

## 2019 U.S. DRIVE Highlight

# Real-Time Detection of Lithium Plating During Fast Charge of Lithium Ion Batteries

*High precision characterization techniques allow early detection of lithium plating and assessment of novel anode improvements.*

## Sandia National Laboratories

Fast charging of lithium ion batteries is a critical enabler for mass EV adoption. Sandia National Laboratories (SNL) has been working with the University of Michigan to develop graphite anodes with novel 3D structures that facilitate faster charging while avoiding lithium plating, a main danger of unaided fast charging. SNL is using its unique high precision cycling capability, developed through ARPA-E funding, to characterize the ability of improved anodes to withstand fast charge and resist lithium plating, and the danger of lithium plating in present-day batteries.

SNL has observed discrete signals related to lithium plating at increased charge rates, using a technique called differential coulometry, which benefits from our high precision cycling capability. Figure 1 shows differential coulometry plots for battery charges at increasing rates (light blue to dark red). The 2.85Ah pouch cell contained a standard graphite anode with no improvements. The cell had an energy density of 200 Wh/kg, which is particularly high and automotive-relevant.

At low charge rates (0.5C, 2 hour charge), peaks from 3.5-3.8V indicate normal charging behavior. At higher rates (> 3C; 20 min charge), a second growing peak at 4.1V indicates a new process occurring, which is believed to be lithium plating. Such an observation allows real-time identification of lithium plating behavior, including at what current it occurred, and to what degree. By identifying the very earliest signs of lithium plating, the project now has a powerful tool to compare unimproved anodes similar to present day batteries, with batteries containing advanced 3D structuring. Using such tools, our project aims to deliver batteries with the ability to charge as quickly as in 10 minutes.

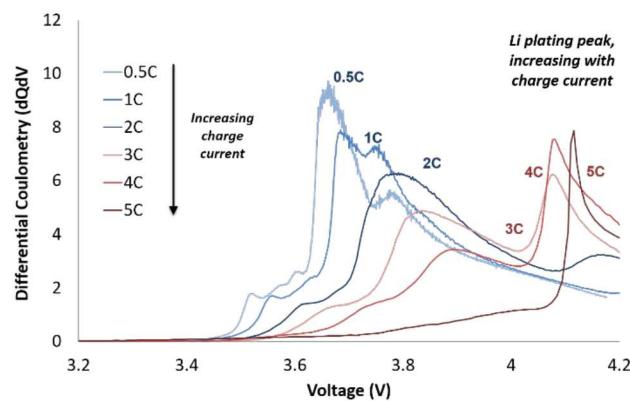


Figure 1: Differential Coulometry ( $dQ/dV$ ) of charge steps



Figure 2: Cell teardown picture of standard graphite anode with clear evidence of plated lithium.

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