Energy & Environmental Science

PAPER

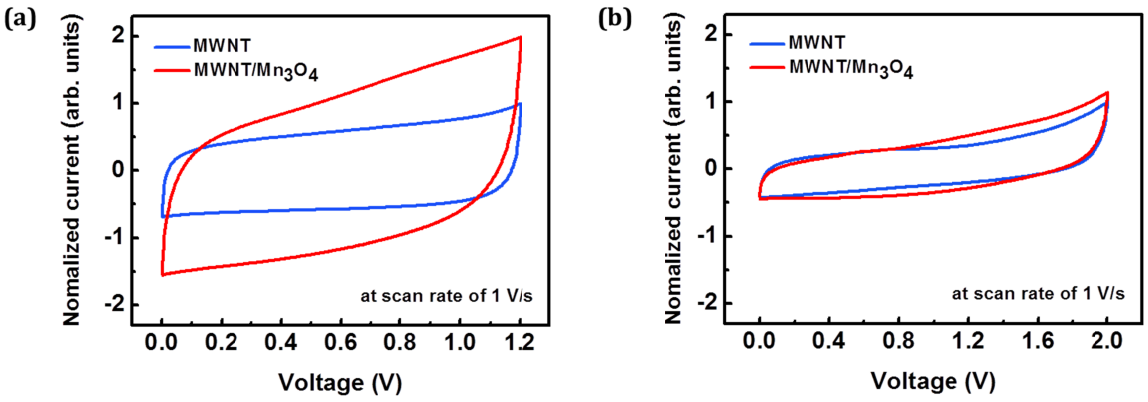

Figure S1. Cyclic voltammetry curves of MSC with (a) PMMA-PC-$LiClO_4$ gel electrolyte and (b) patterned ionogel electrolyte, respectively at a scan rate of 1V/s. The blue and red curves are for LbL-MWNTs and LbL-MWNTs/Mn_3O_4 electrodes, respectively.

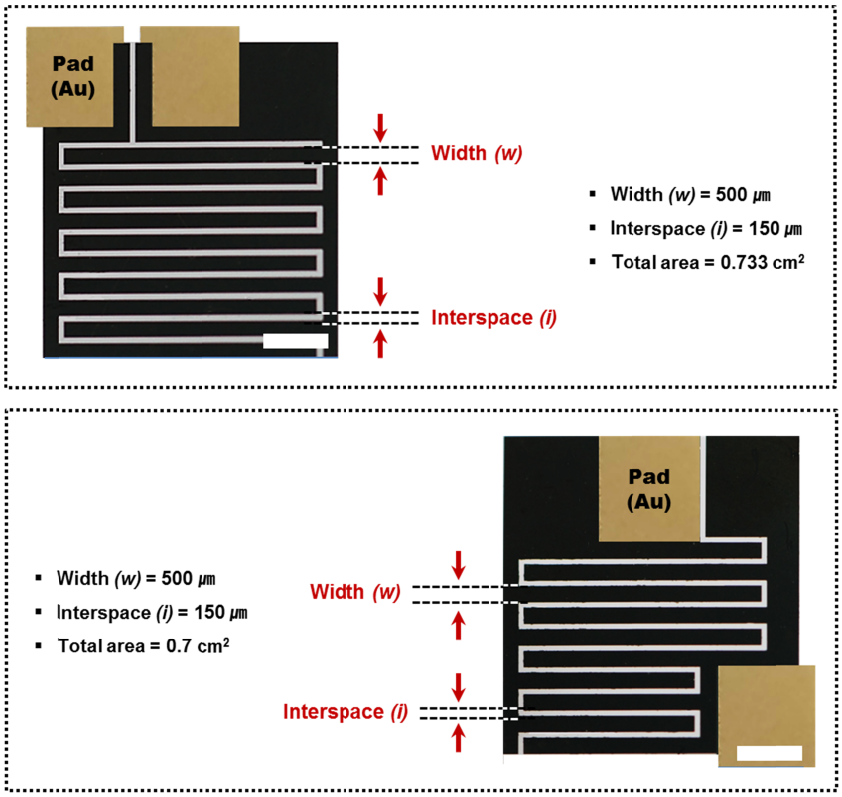

Figure S2. The dimensions of two types of interdigitated electrode, with a scale bar of 2 mm.

