Electronic Supplementary Material (ESI) for Nanoscale

Enhancing Electrochemical Reaction Sites in Nickel-Cobalt Layered Double Hydroxides on Zinc Tin Oxide Nanowires: a Hybrid Material for an Asymmetric Supercapacitor Device

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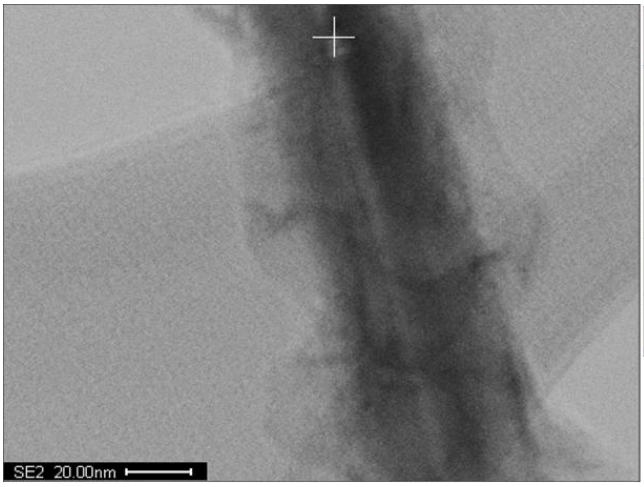
Select area electron diffraction of single crystal ZTO nanowire

Figure S1. Select area electron diffraction of single crystal ZTO nanowire

TEM based EDS element analysis of Ni/Co=1:1 sample



Element	*Wt%*	*At%*
ZnL	42.76	53.51
SnL	47.21	32.54
CoK	04.00	05.56
NiK	06.02	08.39
Matrix	Correction	MThin

Figure S2. EDS element analysis of Ni/Co=1:1 sample. For Ni/Co=1:1 sample, x=0.6 in Ni_xCo_{1-x} LDH based on EDS element analysis.

Schematic comparison of direct depositon and heterostructure

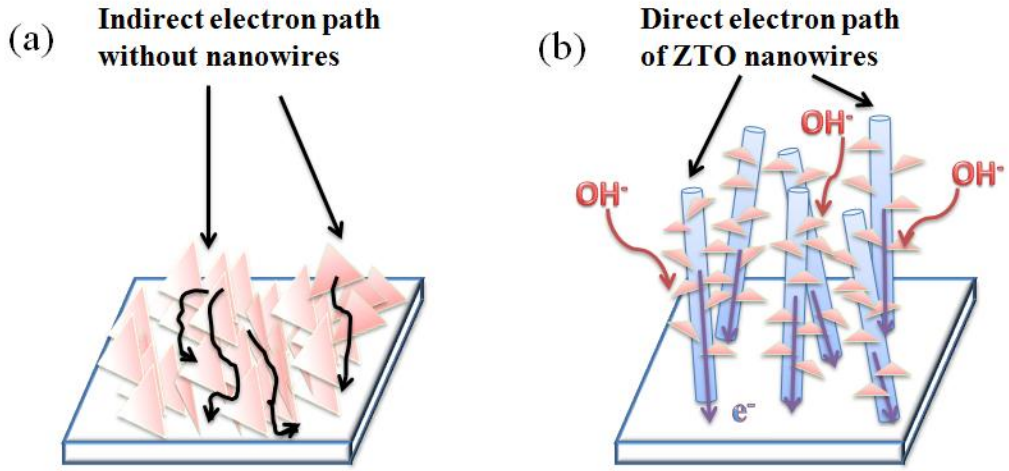


Figure S3. (a) schematic model of indirect electron path of directly deposited sample; (b) direct electron path and easy ion diffusion path of heterostructure.

Electrochemical characterization of activated carbon

Activated carbon has been widely used as negative electrode material in asymmetric supercapacitor devices.[1, 2] Activated carbon electrode material stores/releases energy through reversible adsorption/desorption of electrolyte ions on the surface to charging/discharging electric double layer.[3] Generally, activated carbon has moderate capacitance ranging from 50 to 200 F g^{-1} in aqueous electrolytes within a potential window around 1.0 V.[4, 5] Most importantly, activated carbon is commercially available and low cost, which makes it perfect for supercapacitor negative electrode. The activated carbon has a high Brunauer–Emmett–Teller (BET) surface area of 2084.15 m^2 g^{-1} and a narrow pore distribution around 1.9 nm (Supporting Information Figure S4).

In order to investigate the electrochemical performance of activated carbon, three electrode test is performed using cyclic voltammetry and galvanostatic charge/discharge method in 2 M KOH electrolyte solution (Figure S5). The activated carbon shows a typical rectangle like CV curve within a wide potential range from 10 to 150 mV s^{-1}, indicating a typical electric double layer energy storage mechanism. The specific capacitance of activated carbon as measured using equation 4 at 1 and 20 A g^{-1} is 186.5 and 155.5 F g^{-1} respectively, showing a good rate capability.

