Electronic Supplementary Material (ESI) for Nanoscale.

$Li_4Ti_5O_{12}$ nanowire array based fiber-shaped Li-ion capacitors with superior static/dynamic cycling stabilities

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Supplementary Information:

A. The optimizing method to balance the charges on anode and cathode in the asymmetric LIC.

B. The method to calculate the volume of single electrode and fiber-shaped LICs.

Figure S1. Optical photos of the pristine Ti (down) and LTO-NWA@Ti (up) wires

Figure S2. CV curves of the wire electrodes under different potential windows

Figure S3. CV curves of the wire electrodes under different scan rates

Figure S4. Cyclic voltammetry of LTO electrodes at (a) 5 mV s^{-1}, (b) 10 mV s^{-1}, (c) 20 mV s^{-1}, (d)50 mV s^{-1}, (e)100 mV $s^{-1}$and (f) 200 mV s^{-1}, and the shadowed areas

represent the diffusion-controlle and capacitive contribution.

Figure S5. Specific capacitance of the wire electrodes under different currents

Figure S6. CV curves of the devices under different window voltages

Figure S7. Voltammetric responses at 20 mV s^{-1} and 50 mV s^{-1}. Solid line represents total current from experiment, diffusion controlled current (red shaded region), and capacitive current (green shaded region) are derived.

Figure S8. Comparison of CV and GCD curves of $Li_4Ti_5O_{12}$ NWs@Ti wire electrodes annealed in Ar and H_2/Ar.

Figure S9. Comparative CVs of Cathode AC@Ti and Anode H-LTO at scan rate of 20 mV s^{-1}.

Figure S10. Optical photograph of the LIC's diameter measure with a vernier caliper.

A. The optimizing method to balance the charges on anode and cathode in the asymmetric LIC.

The optimizing method to balance the charges on anode and cathode in the asymmetric LIC is though calculate charge (Q) obtained from CV curves (Figure S9)

$$Q = \frac{1}{2v}\oint I(V)\mathrm{d}V\,, \qquad (1)$$

where v is the scan rate with unit of voltage per second (V s^{-1}), I (V) is the current response as the function of applied voltage (V) with unit of Ampere (A).

Using Equation (1), the charges of Cathode AC@Ti (Q1) and Anode LTO (Q2) were calculated, respectively.

When the Q1= Q2 or almost the same, the balance of cathode and anode finished and this two samples could assemblied together as a LIC.

B. The method to calculate the volume of single electrode and fiber-shaped LICs.

In the single electrode test, the diameter (d) is 100 μm measured from the SEM image of the LTO@Ti wire (Figure 2(a)). The volume of single wire was calculated from the equation below:

$$V = \pi \times (\frac{d}{2})^2 \times L \quad (2)$$

where π is the Pi, L is the length of wire and L= 5 cm.

Using Equation (2), the volume of single electrode was calculated as 3.925×10^{-4} cm^3.

In the LIC's volume calculation, the diameter is about 1 mm which is measured by vernier caliper (Figure S10) and the length is 1 cm. Using Equation (2), the volume of LIC was 7.85×10^{-3} cm^3.

Figure S1. Optical photos of the pristine Ti (down) and LTO-NWA@Ti (up) wires.

