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Supporting Information

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A Multi-Scale Structural Engineering Strategy for High-Performance MXene Hydrogel Supercapacitor Electrode

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Supplementary Materials for

A Multi-Scale Structural Engineering Strategy for High-Performance MXene Hydrogel Supercapacitor Electrode

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Calculation formula of Specific capacitance ($C_{specific}$)Areal capacitance (C_{areal}), Energy density (E), and Power density (P)

$C_{specific} = (\int IdV)/(s\Delta Vm)$ (F g^{-1}) (3-electrode configuration); (1)

$C_{areal,CV} = (\int IdV)/(s\Delta VA)$ (F cm^{-2}) (2-electrode configuration); (2)

$C_{areal,GCD} = (i\Delta t)/(A\Delta V)$ (F cm^{-2}); (3)

$\mathrm{E} = C_{areal,GCD}\Delta V^2/7.2$ (mWh cm^{-2}); (4)

$\mathrm{P} = 3.6\mathrm{E}/\Delta t$ (mW cm^{-3}). (5)

Where m is the solid content of MXene hydrogel electrode, I is current, s is the scan rate, ΔV is the potential window, A is the area of MSC electrodes, i is the applied current, and Δt is the discharge time.

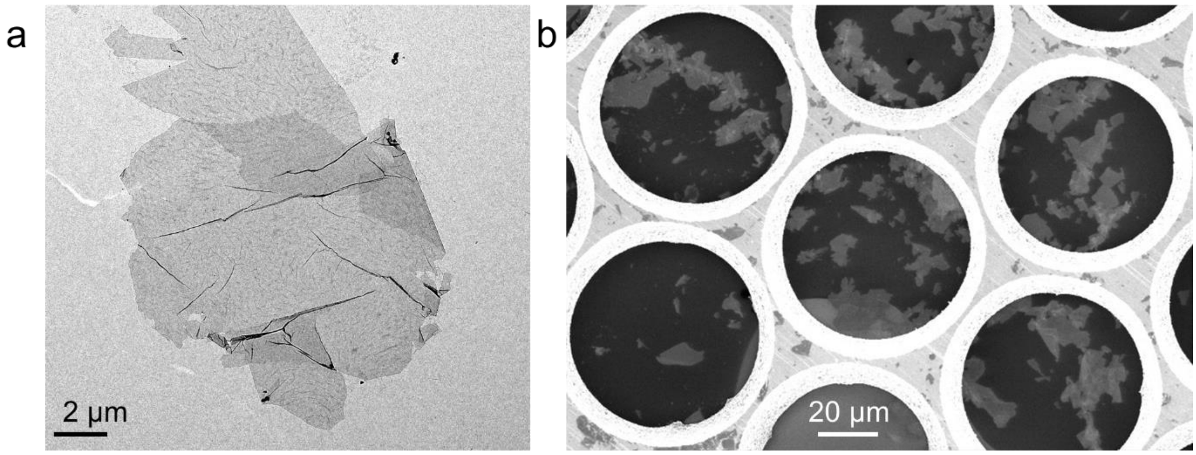

Figure S1. (a) The TEM and (b) SEM image of large MXene flakes for statistical purposes.

