

Supporting information

Three-Dimensional SWCNT and MWCNT Hybrid Networks for Extremely High-Loading and High- Rate Cathode Materials

Dae-wook Kim,^a Nobuyuki Zettsu,^{*,a,b} and Katsuya Teshima^{*,a,b}

^aDepartment of Materials Chemistry, Faculty of Engineering, Shinshu University, 4-17-1

Wakasato, Nagano 380-8553, Japan

^b Research Initiative for Supra-Materials, Shinshu University, 4-17-1 Wakasato, Nagano 380-8553, Japan.

AUTHOR INFORMATION

Corresponding Author

*E-mail: teshima@shinshu-u.ac.jp and zettsu@shinshu-u.ac.jp

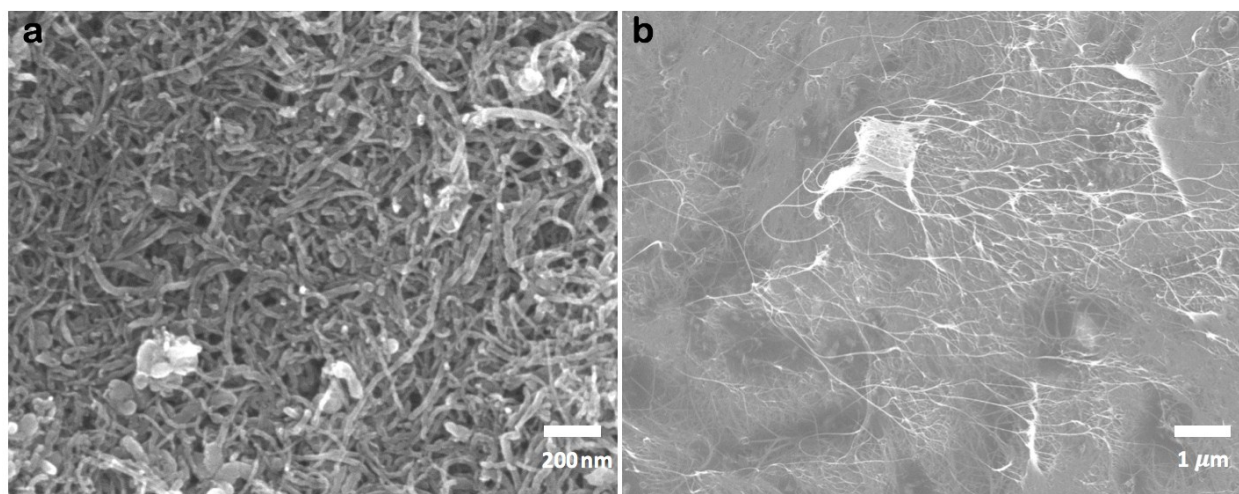


Figure S1. FE- SEM images of (a) MWCNTs and (b) SWCNTs.

