Electronic Supplementary Information

Blow spun N-doped carbon fiber based high performance flexible lithium ion capacitor

Changzhen Zhan,[a] Jianan Song,[b] Xiaolong Ren,[b] Yang Shen, [b] Feiyu Kang,[c] and Zheng-Hong Huang*[b]

[a] National Institute of Clean-and-Low-Carbon Energy, P. O. Box 001, Future Science & Technology City, Changping District, Beijing, 102209, PR China

[b] State Key Laboratory of New Ceramics and Fine Processing, School of Materials Science and Engineering, Tsinghua University, Beijing 100084, China

[c] Engineering Laboratory for Functionalized Carbon Materials, Graduate School at Shenzhen, Tsinghua University, Shenzhen 518055, China

*Corresponding authors. Tel/Fax: +86 10 62773752. E-mail: zhhuang@tsinghua.edu.cn

Characterization methods

Scanning electron microscopy (SEM, LEO1530) and transmission electron microscopy (TEM, Tecnai G20, 200 kV) were used to characterize the samples. N_2 sorption isotherms were measured by using a volume adsorption apparatus at 77 K. The total pore volumes were estimated from single point adsorption (P/P_0= 0.995), the specific surface area was calculated by Brunauer-Emmett-Teller (BET) method, the micropore surface area and micropore volume were determined by t-plot method, and pore size distributions (PSD) were derived from density functional theory (DFT). PHI Quantera Imaging X-ray photoelectron spectroscopy (XPS) was used to investigate the surface chemistry. Phases were examined by X-ray diffraction (XRD, Bruker D8 ADVANCED) operating at an acceleration voltage of 40 kV. The surface functional groups were investigated by Attenuated Total internal Reflectance Fourier Transforms Infrared Spectra (ATR-FTIR, Varian Excalibur 3100). The structure was studied using Raman scattering spectra (Renishaw, InVia-Reflex) using a 532 nm laser.

Electrochemical measurements

LAND battery tester (Jinnuo Electronics Co., Wuhan, China) was used to perform the GCD tests of the LIBs. The voltage windows were 0.01-3 V vs. Li/Li^+ for BSCFs and 1.5 V-4.6 V for BSACFs. Arbin-BT2000 test station was used to test the GCD measurements of symmetric supercapacitors and hybrid devices. The voltage window for symmetric supercapacitors was 0-2.7 V, while the voltage windows for hybrid devices were 1.5-4.5 V. CV tests were performed in VSP-300 electrochemical interface.

Calculation of specific capacitance (C), energy density (E) and power density (P)

The gravimetric capacitance of the supercapacitor and hybrid capacitors was calculated from the

GC curves through the following equation:

$$C = I\,\Delta t / m\Delta V \quad (1)$$

where I is the constant current (A), Δt is the discharge time (s), m is the total mass of the active materials on the two electrodes (g), and ΔV is the total potential deviation(V). And, the specific capacitance of the single supercapacitor electrode (C_s) was calculated by the following equation:

$$C_s = 4\,C \quad (2)$$

The energy density was calculated by numerically integrating the t-V curve area during the discharge process through the equation:

$$E = \int_{t_1}^{t_2} I_g V dt \quad (3)$$

where t_1 and t_2 are the start and end time in the discharge process (s), V is the potential (V). The power density (P) was calculated according to the following equation:

