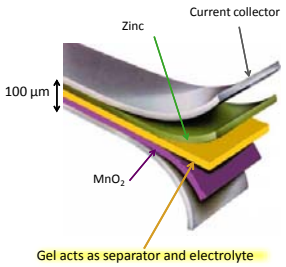
Printed Energy Storage Devices

Christine Ho, Ba Quan, Zuoqian(Joe) Wang, Prof. James Evans, and Prof. Paul Wright

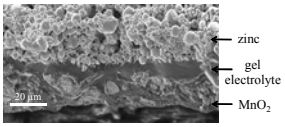
Berkeley BMI Manufacturing Micro Integration Microfabrication Institute

Printed Batteries

We have developed a dispenser printed battery composed of zinc and manganese dioxide electrodes sandwiching an ionic liquid gel electrolyte.



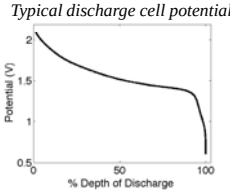
Zinc battery chemistries:
- High power and energy densities
- Inherent safety & low toxicity
- Ease in handling and processing
- Low cost



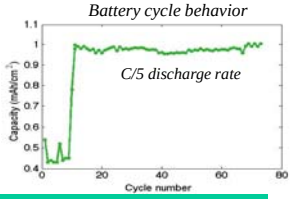
Microbattery cross-section

The ionic liquid gel has very unique properties: fast ion transport, mechanically robust even under compression, and it does not "sweat" or dry out over time.

Typical discharge cell potential

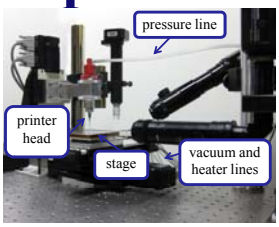


Battery cycle behavior

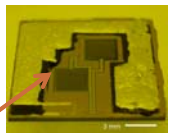


Current microbattery performance		
Capacity	Energy Density	Operating Voltage
1 mAh/cm²	1.5 mWh/cm² 150 mWh/cm³ 130 Wh/kg	1 -2 V

Dispenser Printing

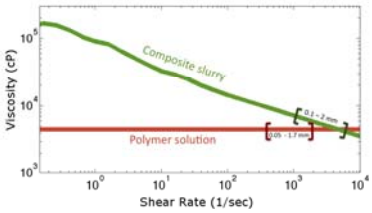


Custom dispenser printer



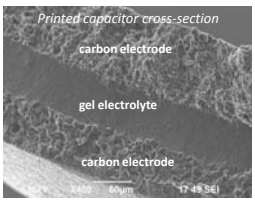
Integration of printed capacitor on a device

- Capable of 10-300 µm size factors
- Large viscosity range (100-10000 cP)
- Ambient, room temperature process
- Low waste
- Fast, scalable, economical

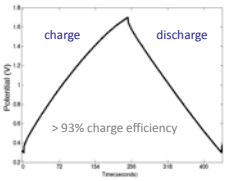


Printed Capacitors

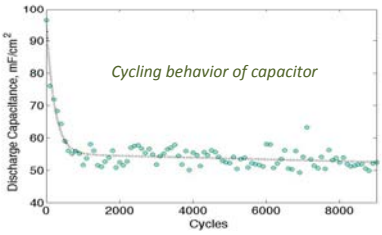
Carbon electrochemical capacitors, having similar materials constituents and geometric configuration, are being developed concurrently with the printed batteries.



Capacitor cell potential

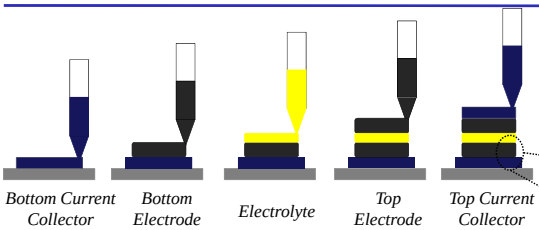


These are very stable and reversible devices; we have cycled a capacitor more than 120,000 times without performance degradation.

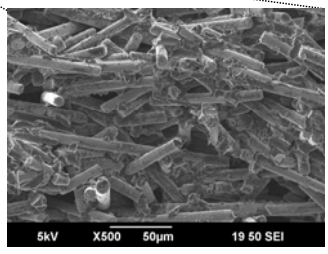


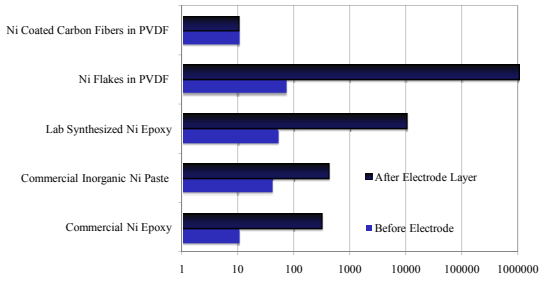
Current electrochemical capacitor performance			
Capacitance	Max. Power	Energy Density	Operating Voltage
100 mF/cm²	600 µW/cm² 60 mW/cm³ 50 W/kg	10 µW-hr/cm² 1 mW-hr/cm³ 1 W-hr/kg	0 – 2 V

Printed Current Collectors



Since we want our devices to be fully printable, we have recently made advancements in a printable current collector made up of nickel coated carbon fibers in a polymer matrix.





Current Collector Sheet Resistance (Ohms)

DRETD Demand Response enabling technology development
iTRIS Center for Information Technology Research in the Interest of Society
pier
BWRC