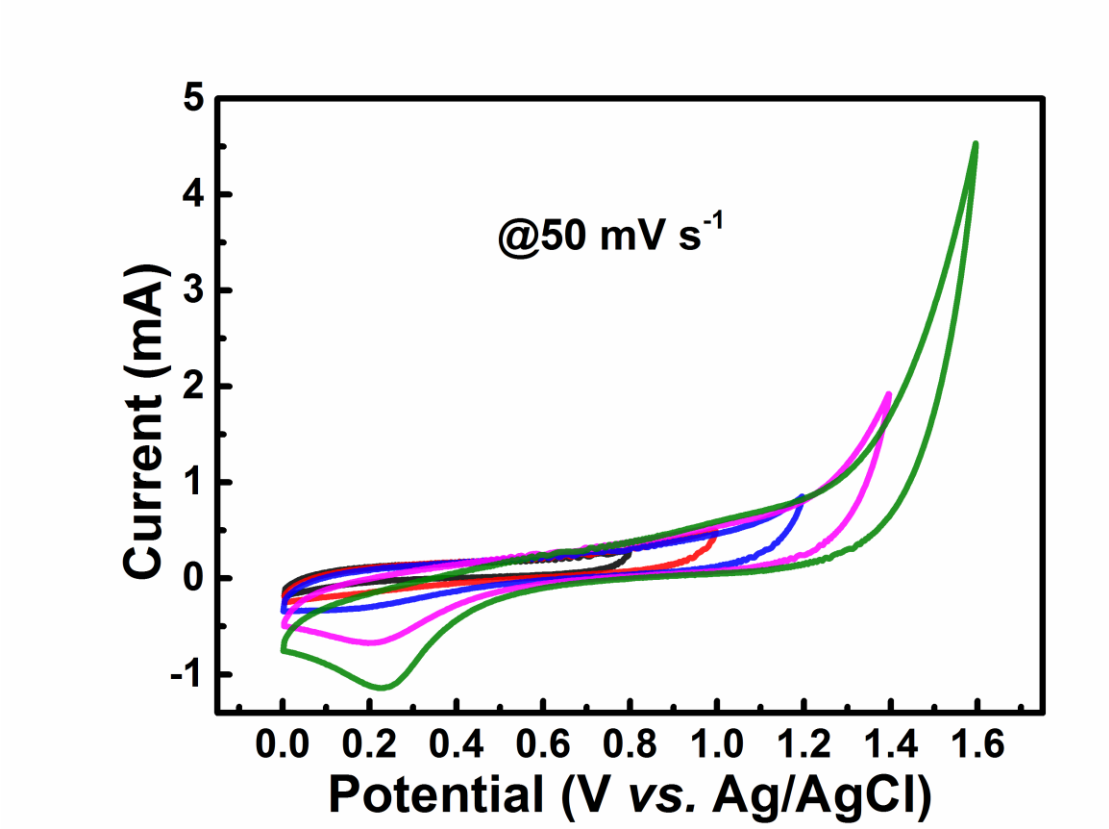

Figure S2. CV curves of the wire electrodes under different potential windows.

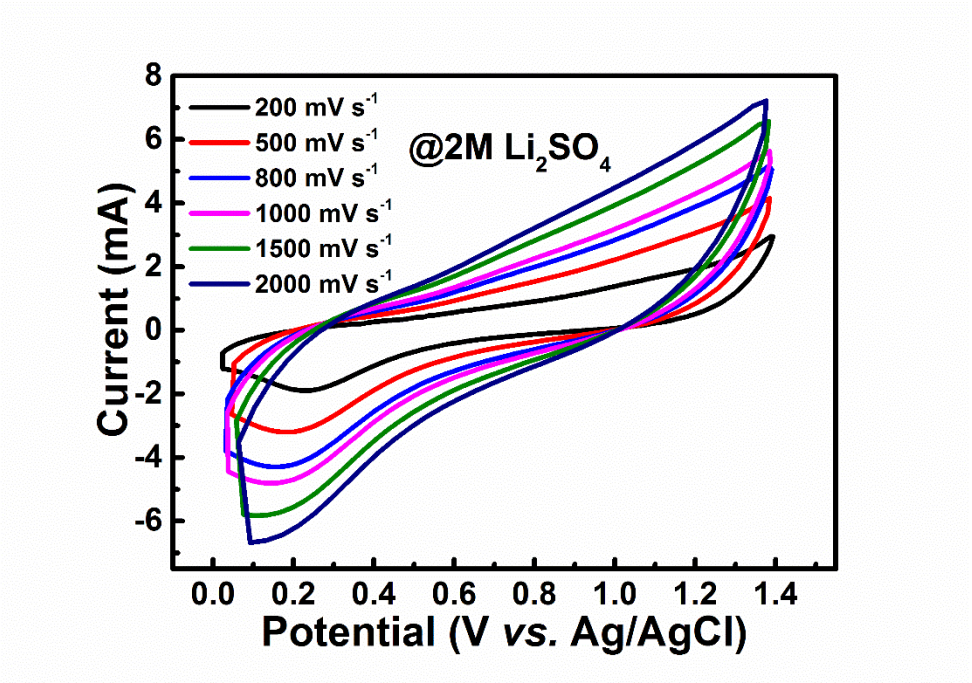

Figure S3. CV curves of the wire electrodes under different scan rates (200-2000 mV s^{-1})

