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

Silk fabric derived transparent carbon fiber net for capacitive touch pads and all solid supercapacitor

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Experimental methods

Chemicals

Manganese acetate ($Mn(ac)_2$, AR), Sodium sulfate (Na_2SO_4), Pristine silk fabric (Taobao Co. Ltd.), Commercial electroplating solution (Au, Ni, and Cu, Yun cai tao tao on Taobao Co. Ltd.), Sodium Perchlorate ($NaClO_4$, AR), PVA (1750w, AR).

Characterization

X-ray diffraction (XRD) patterns were collected on Bruker D8 Advance Powder X-ray diffractometer using Cu Kα radiation. The scanning electron microscopy (SEM) was performed by using a field emission scanning electron microscopy (FESEM, HITACHI, S-4800). Transmission electron microscopy (TEM), high-resolution transmission electron microscopy, and energy dispersive X-ray spectroscopy technique were taken on a JEM-2100 electron microscope operated at 200 kV.

Fabrication of TSF

Commercial available silk fabrics were utilized as raw materials. The fabrics were carbonized under an argon (95%) and hydrogen (5%) mixed atmosphere in a tube furnace at 900 ^oC for 240 min at a rate of 2 $^oC\ min^{-1}$.

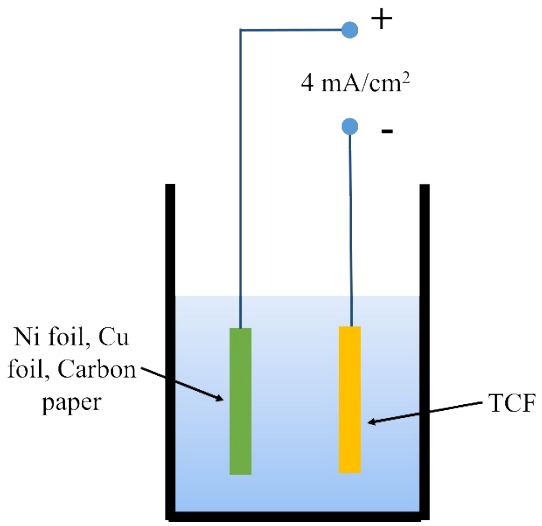
Fabrication of touch pad

The obtained CSF were cut into rectangular strips and then was pasted on the glass (used PVA as paste). The laser with wavelength of 808 nm was used to fabricate the electrode at a power of 5 W. All samples were prepared under room temperature and ambient air. CSF was patterned into 12-14 interdigitated electrodes with a length of 1 cm, a width of 1.2 mm, and a spacing of ≈ 150 μm between two neighboring microelectrodes. The as-prepared electrode was connected to copper wires at both of the two ends with silver paste. Afterward, then liquid PDMS was dropped on the surface to fix and encapsulate the device. Finally, the samples were cured at 80 ^oC for 12 h.

Electroplated Ni, Cu, and Au on the surface of electrode

The as-prepared electrode was electrodeposited with the current of ~4 mA cm^{-2} in a commercial electroplating solution for 25 min at room temperature, used Ni foil, Cu foil, and carbon paper (for Au coating) as counter electrode, as shown in following

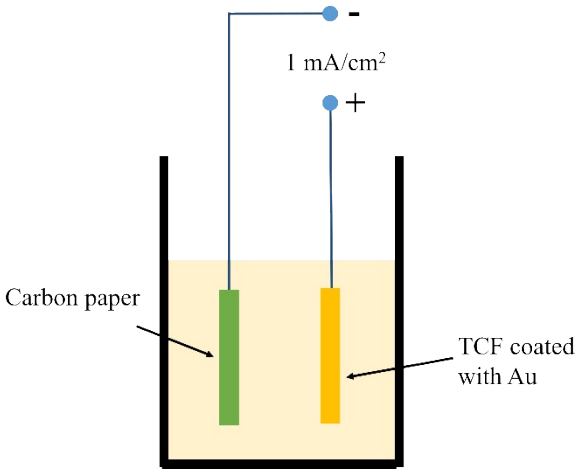
Figure. After electroplating, the as-prepared sample was washed with deionized water and ethanol for 3 times and then dried at 70 °C for 1 h.



