Iron Based Flow Batteries for Low Cost Grid Level Energy Storage

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Purpose

Develop efficient, cost-effective grid level storage capability based on iron.

Goals of this Effort:

- Minimize Cost/Watt by increasing current density - Hardware Cost >> Electrolyte Cost
- Minimize Cost/Whr by increasing plating capacity
- Maximize Efficiency by minimizing current lost to hydrogen evolution

Electrochemistry of the all-Iron system:

Positive:	$Fe^{+2} \Leftrightarrow Fe^{+3}$	+0.77V
Negative:	$Fe^{+2} \Leftrightarrow Fe^{0}$	-0.44V
Cell:	$3Fe^{+2} \Leftrightarrow Fe^{0} + 2Fe^{+3}$	1.21V

Impact on Iron Based Batteries on the DOE OE Energy Storage Mission

Widespread grid level storage will require:

- Low Cost
  - All-Fe battery uses one low cost active element and inexpensive separators
- Environmental Acceptability
  - Mild pH, non-toxic electrolyte
- Geographic Flexibility
  - Iron is readily available from domestic sources

Research Plan

Year 1: COMPLETE

- Ligand Screening – demonstrated $[Fe^{+3}]$ >0.5M @ pH>2
- H_2 evolution suppression – effect of pH, anions evaluated

Year 2: IN PROGRESS

- Effect of Ligands on Fe plating efficiency, morphology
- Separator studies – Fe^{+3}, Ligand crossover

Year 3:

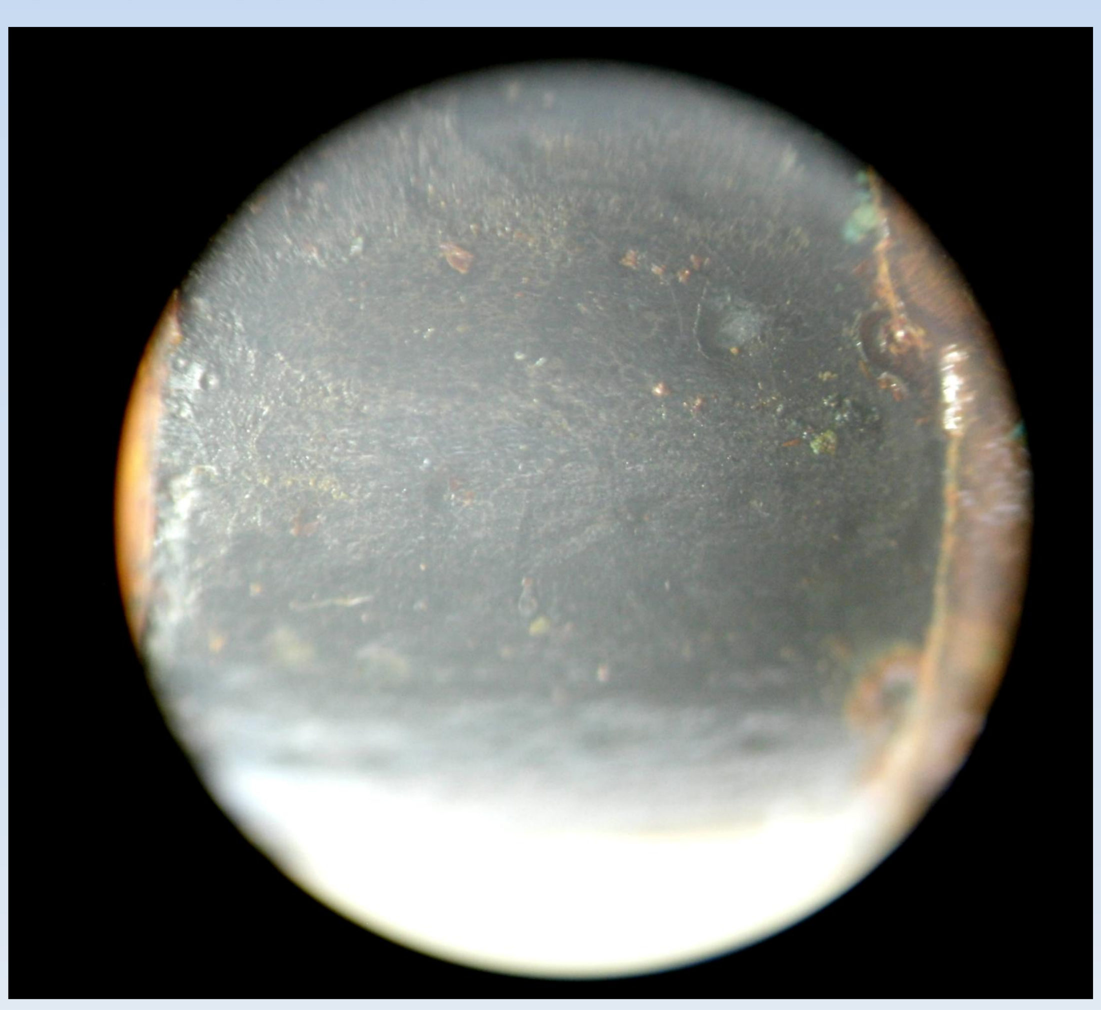
- Optimization of plating capacity, current density to maximize efficiency
- Scale up from 50 cm^2 to 250 cm^2

