

# Safe Aqueous-Based High-Performance Electrochemical Energy Storage

## Team

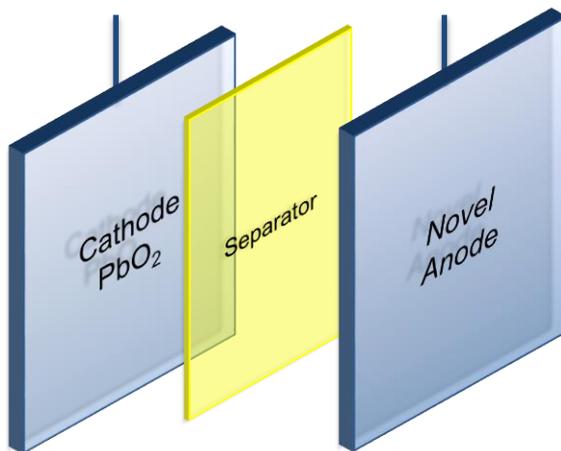
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Team member: Volta Materials Inc.

## Technology Overview

- *Discovered a pseudocapacitive material with high capacitance and rate performance*
- *To develop cheap yet high-performance lead-acid batteries based on existing cathodes and the pseudocapacitive anodes*
- *To manufacture such batteries using existing lead-acid manufacture capability*
- *To explore their use in automobile (start-stop, hybrid) and stationary energy storage.*

## Cell Configuration



## Current Status

### 1) **Status**

- *Scale & low-cost synthesis of the active material demonstrated*
- *Prototyped batteries with high performance demonstrated*