$$P = E/(t_2 - t_1) \quad (4)$$

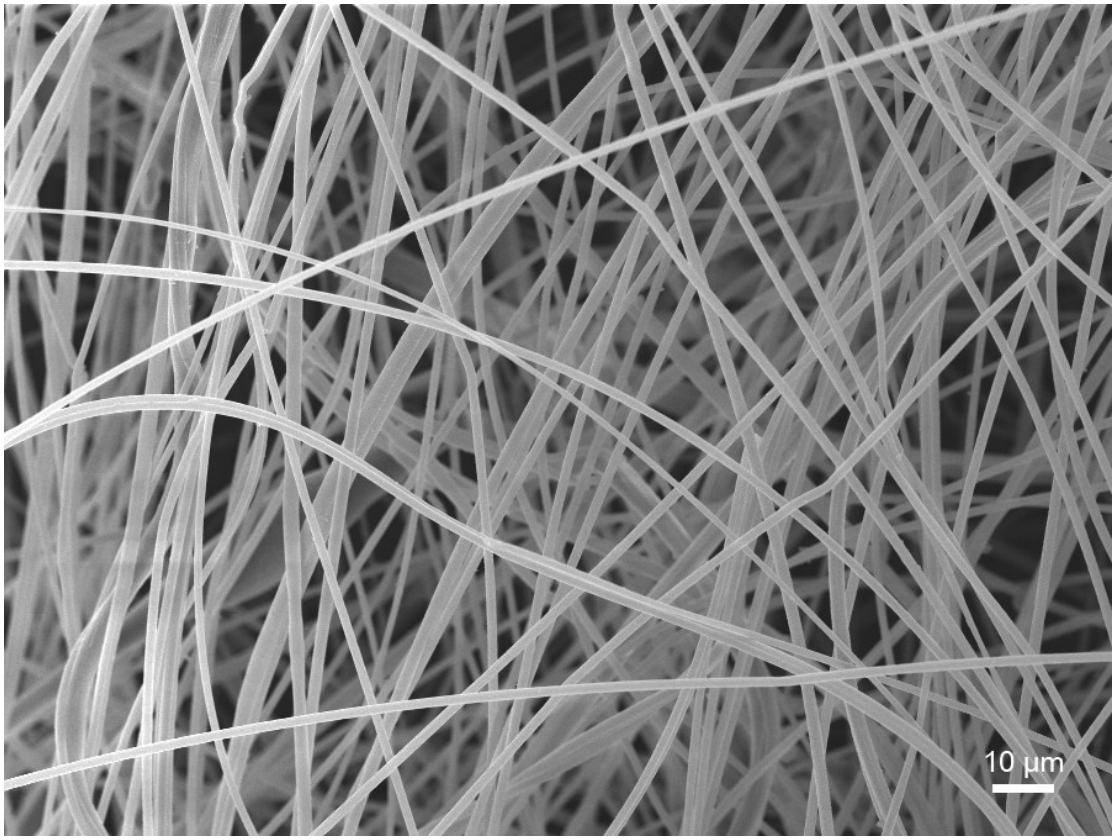

Fig. S1 SEM image of blow spinning PAN fibers.

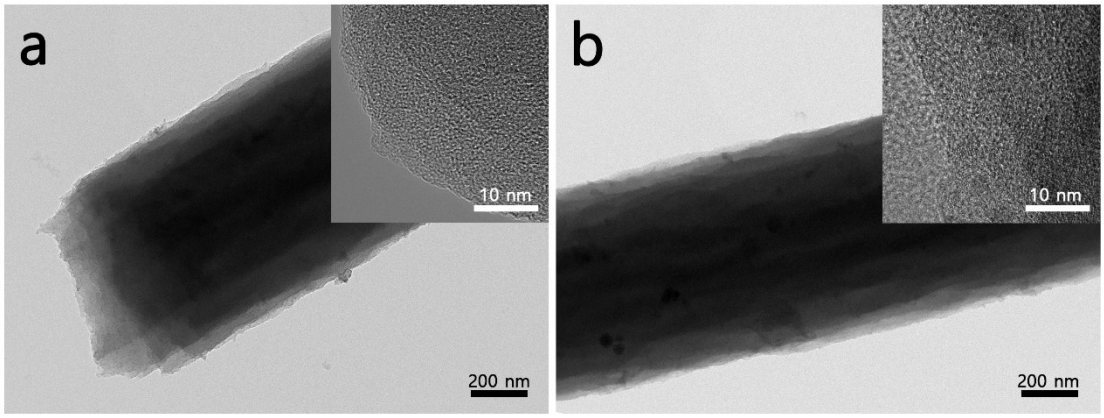

Fig. S2 TEM images of BSCFs(a) and BSACFs(b).

