Printed Energy Storage Devices

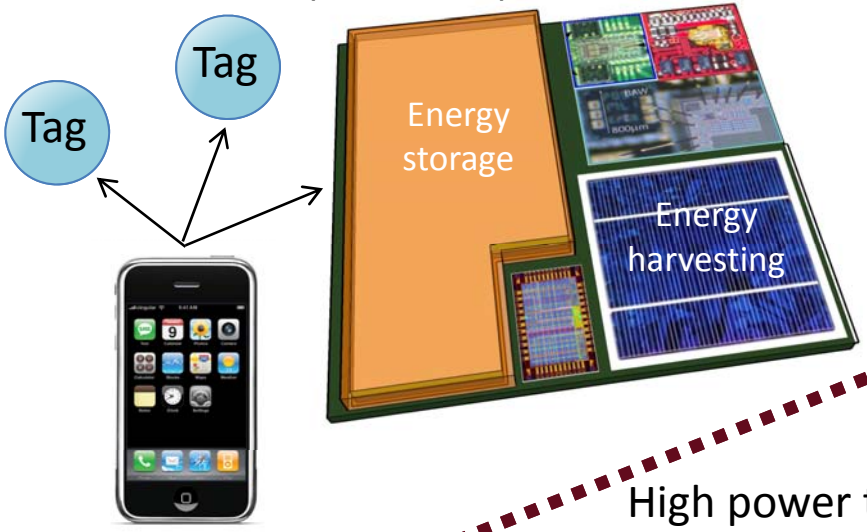
Christine C. Ho[1], Prof. James W. Evans[1] and Prof. Paul K. Wright[2]

[1]*Material Science and Engineering, University of California Berkeley, Berkeley, CA*

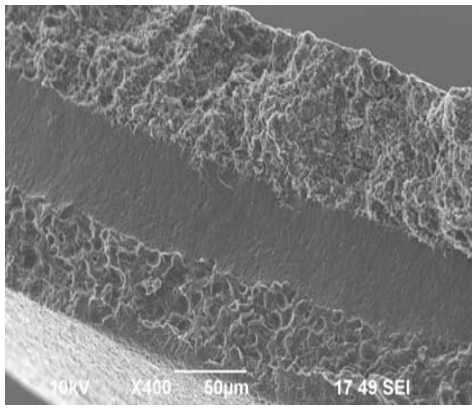
[2]*Mechanical Engineering, University of California Berkeley, Berkeley, CA*

Hybrid Energy Storage

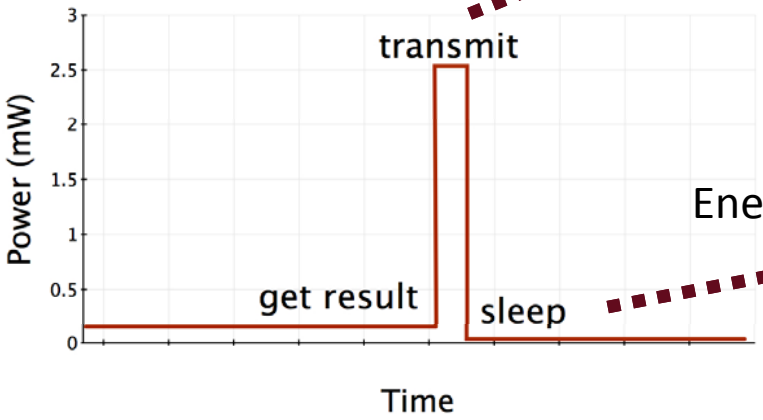
2011 - Active RFID Tag
(1 x 1 cm)



