Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.
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Supporting Information

Interconnected Mesoporous V_2O_5 Electrode: Impact on Lithium Ion Insertion Rate

Electrode Fabrication and Testing:

Electrodes are sputtered with a thin layer of gold, connected to stainless steel mounts by copper tape, then sealed in Parafilm windows with diameters of 5/8". Figure 5-1 shows a schematic of the electrodes mounted and sealed.

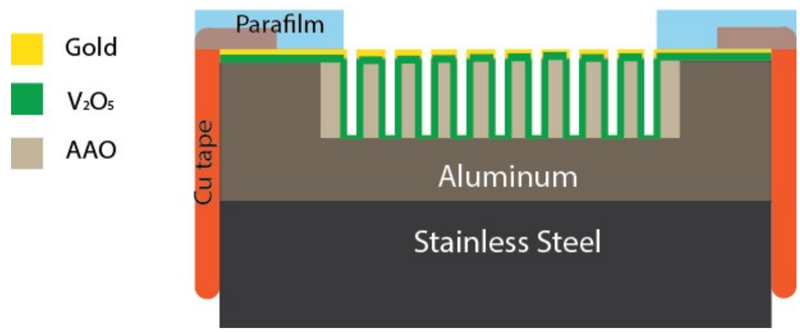

Figure S-1: Schematic of electrode preparation

Charge deconvolution:

Trasatti's method of charge deconvolution extrapolates the charge passed during a series of CVs to the limit of scan rate, v=∞, where it can be assumed that only the fast surface charging is contributing to charge storage. Extrapolating the same charge data to v=0 provides the theoretical total charge, and the difference between the total and the surface charge provides the bulk charge.

In order to extrapolate to the limit of v=0, plot 1/q vs. $v^{1/2}$, where q is the charge passed during the cathodic sweep of the CV at a given v. The y-intercept of that plot is $1/q_{total}$. To determine the limit of q as v approaches ∞, plot q vs $v^{-1/2}$. The y-intercept is $q_{surface.}$ The difference between q_{total} and $q_{surface}$ is the bulk or "Faradaic" charge.