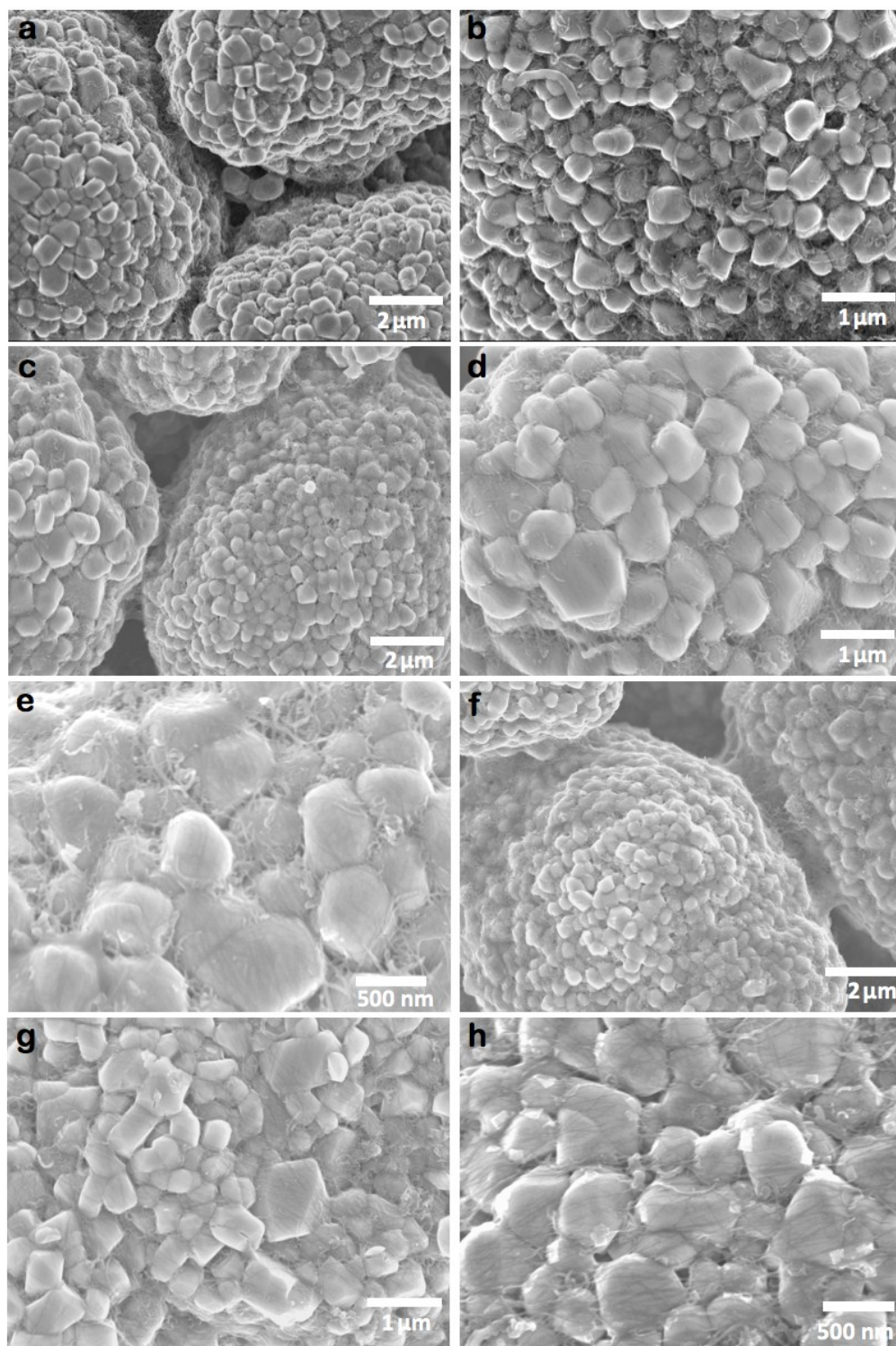


Figure S2. FE- SEM images of NCM/SW electrodes at different magnifications. (a, b) 99NCM/SW0, (c, d, e) 995NCM/SW10, and (f, g, h) 995NCM/SW15 electrodes.