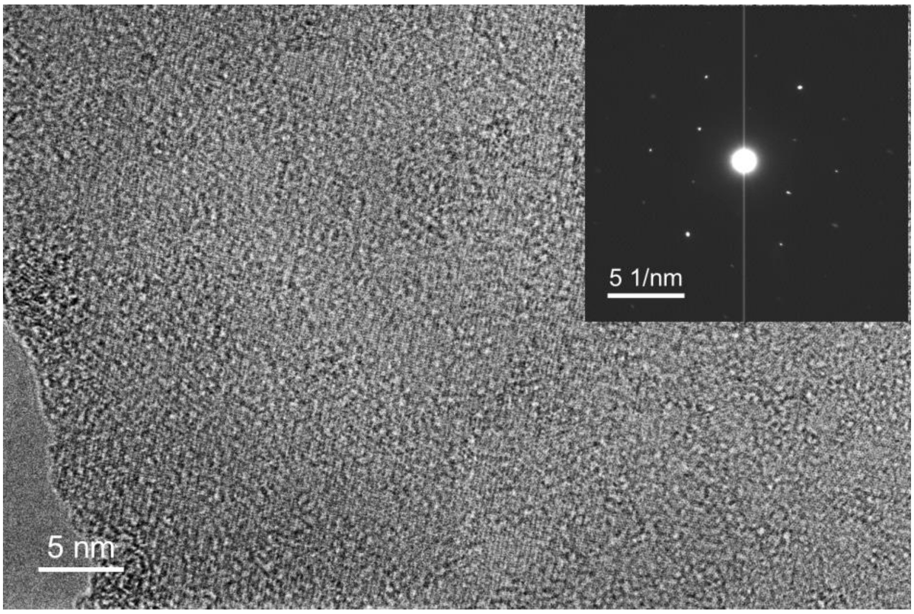

Figure S2. The HRTEM and (inset) SAED image of MXene flakes.

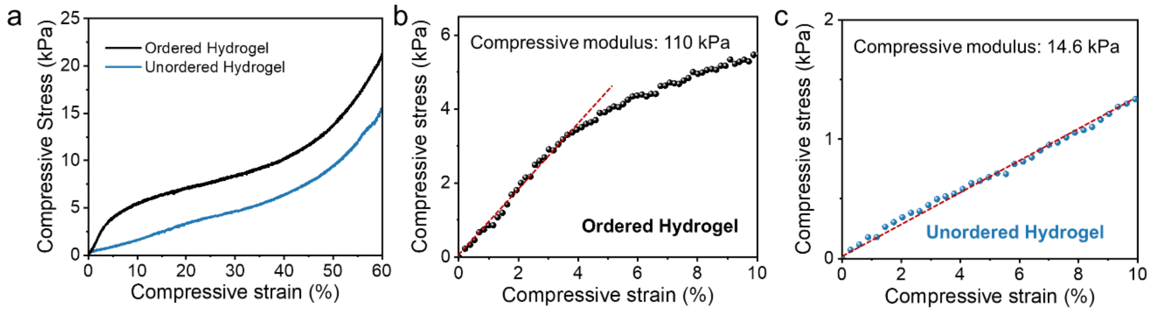

Figure S3. (a) The compressive stress-strain curves and compressive modulus of (b) ordered and (c) unordered MXene hydrogel.

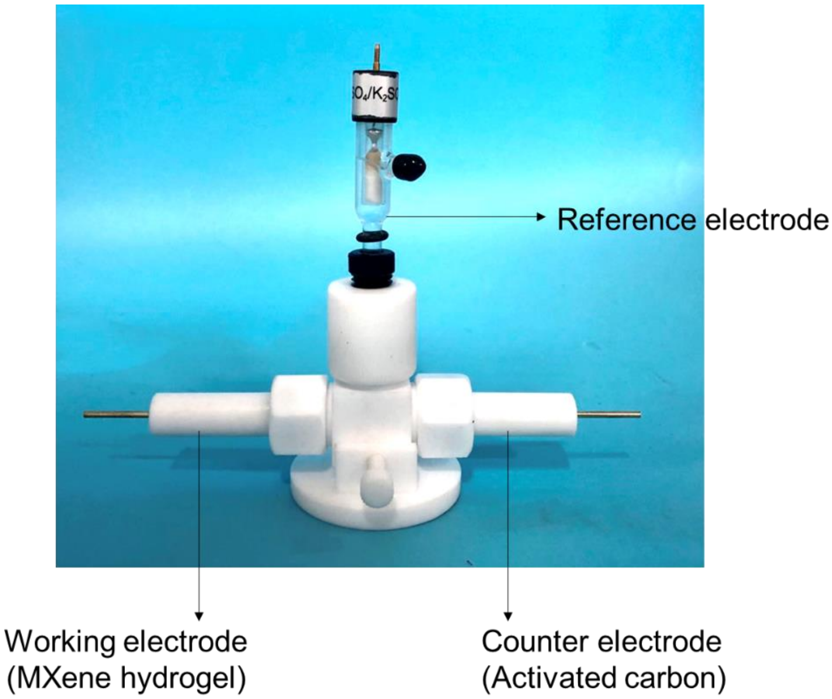

Figure S4. Swagelok-type cell with three-electrode setup.