Carbon Electrochemical Capacitor

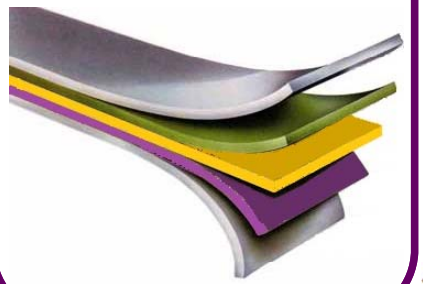


High power transmit



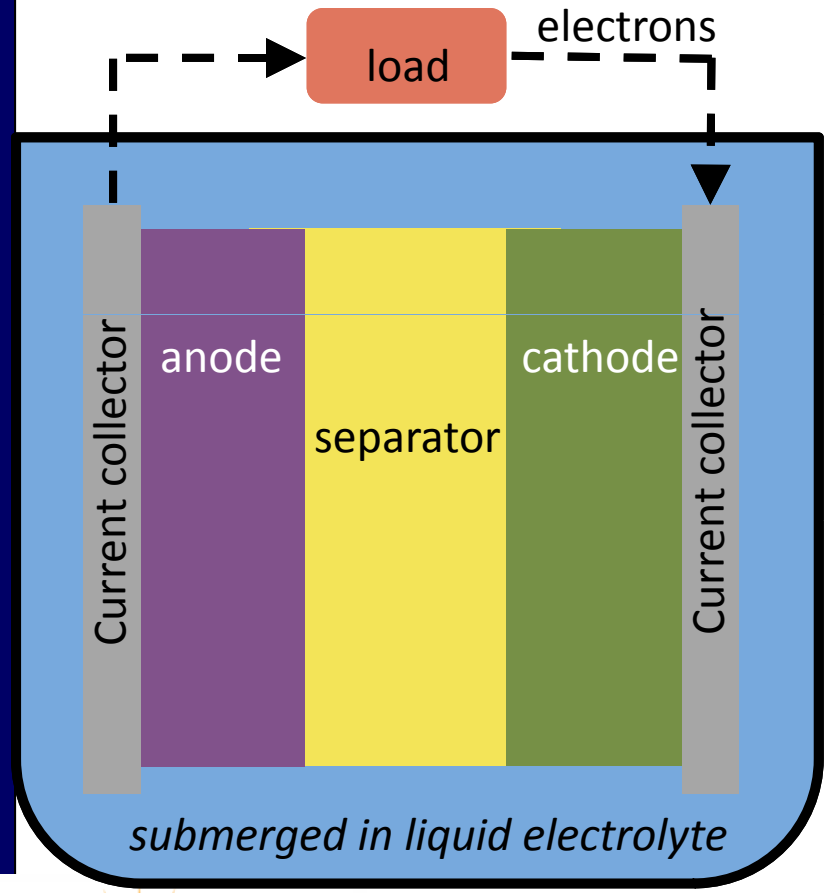
Energy reservoir

Zinc Polymer Battery

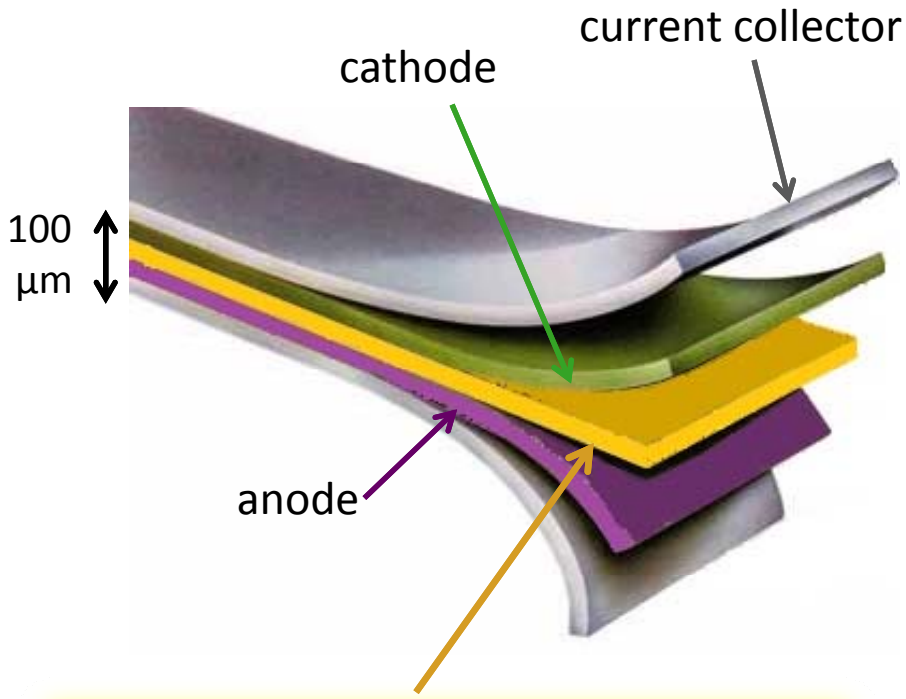


Microbattery Design

Generic Battery



Our Zinc Polymer Battery



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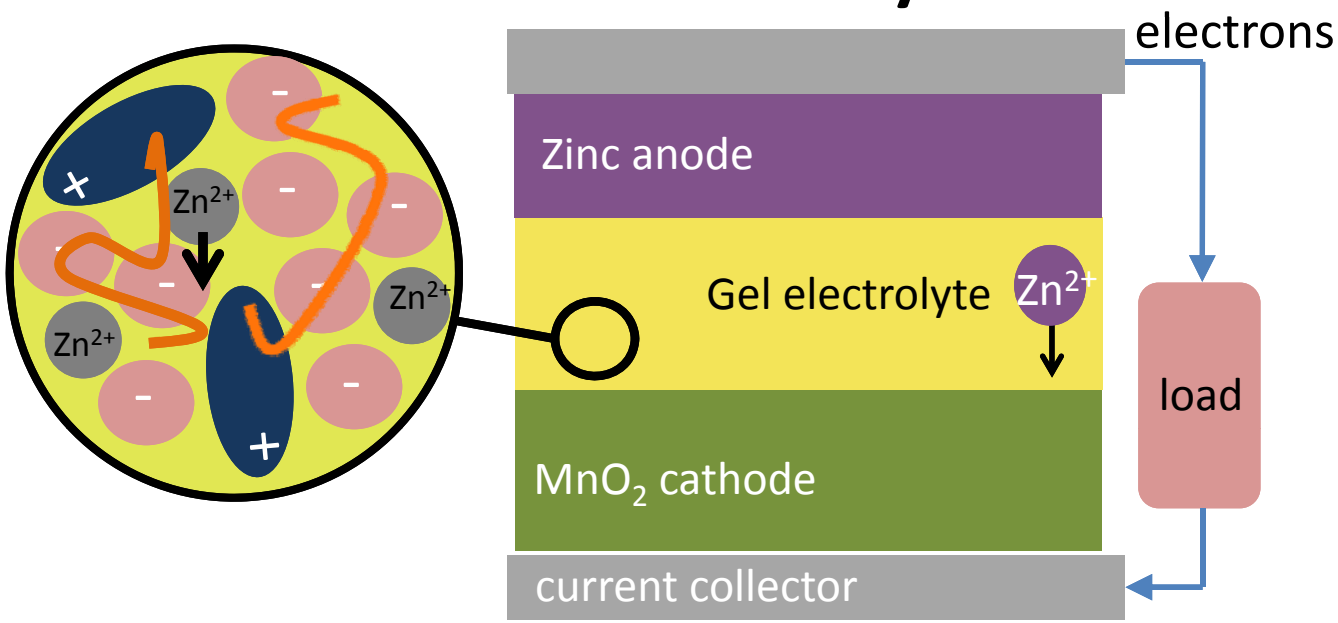
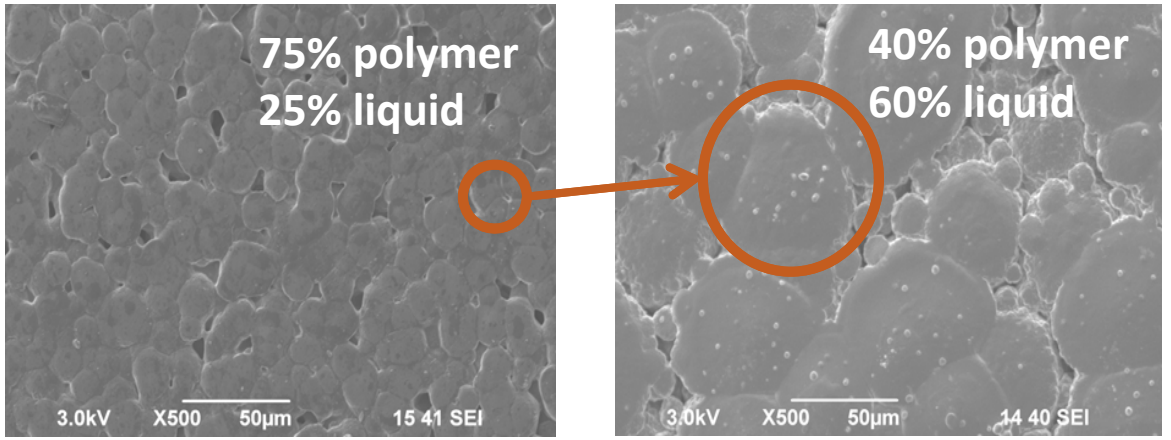
ENERGY COMMISSION

