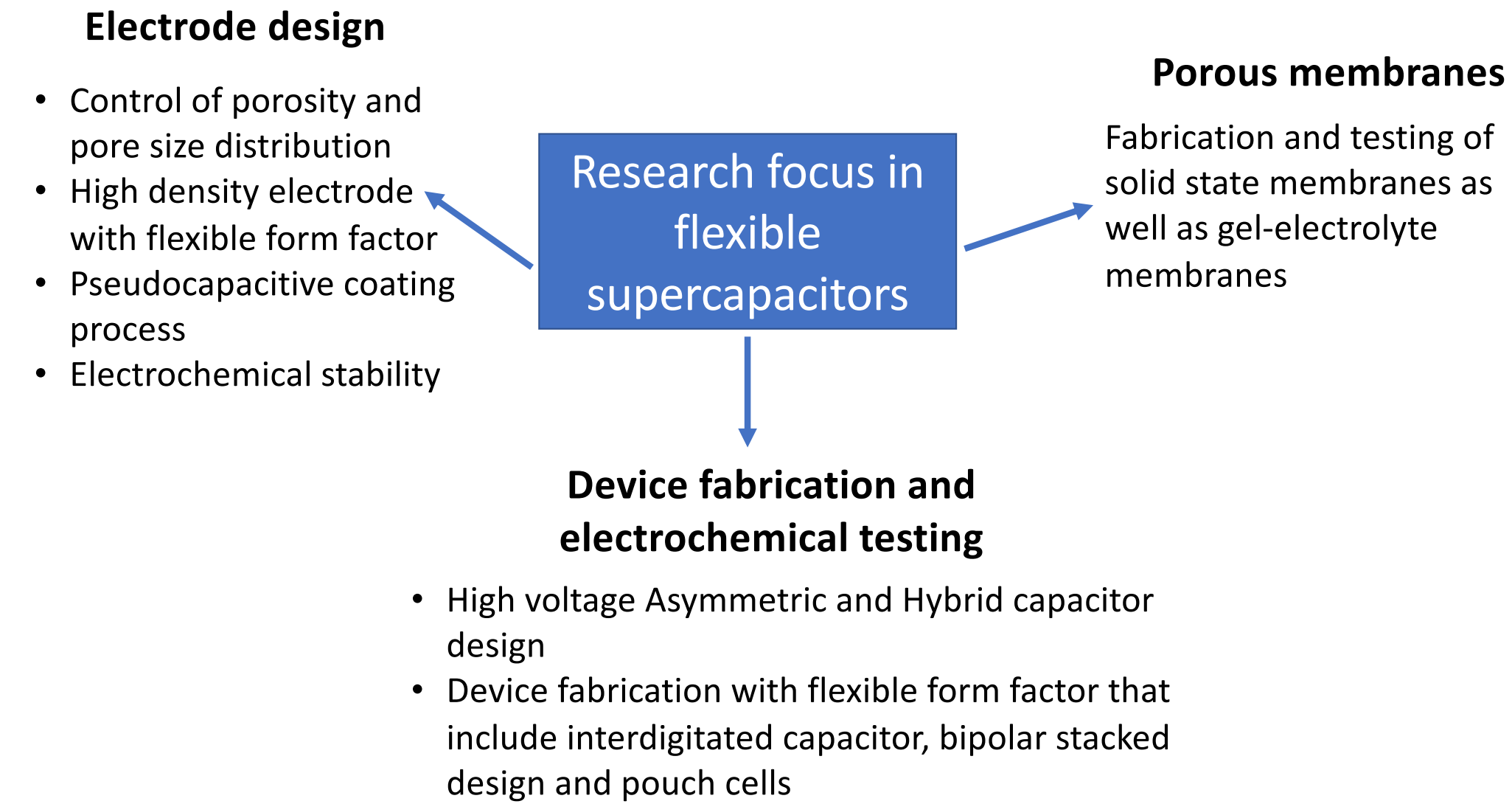
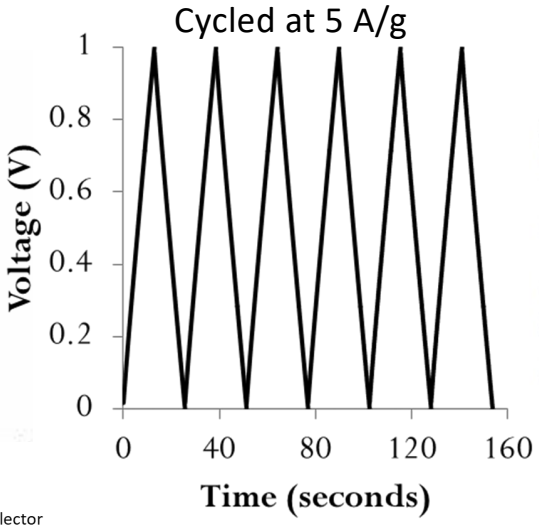
Flexible high energy density supercapacitors

