Dispenser Printed Electrochemical Capacitors

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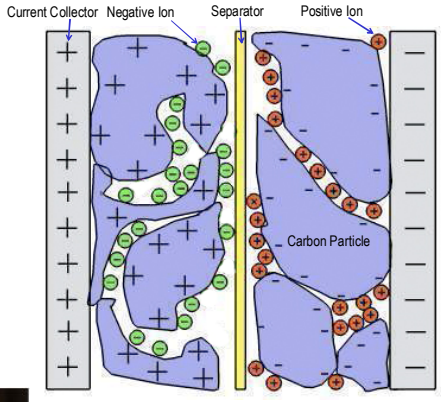
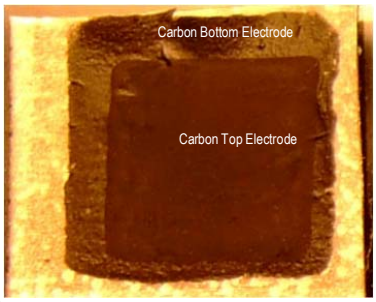
Vision

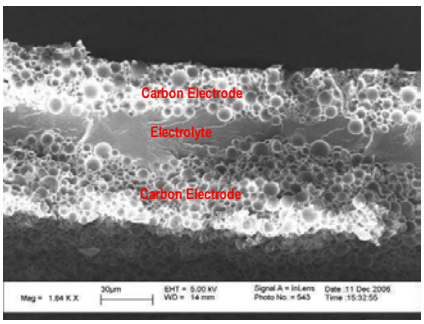
We present a direct-write, pneumatic dispenser printing method for additively fabricating solid-state, carbon supercapacitors directly on-chip in room temperature, ambient conditions. This proves to be a flexible method for integrating electrochemical energy storage components onto a device, and tailoring its performance to a specific application's demands.



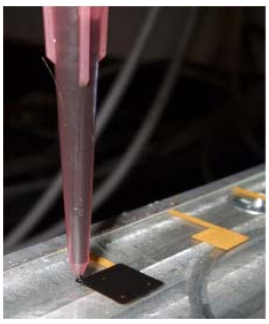
Schematic of an electrochemical capacitor



Printed capacitor on stainless steel substrate (Electrolyte is clear layer sandwiched between 2 electrodes)



SEM of capacitor cross section



Dispenser printer depositing carbon pad

Research Questions

- What materials chemistries will provide optimal energy storage and/or high rate performance at small dimensions?
- Are these materials properties optimized when dispenser printed?
- What geometries can be patterned using the dispenser printed and how will they optimize the electrochemical performance of the energy storage system?

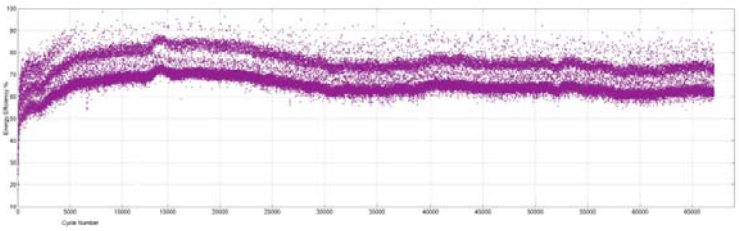
Methods

A pneumatic dispenser printer on a 3-axis micron resolution stage is used to pattern "inks." These inks are slurries of an active material in a polymer binder (such as PVDF, PEO, or PVA). The viscosity of the inks can be tailored using a solvent. Feature sizes of 40 microns have been achieved, and films ranging from 1-500 microns thick can be printed depending on particle sizes. The ability to print thin and thick films allows for interesting devices to be fabricated using dispenser printing.

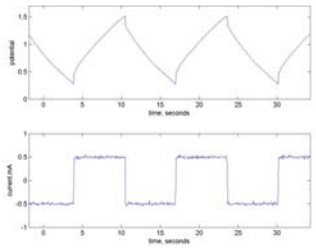
Electrochemical capacitors are fabricated using MCMB activated carbon in a PVDF gel binder. $BMIM+BF_4^-$ serves as an ion conducting electrolyte. Electrodes and a sandwiched electrolyte layer are printed subsequently on a substrate. The geometries and thicknesses of each layer can be designed to meet the electrochemical performance needs of a given application.

Findings

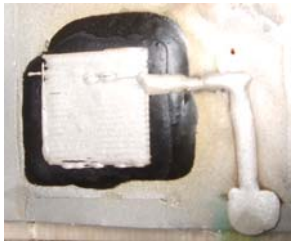
Printed encapsulated supercapacitors have been charged and discharged continuously for more than 70,000 cycles without degradation in performance. The capacitors have exhibited an average discharge capacitance of 1.63 mF/cm^2, 66.5 $\mu W/cm^2$ discharge power, and 0.18 μW-hr/cm^2 discharge energy. Further investigations of various activated carbons and printed current collector material candidates are being explored.



Energy efficiency of capacitor over prolonged cycling



Example of charge and discharge cycles



Capacitor with printed top current collector

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