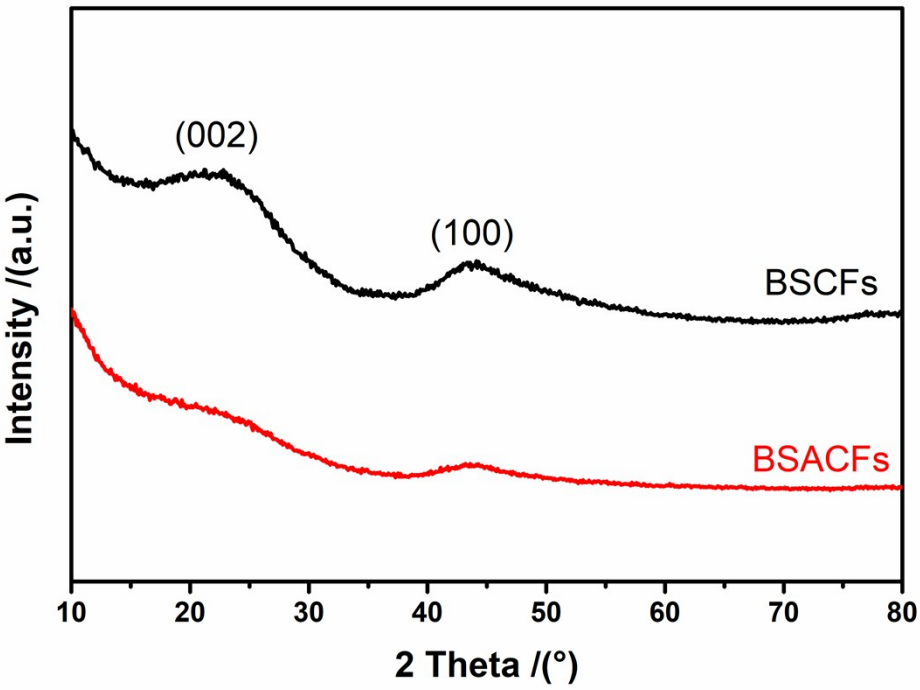

Fig. S3 XRD pattern of BSCFs and BSACFs

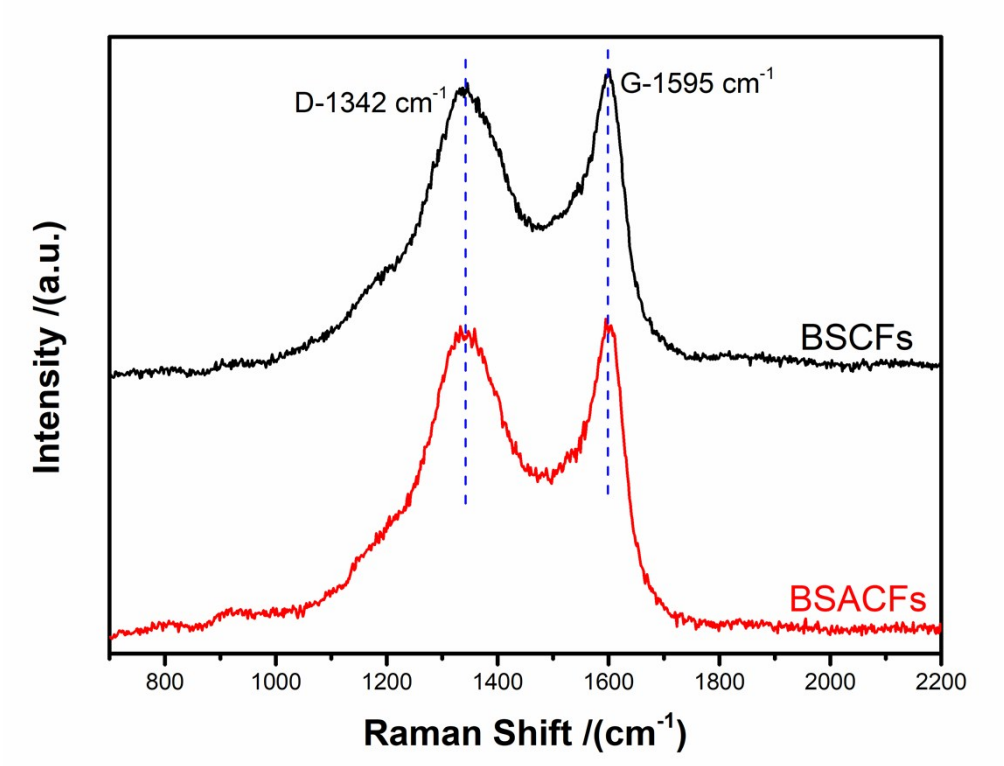

Fig. S4 Raman spectrum of BSCFs and BSACFs