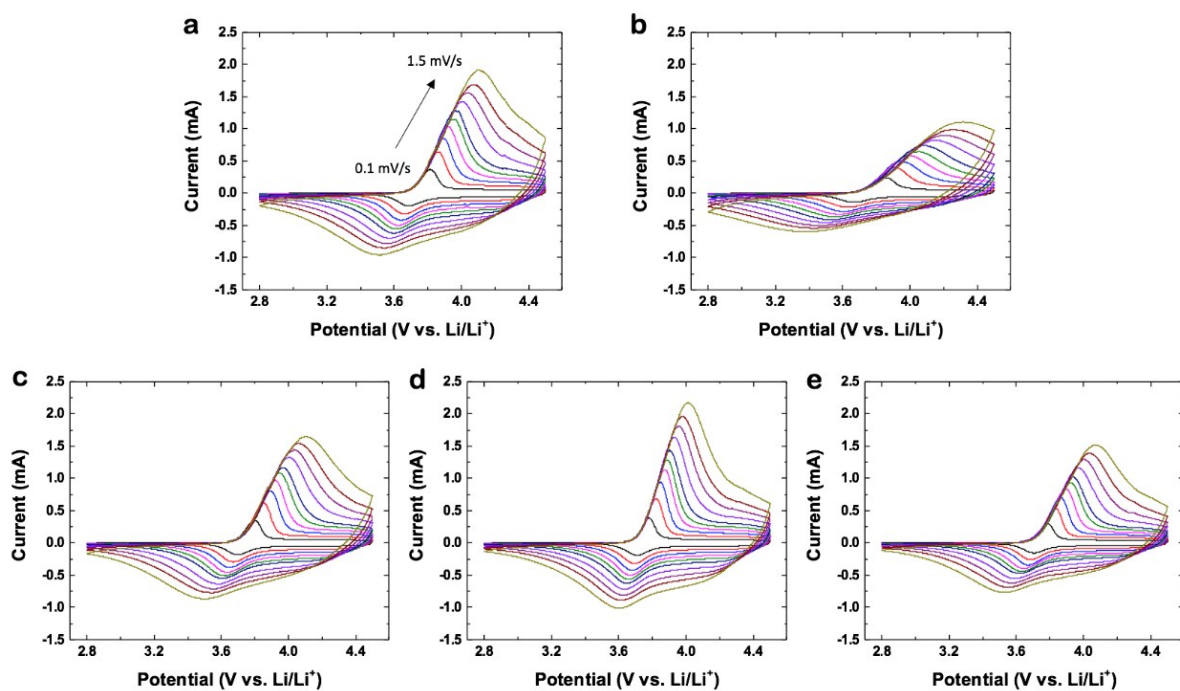


Figure S3. Cycling voltammetry profiles at various scan rates from 0.1 to 1.5 mV/s. (a) 99NCM/SW0, (b) 995NCM/SW0, (c) 995NCM/SW10, (d) 995NCM/SW12, and (e) 995NCM/SW15 electrodes.