Ni, Cu, and Au plating into the TCF template

Electrodeposited MnO_2 on the surface of Au coated electrode

An aqueous solution of 0.5 M $Mn(CH_3COO)_2$ and 0.5 M Na_2SO_4 was prepared. About 10 wt% ethanol was added to improve the wetting. The as-prepared electrode was electrodeposited with the current of ~1 mA cm^{-2} for 10-30 min and a carbon paper counter electrode at room temperature. Finally, the as-prepared sample was washed with deionized water for 3 times and then dried at 70 °C for 2 h.



Electrodeposition of nickel MnO_2

Fabrication of all solid supercapacitor

The $NaClO_4$/PVA gel electrolyte was prepared by mixing PVA powder with water (1 g of PVA/10 mL of H_2O) and $NaClO_4$ (0.56 g) at 80 °C for 2h. After that, the electrolyte

was applied to the active area of the devices, and was dried under ambient conditions for 4 h-8h before testing.

Electrochemical Characterization of the all solid supercapacitor

The electrochemical performances of the all solid supercapacitor were characterized by CV and galvanostatic charge-discharge experiments using an electrochemical station (CHI 660D). The areal specific capacitance (CA) materials were calculated from galvanostatic charge–discharge curves according to Equations (1) and (2) , respectively:

$$C_A = \frac{1}{Av\Delta V}\int_{V_o}^{V} IV dV$$

where A is the areal (cm^2) of the active material, v is the potential scan rate ($V\ s^{-1}$), I is the response current (A), and ΔV is the potential window (V)

$$C_A = \frac{I\Delta t}{A\Delta V}$$

where Δt is the discharge time (s), I is the discharge current (A), ΔV is the potential window (V), and A is the areal (cm^2) of the active material.