BET test of active carbon

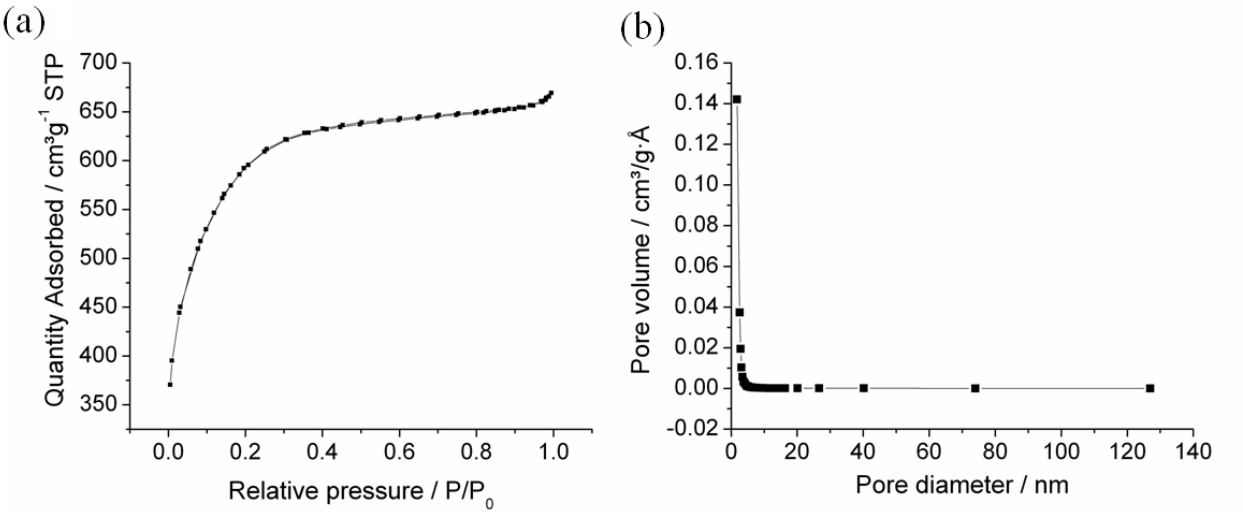


Figure S4. (a) Isothermal adsorption plot of active carbon at 77k; (b) pore distribution of active carbon.

Electrochemical characterization of activated carbon

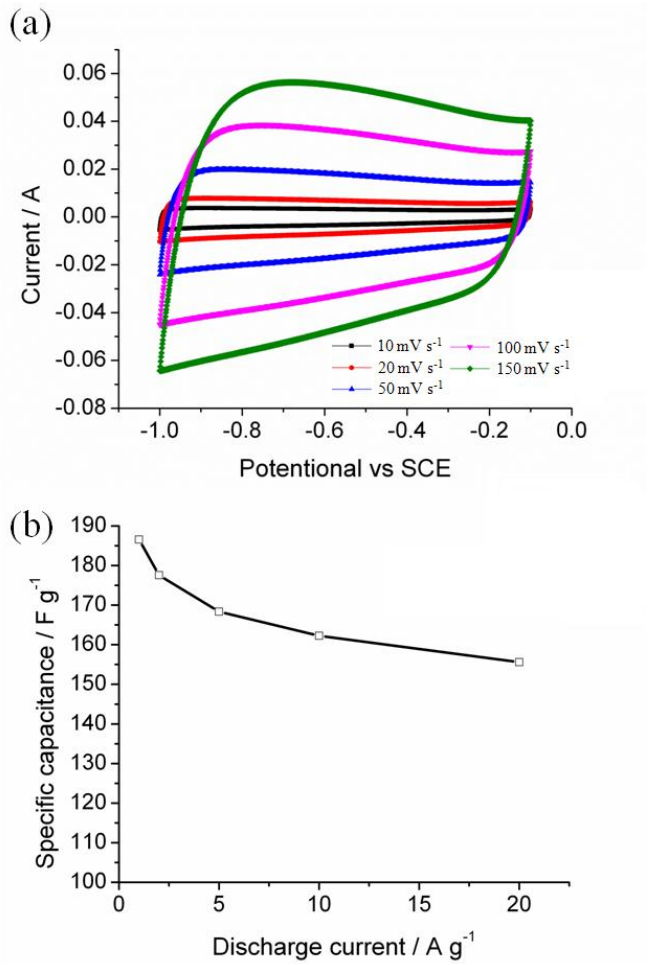


Figure S5. (a) CV curves of activated carbon in 2 M KOH at different scan rates; (b) specific capacitance vs discharge current relationship of activated carbon.