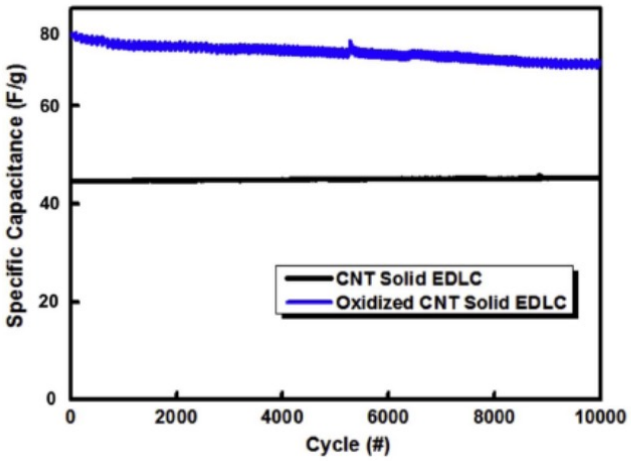
Ramakrishnan Rajagopalan
Department of Engineering – Applied Materials
The Pennsylvania State University

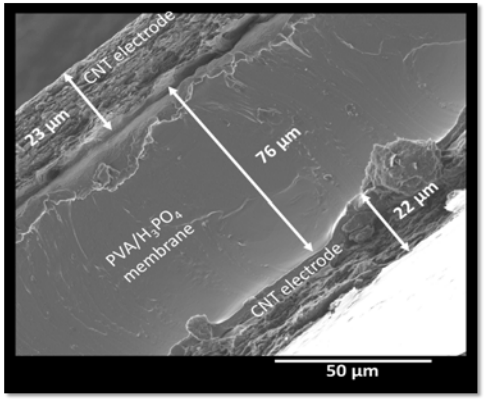

Electrode design
Control of porosity and pore size distribution
High density electrode with flexible form factor
Pseudocapacitive coating process
Electrochemical stability
Research focus in flexible supercapacitors
Porous membranes
Fabrication and testing of solid state membranes as well as gel-electrolyte membranes
Device fabrication and electrochemical testing
High voltage Asymmetric and Hybrid capacitor design
Device fabrication with flexible form factor that include interdigitated capacitor, bipolar stacked design and pouch cells

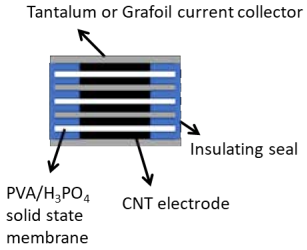
Carbon nanotube based solid state capacitor

