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

Supplementary Information

Three-dimensional $NiCo_2O_4$@$NiWO_4$ core-shell nanowire arrays for high performance supercapacitor

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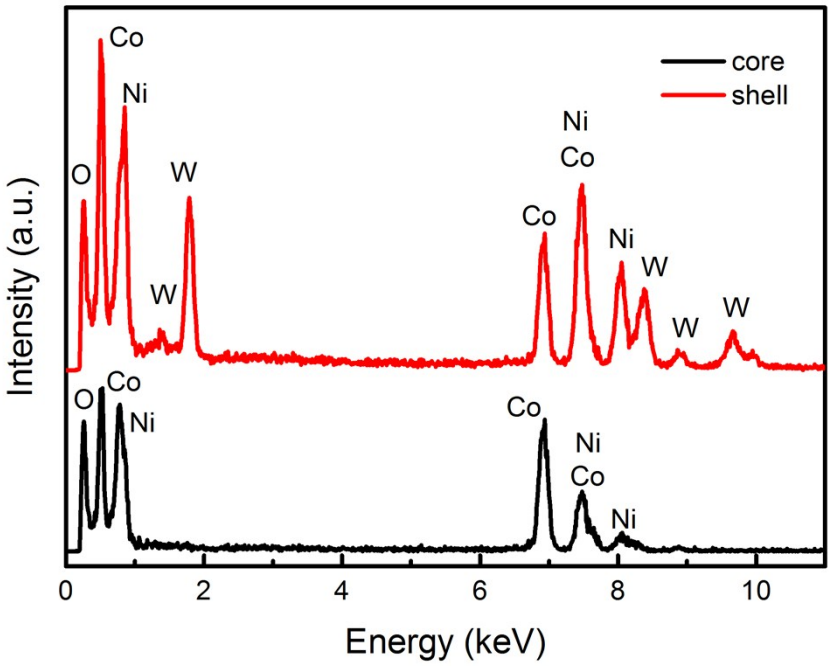

Fig. S1 EDS analysis of $NiCo_2O_4$@$NiWO_4$ hybrid nanowires (8h).

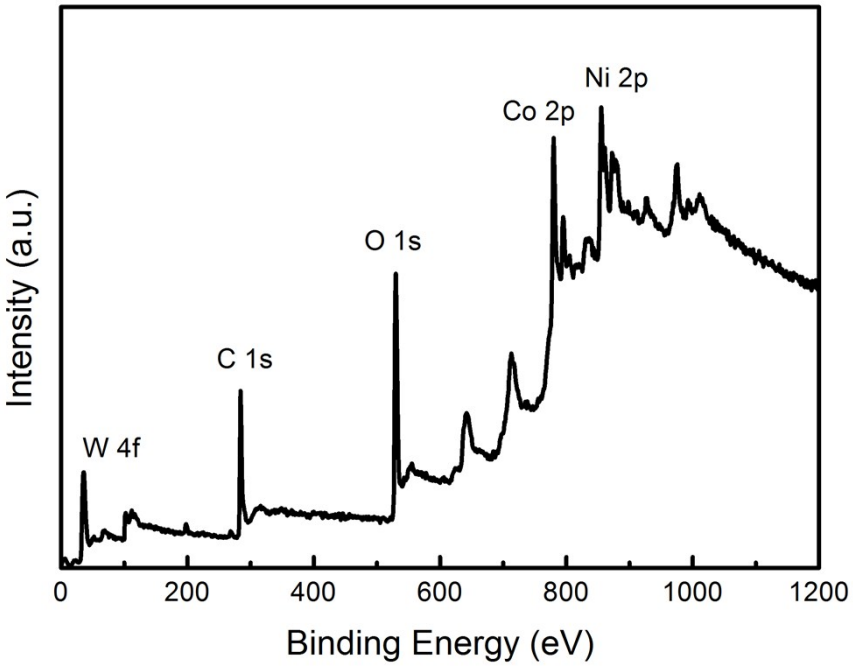

Fig. S2 Wide-scan XPS spectra of $NiCo_2O_4$@$NiWO_4$ hybrid nanowires (8h).

