

Asymmetric membrane structure: a general solution for stabilizing high capacity lithium ion battery anodes

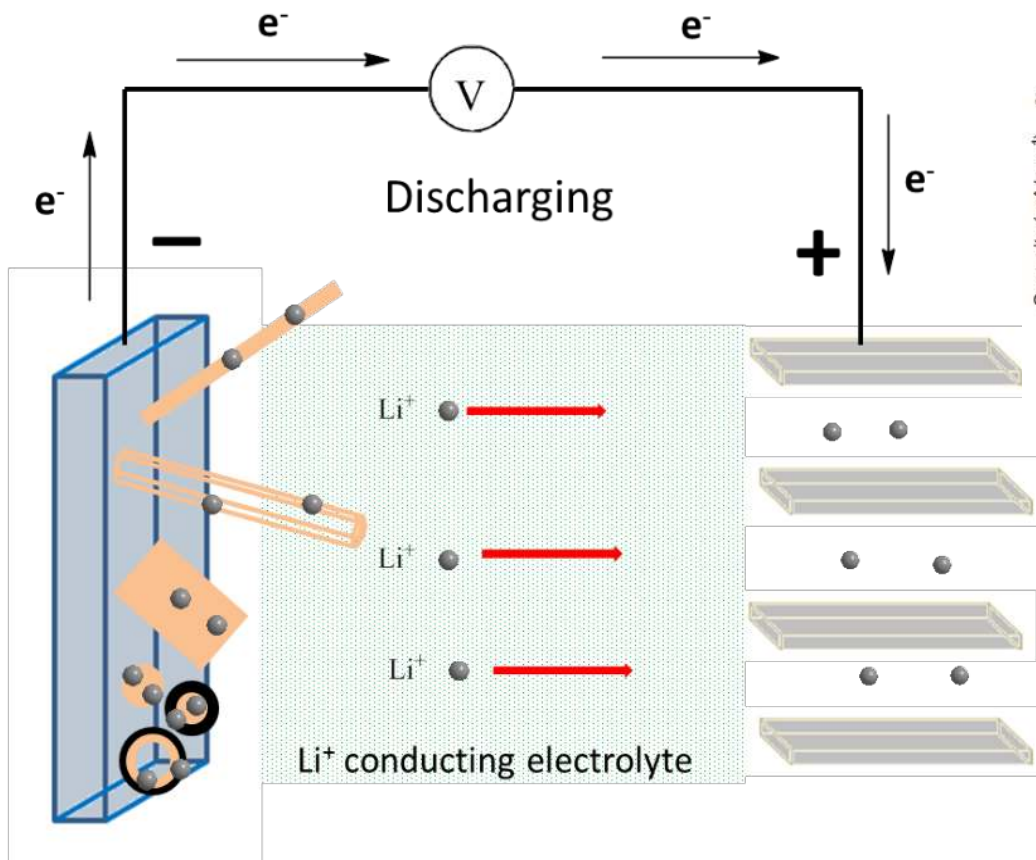
Ji Wu, PhD

Department of Chemistry and Biochemistry
Georgia Southern University

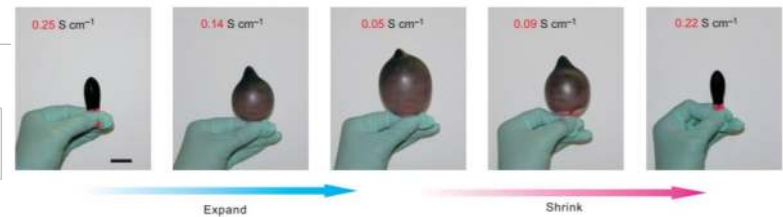
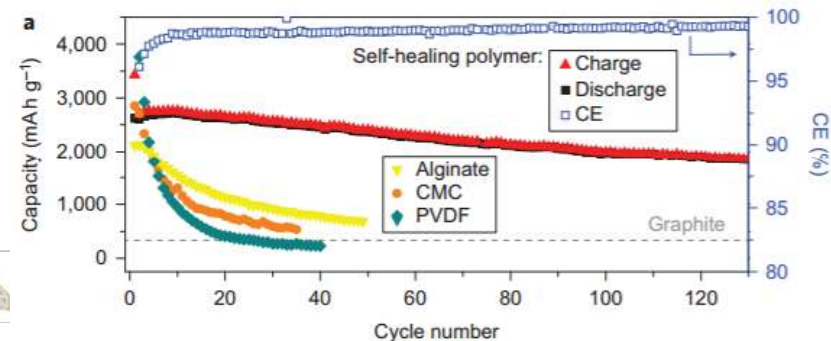


2020 ACS meeting @ Philadelphia

Nanotechnology for High Capacity LIB Alloying Anodes



Wu, J., et al., *Advanced Energy Materials*, **2014**, 4, 1300882 (1-23).