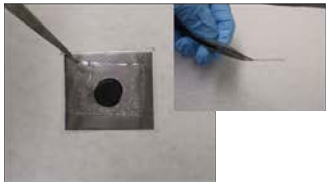


Enhancement in capacitance through pseudocapacitance

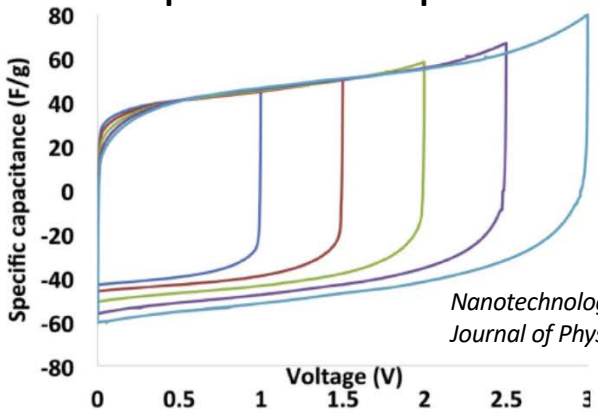






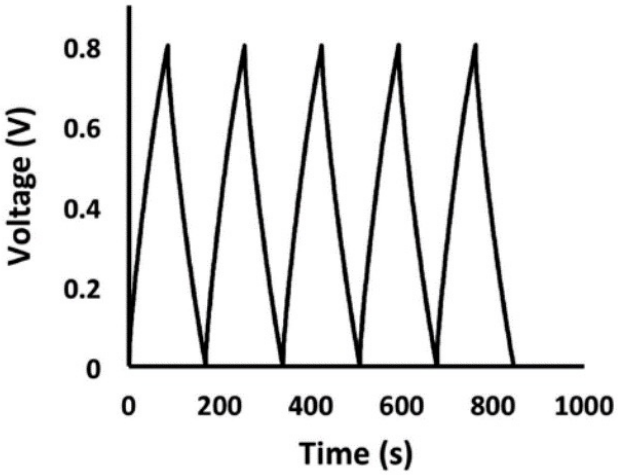


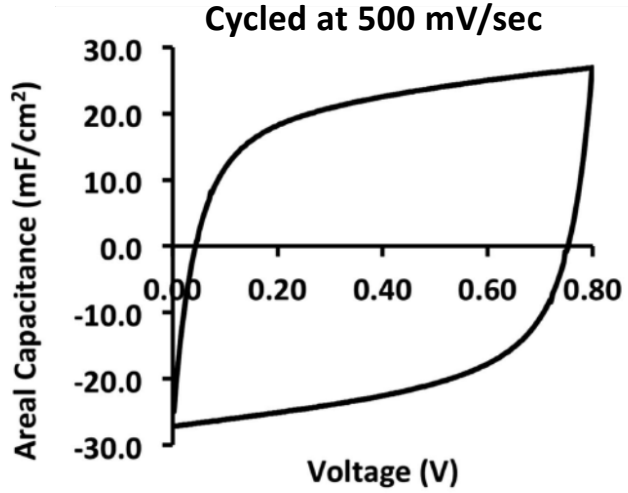
Bipolar stacked capacitor

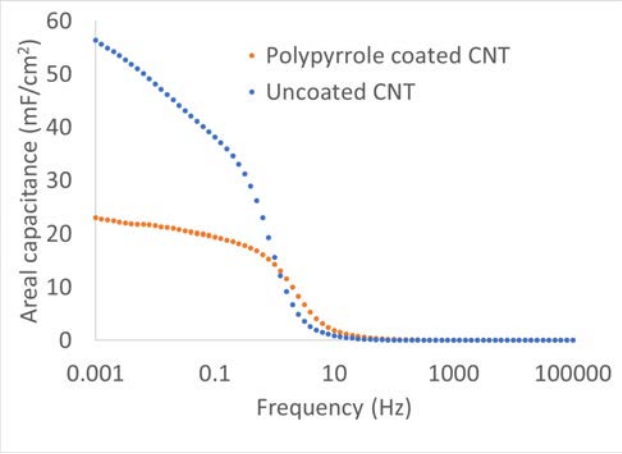


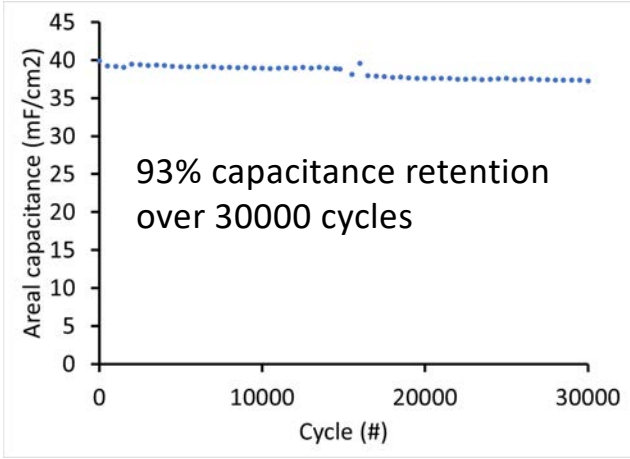
Nanotechnology, 29,035605 (2017)