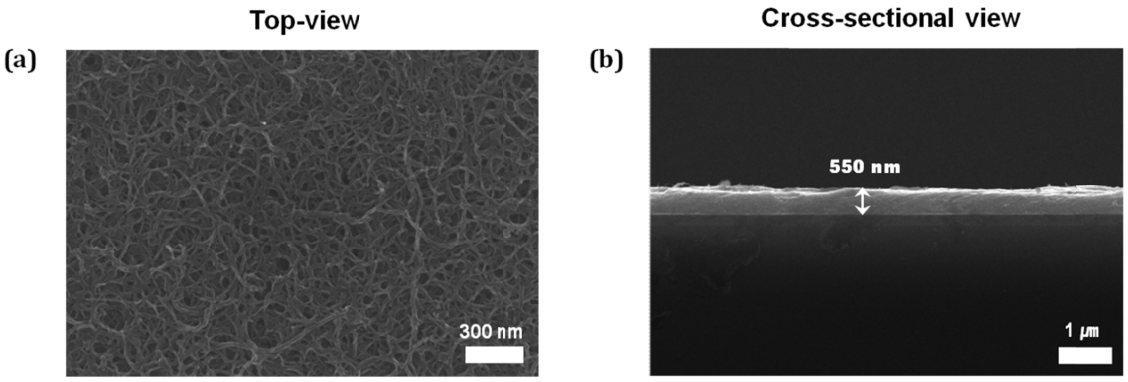

Figure S3. SEM image of the LbL-MWNTs/Mn_3O_4 multilayer film. (a) Top-view and (b) Cross-sectional view. The film thickness was measured to be approximately 550 nm.

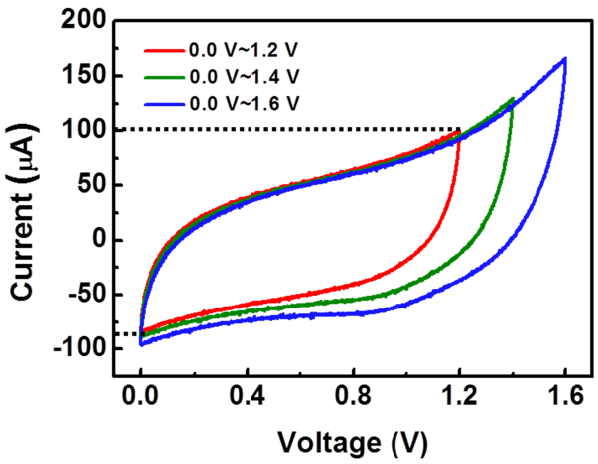

Figure S4. Cyclic voltammetry of LbL-MWNT/Mn_3O_4 MSC with various voltage ranges.

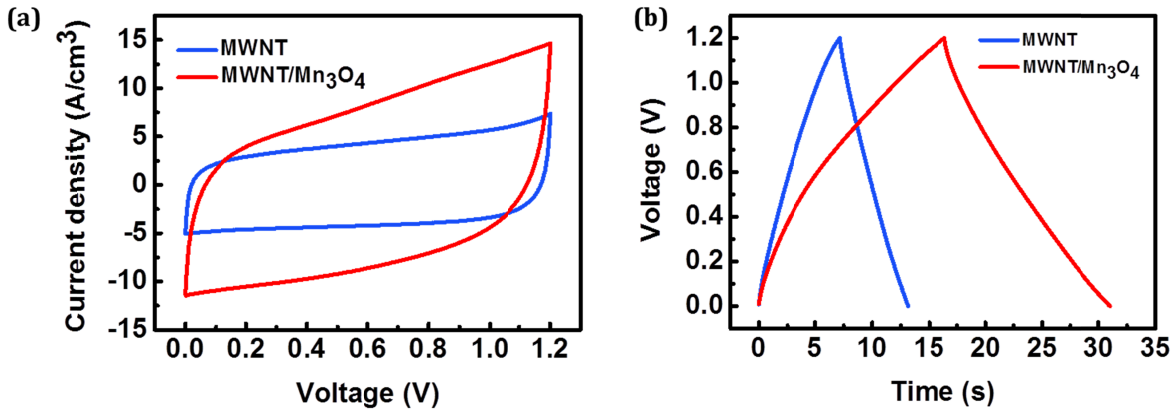

Figure S5. Electrochemical performance of LbL-MWNTs (blue) and LbL-MWNT/Mn_3O_4 (red) MSCs. (a) CV curves measured at a scan rate of 1 V/s. (b) Galvanostatic charge-discharge curves at a current density of 1.0 A/cm^3.