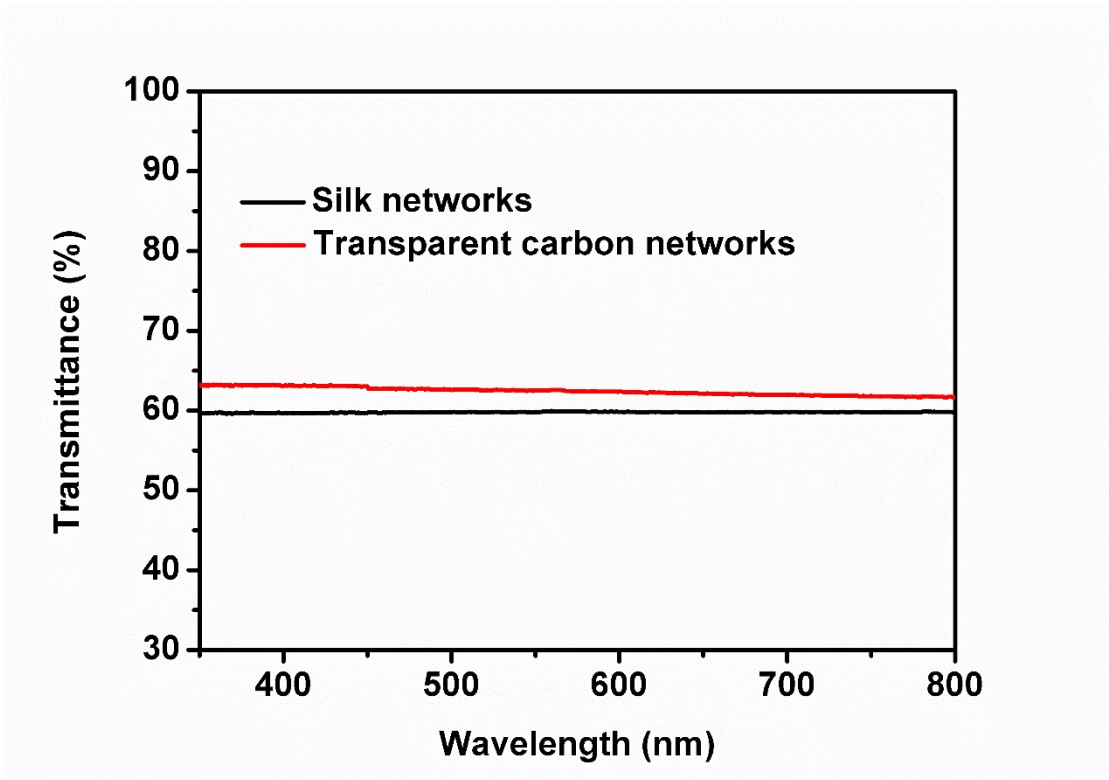


Fig. S1. Transmittance spectra of the pristine silk fabric networks, the transparent carbon fiber networks.

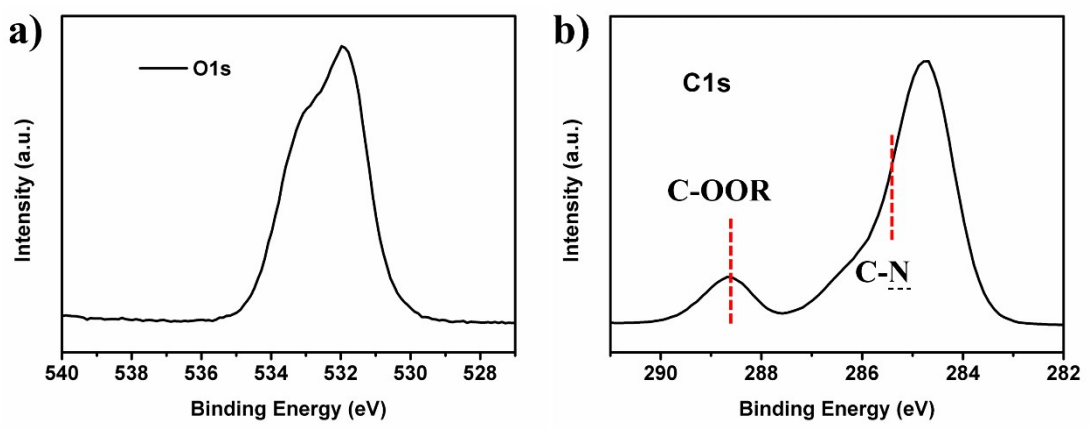


Fig. S2. High resolution spectrum of (a) O1s and (b) C1s XPS peak of the carbonized silk fabric

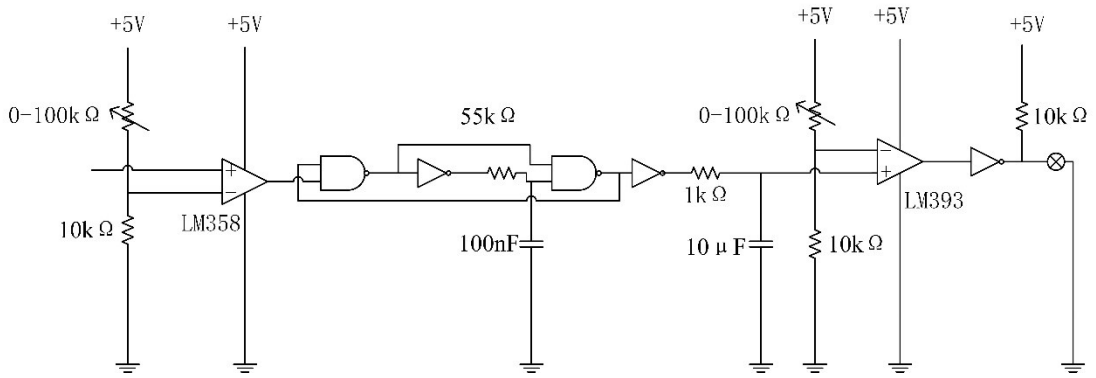


Fig. S3. Schematic of monostable circuits.