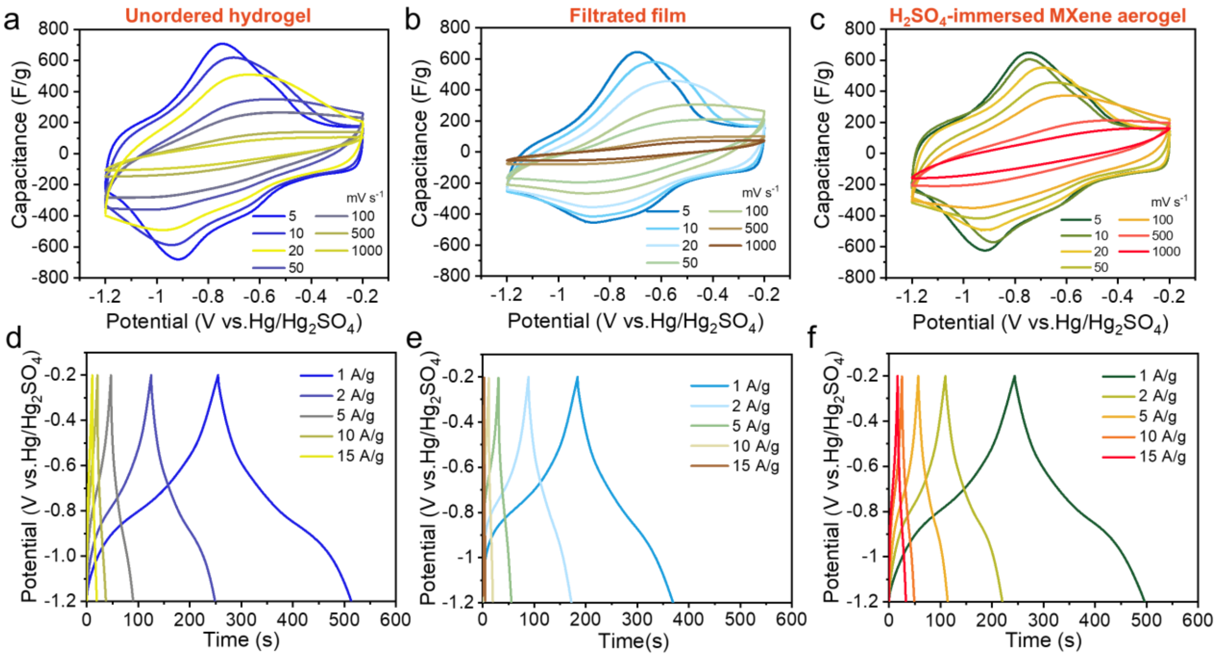

Figure S5. (a, b, and c) CV curves and (d, e, and f) GCD profiles of unordered hydorgel, filtrated film, and H_2SO_4-immersed MXene aerogel, respectively.

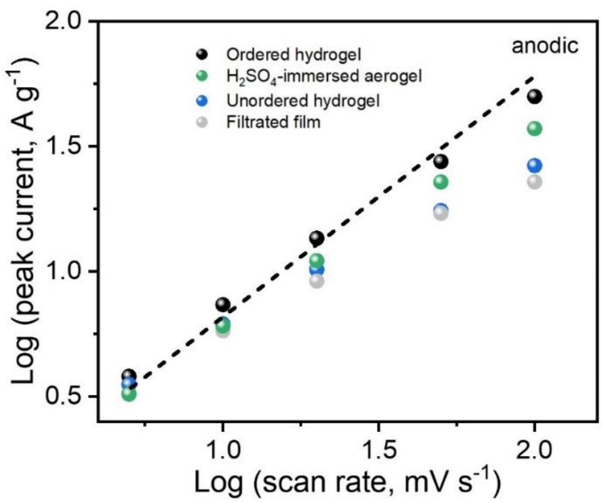

Figure S6. Plot of the anodic peak current against the scan rate for the four MXene samples.

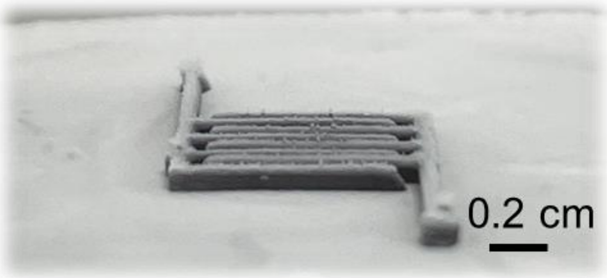

Figure S7. Unidirectional-freezing MXene MSC.

