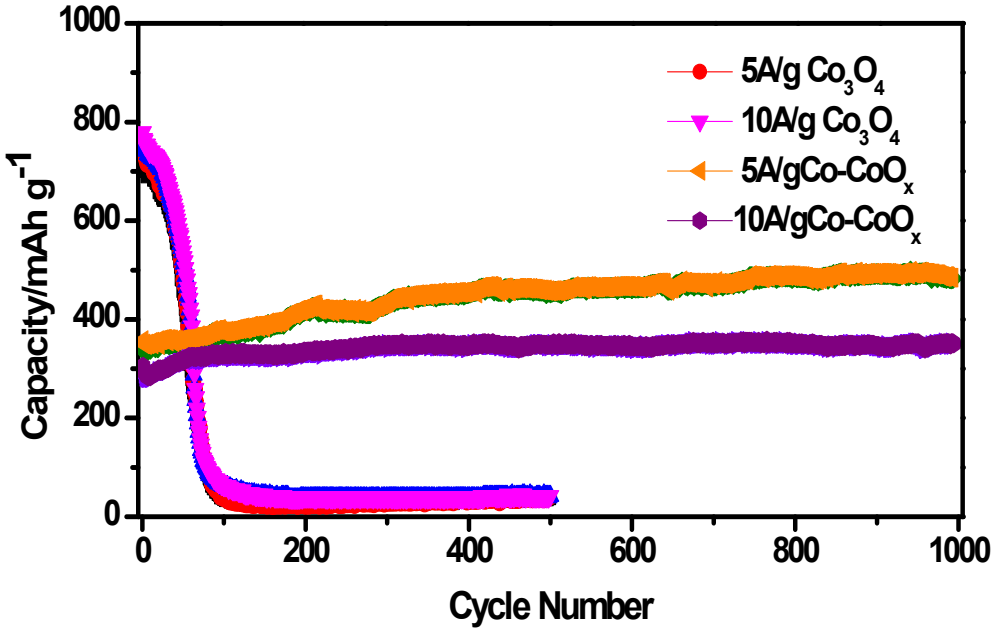

Fig. S8 Cycling performance of Co_3O_4 and Co-CoO_x at current densities of 5 A g^{-1} and 10 A g^{-1}. These capacity data are based on the total mass of Co and CoO_x. It is obvious that Co-CoO_x NWAs have a better cycle performance than Co_3O_4 NWAs even when metallic Co is include in active materials.

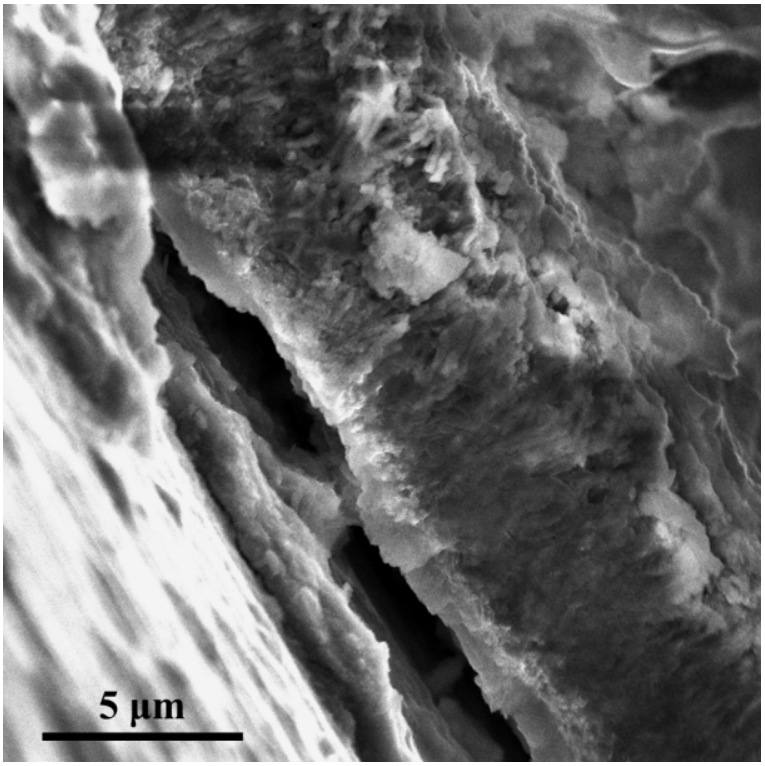

Fig S9 SEM image of Co-CoO_x NWAs from the side view after 200 cycles at 20A g^{-1}.
After 200 cycles, the thickness of Co-CoO_x array changes to 6 μm. The change of electrode thickness is related to the large volume change of Co-CoO_x array during cycling, and the formation of solid electrolyte interphase (SEI) film.