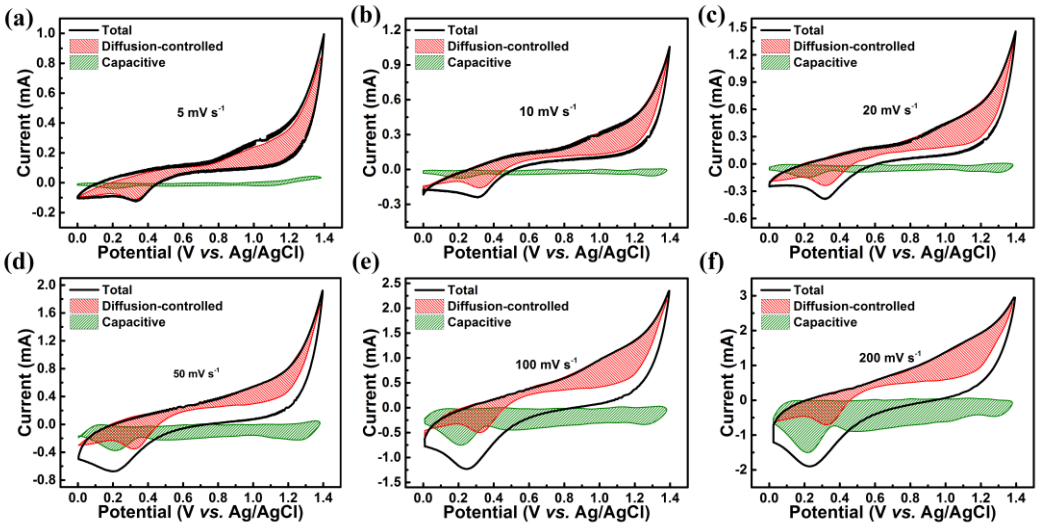

Figure S4. Cyclic voltammetry of LTO electrodes at (a) 5 mV s^{-1}, (b) 10 mV s^{-1}, (c) 20 mV s^{-1}, (d)50 mV s^{-1}, (e)100 mV $s^{-1}$and (f) 200 mV s^{-1}, and the shadowed areas represent the diffusion-controlle and capacitive contribution.

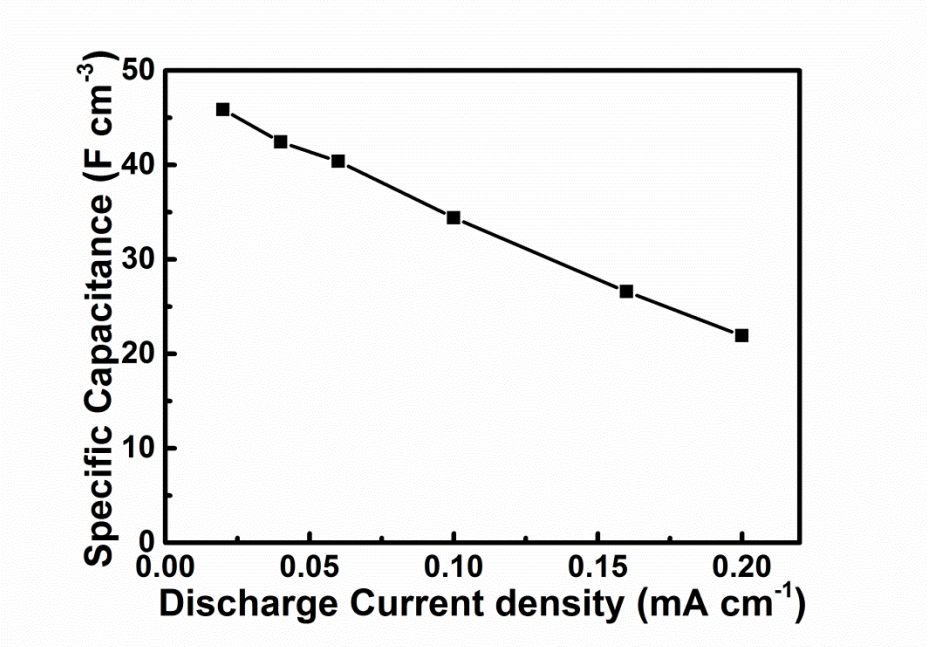

Figure S5. Specific capacitance of the wire electrodes under different current densities.