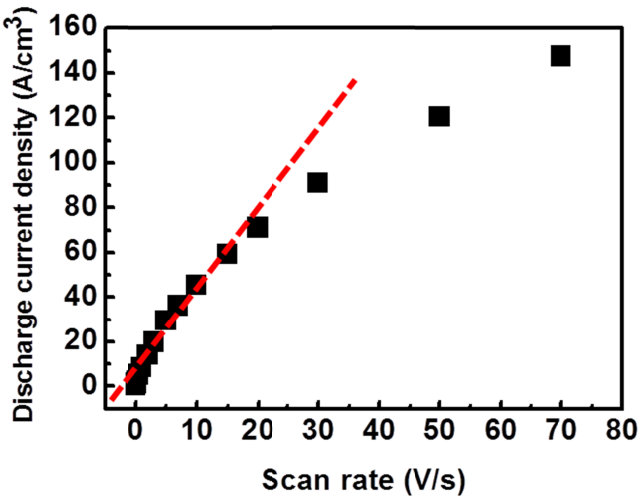

Figure S6. Linear dependence (red line) of the discharge current density on the scan rate.

	Initial	1 day	2 days	3 days	5 days	7 days	10 days	14 days
Temperature (℃)	25.0	24.9	24.5	25.0	25.4	27.2	24.8	25.4
Humidity (%)	37.7	34.0	38.7	33.6	37.2	34.5	35.4	37.0

Table S1. The temperature and relative humidity of the ambient environment for 2 weeks during the measurements.

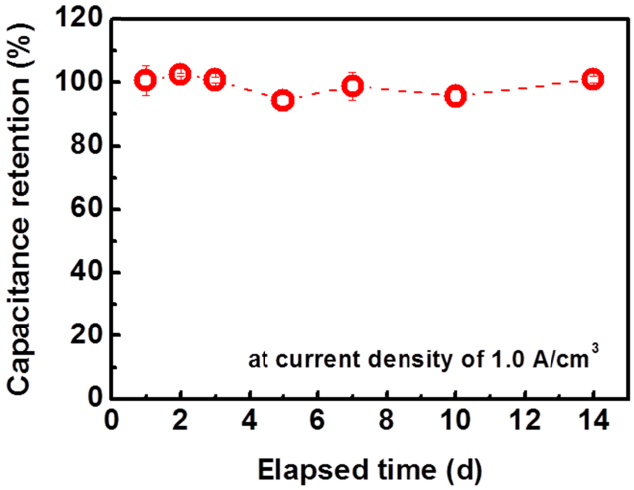

Figure S7. Capacitance retention taken from five LbL-MWNT/Mn_3O_4 MSCs with error bars. Capacitance value was evaluated by taking charge-discharge curves at a current density of 1.0 A/cm^3.

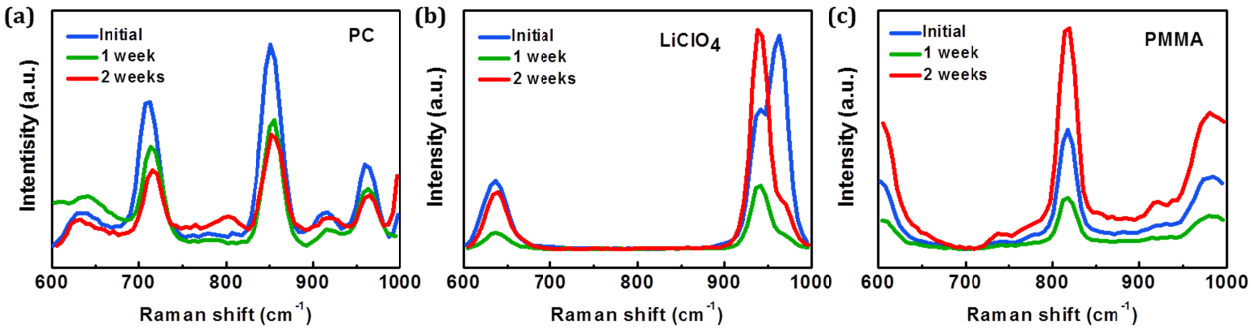

Figure S8. Raman spectra of (a) PC, (b) $LiClO_4$, and (c) PMMA in the region of 600–1000 cm^{-1} with elapsed time in ambient air.