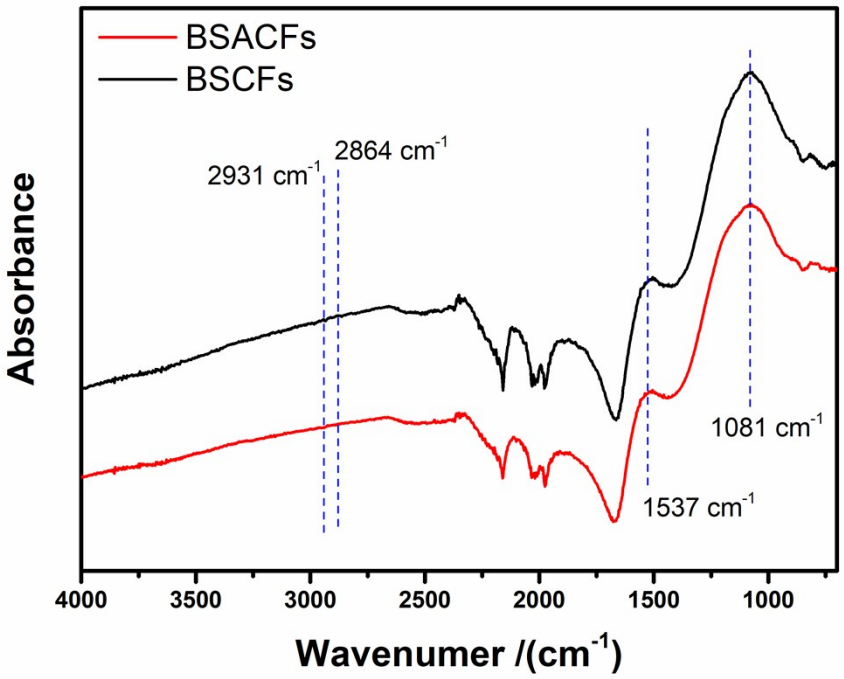

Fig. S5 ATR-FTIR spectra of BSCFs and BSACFs

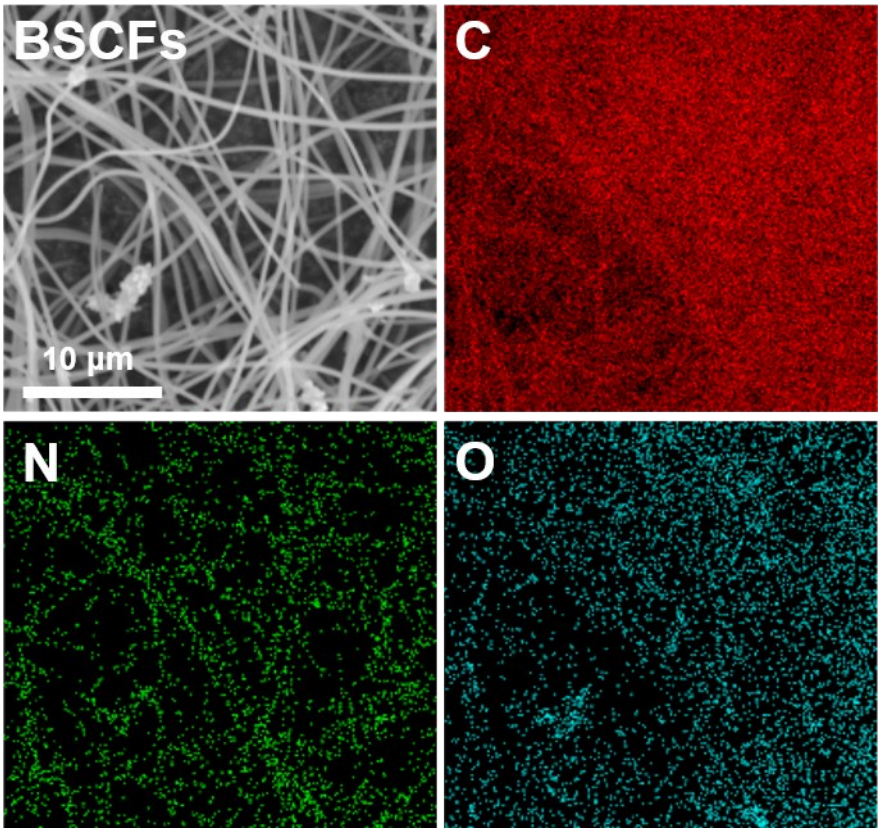

Fig. S6 SEM image and corresponding elemental mappings of BSCFs