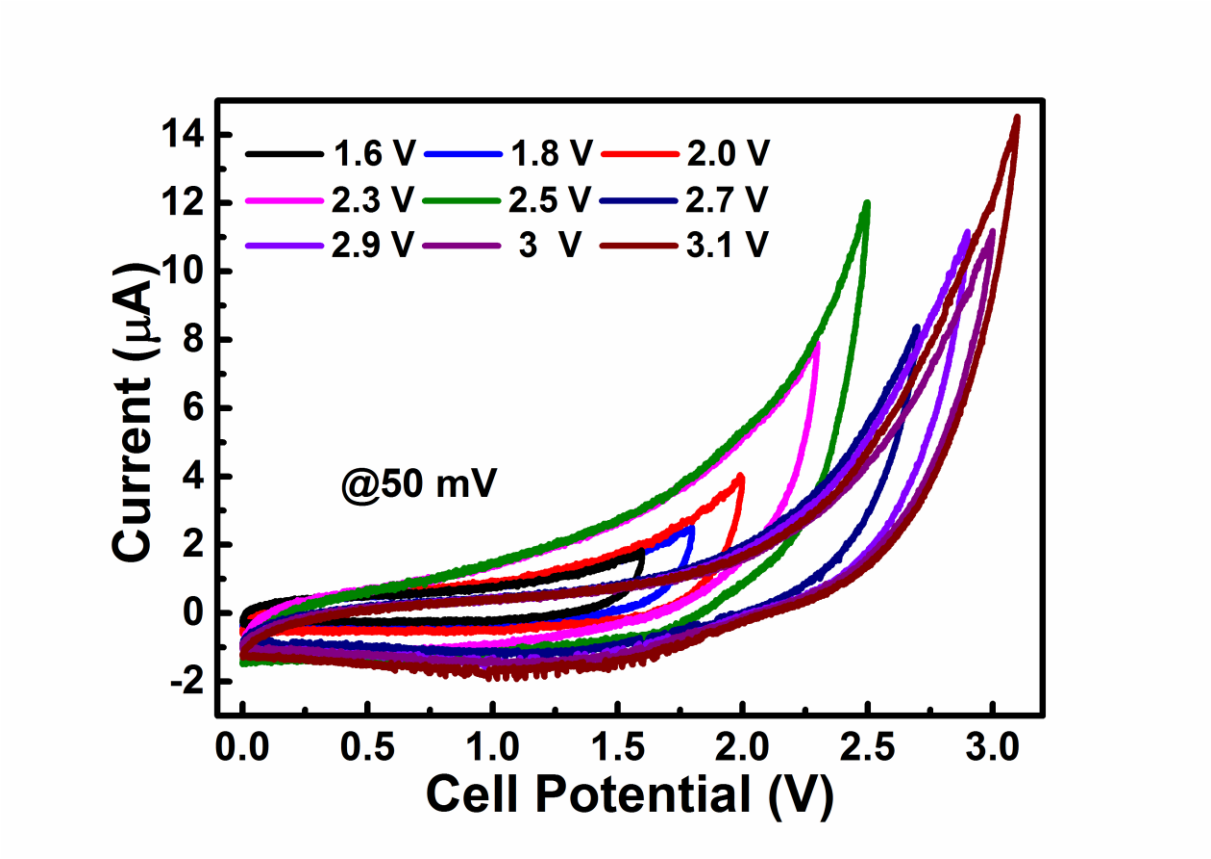

Figure S6. CV curves of the devices under different window voltages.