Gel Electrolyte



Liquid swells polymer to form gel electrolyte



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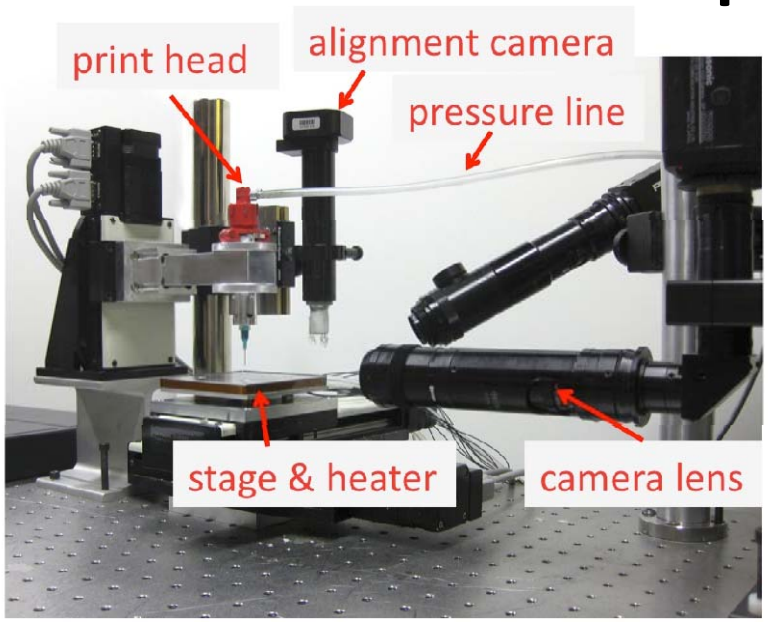
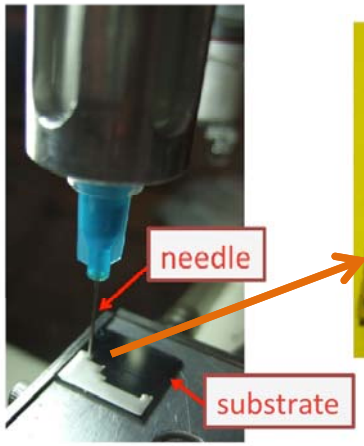
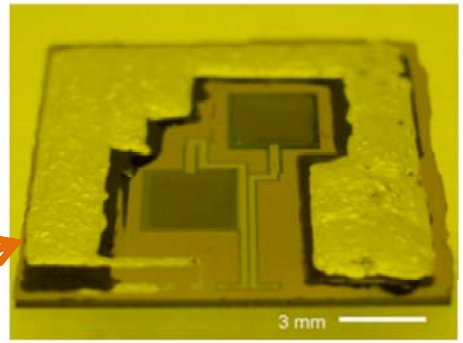
Fabrication: Dispenser Printing

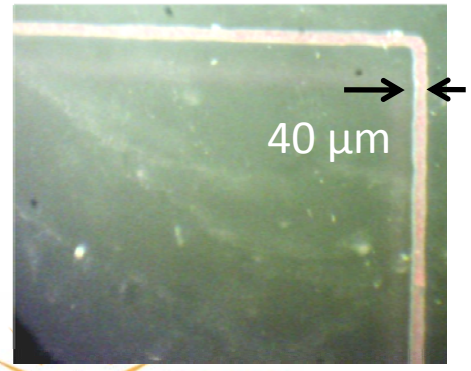




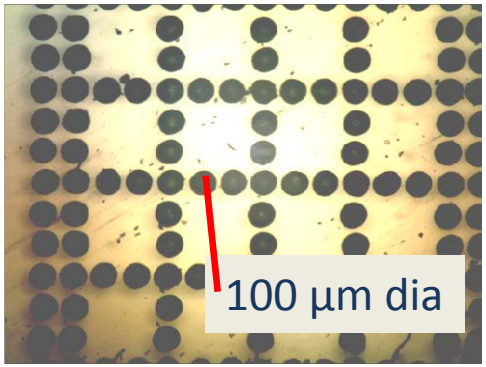
Integration of vibration energy harvester with printed capacitor



Continuous Printing



Drop on Demand



Dispenser printing:

- Capable of 5-300 µm size factors
- Large viscosity range (100-10000 cP)
- Ambient temperature process
- Low waste
- Fast, scalable, economical
- Continuous assembly processing

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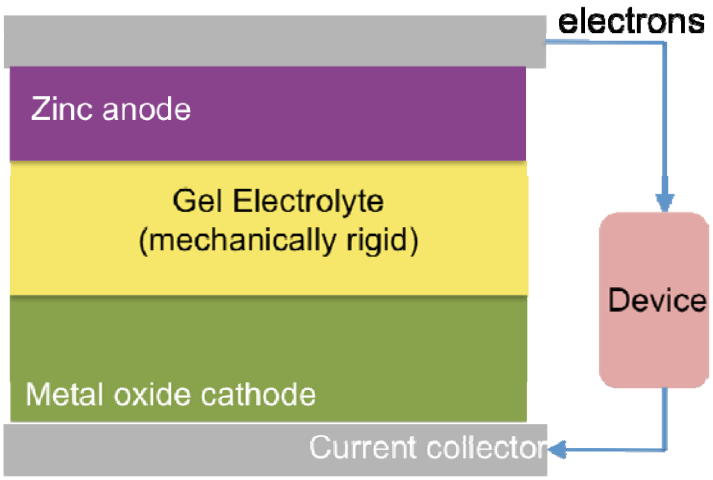
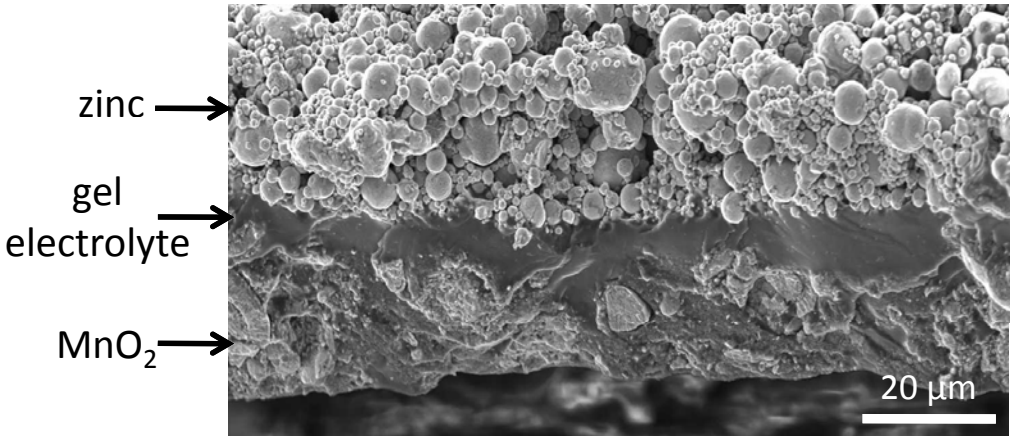
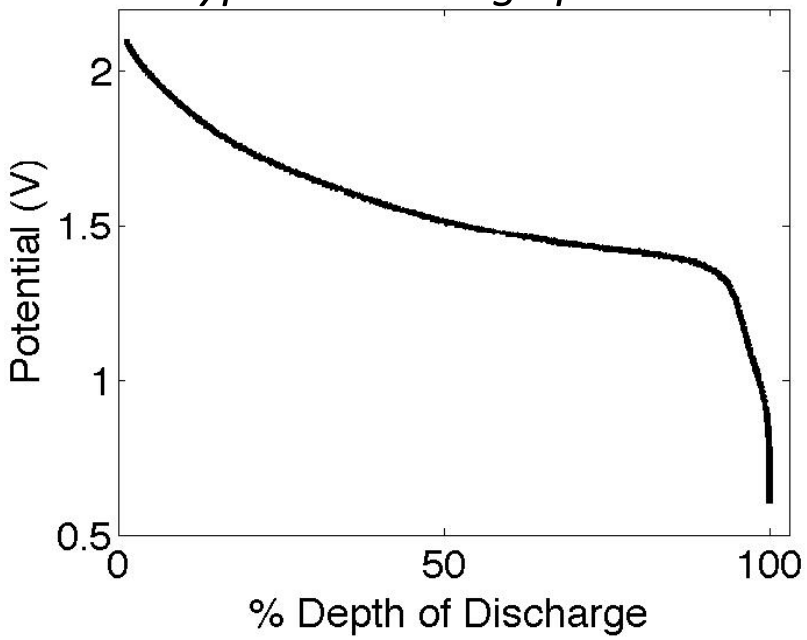
Printed Battery