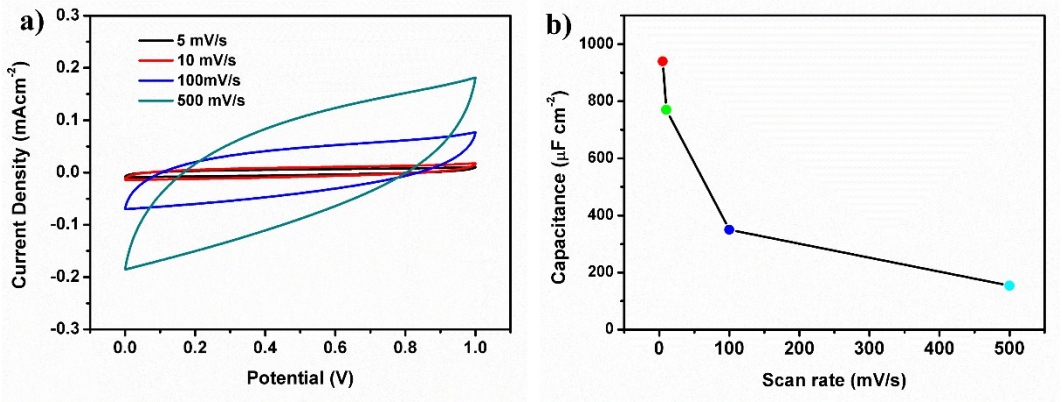


Fig. S4. (a) CV of TCF measured with5–500 mV s^{-1} scan rates; (b) the specific capacitances of the supercapacitor at various scan rates.

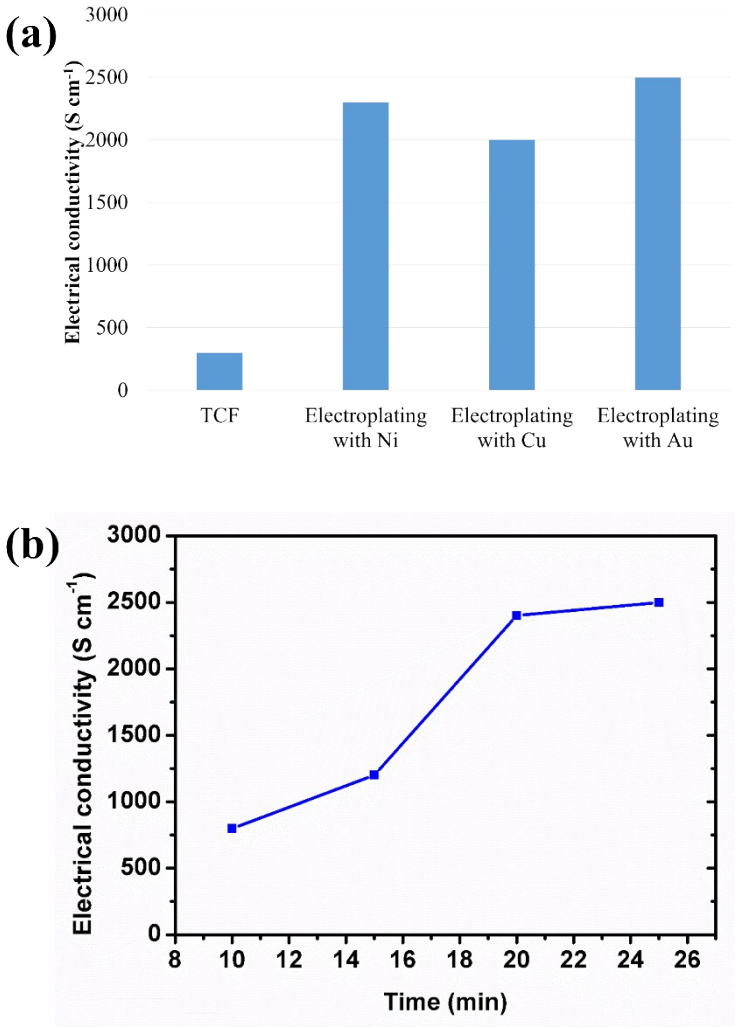


Fig. S5. (a) The conductivity of TCF electroplated with Ni, Cu, and Au; (b) The conductivity of TCF-Au with different electroplated time.