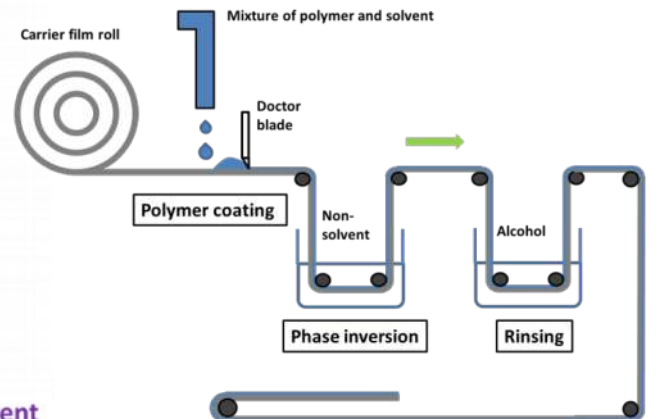
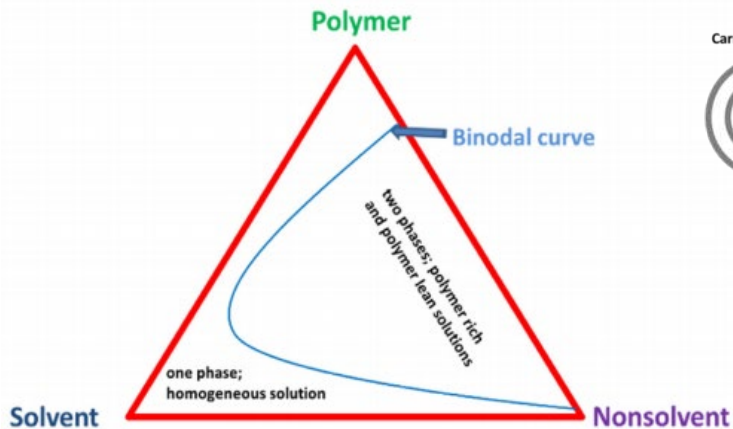
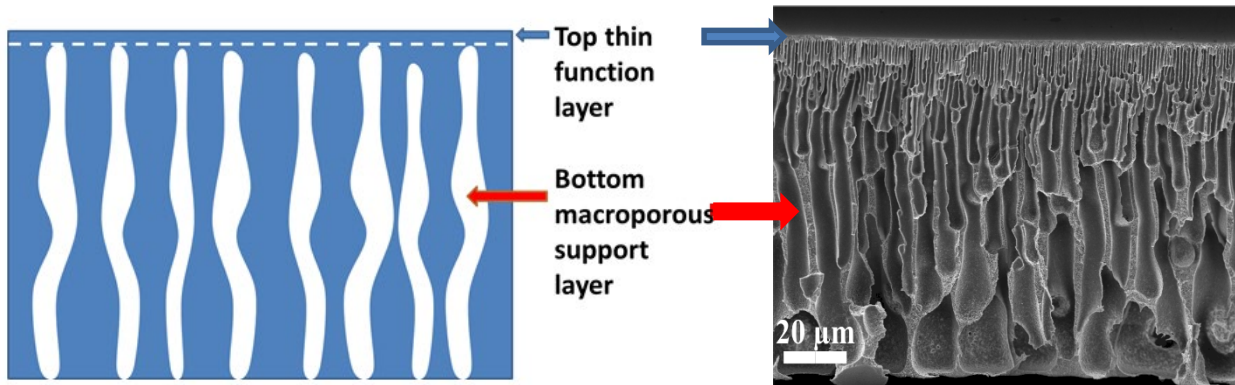


Wang, C., et al., *Nature Chemistry*, 2013. 5(12): p. 1042-1048.

PLUS:

- (1) new binders like poly(acrylic acid) (PAA), sodium carboxymethyl cellulose (CMC), and cross-linked PAA-CMC (c-PAA-CMC), etc. have been tested to improve cycling performance.
- (2) new electrolyte additives such as Fluoroethylene carbonate (FEC) and vinylene carbonate (VC) can also enhance the lifespan of high capacity alloy electrodes.
- (3) Low Tg elastomers function as 'self-healing' binder for high capacity LIBs.

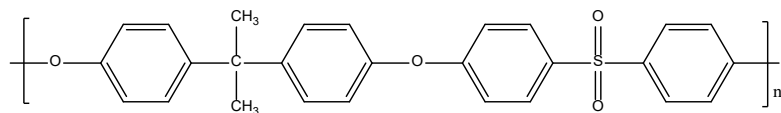
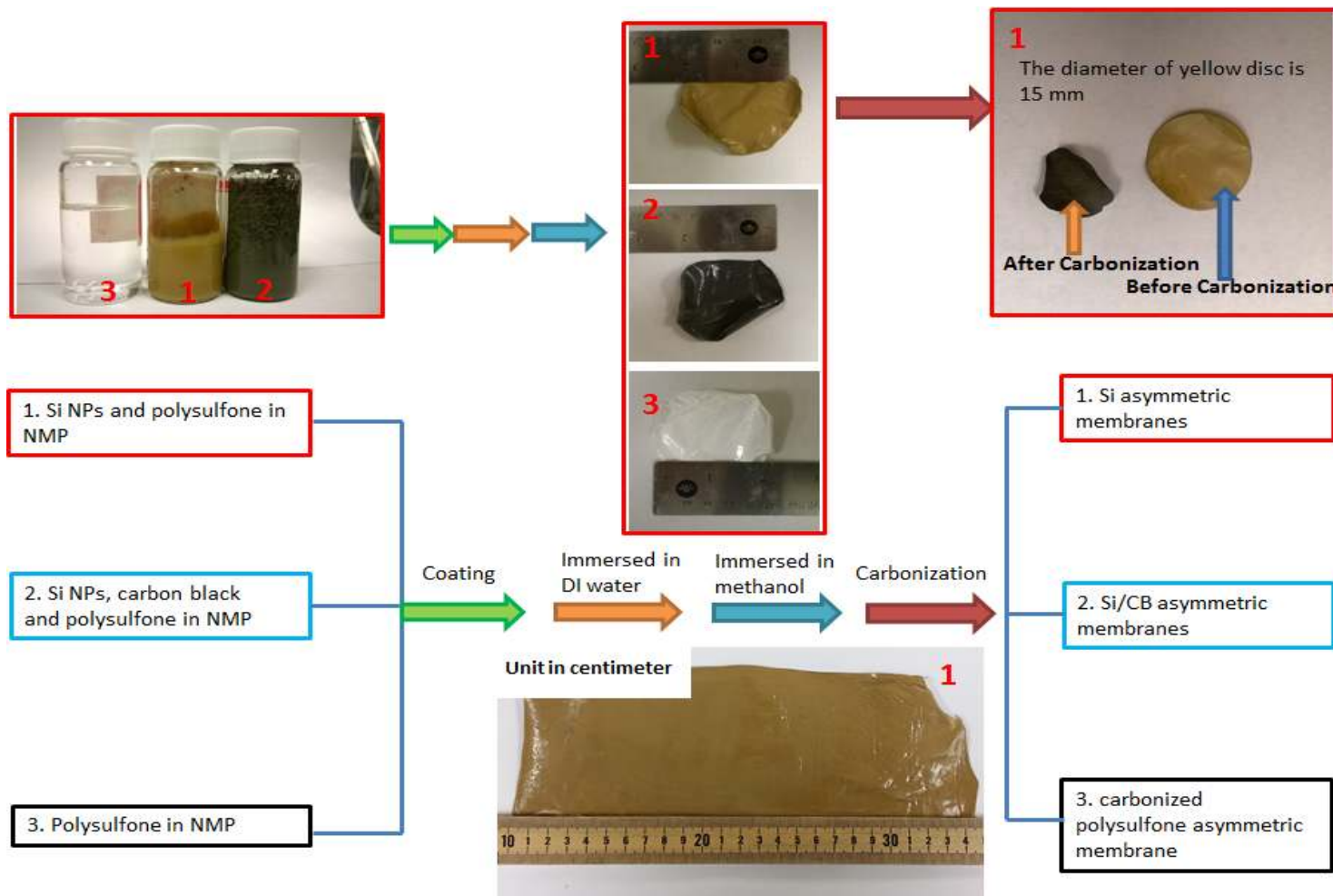
Polymeric Asymmetric Membranes