Microbattery cross-section



Typical discharge potential



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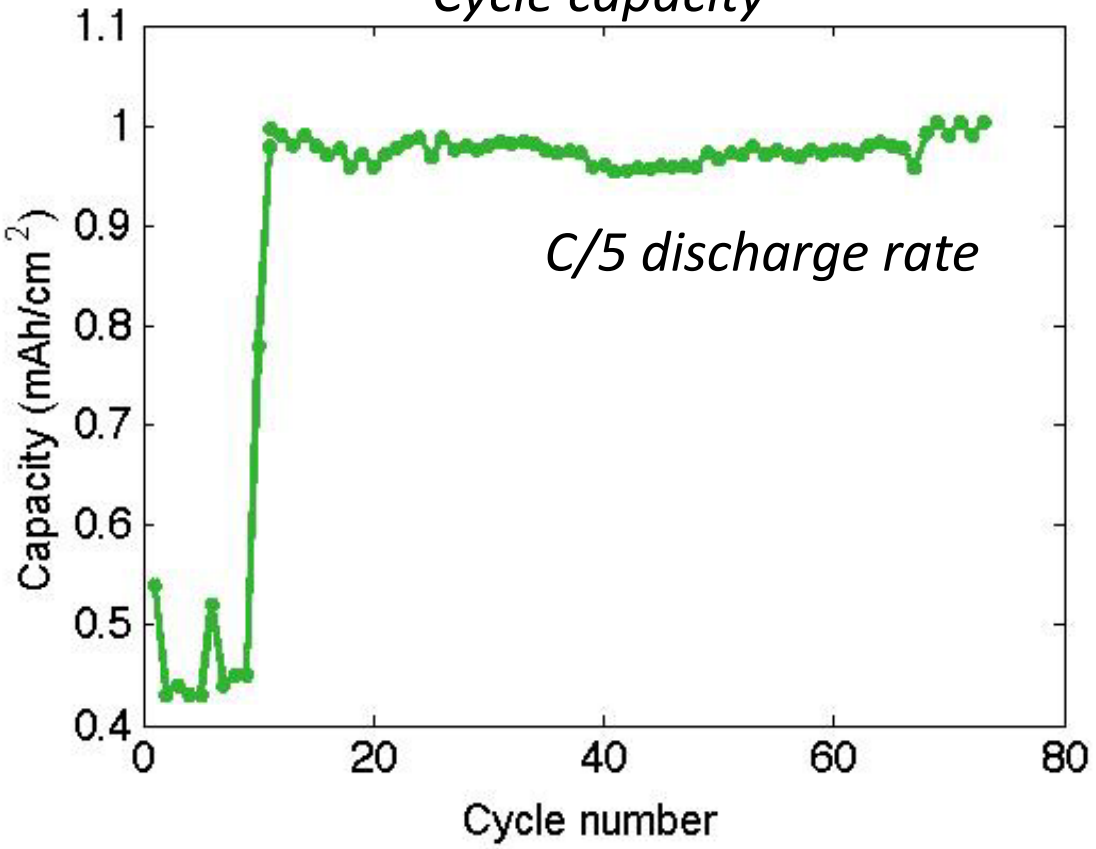
Battery Performance

Cycle capacity



Current microbattery performance		
Capacity	Energy Density	Operating Voltage
1 mAh/cm^2	1.5 mWh/cm^2 150 mWh/cm^3 130 Wh/kg	1 -2 V

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Hybrid Energy Storage

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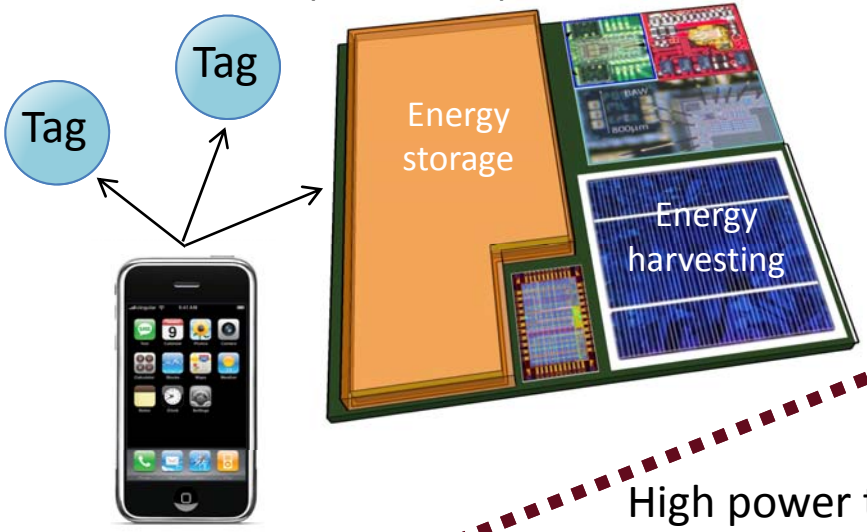
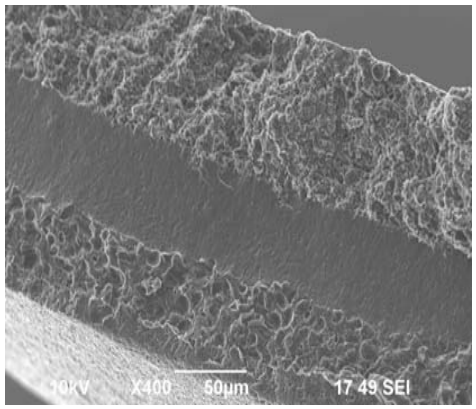