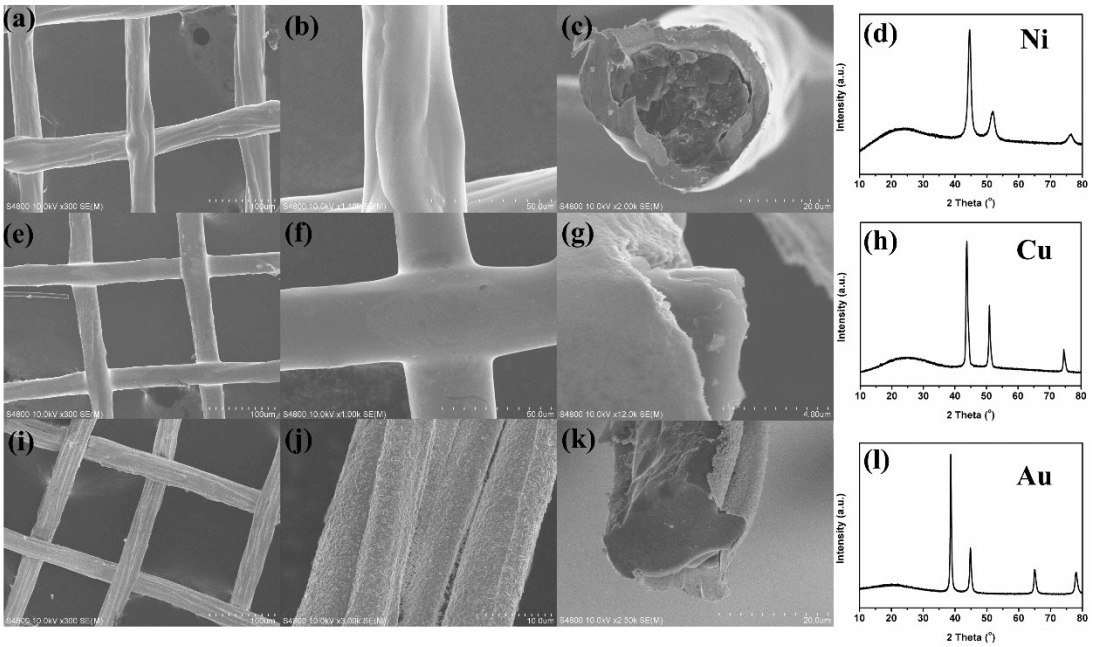


Fig. S6. SEM images and XRD patterns of TCS electroplated with (a-d) Ni, (e-h) Cu, and (i-k) Au.