Advantages of Asymmetric Membrane Structure for High Capacity LIB Alloying Anodes

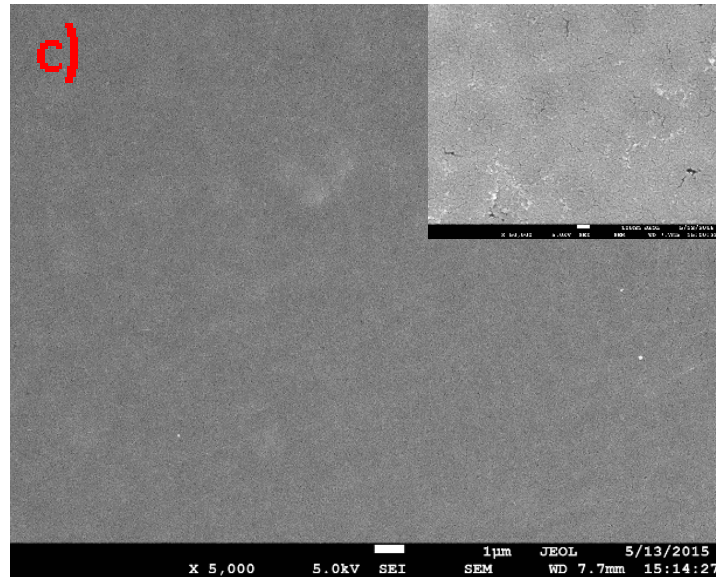
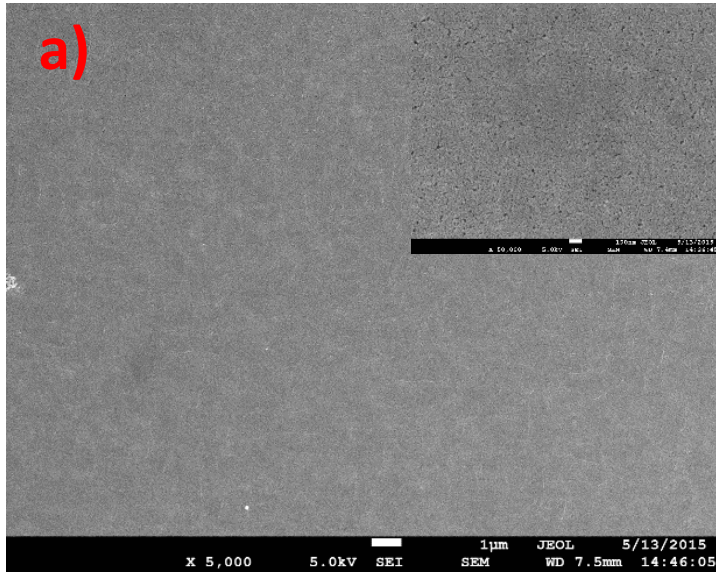
1. The void structure can provide free volume for electrode expansion.
2. The strong and unique asymmetric structure can enhance mechanical strength.
3. The thin coating of carbon can benefit the formation of relatively stable artificial SEI layer.
4. The porous carbon cages can intercept and thus prevent the loss of fractured alloying anode materials.

Thin Film Si Asymmetric Membranes for High Capacity LIB Anode

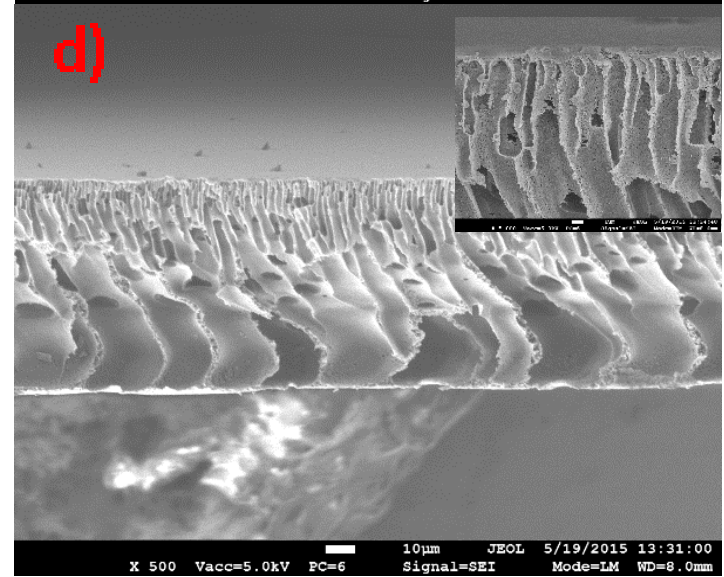
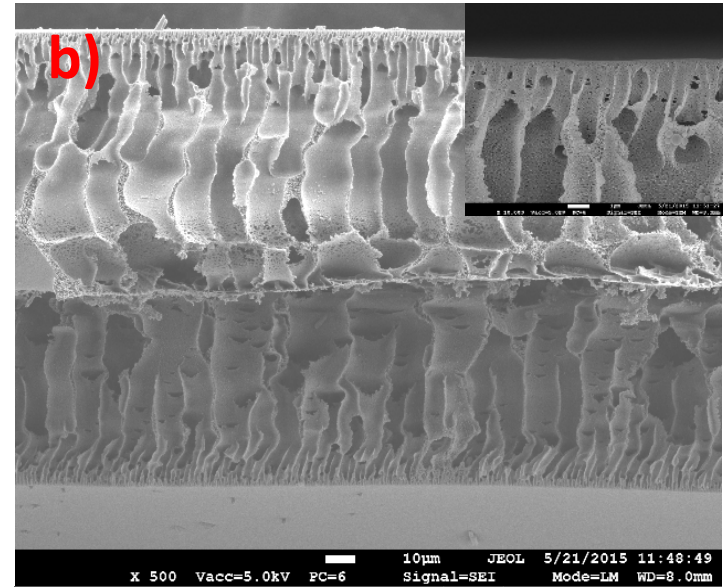