Carbon Electrochemical Capacitor



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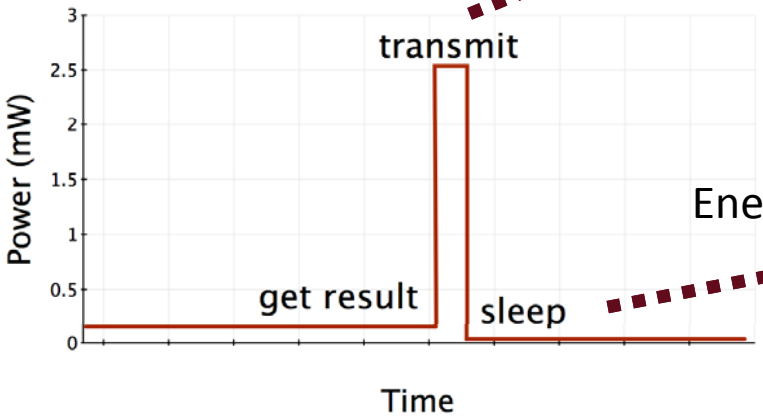

Energy reservoir

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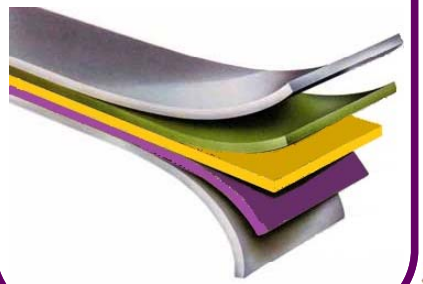
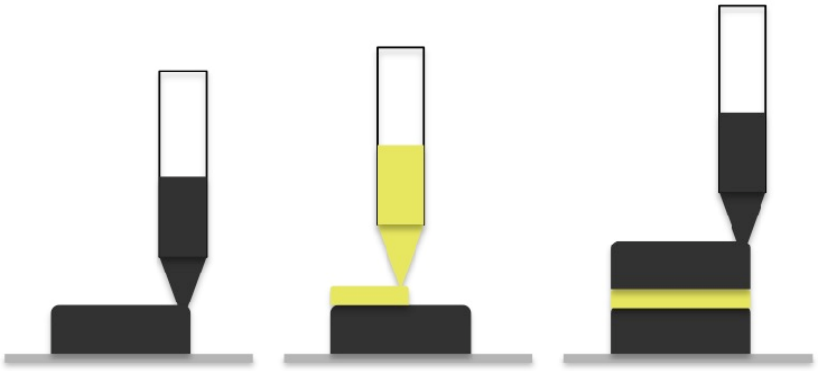
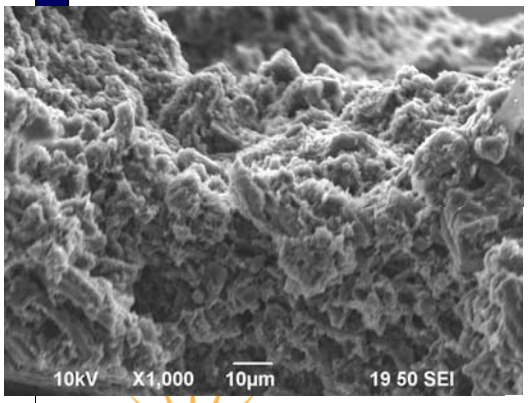