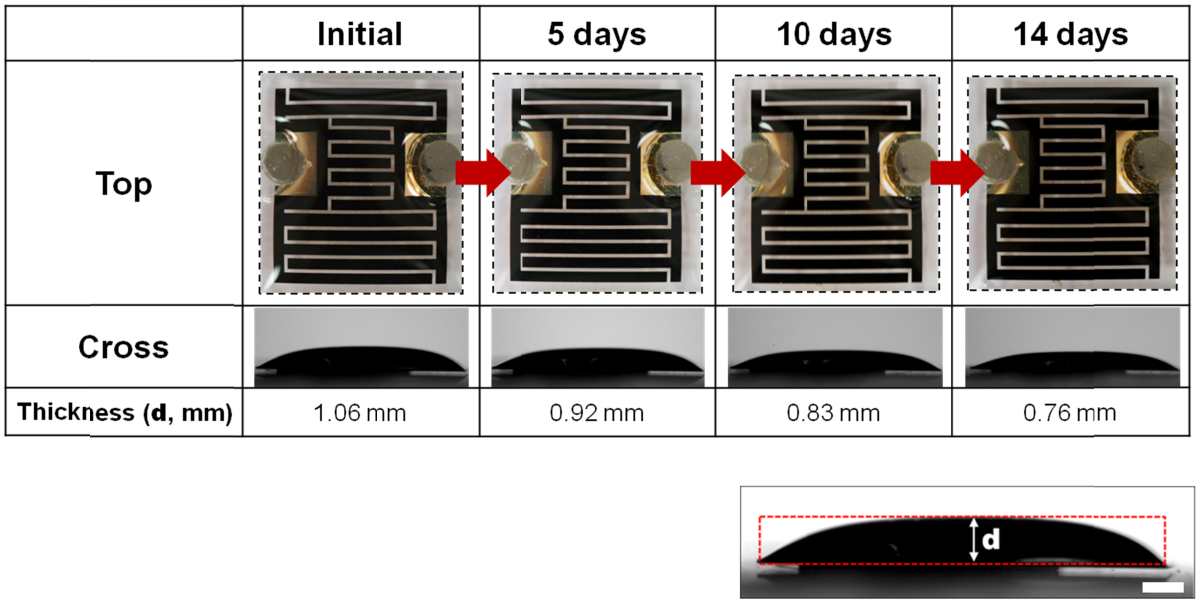

Figure S9. Optical images of PMMA-PC-$LiClO_4$ gel electrolyte drop-casted onto the LbL-MWNT/Mn_3O_4 planar MSC, which were taken with elapsed time in ambient air. The figure at the bottom shows a cross-sectional view of non-aqueous solvent based gel electrolyte, with a scale bar of 1 mm.