C content in PS: ~73 wt.%

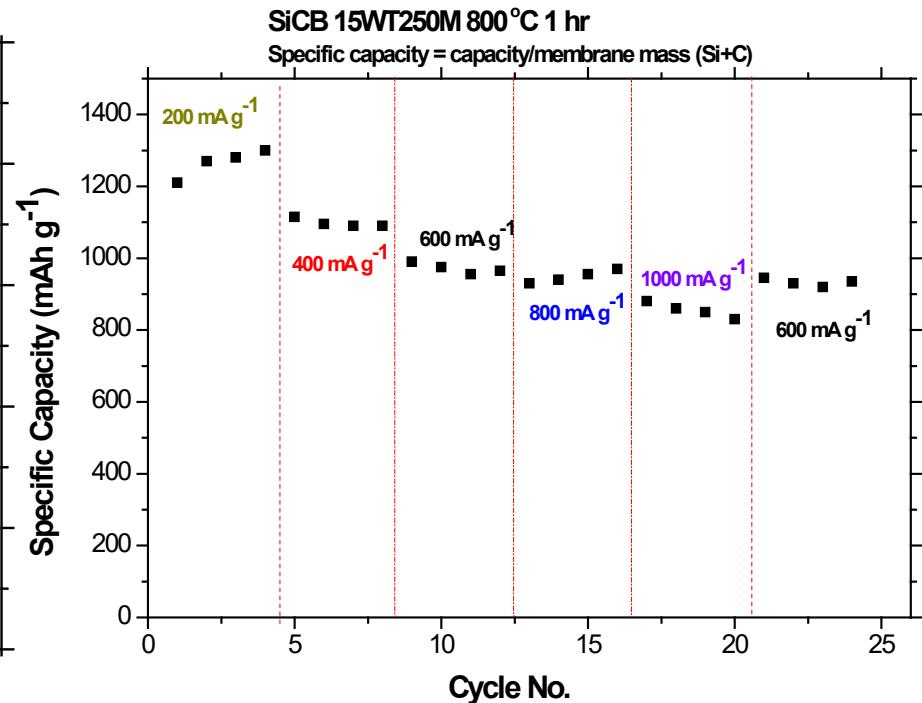
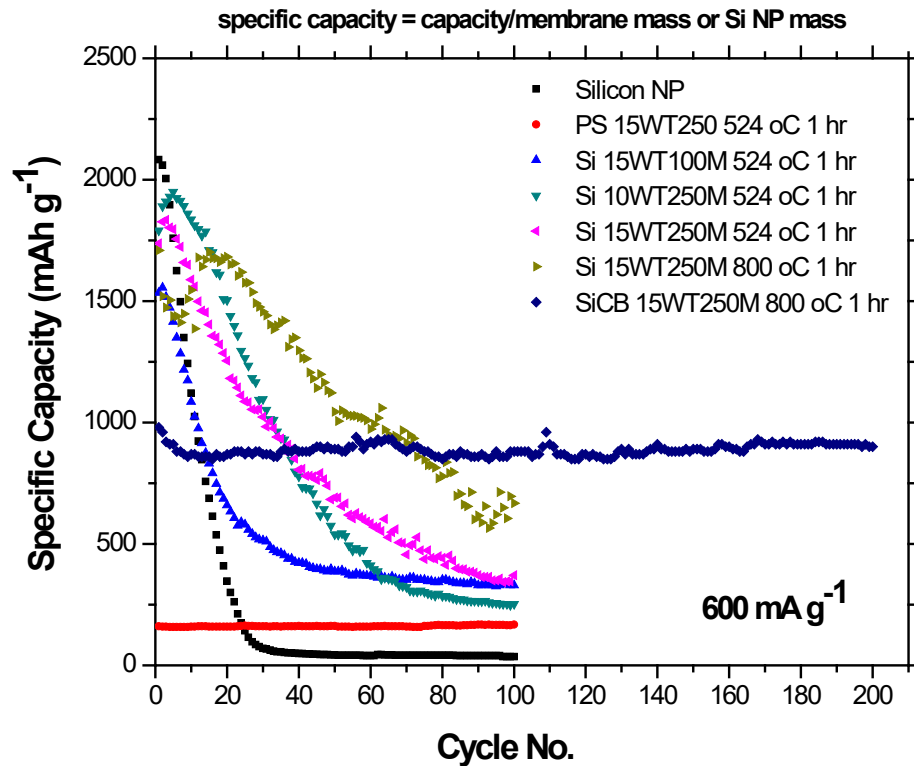
Characterization of Asymmetric Membranes



Polysulfone membranes

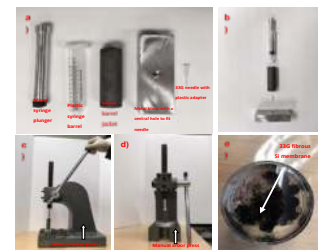
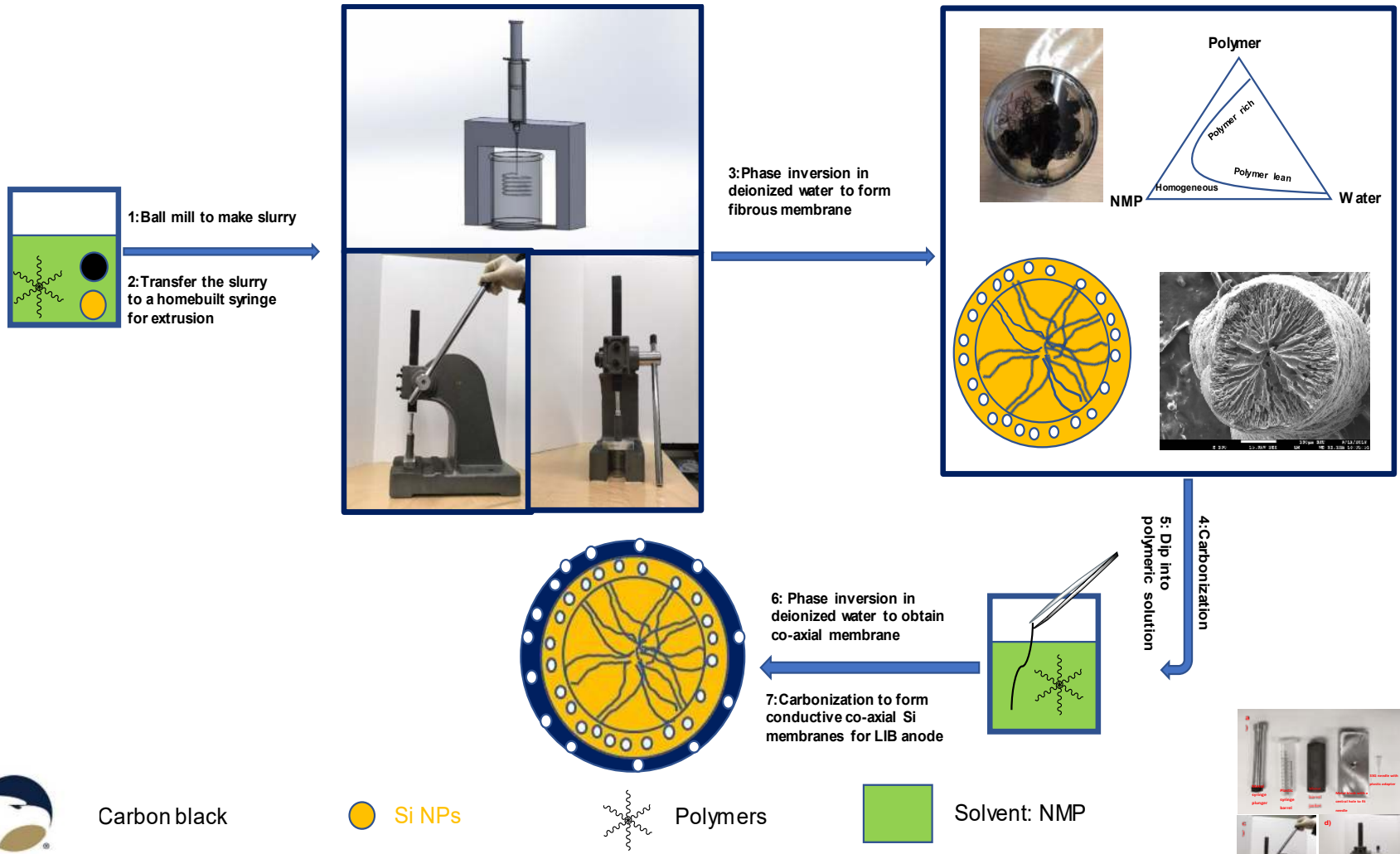