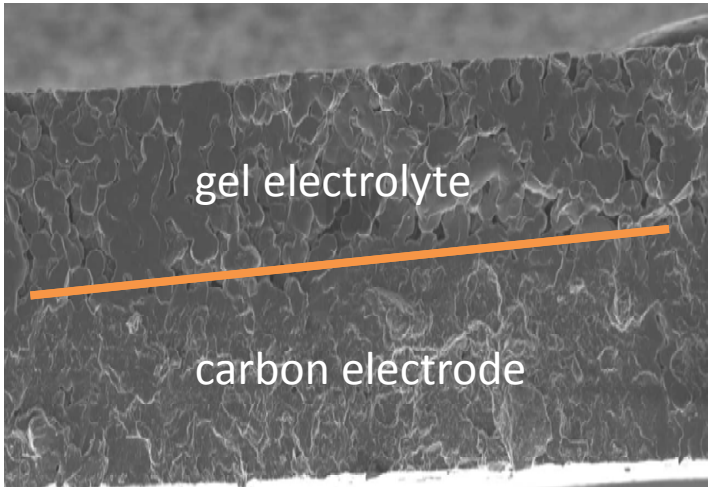
Printed electrochemical capacitors

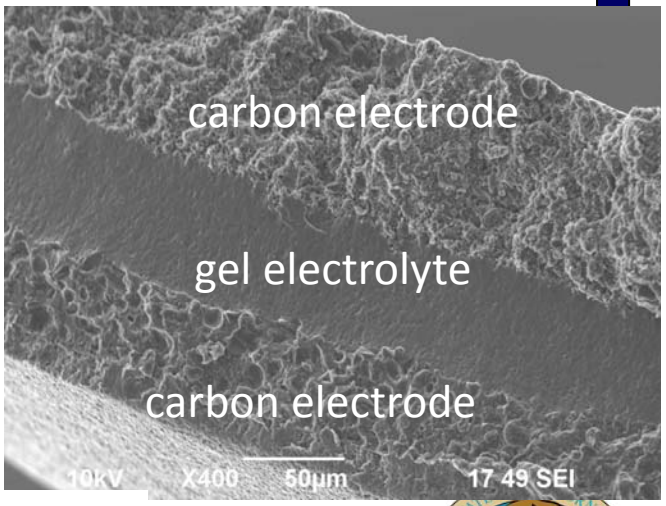


carbon electrode gel electrolyte carbon electrode

carbon electrode







Printed capacitor

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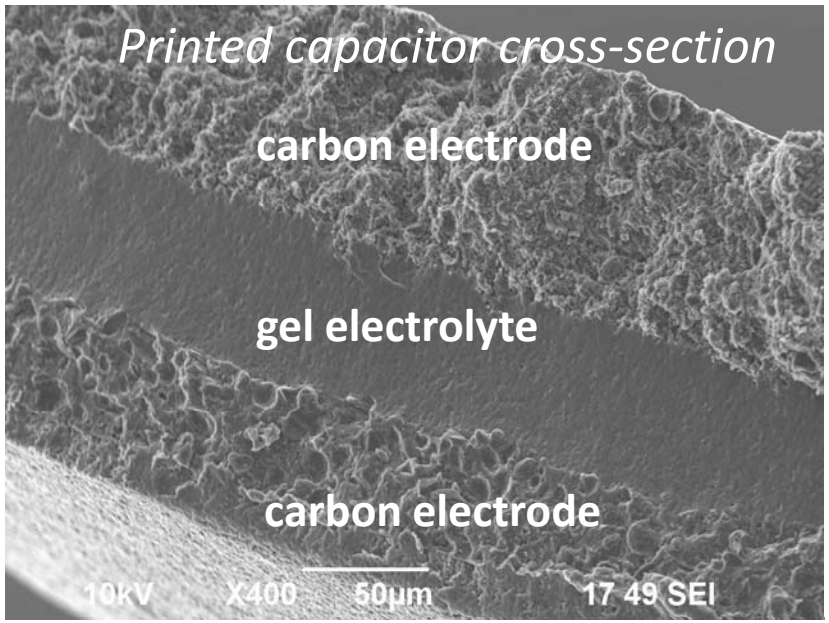
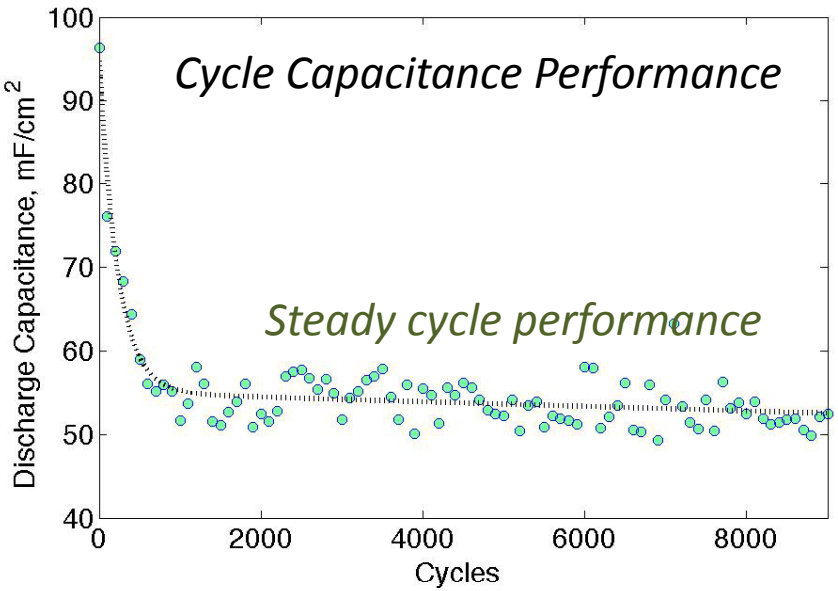
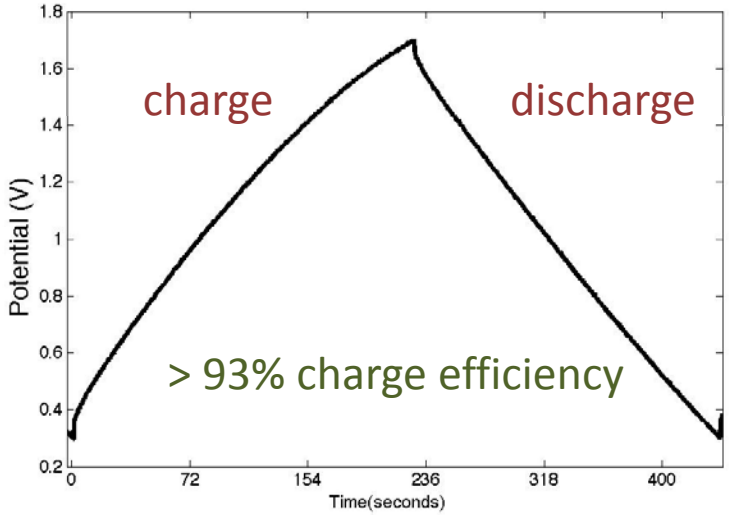
Capacitor performance



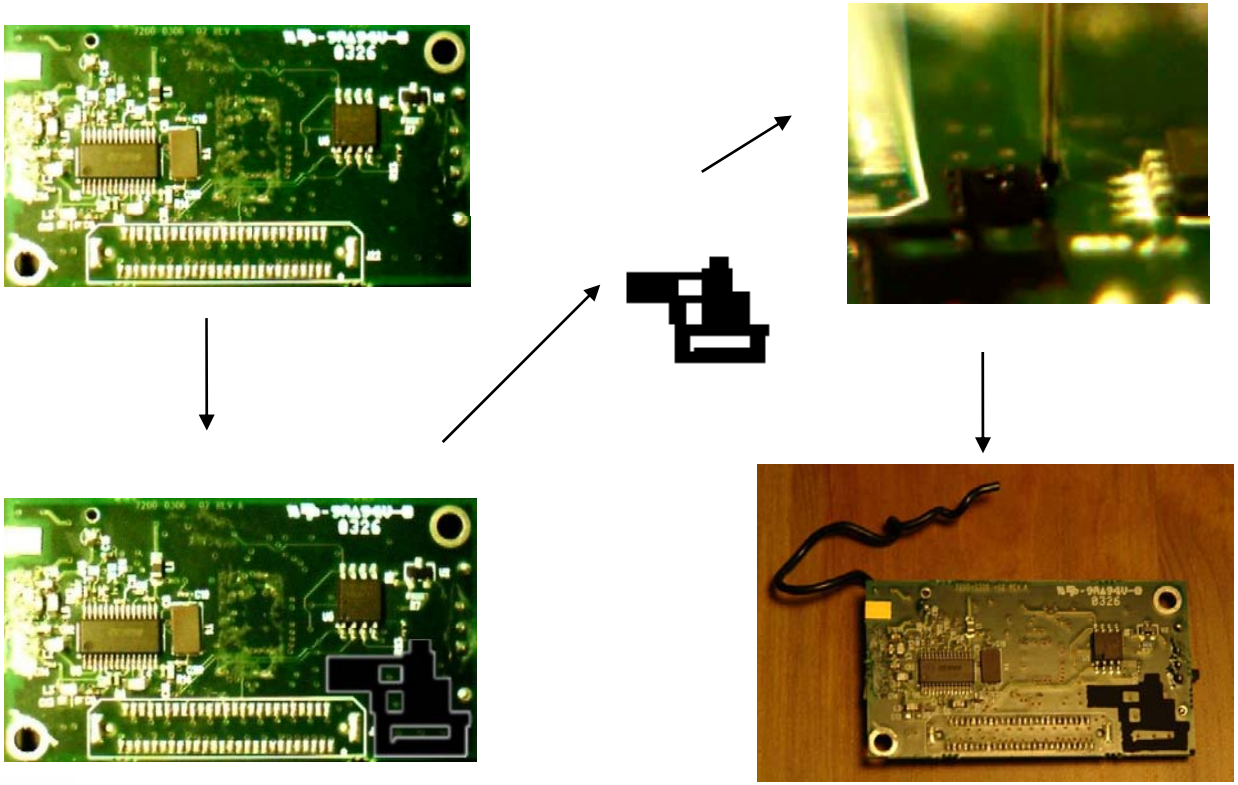


Charge and Discharge Potentials for 1 mA



Current electrochemical capacitor performance			
Capacitance	Max. Power	Energy Density	Operating Voltage
100 mF/cm^2	600 µW/cm^2 60 mW/cm^3 50 W/kg	10 µW-hr/cm^2 1 mW-hr/cm^3 1 W-hr/kg	0 – 2 V