Recent Results

Demonstrated Adherent, Stress-Free, Dendrite-Free Plating

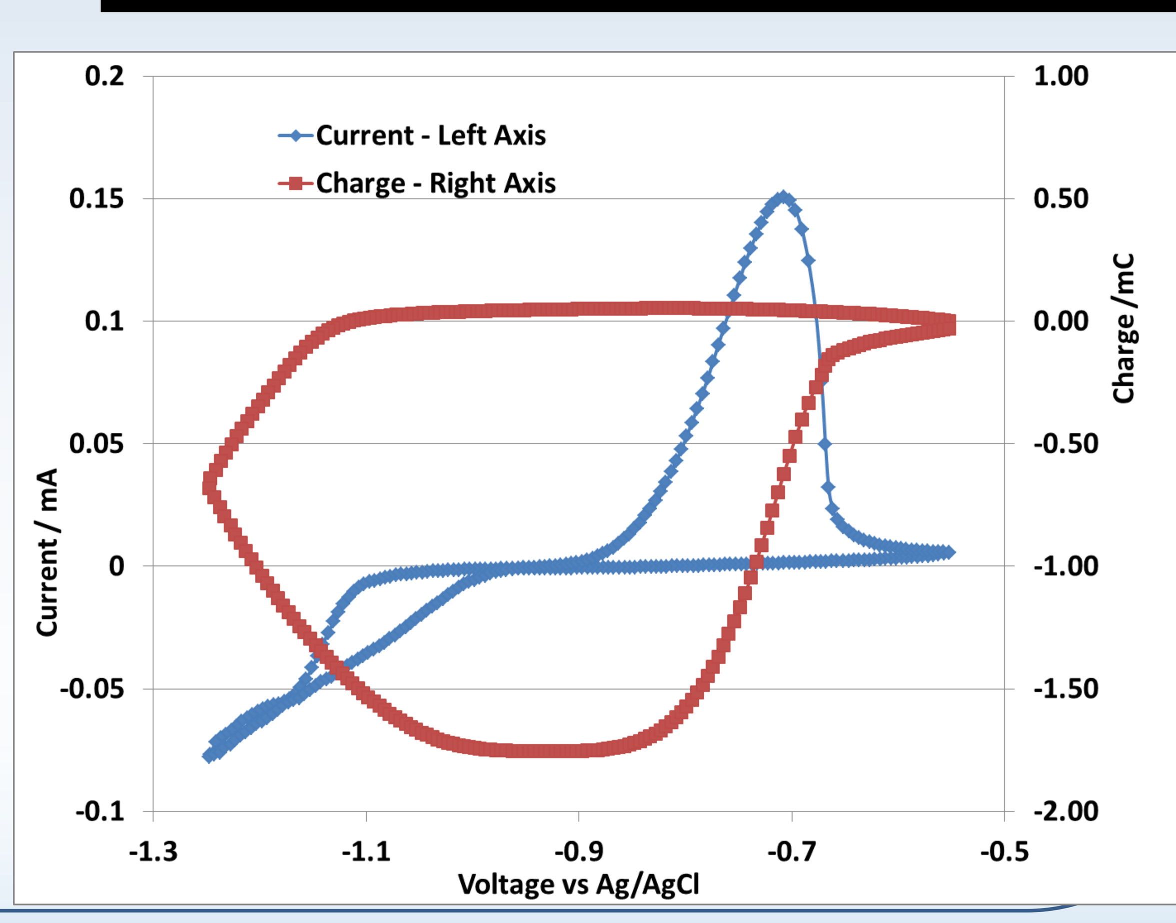
Deposit Thickness Shown is Equivalent to 75 mAh/cm^2