Journal of Physical Chemistry C, 118, 2943 – 2952 (2014)

CNT based interdigitated capacitor





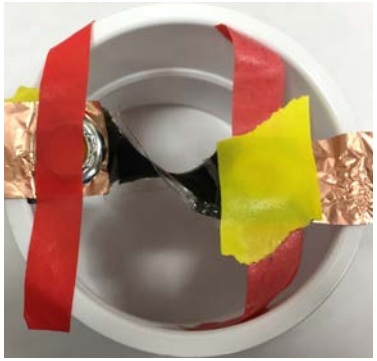


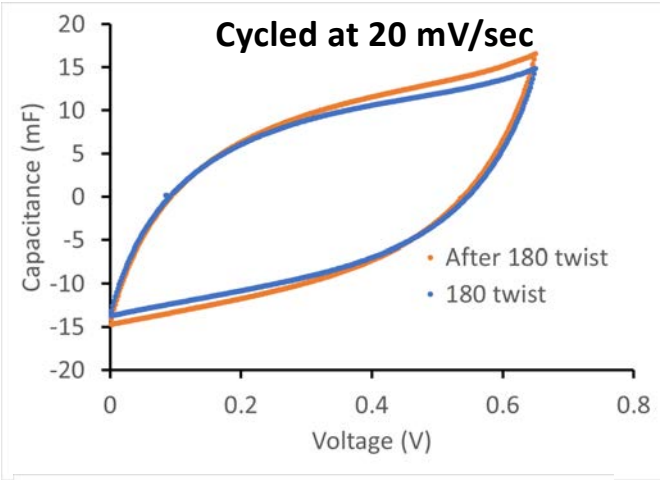


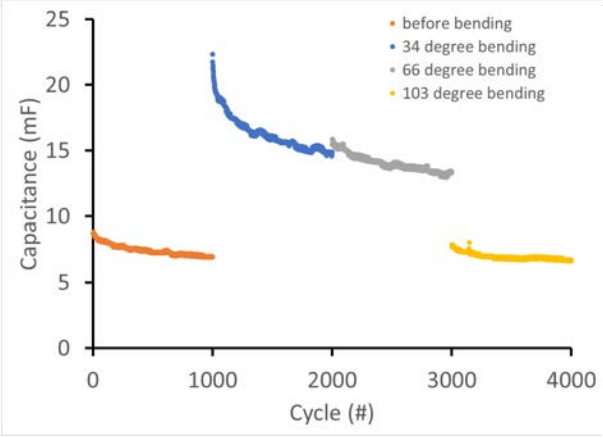
- Interdigitated solid state capacitors were fabricated by laser scribing CNT electrodes
- Areal capacitance almost double using polypyrrole coated electrodes with excellent cyclability