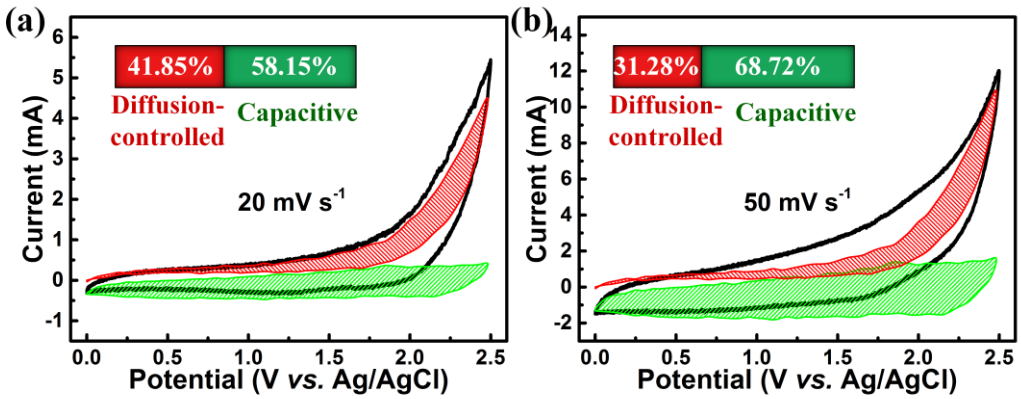

Figure S7. Voltammetric responses at 20 mV s^{-1} and 50 mV s^{-1}. Solid line represents total current from experiment, diffusion controlled current (red shaded region), and capacitive current (green shaded region) are derived.

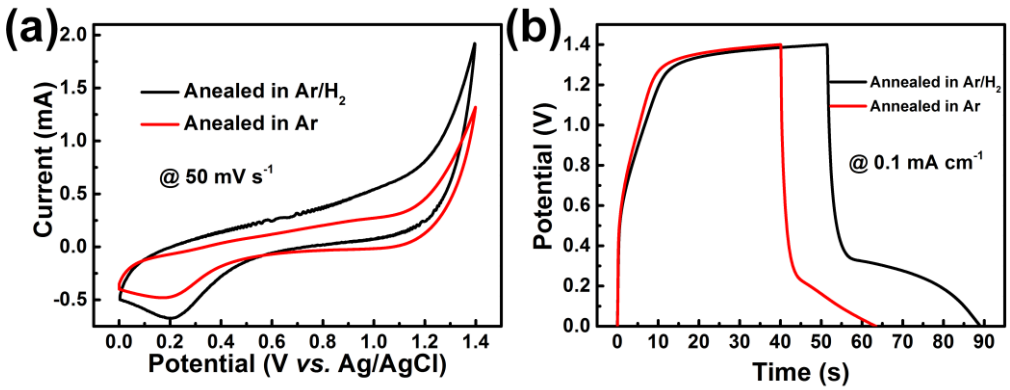

Figure S8. Comparison of CV and GCD curves of $Li_4Ti_5O_{12}$ NWs@Ti wire electrodes annealed in Ar and H_2/Ar, respectively.

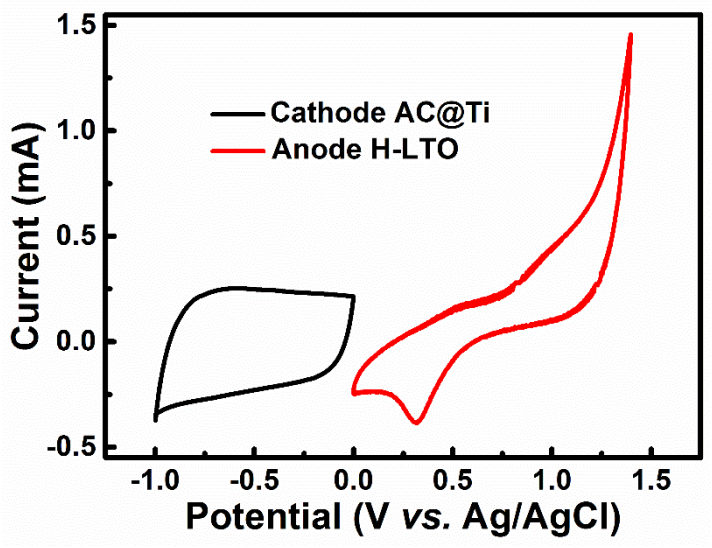

Figure S9. Comparative CVs of Cathode AC@Ti and Anode H-LTO at scan rate of 20 mV s^{-1}.

Figure S10. Optical photograph of the LIC's diameter measure with a vernier caliper.