"Printing on Green"



Thin and flexible displays

Thin, flexible displays need complimentary thin, flexible power source

e-reader

digital media refrigerator

smart labels

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Printed Media

Printable Batteries

Battery deposition can be incorporated into the automated printing process line

Sunday, February 1, 2009

San Francisco Chronicle

Jolt needed even if it's not perfect, experts say

Chronicle begins new era

The green revolution

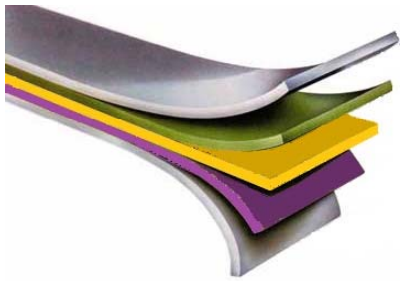
Political pull eased Scouts' dam problem

Parties take whack in tough economy

Print media advertisement

Large-scale energy storage

Zinc Polymer Battery



150 mWh/cm³

Prefabricated walls

~ 2,600 sq. ft

Printed Energy Storage Devices

- Fully printed energy storage devices (batteries and electrochemical capacitors) were fabricated
- Direct write dispenser printing is a flexible tool that can be useful for tailoring energy storage devices to provide optimal performance for a given application.
- Implementation and testing of printed energy storage devices is underway

- Acknowledgements: California Energy Commission, Delta Electronics, Berkeley Manufacturing Institute and Berkeley Wireless Research Center, Center for Information Technology Research in the Interest of Society

For more information, contact: christine.c.ho@berkeley.edu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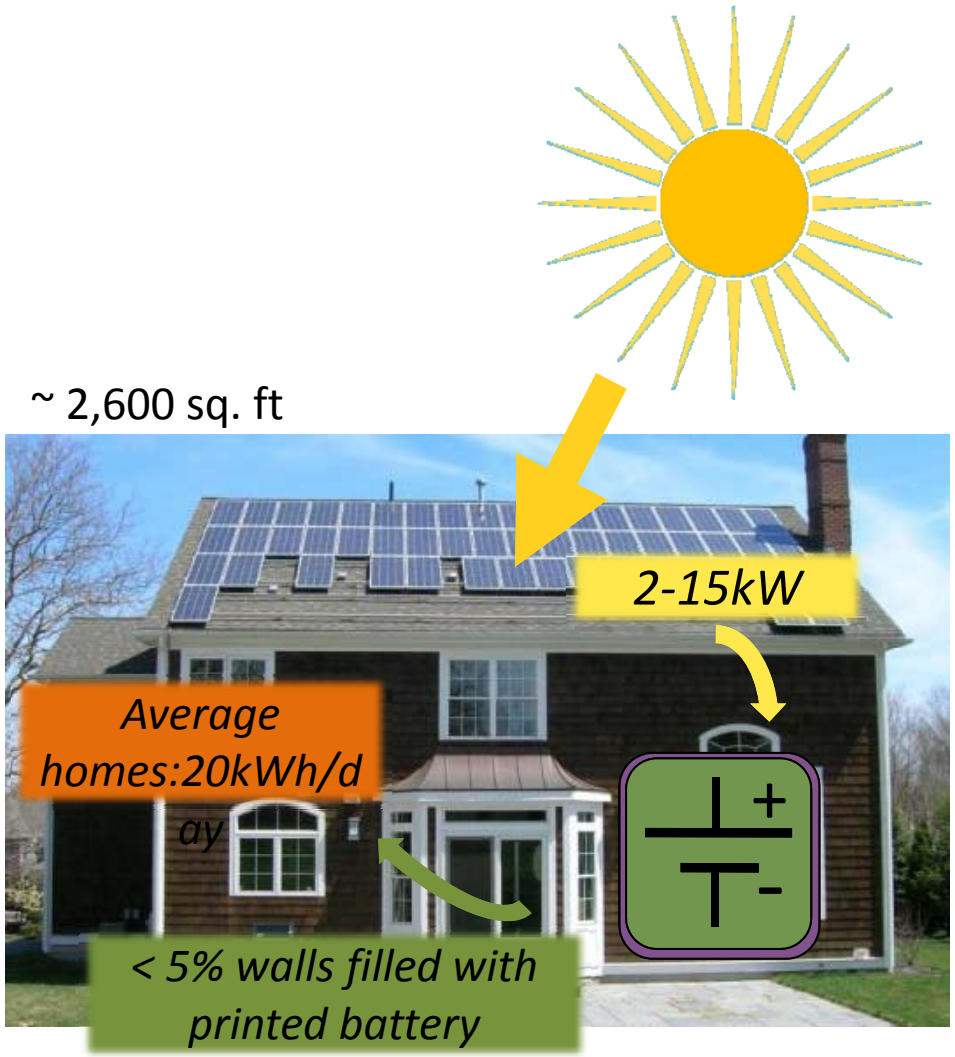
ENERGY COMMISSION



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Costs

Newsprint costs ~ $0.05/sq. meter

A square meter of printed battery stores 15 Wh

Component	$/sq. meter
Zinc	0.65
MnO_2	0.26
Organics	0.20
Collector/substrate	0.10
Printing	0.20
TOTAL	$1.51 = ***$101/kWh***