Flexible polypyrrole coated solid state capacitor

180° twist

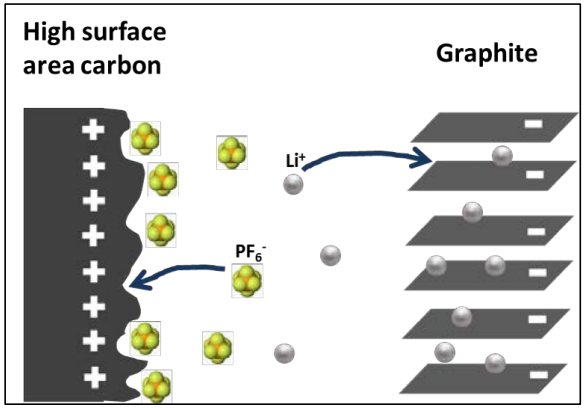


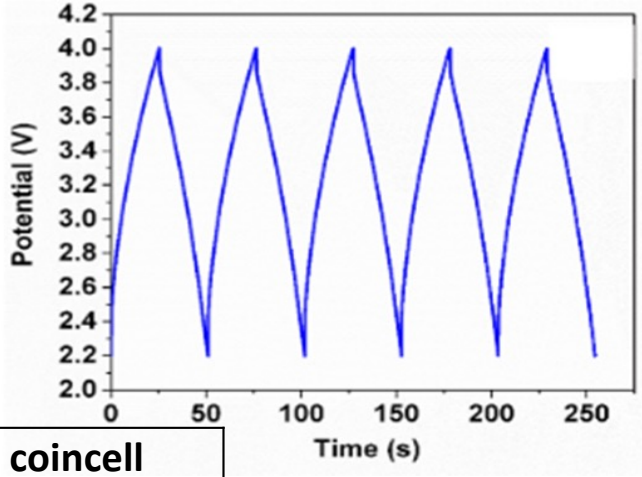


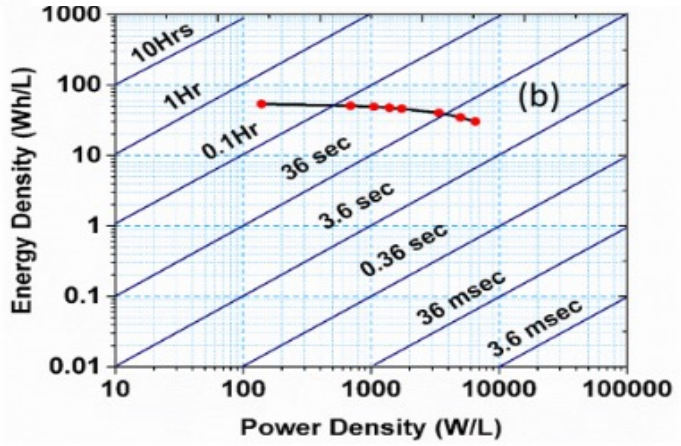


- Polypyrrole was electrodeposited on nonwoven carbon fiber electrodes that exhibit good mechanical flexibility
- The symmetric solid state capacitor showed excellent mechanical flexibility with good capacitance retention under different degrees of bending and twisting

High energy density Lithium-ion capacitor design

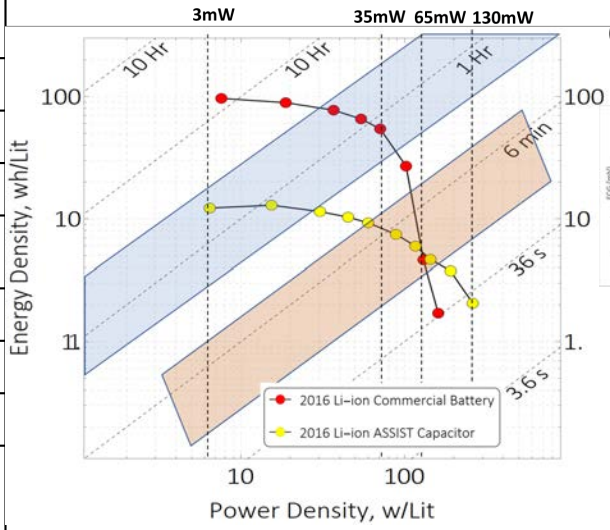






Carbon, 152, 89 -97 (2019)

Specifications	2016 coincell prototype
Cell Voltage	3.8V
Capacity	2.5 mAh (4.7F)
Nominal current	4C (10 mA)
Maximum current	50 mA for 36s
Operable Voltage range	2.2 – 3.8V
Leakage current	< 1 µA
Self discharge	10% over 2 months
Volumetric packaged energy density (Wh/l)	13 Wh/L



Capacitor powered health sensor platform