The comparative CV curves of both positive and negative electrodes

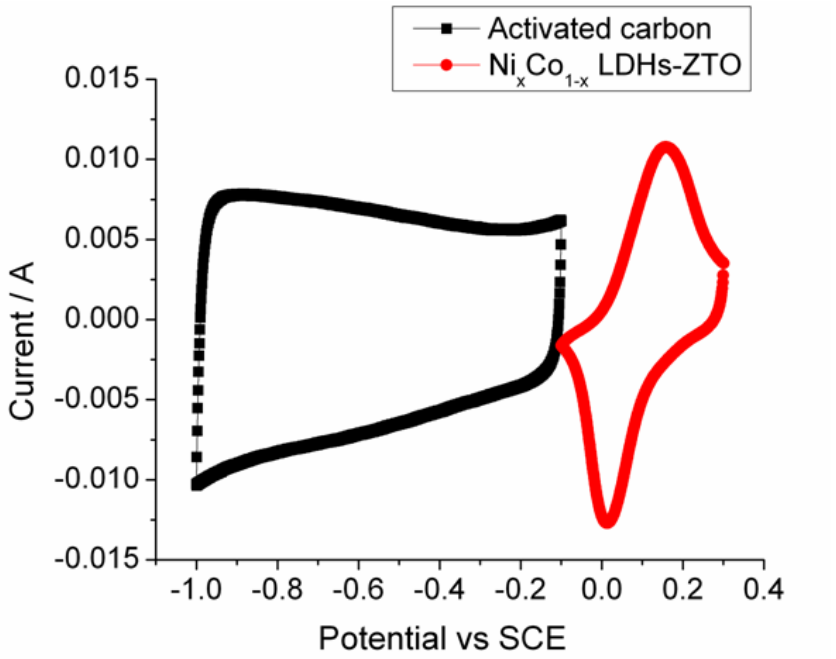


Figure S6. Comparative CV curves of activated carbon and Ni_xCo_{1-x} LDHs-ZTO heterostructure

Optimization of working voltage

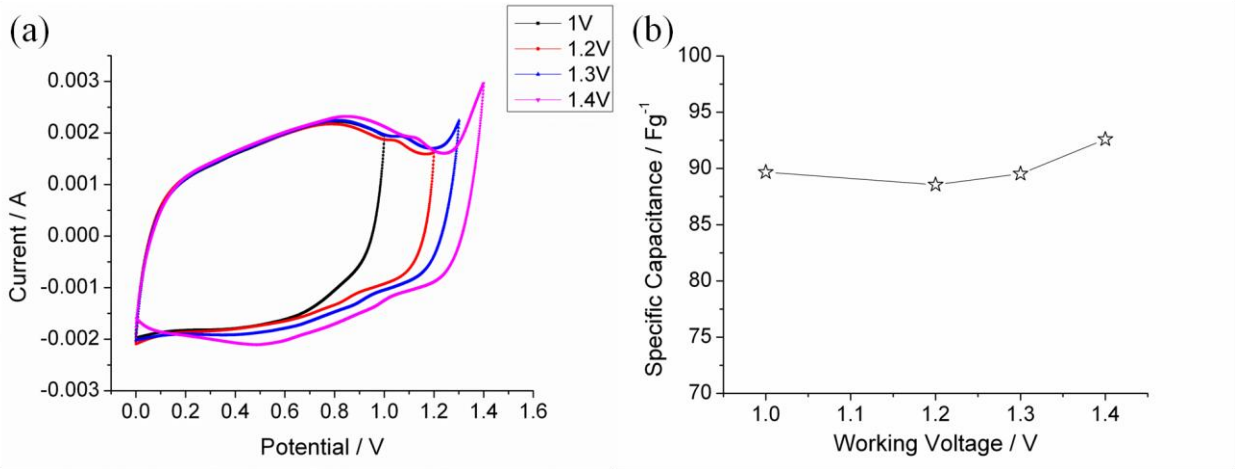


Figure S7. A two electrode test in 2 M KOH electrolyte is carried out by cycling voltammetry at a scan rate of 20 mV/s, as shown in Figure S6a. The CV curves show a distinct distortion and sharp increase of current at potential windows of 1.3 V and 1.4 V, which may result from the H_2 evolution at negative electrode in alkaline electrolyte. From Figure S6b, a C_{sp} around 90 F/g could be achieved from 1 V to 1.3 V, however, at 1.4 V the C_{sp} reaches the maximum value of 92.6 F/g. Considering both the requirement of high energy density and the safety of device, we take 1.2 V as the optimum working potential of our asymmetric device. (a) CV curves of an optimized Ni_xCo_{1-x} LDH-ZTO/Activated carbon two electrode cell measured at different potential window in 2M KOH electrolyte; (b) specific capacitance of Ni_xCo_{1-x} LDH-ZTO/Activated carbon two electrode cell at a scan rate of 20 mV/s.

References:

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