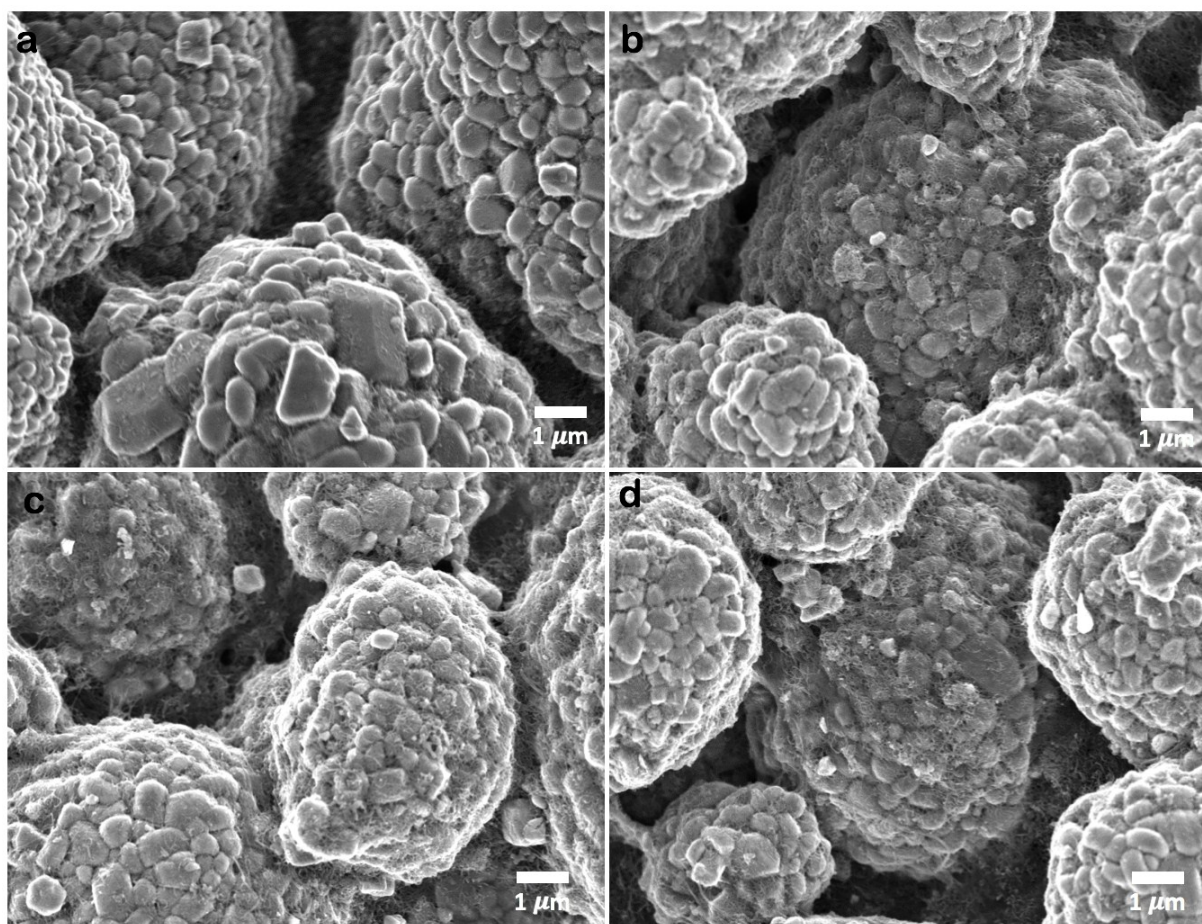


Figure S4. FE- SEM images of NCA/SW electrodes. (a) 99NCA/SW0, (b) 99NCA/SW1, (c) 99NCA/SW5, and (d) 99NCA/SW10.