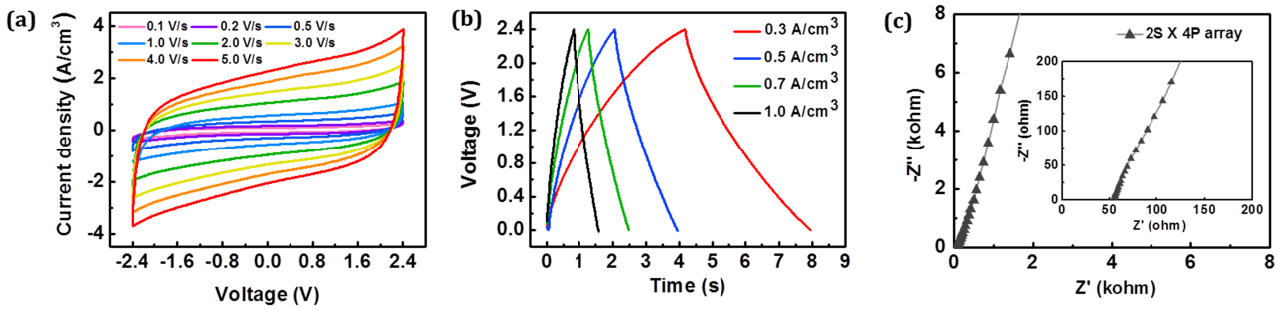

Figure S10. The electrochemical performance of a 2 × 4 MSC array integrated onto a deformable substrate. (a) CV curves obtained at various scan rates from 0.1 V/s to 5.0 V/s. (b) Galvanostatic charge-discharge curves at different current densities of 0.3 A/cm^3, 0.5 A/cm^3, 0.7 A/cm^3, and 1.0 A/cm^3. (c) Nyquist plot. The inset shows the high-frequency region in more detail. Here, the ESR was evaluated to be 53 Ω.

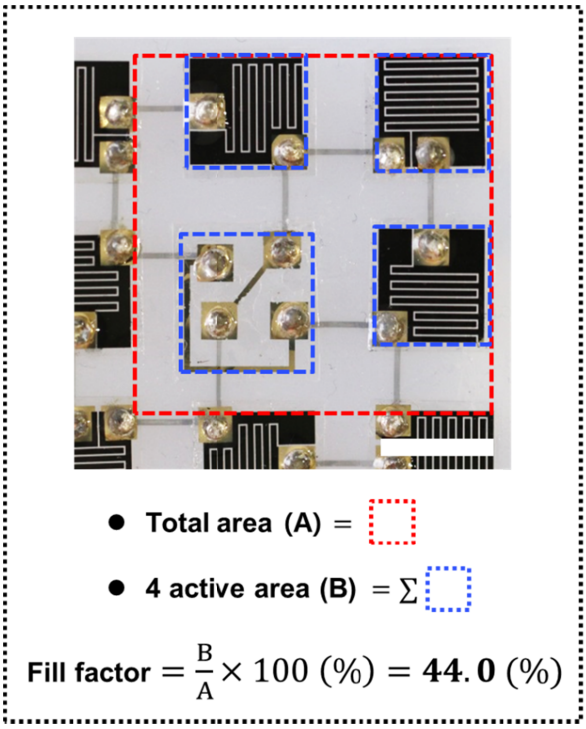

Figure S11. Definition and estimation of the fill factor for MSCs array integrated onto stretchable substrate, with a scale bar of 1 cm.

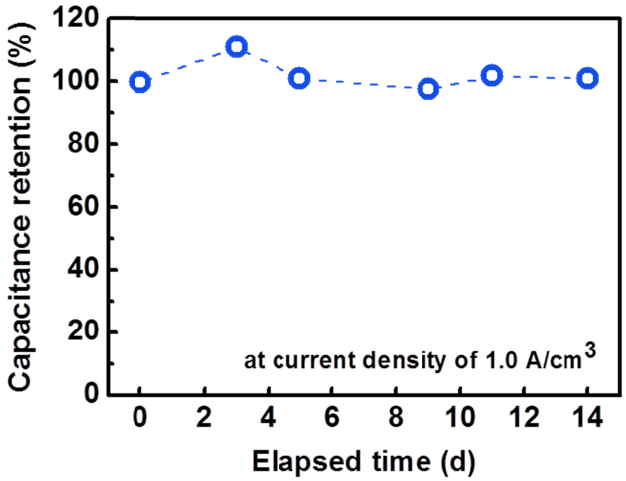

Figure S12. Capacitance retention of the encapsulated MSC with Ecoflex film over elapsed time in ambient air measured by charge-discharge curve at a current density of 1.0 A/cm^3.