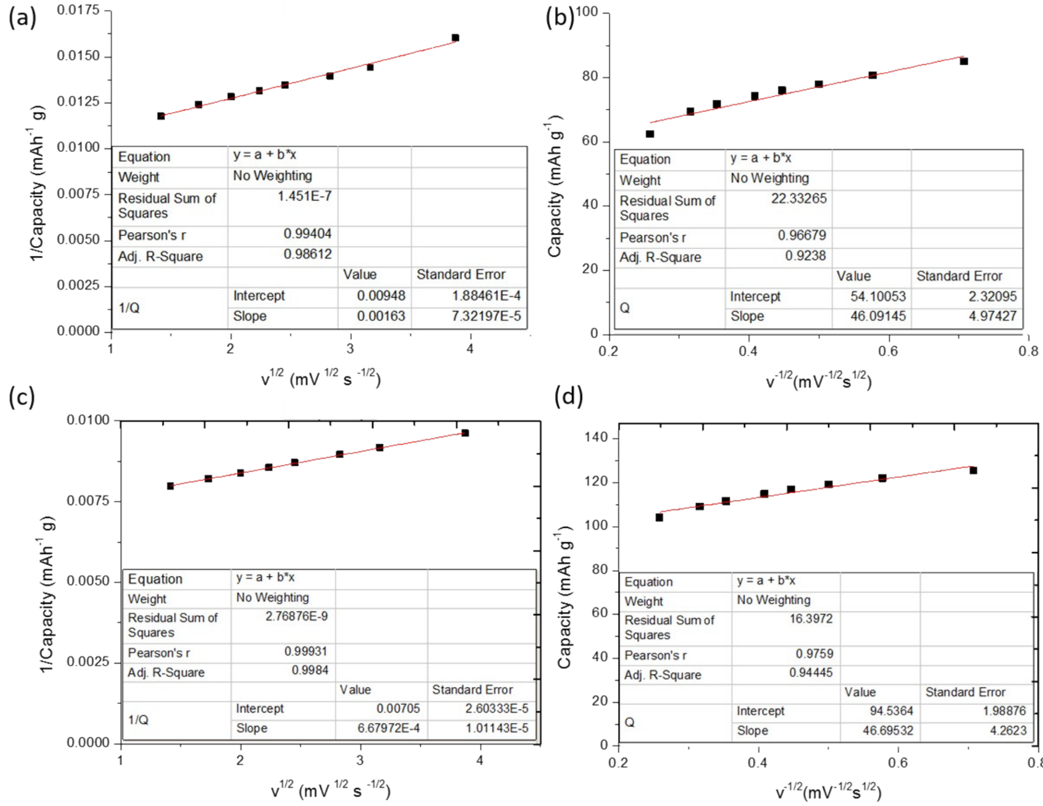

Figure S-2: Plots for the total (a) and surface (b) charge of the straight pore electrodes and the total (c) and surface (d) charge of the electrodes with three interconnections. The red lines and inset tables are the linear fits to the experimentally measured data.

Electrochemical Impedance Spectroscopy:

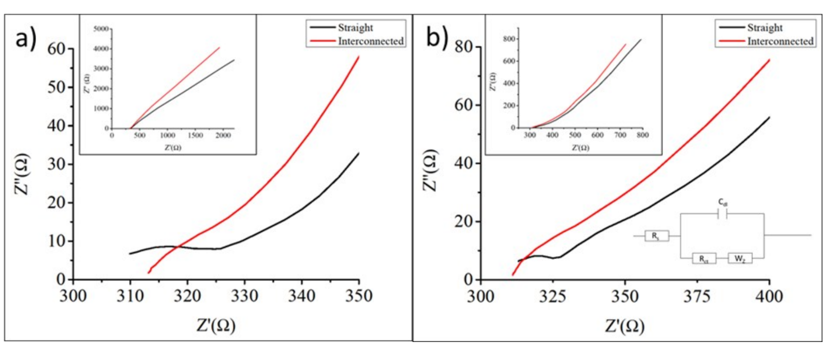

Figure S-3: Nyquist plot of straight and interconnected pores at (a) 3.8V, and (b) 2.6V vs Li. EIS measurements were taken from 200 kHz to 50 mHz with the voltage amplitude of 10mV. The inset in Figure S-3a and S-3b are the overview impedance spectra at their given potential. The schematic of the Randle's circuit is also shown inset in Figure S-3b.

	At 3.8V		At 2.6V	
	Straight	Interconnected	Straight	Interconnected
Rs (Ohm)	307	312	310	311
Rct (Ohm)	15	5	14	14
Cdl (μF)	1	22	1	26
Wz(Ohm/s)	503	300	537	291

Table S1: Impedance data fit to a standard Randle's circuit.

Figures S3A and C were fit to a Randle's circuit using ECLab's Z-fit function. The values of each component are tabulated in Table S1. Due to the complexity of the impedance spectra, only high frequency portion of the spectra was used to fit to the simple Randle's circuit. From the information obtained, at fully charged (3.8V) and discharged (2.6V), the charge transfer impedance is similar between the straight and interconnected electrodes. It also shows that the double layer capacitance is higher for interconnected electrodes, supporting the increased in fast surface reaction area of the interconnected electrode. The possible reason why the semi-circle in interconnected electrodes is convoluted, i.e. no clear semi-circle, is due to the increased double layer, fast reaction capacitance. Using the Z-fit function, theoretical impedance spectra can be simulated. Using the same values as the straight electrodes, by increasing the double layer capacitance value, similar spectra as interconnecting electrodes can be simulated, suggesting that the double layer capacitance is most likely the main cause for this difference observed.