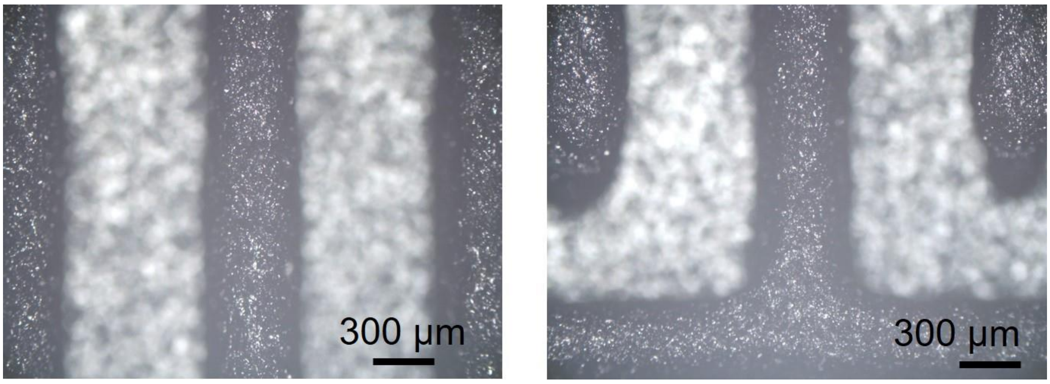

Figure S8. The optical microscope photographs of 3D-printed MXene MSC.

Table S1. The comparison of MXene-based MSCs electrochemical performance.

Materials	Methods	Electrolyte	Areal capacitance ($mF\ cm^{-2}$)	Rate performance ($mF\ cm^{-2}$)	Energy density ($\mu Wh\ cm^{-2}$)	Power density ($mW\ cm^{-2}$)	Ref.
$Ti_3C_2T_x$	3D-printing	PVA/H_2SO_4	1035 ($2\ mV\ s^{-1}$)	4.68 ($500\ mV\ s^{-1}$)	51.7	5.7	[1]
$Ti_3C_2T_x$	3D-printing	PVA/H_2SO_4	2100 (1.7 mA cm-2)	1000 ($42.7\ mA\ cm^{-2}$)	24.4	0.64	[2]
MXene-AgNW-MnONW-C60	3D-printing	PVA/KOH	216.2 ($10\ mV\ s^{-1}$)	72.8 ($2000\ mV\ s^{-1}$)	19.2	58.3	[3]
MXene sediment	Screen-printing	PVA/H_2SO_4	158 ($0.08\ mA\ cm^{-2}$)	127 ($2.4\ mA\ cm^{-2}$)	1.64	0.778	[4]
$Ti_3C_2T_x$	Laser-scribing	PVA/H_2SO_4	25 ($20\ mV\ s^{-1}$)	10 ($1000\ mV\ s^{-1}$)	0.77	46.6	[5]
$Ti_3C_2T_x$	Stamping	PVA/H_2SO_4	61 ($0.025\ mA\ cm^{-2}$)	50 ($0.8\ mA\ cm^{-2}$)	0.63	0.33	[6]
$Ti_3C_2T_x$	Extrusion-printing	PVA/H_2SO_4	43 ($0.005\ mA\ cm^{-2}$)	33 ($0.05\ mA\ cm^{-2}$)	0.32	0.0114	[7]
$Ti_3C_2T_x/RuO_2$	Laser-engraving	$1\ M\ H_2SO_4$	60 ($5\ mV\ s^{-1}$)	50 ($20\ mV\ s^{-1}$)	19	1.5	[8]
$Ti_3C_2T_x/Be^{2+}$	Template-depositing	$ZnSO_4$/Gelatine	77.2 ($5\ mV\ s^{-1}$)	31 ($100\ mV\ s^{-1}$)	3.86	0.12	[9]
$Ti_3C_2T_x$/CNF	Template-depositing	PVA/H_2SO_4	25.3 ($2\ mV\ s^{-1}$)	13 ($200\ mV\ s^{-1}$)	0.08	0.145	[10]
$Ti_3C_2T_x$/CNT	Extrusion-printing	PVA/H_3PO_4	30.8 ($0.025\ mA\ cm^{-2}$)	20 ($0.4\ mA\ cm^{-2}$)	8.37	17.3	[11]
$Ti_3C_2T_x$	**3D-printing and UFAT method**	**PVA/H_2SO_4**	**2004 ($1.2\ mA\ cm^{-2}$)**	**1202 ($60\ mA\ cm^{-2}$)**	**100**	**0.38**	**This work**

Movie S1. 3D printing all-MXene MSC.

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