Extreme Fast-Charging Lithium-Ion Batteries

PI: Edward Buiel

Coulometrics, LLC

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Project ID: BAT398

Relevance

- **Objectives:**
  - Develop reliable eXtreme Fast Charging (XFC) 6C charge rate lithium-ion batteries (LIBs) to allow electric vehicles (Evs) to charge fully in just 10 minutes.
  - Minimize impact of high-rate charge on energy density maintaining at least 144 Wh/kg
  - Ensure that the technologies developed will provide fast-charge performance over the expected life of the EV.

- **Impact:**
  - Accelerate the adoption and EVs by developing lithium ion battery technologies and materials that will facilitate fast charging.

Milestones

Date	Milestones and Go/No-Go Decisions	Status
August 2019	≥120Wh/kg cell suitable for 500 6C charge/1C discharge cycles exhibiting <20% fade	Complete
August 2020	≥180Wh/kg cell suitable for 500 6C charge/1C discharge cycles exhibiting <20% fade	Ongoing

Approach

- Develop XFC LIBs focusing optimizing the following individually in budget period 1:
  - Anode material development
  - Cell design optimizations
  - Electrolyte optimization
- Build and test 18650 using a variety of state-of-the-art testing procedures
  - HPC
  - Onset of lithium plating determination (OLiP)
  - DOE XFC testing protocol
- Down-select optimized materials and battery designs for fully optimized cell testing in budget period 2.
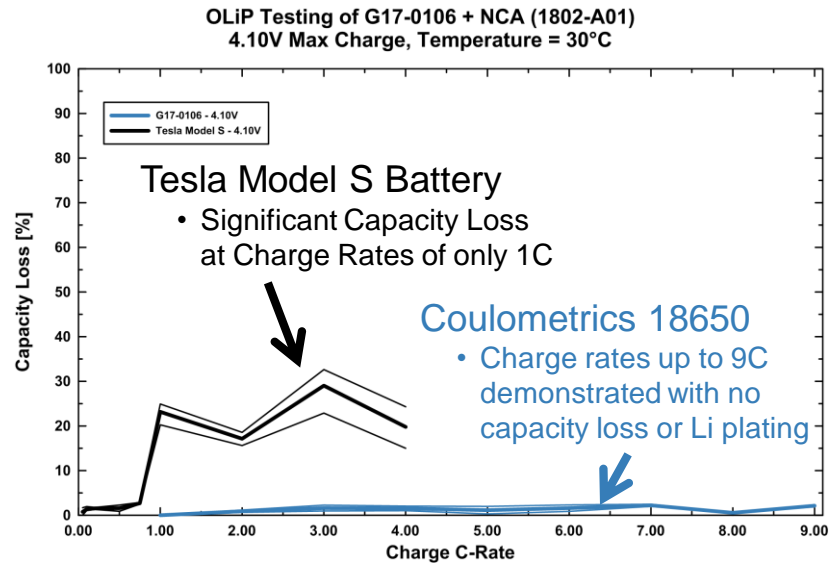
Accomplishments

- Production of 18650 sized full cell that meets BP1 milestone

- Reduction of full cell impedance by 42% through optimized cell design techniques

- Reduction of full cell impedance by 22% through optimized anode material and formulation

Accomplishments

Coulometrics
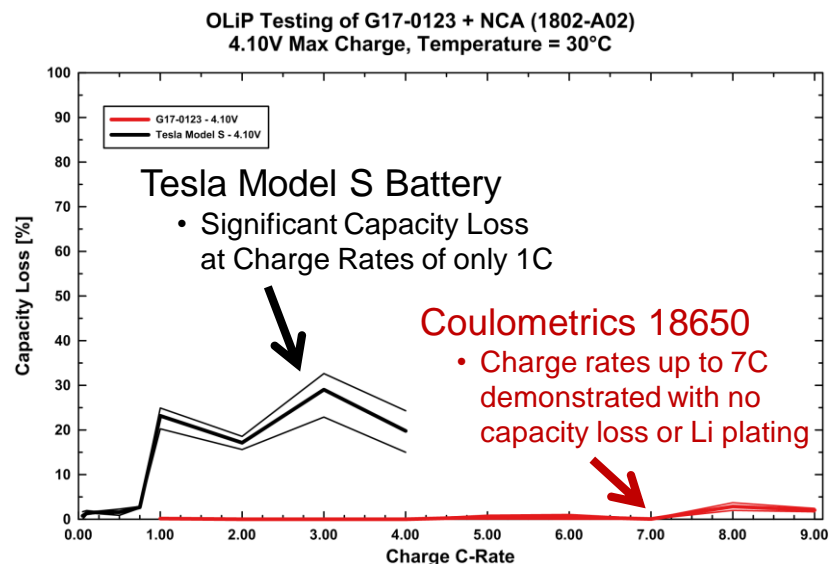
Gen 3 natural graphite power cell