Deposits up to 150 mAh/cm^2 have been made



Demonstrated Coulombic Efficiency >99% for Iron Plating

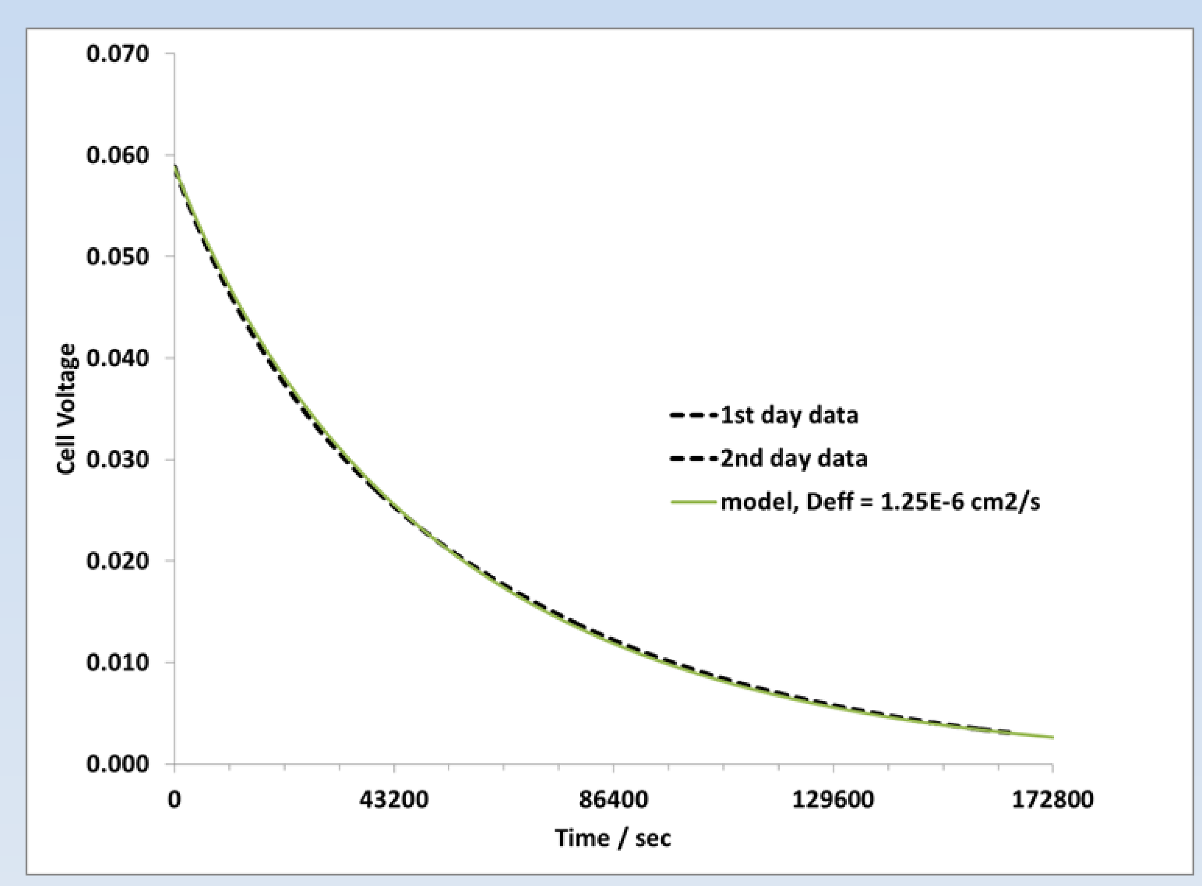
T = 60C



Recent Results

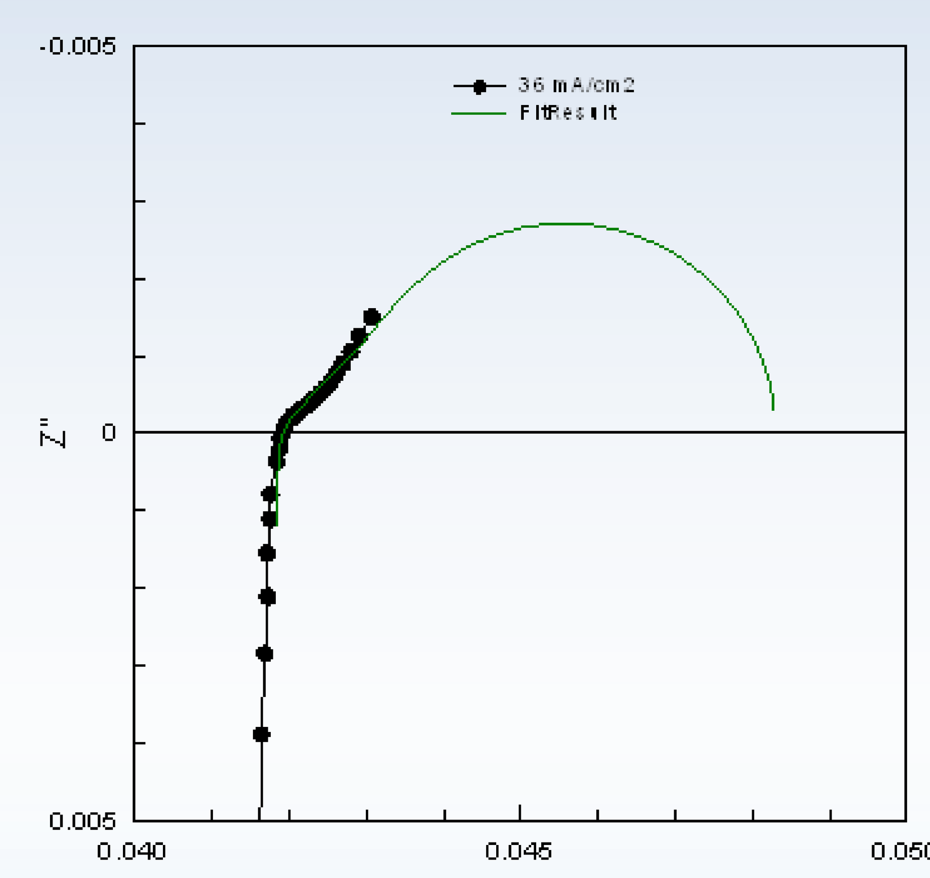
Measurement and model of Fe+3 crossover

- Room Temperature
- Daramic Separator
- Equivalent to 0.5% Capacity Loss in 24 hrs with Electrolyte Circulating



Measurement and model of Fe(II)/Fe(III) Overpotentials

- Negligible Kinetic Loss
- Ohmic and Mass Transfer Overpotentials
- Total Overpotential <20 mV @ 0.1 A/cm^2



Sandia National Laboratories

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