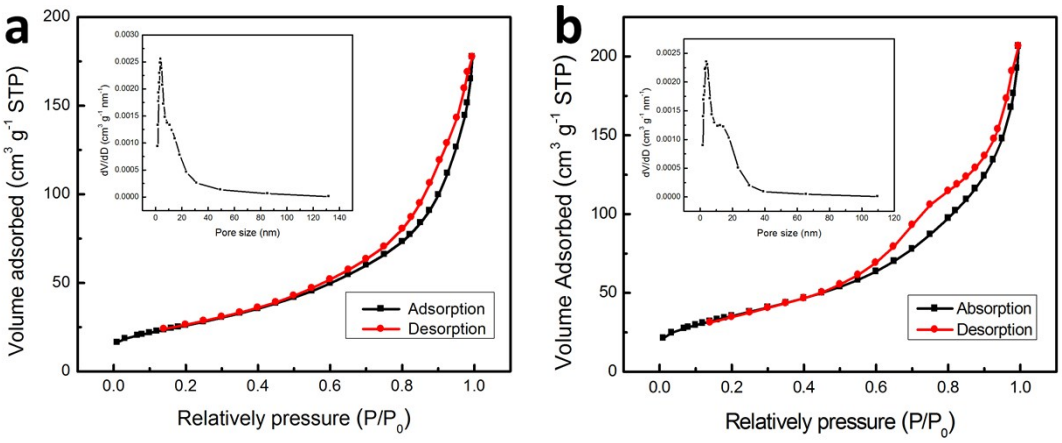

Fig. S3 N_2 adsorption-desorption isotherms of (a) $NiCo_2O_4$ nanowires and (b) $NiCo_2O_4$@$NiWO_4$ hybrid nanowires (the inset shows the pore size distribution).

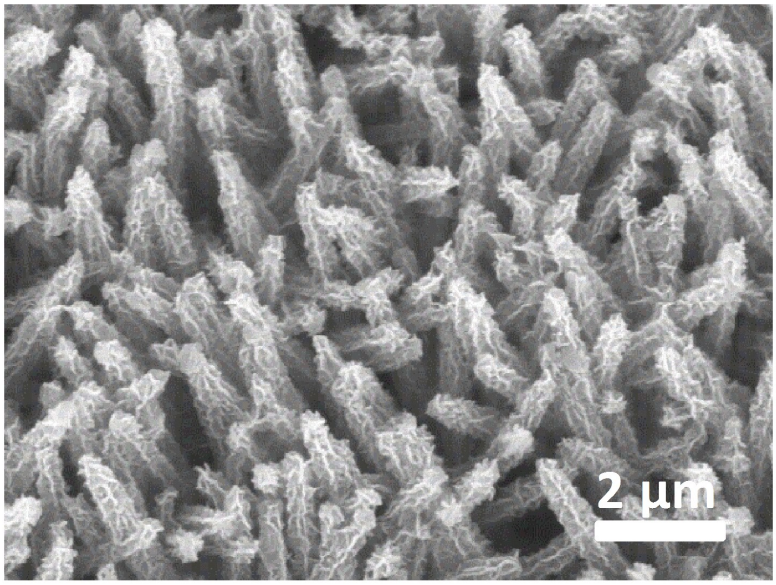

Fig. S4 SEM image of $NiCo_2O_4$@$NiWO_4$ electrode (8h) after charge-discharge for 6000 cycles.