### 2) **Next Technical**

- *Reduce the cost of the batteries while maintain the high performance*

### 3) **Next Commercial**

- *Scale production of the batteries*

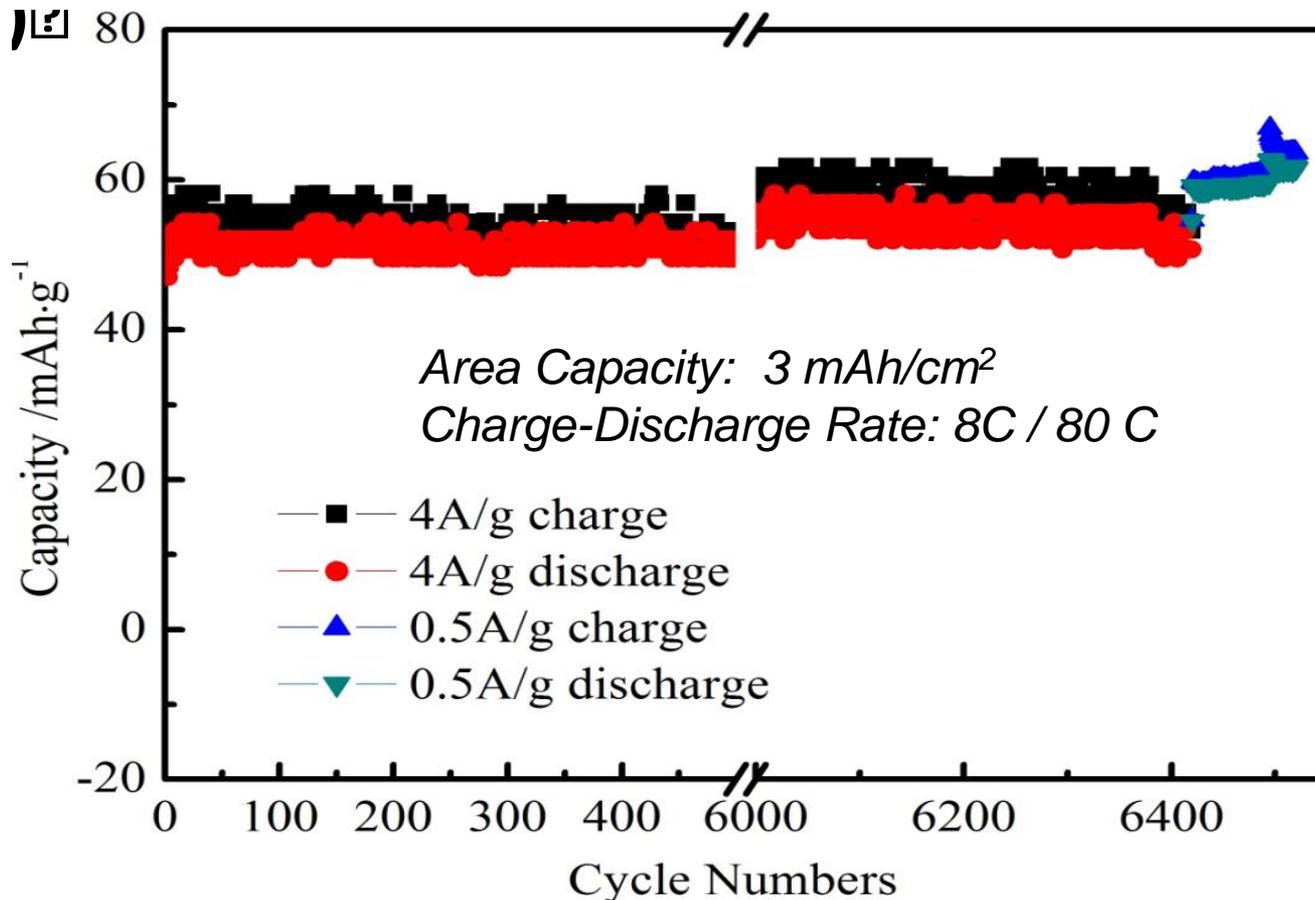
### 4) **Help Needed**

- *Identify manufacture partner in US*
- *Market the technology*

## Project Statistics

Award Amount	\$0.5M
Award Timeline	Nov 2013 – June 2015
Next Stage Target	1 KW Prototype ~ \$1.25M
Collaborations Sought	Volta Materials Inc.

# Long-Life Thick Anode Electrodes

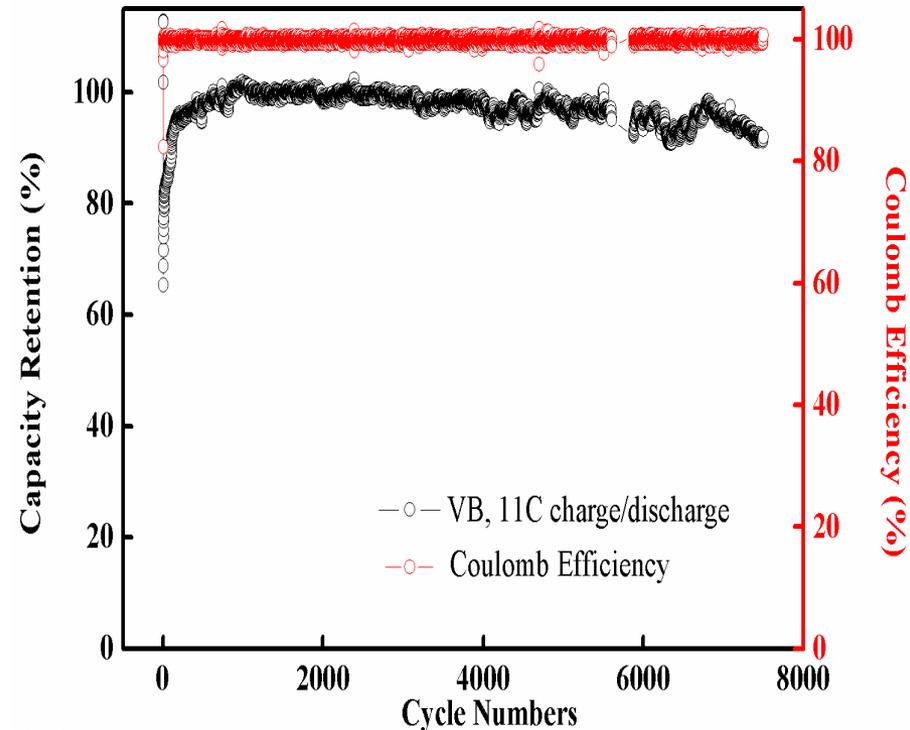


Low Cost ~\$16-\$20/kg of the active materials with a ton-scale production  
(Active Carbon for capacitors \$30-50/kg)