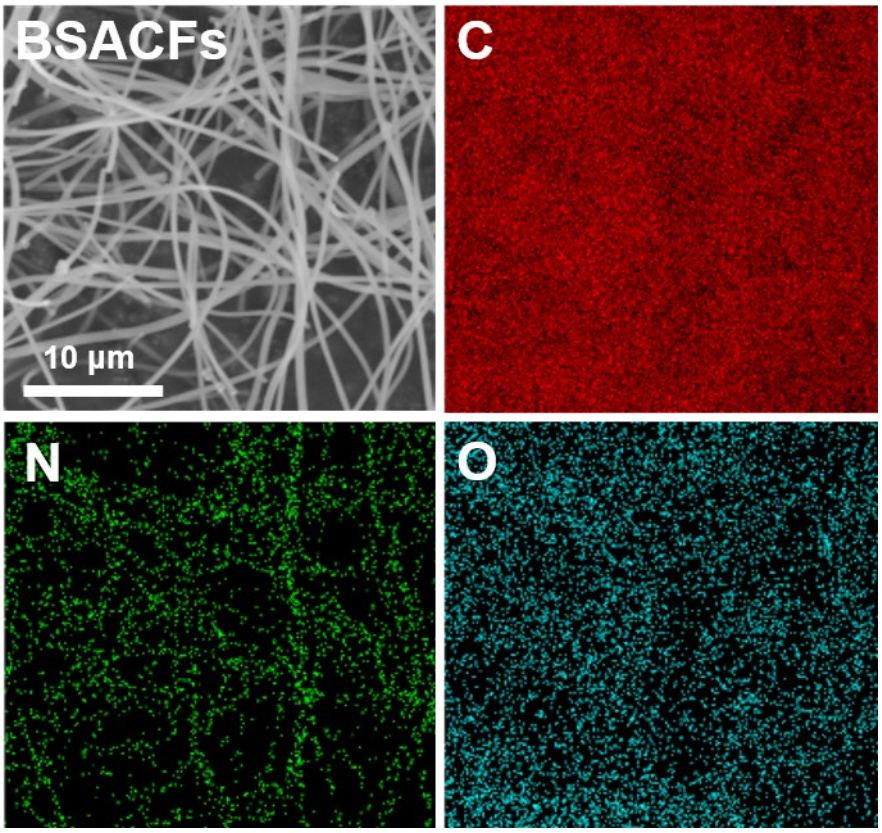

Fig. S7 SEM image and corresponding elemental mappings of BSACFs

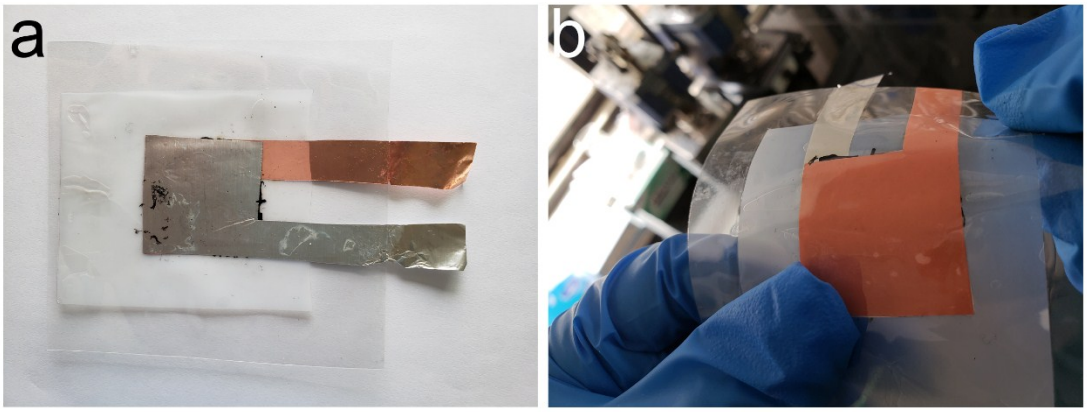