- 1630mAh

- 87.7% FCE

- 10.04mΩ ACIR

OLiP Testing of G17-0106 + NCA (1802-A01)
4.10V Max Charge, Temperature = 30°C

Tesla Model S Battery
- Significant Capacity Loss
  at Charge Rates of only 1C

Coulometrics 18650
- Charge rates up to 9C
  demonstrated with no
  capacity loss or Li plating

Cell Weight [g]	Initial Energy [Wh/kg]	Final Energy [Wh/kg]	Energy Loss [%]
42.4	121.2	118.1	**2.52%**

Accomplishments

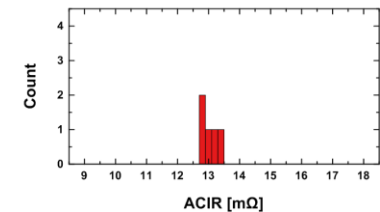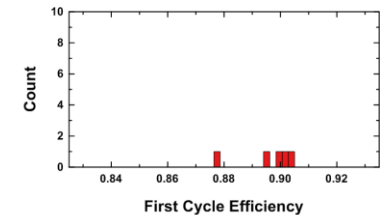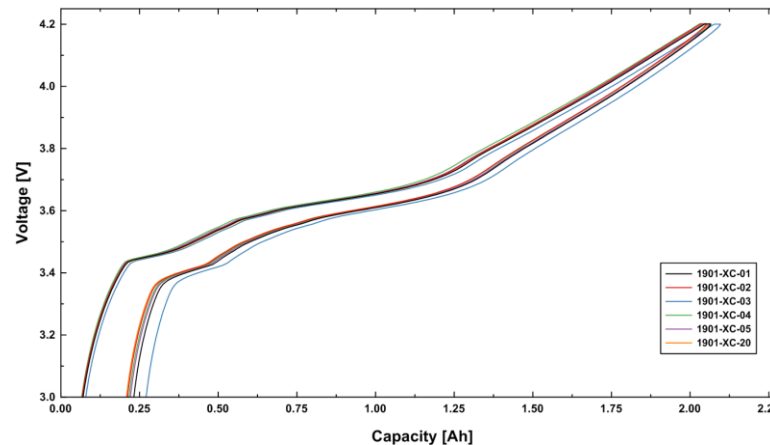Gen 3 artificial graphite power cell

- 1654mAh
- 88.2% FCE
- 10.48mΩ ACIR

OLiP Testing of G17-0123 + NCA (1802-A02)
4.10V Max Charge, Temperature = 30°C

- G17-0123 - 4.10V
- Tesla Model S - 4.10V

Tesla Model S Battery
- Significant Capacity Loss at Charge Rates of only 1C

Coulometrics 18650
- Charge rates up to 7C demonstrated with no capacity loss or Li plating

Cell Weight [g]	Initial Energy [Wh/kg]	Final Energy [Wh/kg]	Energy Loss [%]
42.6	120.8	118.5	**1.89%**

Accomplishments
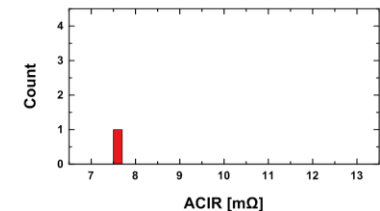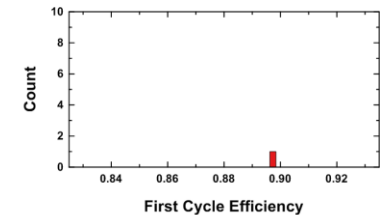
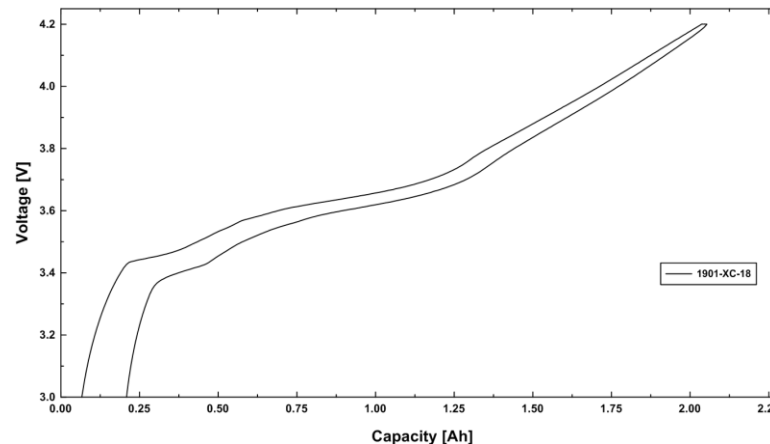Coulometrics