# High Performance Volta Batteries with Long Cycling Life

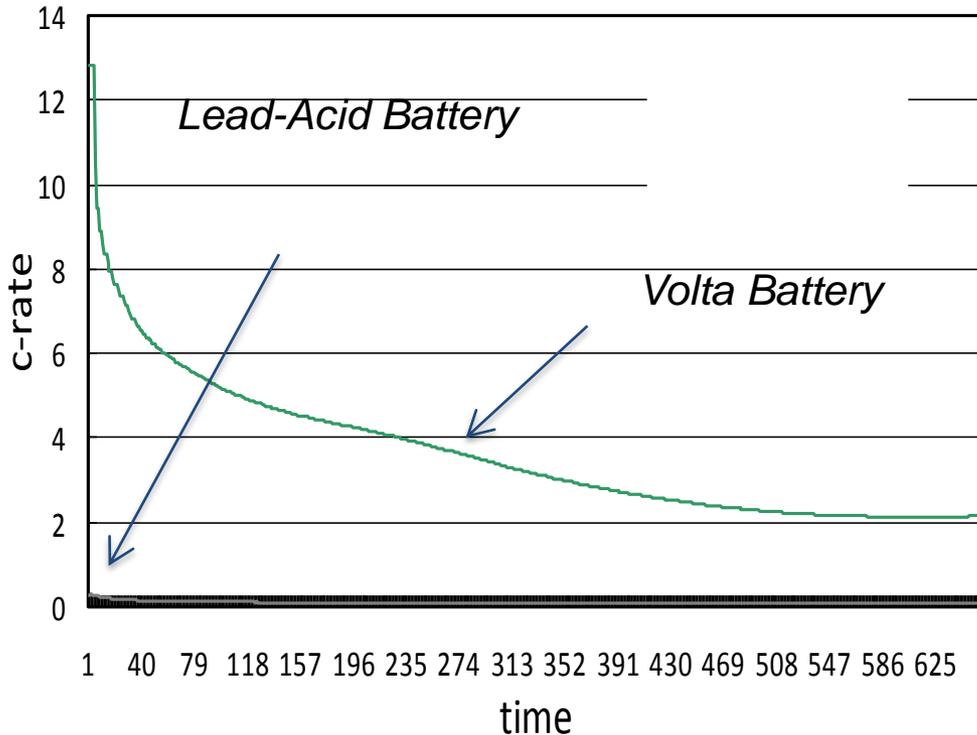
- **Cycling Life:**  
*> 5,000 cycles at 10 C, 100% DOD*
- **Power Density:**  
*10-20 times over lead-acid batteries*
- **Energy Density**  
*Similar to lead-acid batteries*
- **Manufacture:**  
*Utilize existing lead-acid capabilities,  
low CAPEX*
- **Safety:**  
*Aqueous system, non-flammable*
- **Outstanding performance**  
*Outstanding low-temperature performance  
Fast charging*

*Full Cell Cycling Life  
(over 8,000 Cycles at 11C rate)*



# SuperBattery Exhibits Outstanding Charge Capability

Charge Curves for Superbattery and Lead-Acid Battery



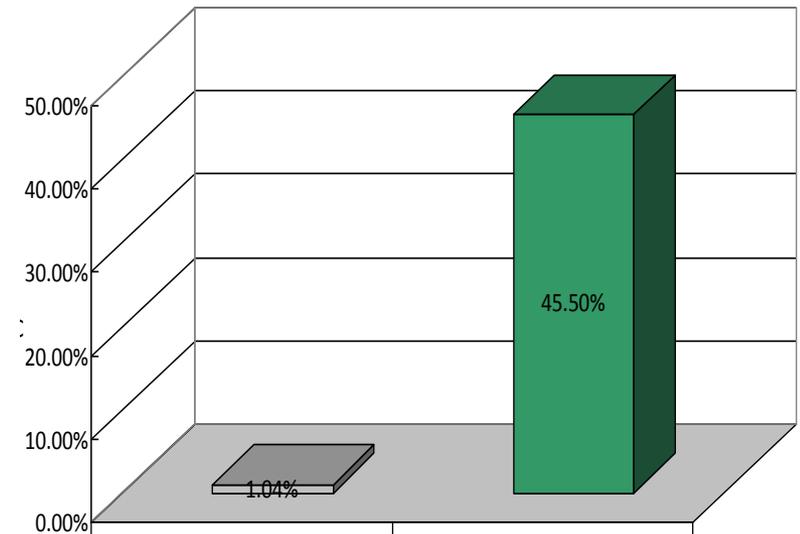
**Method:** charge the cell from 50% SOD under a constant voltage of 2.4 V