Si Asymmetric Membranes for High Capacity LIB Anode

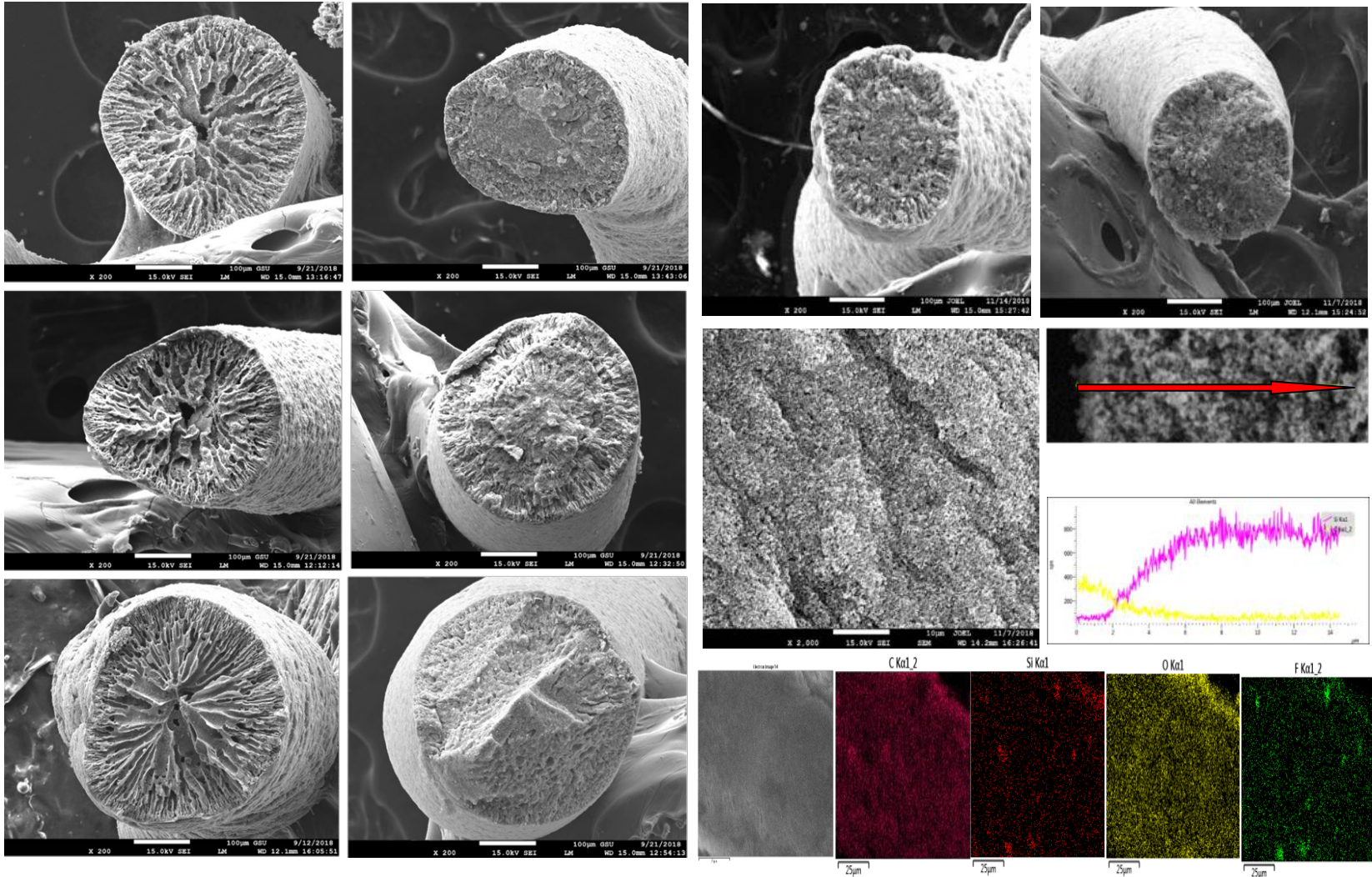


Electrochemical performance of Carbonized Si/CB asymmetric membranes

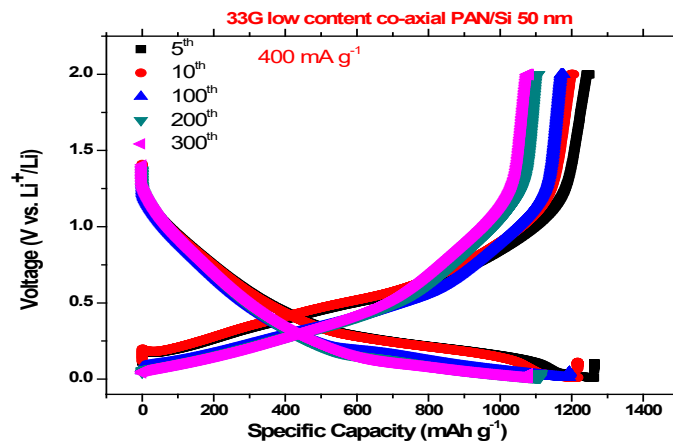
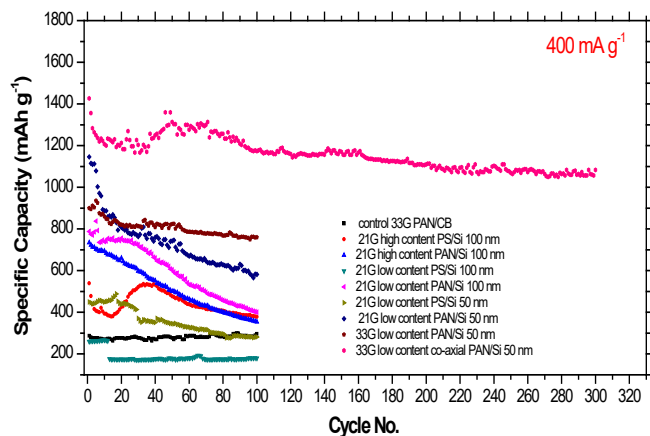
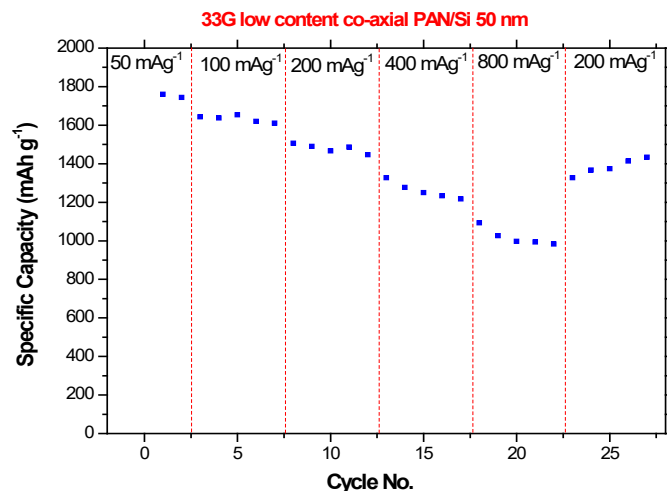