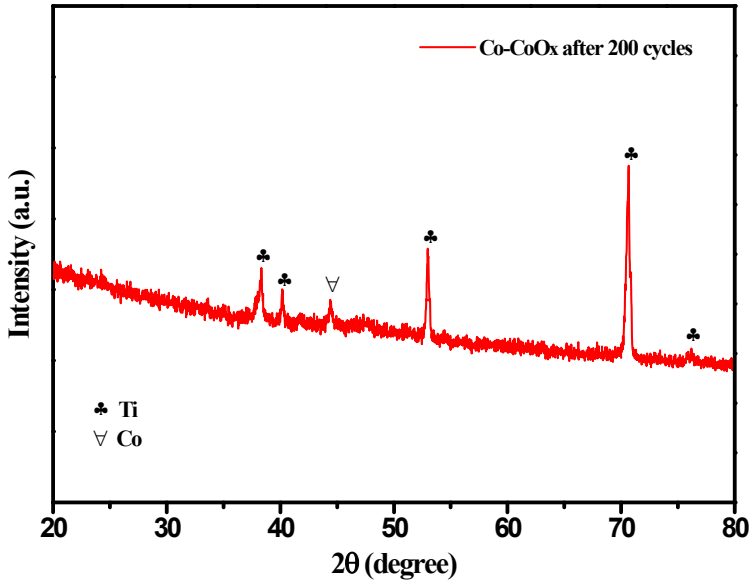

Fig. S10 XRD patterns of Co-CoO_x array after 200 cycles at 20 A g^{-1}

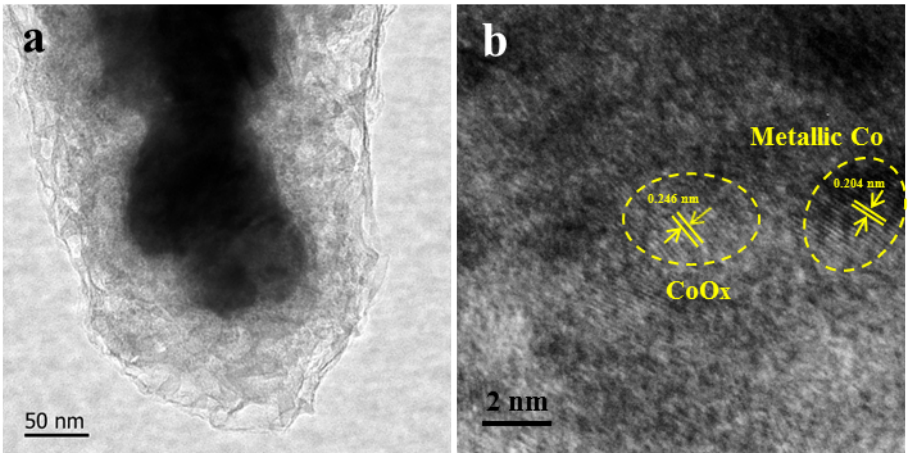

Fig. S11 TEM images of Co-CoOx array electrode after 200 cycles at 20 A g^{-1}.

References

1. Y. Ren, P. G. Bruce and Z. Ma, *J. Mater. Chem.*, **2011**, 21, 9312.

2. B. Wang, Z. Qin, G. Wang, Z. Wu, W. Fan, H. Zhu, S. Li, Y. Zhang, Z. Li and J. Wang, *Catalysis Lett.*, **2013**, 143, 411-417.

3. L. Zhan, S. Wang, L. Ding, Z. Li and H. Wang, *Electrochim. Acta*, **2014**, 135, 35-41.