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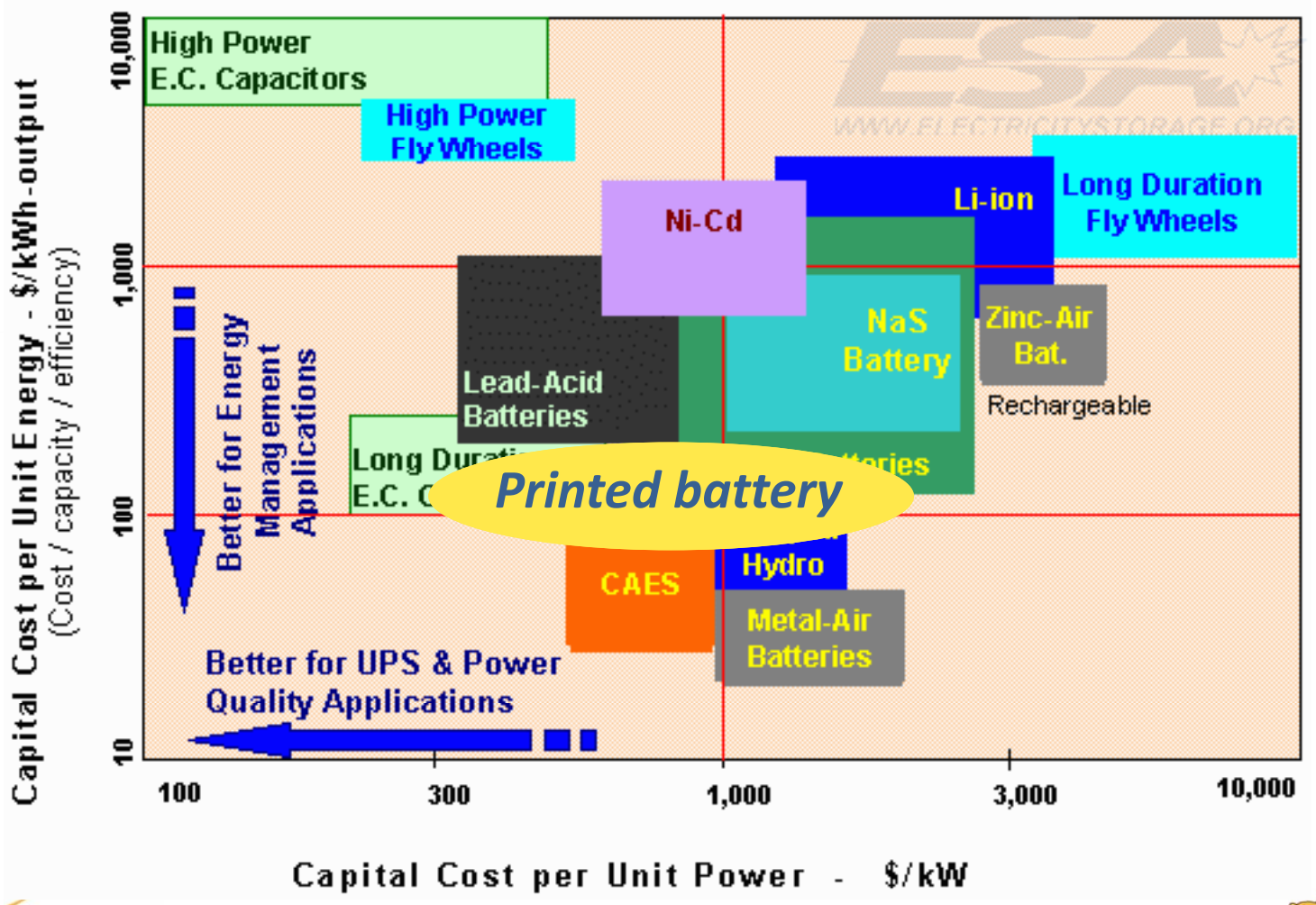
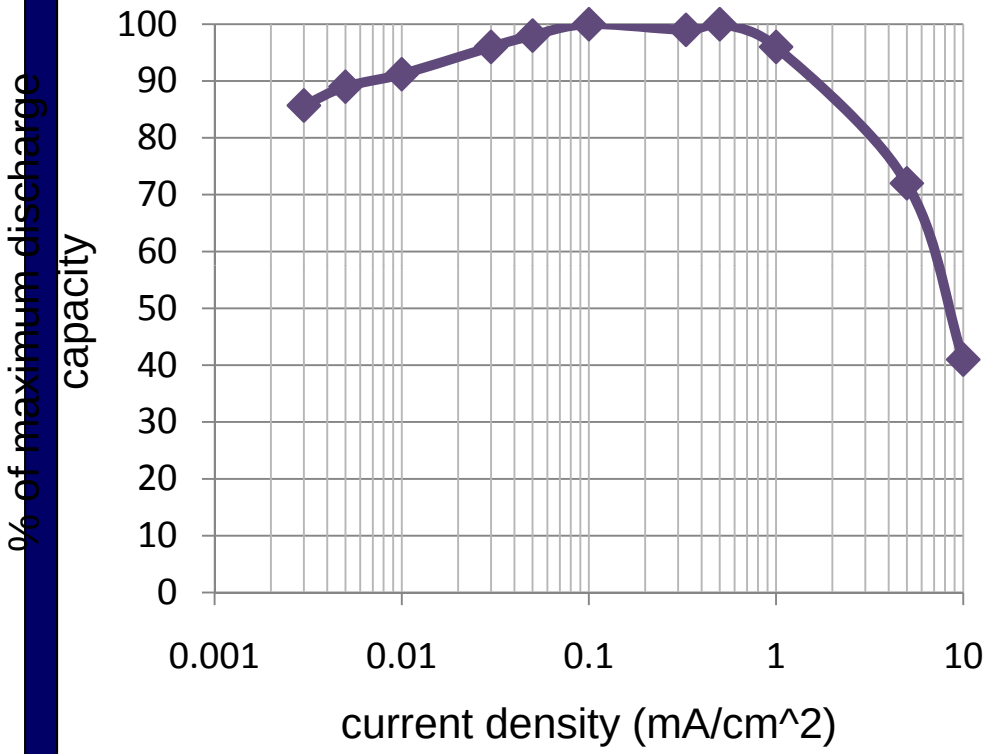
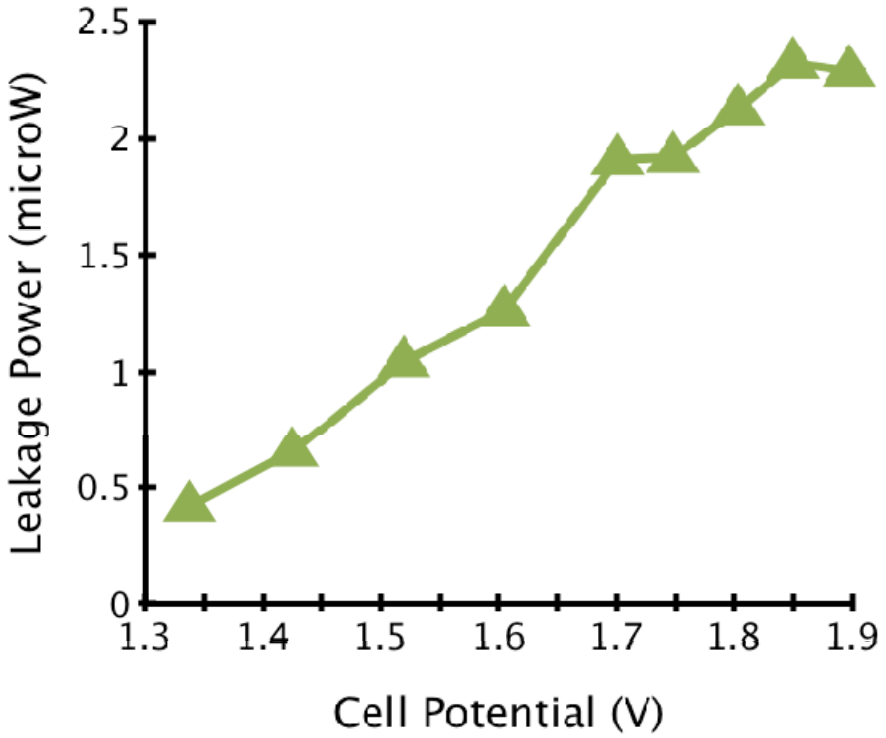


http://www.electricitystorage.org/site/technologies/

Storage capacity as a function of discharge current



Device leakage with respect to cell voltage



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