Fig. S8 Photos of FHSC fabricated by coupling BSACFs and pre-lithiated BSCFs.

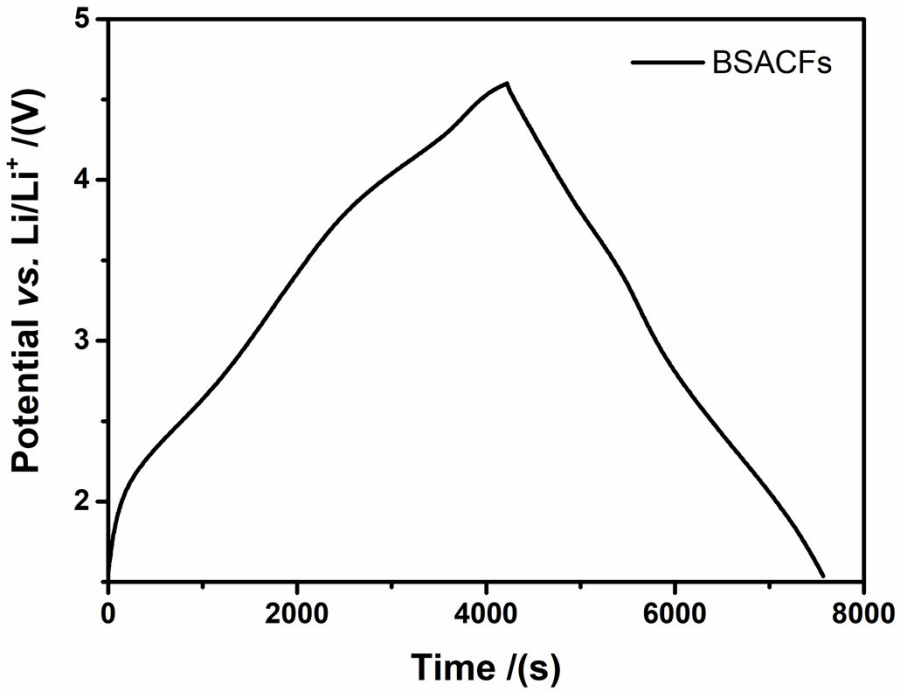

Fig. S9 GCD curves of BSCFs in a high potential range of 1.5-4.6 V.