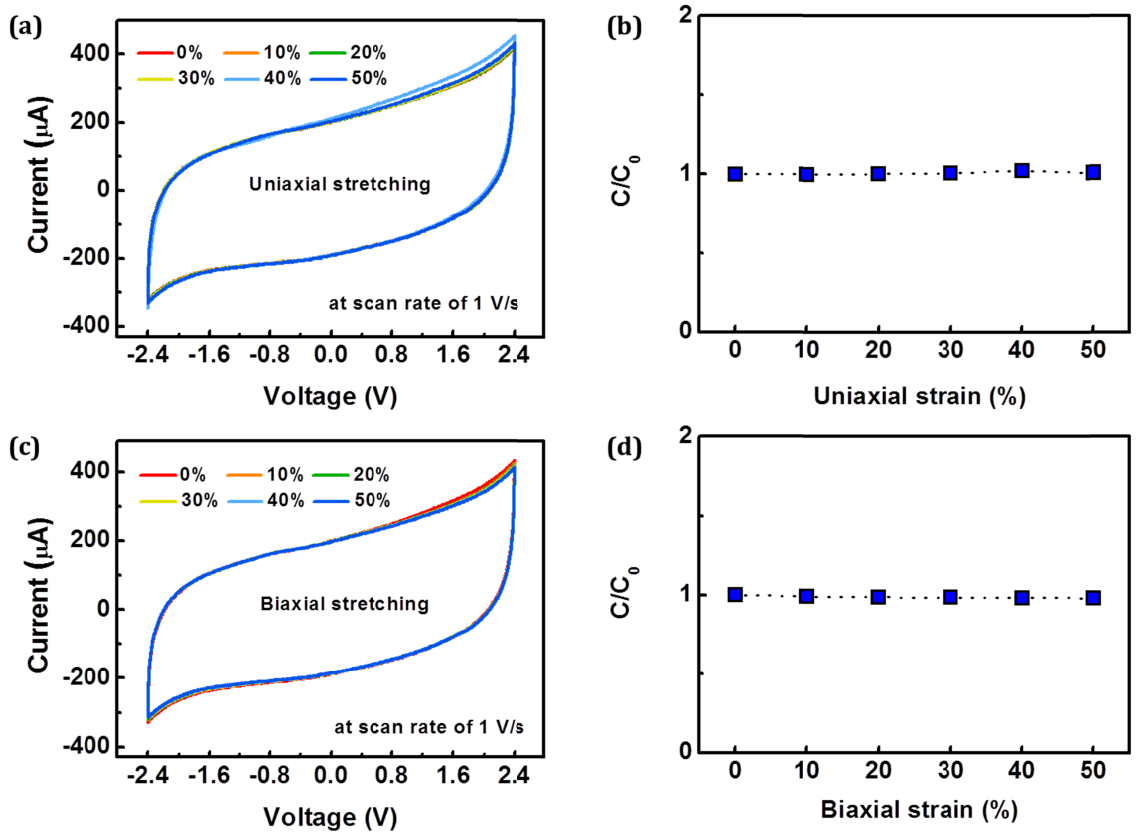

Figure S13. The electrochemical performance of the MSC array upon uniaxial and biaxial stretching. (a) CV curves obtained at a scan rate of 1 V/s under uniaxial stretching of up to 50%. (b) Normalized capacitance (C/C_0) with uniaxial strain from 0 to 50%. (c) CV curves obtained at a scan rate of 1 V/s under biaxial strain of up to 50%. (d) Normalized capacitance (C/C_0) with biaxial strain from 0 to 50%. Here, C_0 and C are the capacitance before and after stretching, respectively.

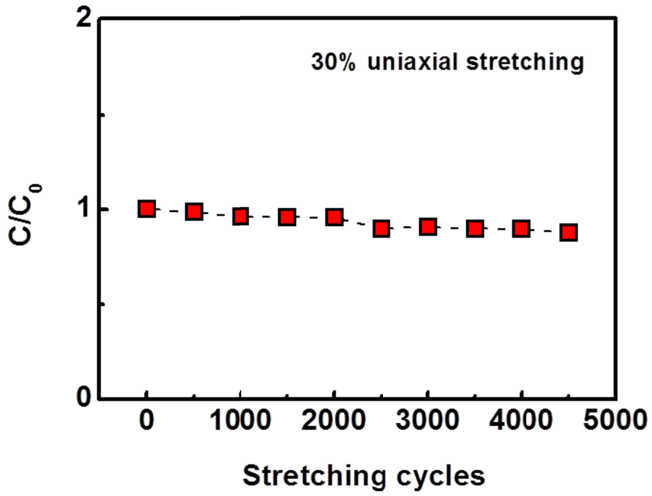

Figure S14. Normalized capacitance (C/C_0) with repeated cycles of uniaxial stretching by 30%. Here, C_0 and C are the capacitance before and after stretching, respectively.