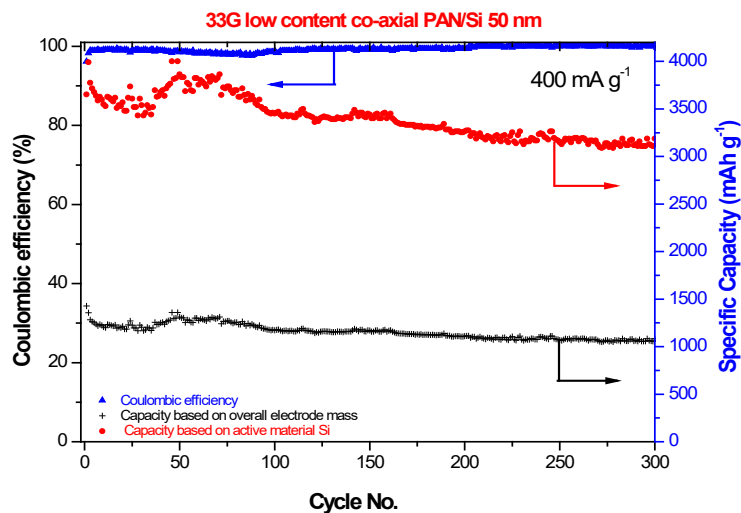
Coaxial Fibrous Silicon Asymmetric Membranes for High Capacity LIB Anode



Coaxial Fibrous Silicon Asymmetric Membranes for High Capacity LIB Anode

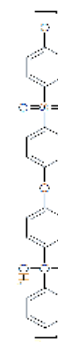
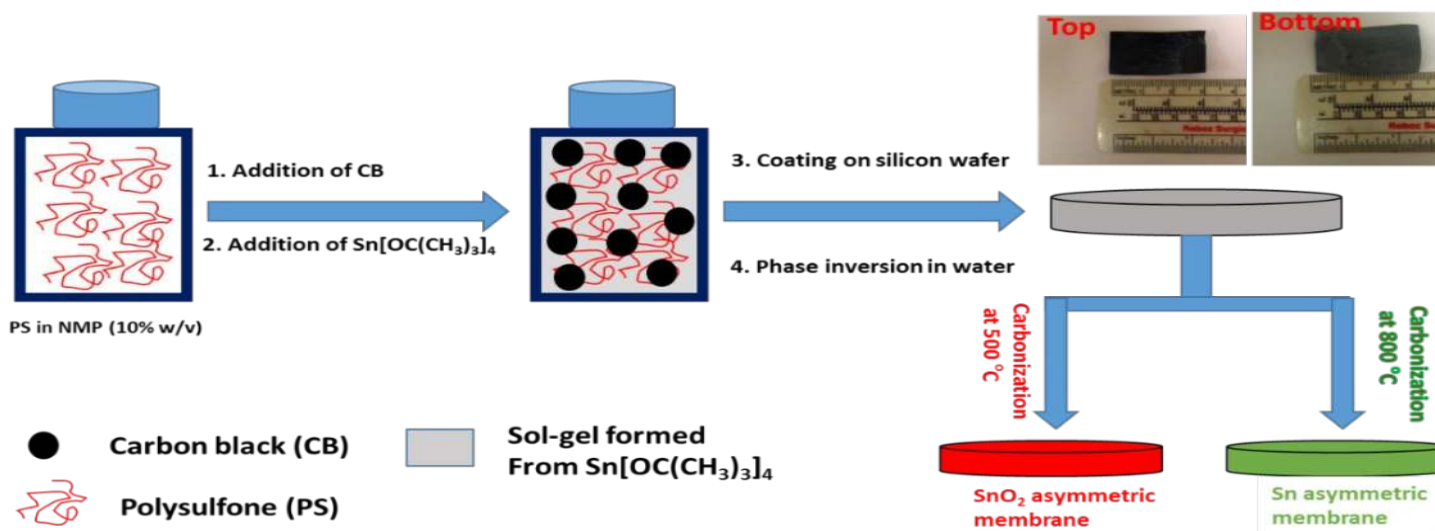