SuperBattery Effectively Uptakes High Current Charge

## Rapid Charging Capability

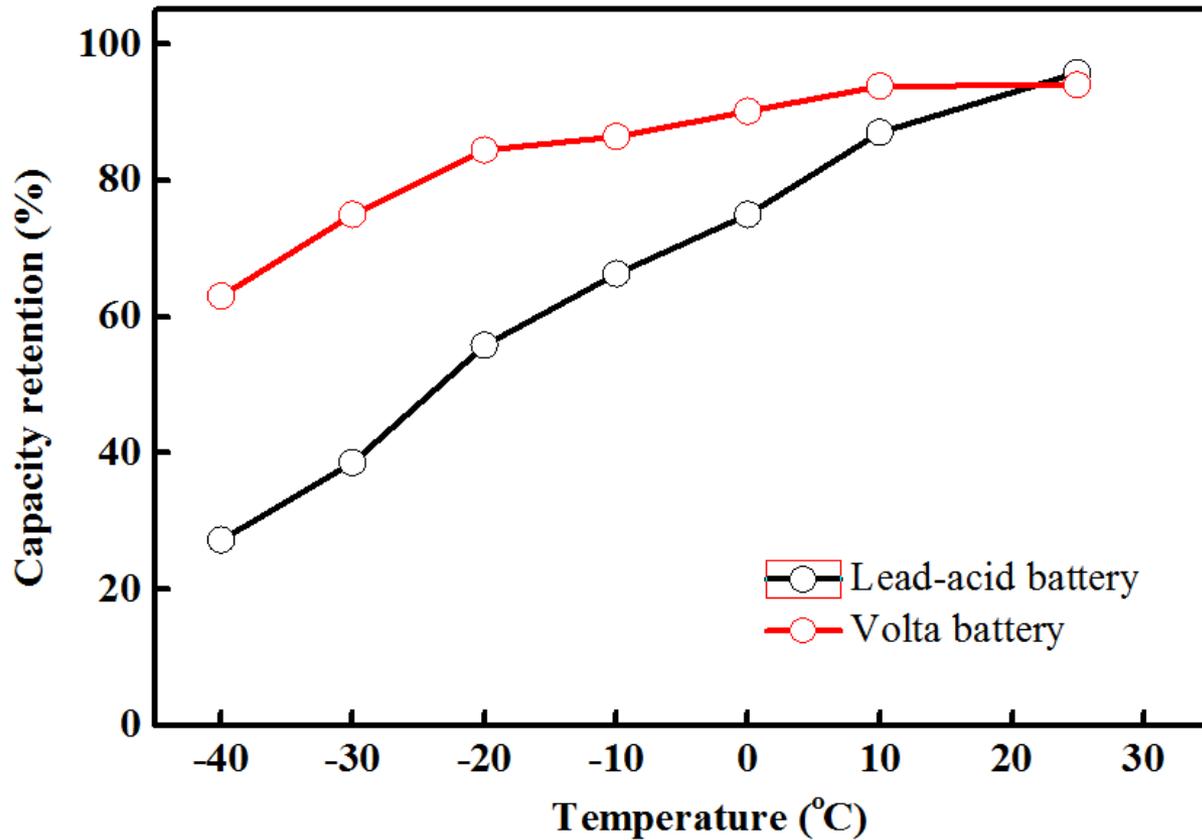
5-Min Charging increase the SOD from 50% to 95.5% for Volta Battery  
Vs.  
50% to 51.0% for Lead-Acid Battery

Increased State of Charge (SOD) after 5 min charging (2.4 V) from 50% SOD



# Outstanding Low-Temperature Performance

Temperature (°C)	25	10	0	-10	-20	-30	-40
Lead-acid Battery (%)	95.8	87	75	66.3	55.8	38.5	27.2
Volta Battery (%)	95.0	94	86.4	84.4	75	70	63



## Summary of the Achievements for the Seeding Project

1. *Demonstrated the scale synthesis of the active material*
2. *Fabricated prototyped batteries with ultralong life, high power, and outstanding low-temperature performance*

## Developments to be Made for the Plusup

1. *Reduce the cost of the battery through developing doping technologies*
2. *Explore their scale production using existing lead-acid manufacture capability*
3. *Implicate and market the technology for*
  - *Transportation (start-stop technology, hybrid vehicles, bus)*
  - *Communications*
  - *Renewal energy storage and grid energy storage*
4. *US manufacture of the batteries with the high performance of Lithium-ion batteries and with the low cost of lead-acid batteries.*

*Rejuvenate the 150 year old lead-acid battery technology*