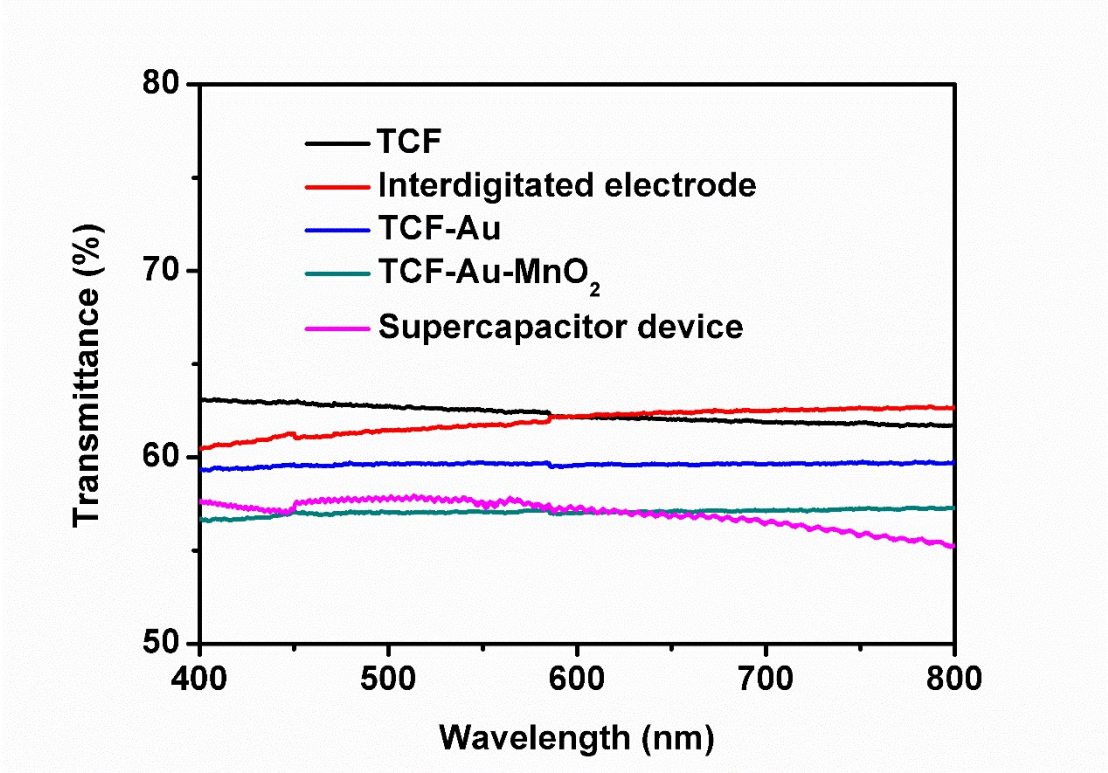


Fig. S7. Transmittance spectra of the as-prepared samples.