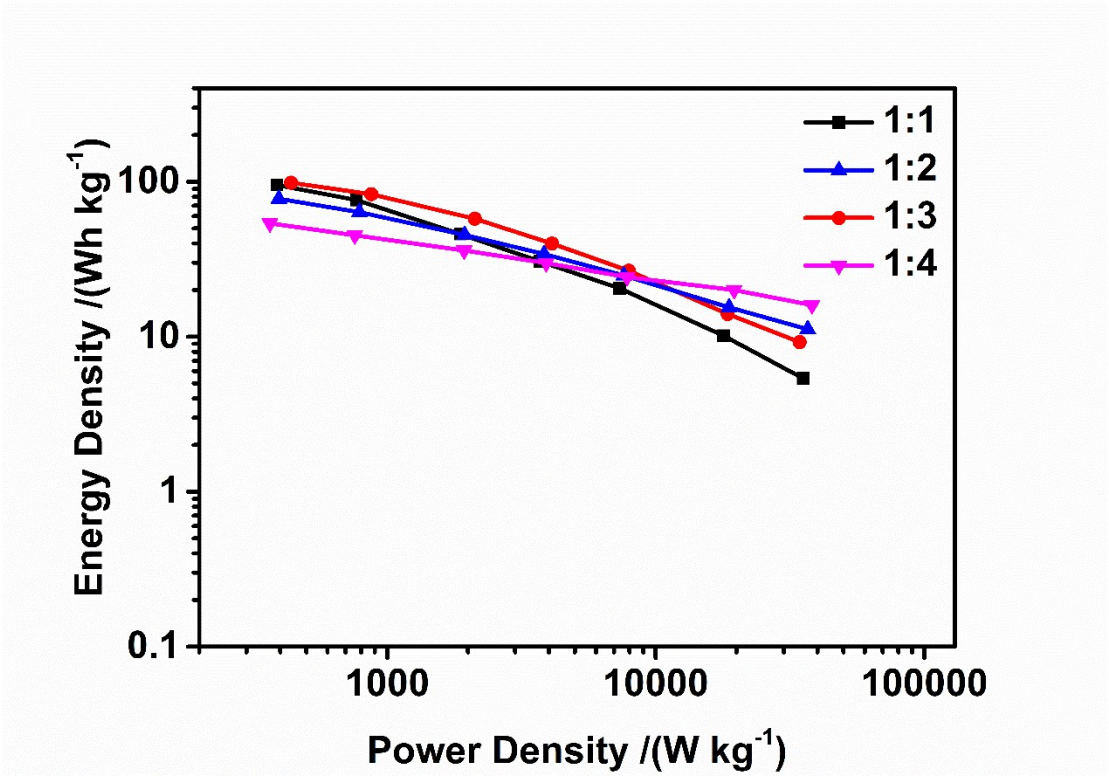

Fig. S10 Ragone plots of FHSCs with different mass ratio of two electrodes.

Table S1 Physicochemical properties of the BSACF series samples.

Samples	S_{BET}[a] (m^2g^{-1})	V_{total}[b] ($cm^3\ g^{-1}$)	Flexibility[c]
BSACF	1412	0.938	YES
BSACF-700	701	0.423	YES
BSACF-900	976	0.886	NO

[a] Specific surface area calculated by BET method.

[b] Total pore volume.

[c] Flexibility of the activated non-woven fabrics

Table S2 Electrochemical properties of literature reported flexible capacitors.

Electrode materials system	**Maximum energy density (W h kg^{-1})**	**Maximum power density (kW kg^{-1})**	**Cycle stability**	**Reference**
Nb_2O_5@C//AC	95.55	5.35	87%@1000	*Adv. Funct. Mater.,* 2018, 28(1): 1704330.
TiO_2//Graphene hydrogel	82	19	73%@600	*Small*, 2015, 11(12): 1470-1477.
NTO//PSC	111.2	11.2	86%@3000	*Nano letters*, 2016, 16(9): 5938-5943.
$NaTi_2(PO_4)_3$//N-doped C	-	-	77%@200	*Nano Energy*, 2018, 50: 623-631.
LTO@CT//NCG	76	-	79%@5000	*Nano Research*, 2017, 10(12): 4448-4456.
BSACFs//BSCFs	**98**	**34**	**94%@4000**	**This work**