Baseline natural
graphite power cell

- 1850mAh

- 89.6% FCE

- 13.00 mΩ ACIR

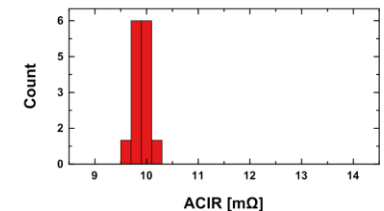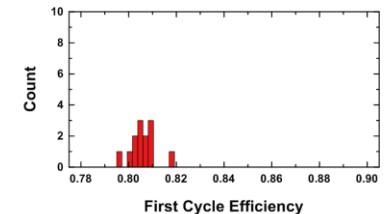# Accomplishments

Gen 4 natural
graphite power cell
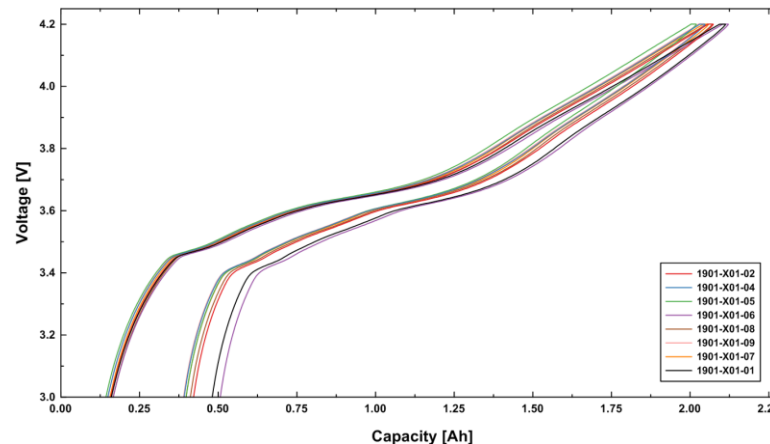
- 1844mAh

- 89.8% FCE

- **7.56**mΩ ACIR

Accomplishments

Coulometrics

Gen 2 artificial graphite power cell featuring optimized particle size

- 1640mAh

- 79.8% FCE

- 9.88mΩ ACIR

Response to Previous Year Reviewers' Comments

- This project was not reviewed last year

Partartnerships

- Coulometrics is currently working with a medical device company and will manufacture XFC batteries in Chattanooga, TN.

- Coulometrics is also working with automotive OEMs, power tool companies, and defense contractors to use Coulometrics XFC technologies in batteries produced by Coulometrics in Chattanooga, TN.

Remaining Challenges

- Complete the materials optimization work and homologate results in 18650 LIBs with balance of high-charge rate, high energy density, and long life.

- Existing technologies developed as a result of this program are being commercialized in a new battery manufacturing facility that is being built in Chattanooga, TN.

Any proposed future work is subject to change based on funding levels

Future Work

- FY19-FY20 Proposed work:
    - Complete material and cell optimization work currently planned for BP1 tasks.
    - Complete full cell homologation of optimized material and cell designs in BP2.
    - Ensure full cell homologation results in batteries that exhibit long life and limited resistance increase over the life of the cell. This could lead to premature cell failure due to lithium plating on the negative electrode during XFC.

Any proposed future work is subject to change based on funding levels

Summary

- Development work and testing conducted in Budget Period 1 indicates that Coulometrics is on track to deliver 18650 lithium ion batteries that will exhibit:
  - 6C fast charging capability
  - 144 Wh/kg energy density
- Current Budget Period 1 Milestone already accomplished:

Date	Milestones and Go/No-Go Decisions	Status
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