Coaxial Fibrous Silicon Asymmetric Membranes for High Capacity LIB Anode

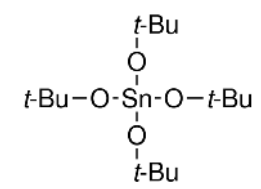
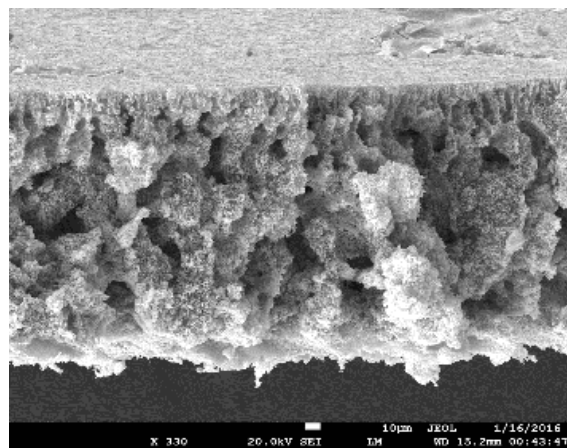
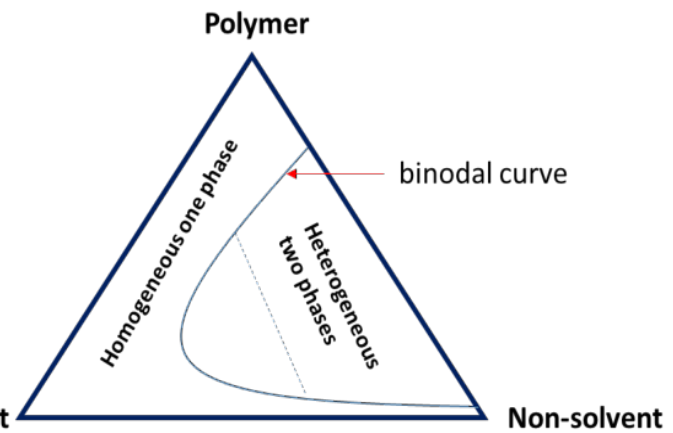


Fabrication of SnO₂ Asymmetric Membranes for High Capacity LIB Anode

**Fabrication of SnO₂ and Sn Asymmetric Membranes:
phase inversion combined with sol-gel chemistry**

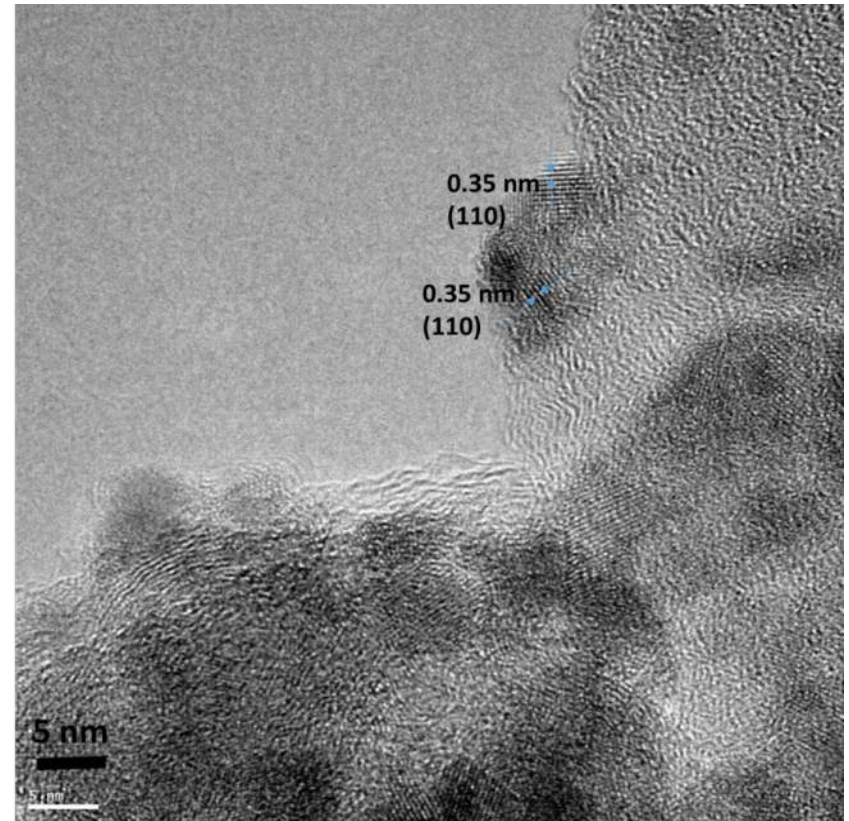
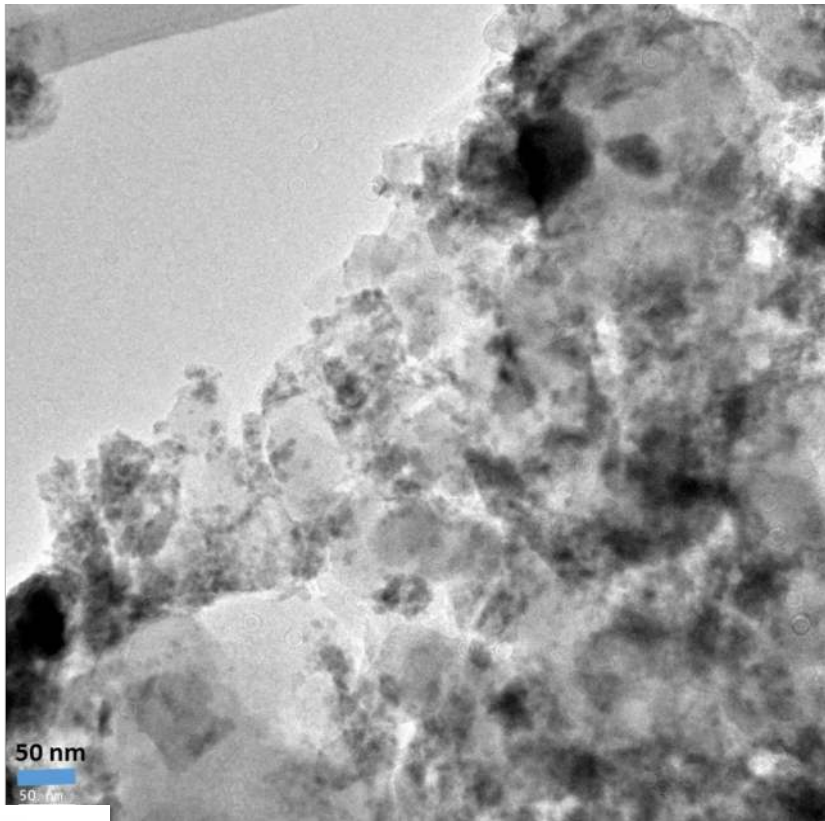