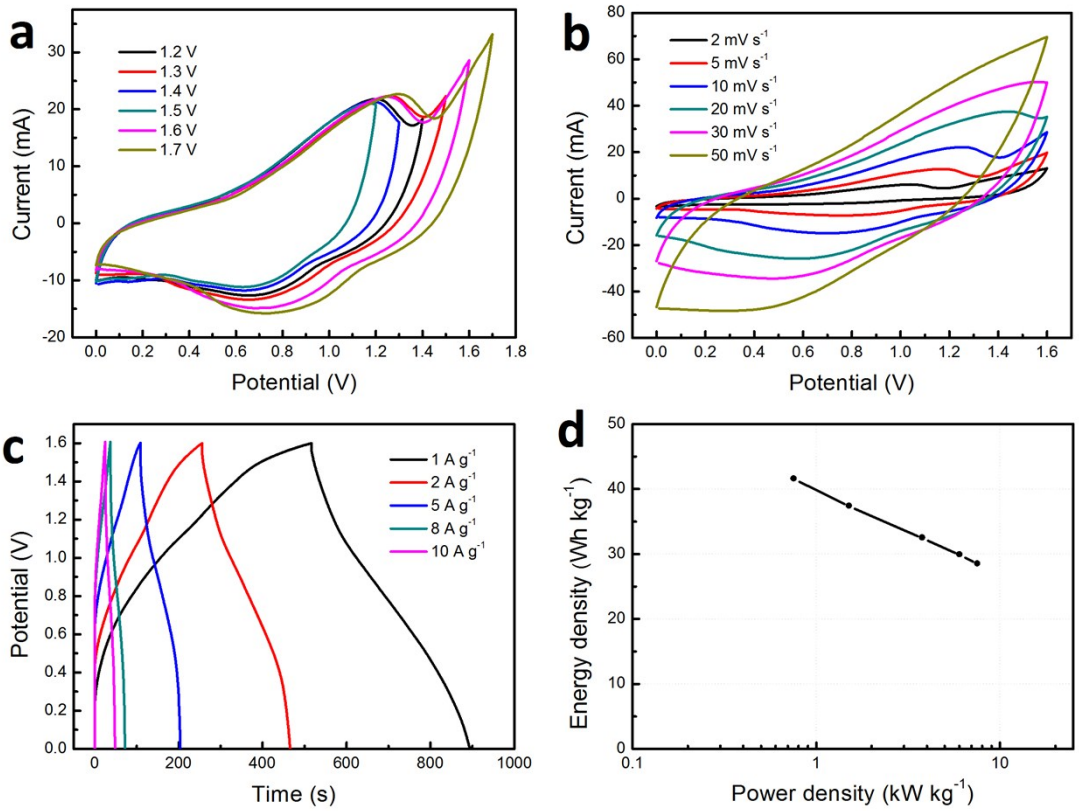

Fig. S5 (a) CV curves of the $NiCo_2O_4$@$NiWO_4$ hybrid electrode (8 h)//AC ASC device collected at various potential windows from 1.2 to 1.7 V; (b) CV curves of the ASC device at different scan rates from 2 to 50 mV s^{-1}; (c) GCD curves of the ASC device at various current densities from 1 to 10 A g^{-1}; (d) Ragone plot of the as-fabricated ASC device.

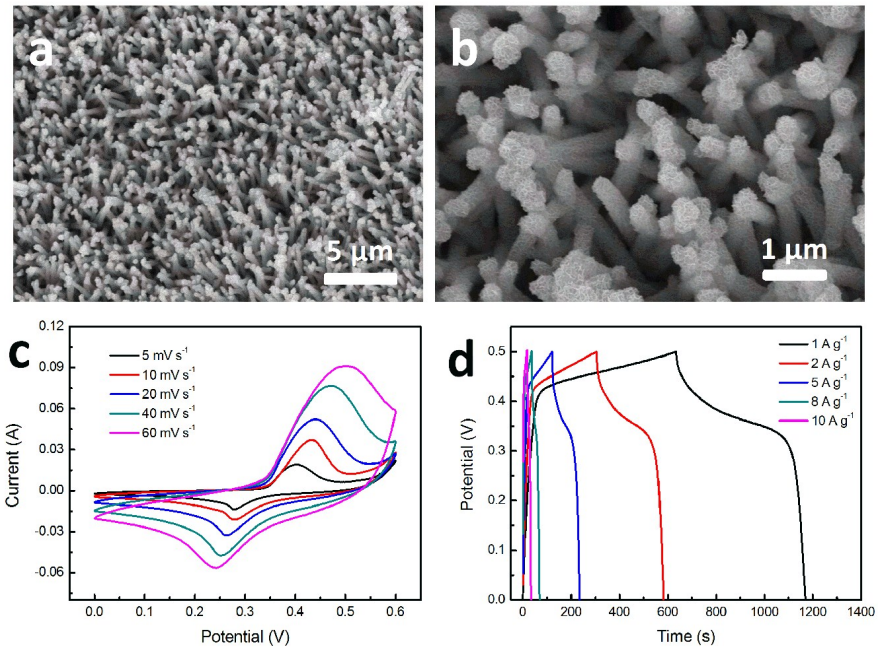

Fig. S6 (a, b) SEM image of the $NiCo_2O_4$@NiO hybrid nanowires; (c) CV curves of $NiCo_2O_4$@NiO hybrid electrode at different scan rates from 5 to 60 mV s^{-1}; (d) GCD curves of $NiCo_2O_4$@NiO hybrid electrode at various current densities from 1 to 10 A g^{-1}.