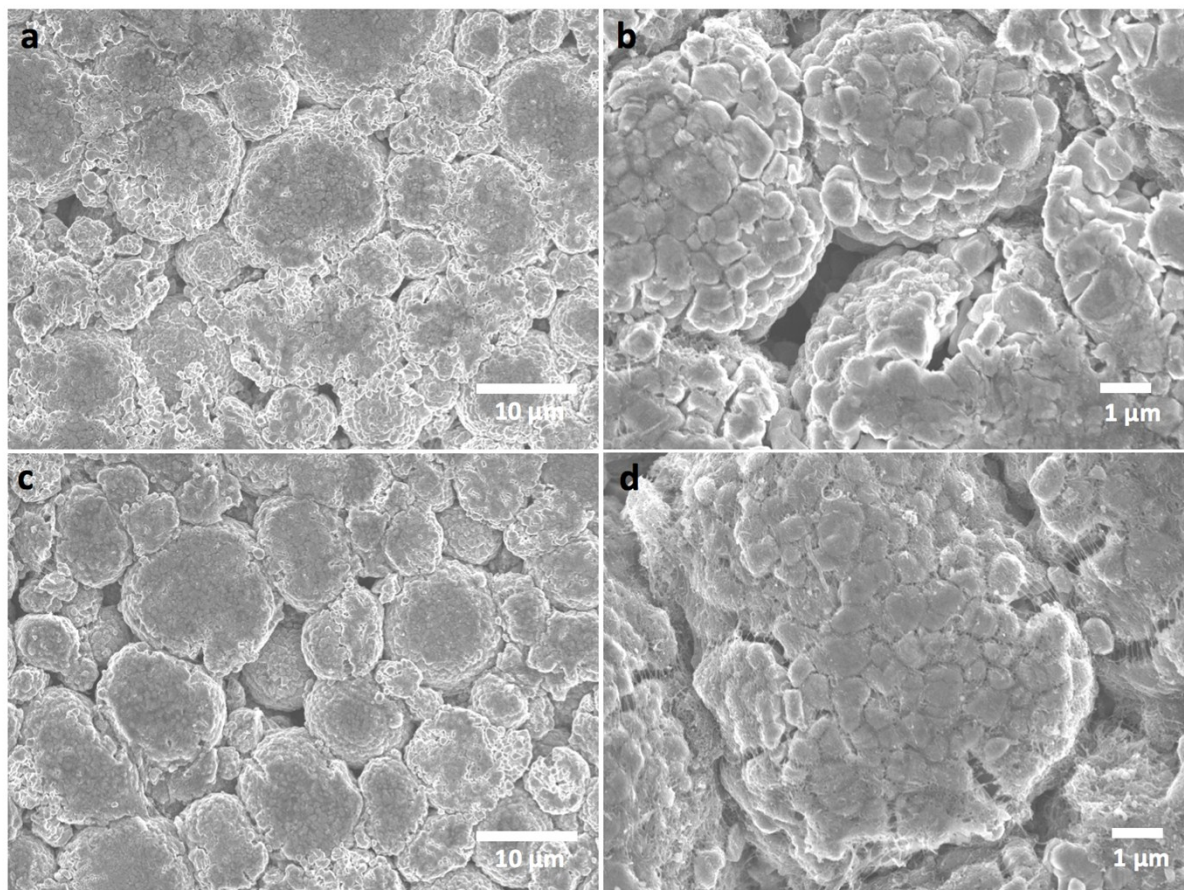


Figure S5. FE-SEM images of cycled cathode surface of (a, b) 99NCA/SW0 and (c, d) 99NCA/SW5.

Table S1. Prepared electrodes compositions.

	Electrode composition (wt%)		CNTs composition (wt%)	
	Active materials	Conductive agents	MWCNT	SWCNT
99NCM/SW0	99 (NCM)	1 (MWCNT)	100	0
995NCM/SW0	99.5 (NCM)	0.5 (MWCNT)	100	0
995NCM/SW10	99.5 (NCM)	0.5 (MWCNT+SWCNT)	90	10
995NCM/SW12	99.5 (NCM)	0.5 (MWCNT+SWCNT)	88	12
995NCM/SW15	99.5 (NCM)	0.5 (MWCNT+SWCNT)	85	15
99NCA/SW0	99 (NCA)	1 (MWCNT)	100	0
99NCA/SW1	99 (NCA)	1 (MWCNT+SWCNT)	99	1
99NCA/SW5	99 (NCA)	1 (MWCNT+SWCNT)	95	5
99NCA/SW10	99 (NCA)	1 (MWCNT+SWCNT)	90	10

Table S2. Diffusion coefficient and peak separation obtained from Figure S3.

Electrode	Peak voltage (V)			Diffusion coefficient	
	Anodic	Cathodic	Separation	Delithiation	Lithiation
99NCM/SW0	3.814	3.684	0.130	3.73×10^{-9}	9.31×10^{-10}
995NCM/SW0	3.859	3.663	0.195	1.16×10^{-9}	3.40×10^{-10}
995NCM/SW10	3.798	3.695	0.102	2.99×10^{-9}	7.55×10^{-10}
995NCM/SW12	3.779	3.710	0.069	5.21×10^{-9}	1.04×10^{-9}
995NCM/SW15	3.787	3.705	0.082	2.47×10^{-9}	5.84×10^{-10}

Table S3. Interfacial resistivity of NCM/SW electrodes.

Electrode	Interfacial resistivity ($\Omega \text{ cm}^2$)
99NCM/SW0	$9.88 \pm 0.53 \times 10^{-4}$
995NCM/SW0	$1.89 \pm 0.57 \times 10^{-2}$
995NCM/SW10	$4.83 \pm 0.33 \times 10^{-3}$
995NCM/SW12	$9.56 \pm 0.43 \times 10^{-4}$
995NCM/SW15	$5.38 \pm 0.48 \times 10^{-3}$

Table S4. Surface film (R_{sf}) and charge transfer (R_{ct}) resistances of NCM/SW electrodes.

Electrode	R_{sf} (Ω)	R_{ct} (Ω)
99NCM/SW0	4.6	3.8
995NCM/SW0	8.5	10.1
995NCM/SW10	6.8	4.4
995NCM/SW12	4.4	3.7
995NCM/SW15	7.6	4.8