Polysulfone

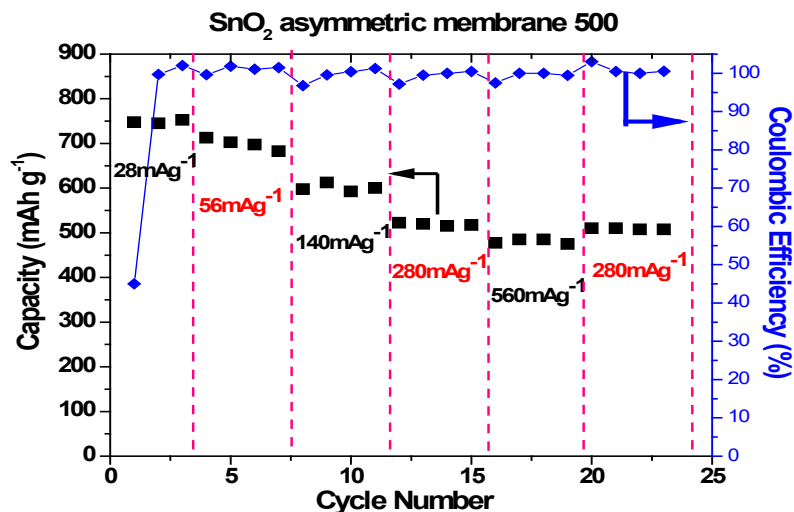
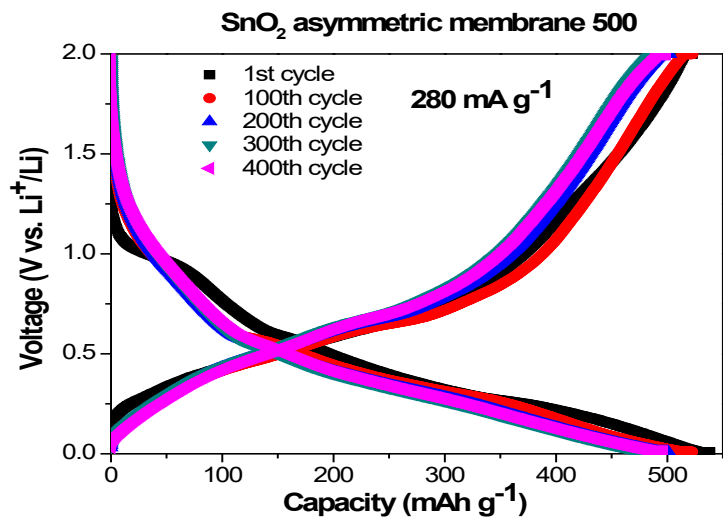
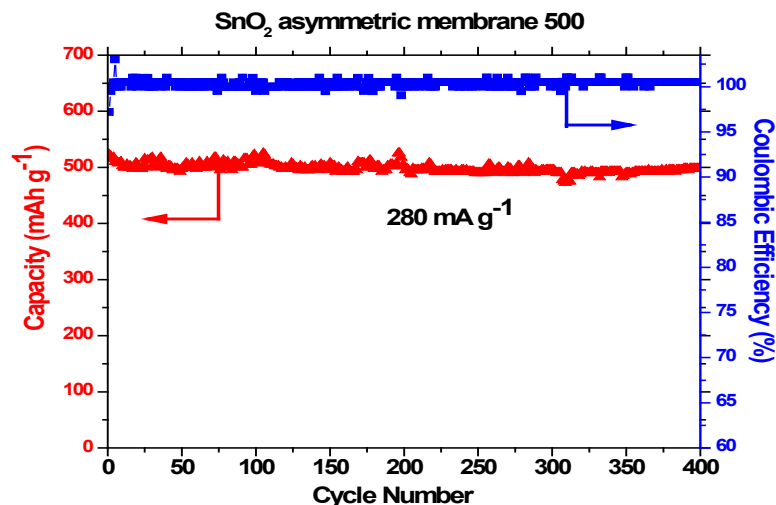
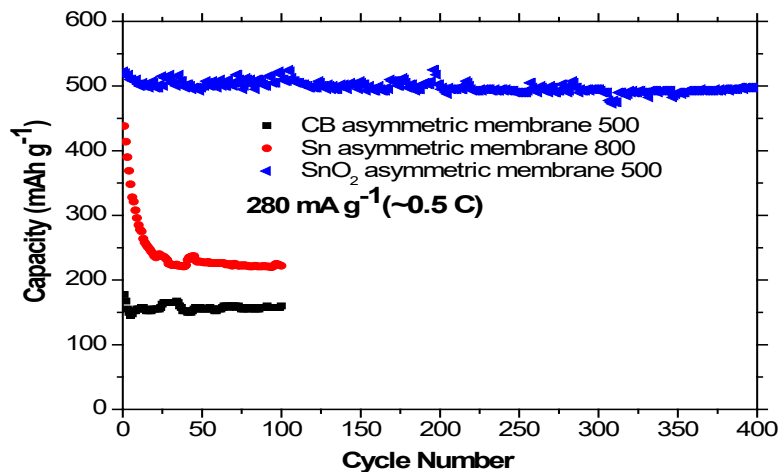


Tin(IV) tert-butoxide

Fabrication of SnO₂ Asymmetric Membranes for High Capacity LIB Anode



Fabrication of SnO₂ Asymmetric Membranes for High Capacity LIB Anode



Conclusions

- ❑ We demonstrated that scalable polymeric membrane technology can be adapted to obtain various inorganic asymmetric membranes via a self-assembly mechanism for high capacity lithium ion battery anodes.
- ❑ The unique nano- and macro-porous asymmetric structure can provide robust mechanical support and free volume to accommodate the large volume change during repeated lithiation/de-lithiation, resulting in excellent cycling and rate performance.
- ❑ Lastly, this asymmetric membrane strategy can also provide a generic solution to the large volume change problem in other types of alloying anodes, by combining with surface coating and chemical etching.

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