$NiCo_2O_4$@NiO hybrid nanowires are prepared for comparison with $NiCo_2O_4$@$NiWO_4$ hybrid nanowires. The morphology and electrochemical performance of $NiCo_2O_4$@NiO hybrid nanowires are shown in Fig. S5. It can be seen that $NiCo_2O_4$ nanowires are decorated with NiO nanosheets, forming highly porous core-shell heterostructures. The NiO nanosheets are interconnected with each other and there are abundant space between neighboring nanowires. A pair of redox peaks can be clearly observed in each CV curve (Fig.S5c), indicating that the capacitance is mainly based on the Faradaic redox mechanism. The $NiCo_2O_4$@NiO hybrid electrode delivers a specific capacitance of 1220.8, 1147.1, 1067, 1011.7 and 981.5 F g^{-1} at a current density of 1, 2, 5, 8 and 10 A g^{-1}, respectively. The capacitance retention is 80.4% when the current density is increased from 1 A g^{-1} to 10 A g^{-1}. Therefore, $NiCo_2O_4$@$NiWO_4$ hybrid electrode exhibits superior supercapacitive performance than $NiCo_2O_4$@NiO hybrid electrode.

Table S1 The electrochemical properties of the $NiCo_2O_4$@$NiWO_4$ hybrid electrode (8 h) compared with other references.

Types of materials	Areal (specific) capacitance	Rate capability	Cycling stability	Ref.
$NiCo_2O_4$@$NiCo_2O_4$ core /shell nanoflake arrays	1.55 F/cm^2 at 2 mA/cm^2	74.8% retention from 2 to 40 mA/cm^2	98.6% retention after 4000 cycles at 5 mA/cm^2	1
$NiCo_2O_4$@MnO_2 nanowire arrays	3.31 F/cm^2 at 2 mA/cm^2	50.2% retention from 2 to 20 mA/cm^2	88% retention after 2000 cycles at 10 mA/cm^2	2
$NiCo_2O_4$@TiN core/shell nanowires	998 mF/cm^2 at 2 mA/cm^2	58.3% retention from 2 to 20 mA/cm^2	72.2% retention after 2000 cycles at 10 mA/cm^2	3
$NiCo_2O_4$@$NiMoO_4$ nanowire/nanosheet arrays	5.80 F/cm^2 at 10 mA/cm^2	83.6% retention from 10 to 80 mA/cm^2	81.8% retention after 5000 cycles at 50 mA/cm^2	4
$MnMoO_4$/$CoMoO_4$ heterostructured nanowires	204.1 F/g at 0.5 A/g	66% retention from 0.5 to 3 A/g	98% retention after 1000 cycles at 20 A/g	5
$NiCo_2O_4$@$MnMoO_4$ core/shell Nanoflowers	1118 F/g at 1 A/g	66.7% retention from 1 to 10 mA/cm^2	87.85% retention after 5000 cycles at 1 A/g	6
$NiCo_2O_4$@Ni_3S_2 nanothorn arrays	1716 F/g at 1A/g	64.3% retention from1 to 20 A/g	83.7% retention after 2000 cycles at 4 A/g	7
$NiCo_2O_4$@$MnMoO_4$ Nanocolumn Arrays	1705.3 F/g at 5 mA/cm^2	62.3% retention from 1 to 20 mA/cm^2	92.6% retention after 5000 cycles	8
$NiCo_2O_4$@$CoMoO_4$ nanowire/nanoplate arrays	1280.2 F/g at 10 mA/cm^2	65.8% retention from 10 to 60 mA/cm^2	74.1% retention after 1000 cycles at 60 mA/cm^2	9
$NiCo_2O_4$@$Co_xNi_{1-x}(OH)_2$ nanosheet arrays	987.3 F/g at 5 A/g	83.7% retention from1 to 50 A/g	88.3% retention after 3000 cycles	10
$ZnCo_2O_4$@$NiCo_2O_4$ core/sheath nanowires	1476 F/g at 1 A/g	63.8% retention from 1 to 20 A/g	98.9% retention after 2000 cycles at 10 A/g.	11
$NiCo_2O_4$@$NiWO_4$ core/shell Nanowires	1384 F/g at 1 A/g	85.5% retention from 1 to 10 A/g	87.6% retention after 6000 cycles at 5 A/g	This work

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