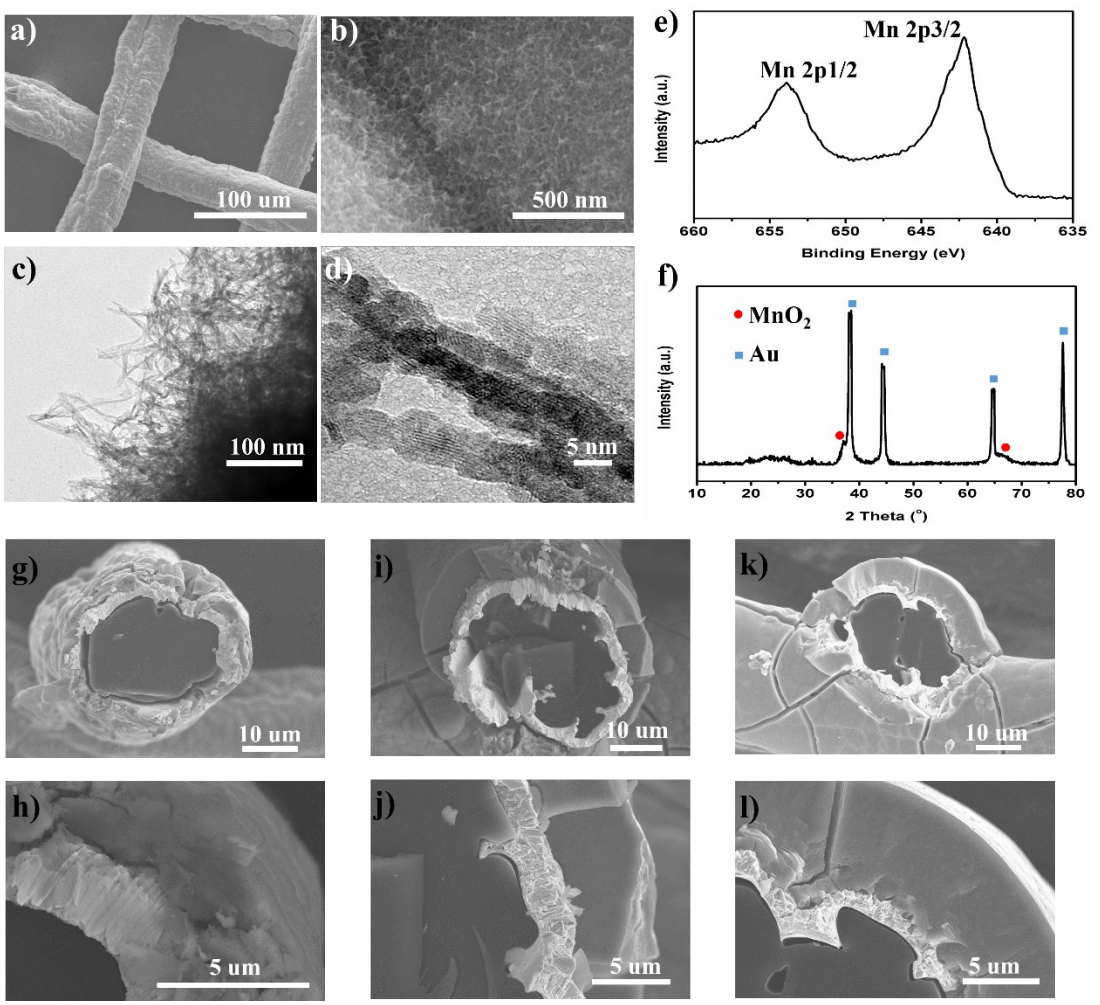


Fig. S8. (a and b) SEM images of MnO_2-10; (c and d) TEM images of MnO_2; (e) XPS of Mn2P; (f) XRD patterns of electrode; SEM images of MnO_2-10 (g and h), MnO_2-20 (i and j), MnO_2-30 (k and l).

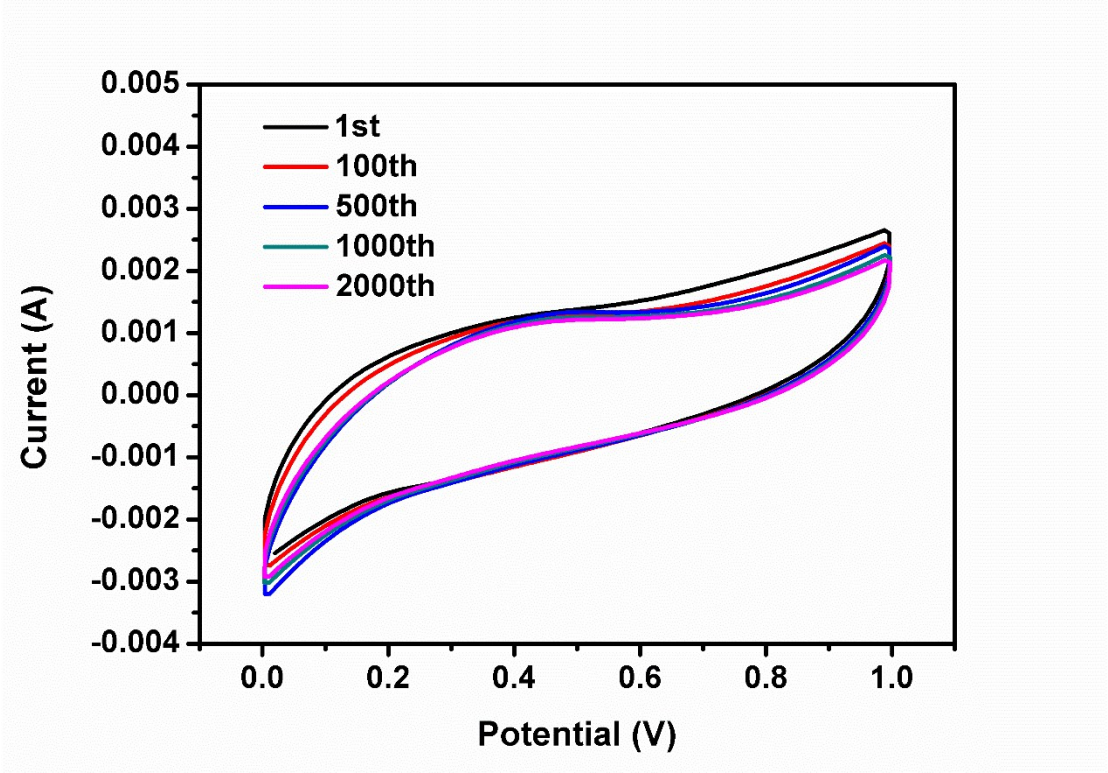


Fig. S9 Cycling stability of transparent supercapacitor (MnO_2-20) at a scan of 500 mV s^{-1}.