National Aeronautics and Space Administration

Zero-volt tolerant lithium-ion batteries for surviving spacecraft dead bus scenarios

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Program: FY22 R&TD Topics
Strategic Focus Area: Energy storage

Objective:

Develop battery materials to resist degradation during deep discharge (zero-voltage) events.

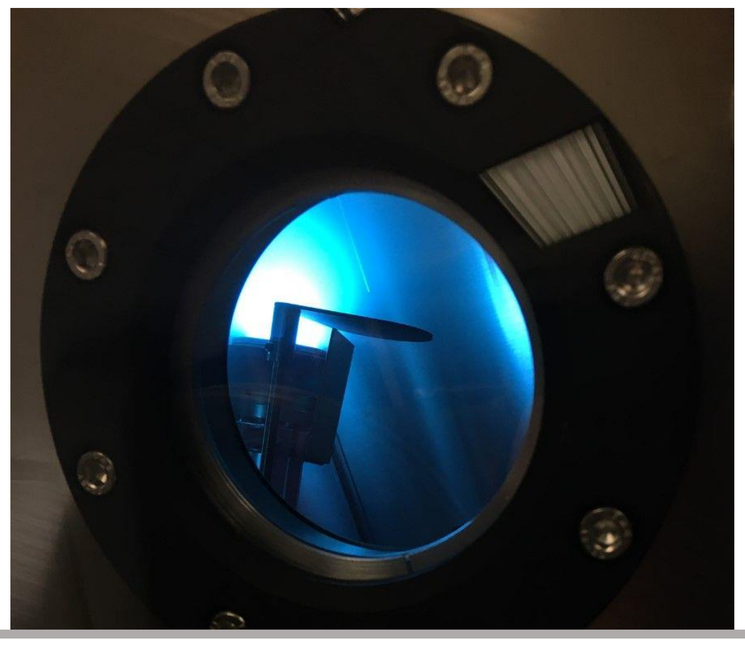
- Investigate novel anode substrate materials
- Investigate modified electrolytes
- Incorporate materials into prototype coin cells

Background:

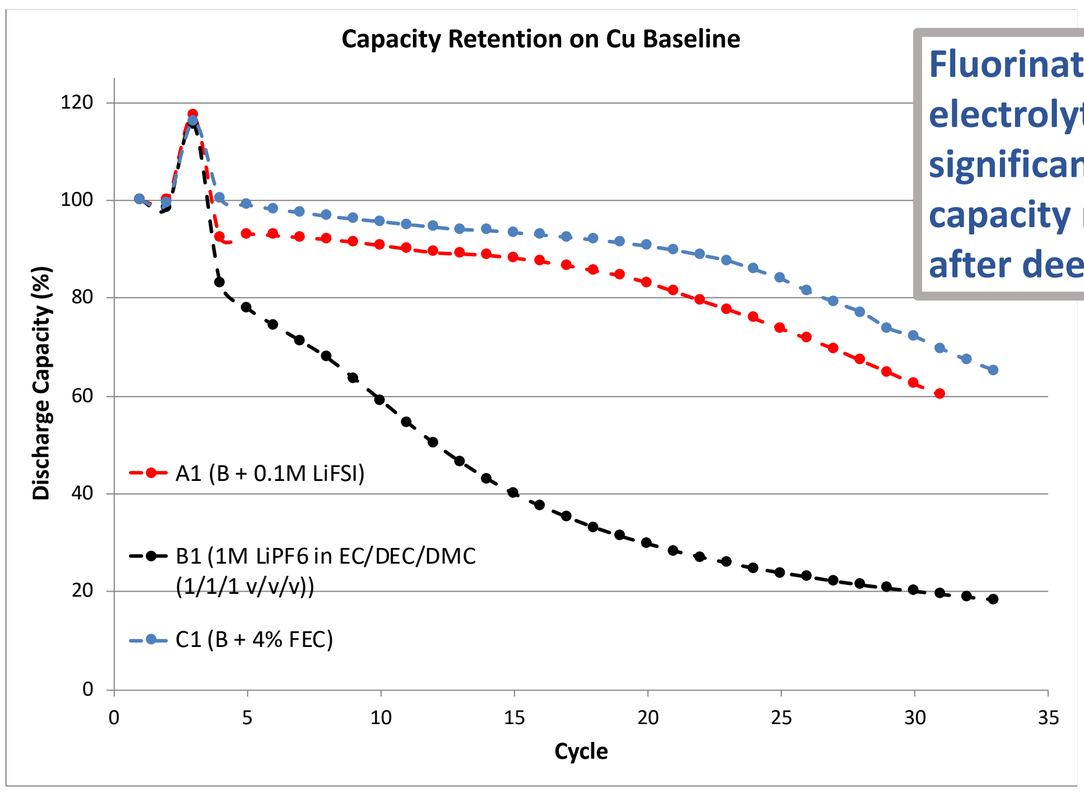
Most lithium-ion batteries are discharged only to a 2.5V minimum; discharging further to an even lower voltage will allow permanent damage to occur, primarily through corrosion at the anode. Cell capacity is lost in the best cases, and shorting and catastrophic failures can result in the worst cases. **The need to maintain charge on lithium-ion cells represents a potentially mission-ending failure mode that must be avoided in any flight systems using lithium-ion batteries.**

Approach:

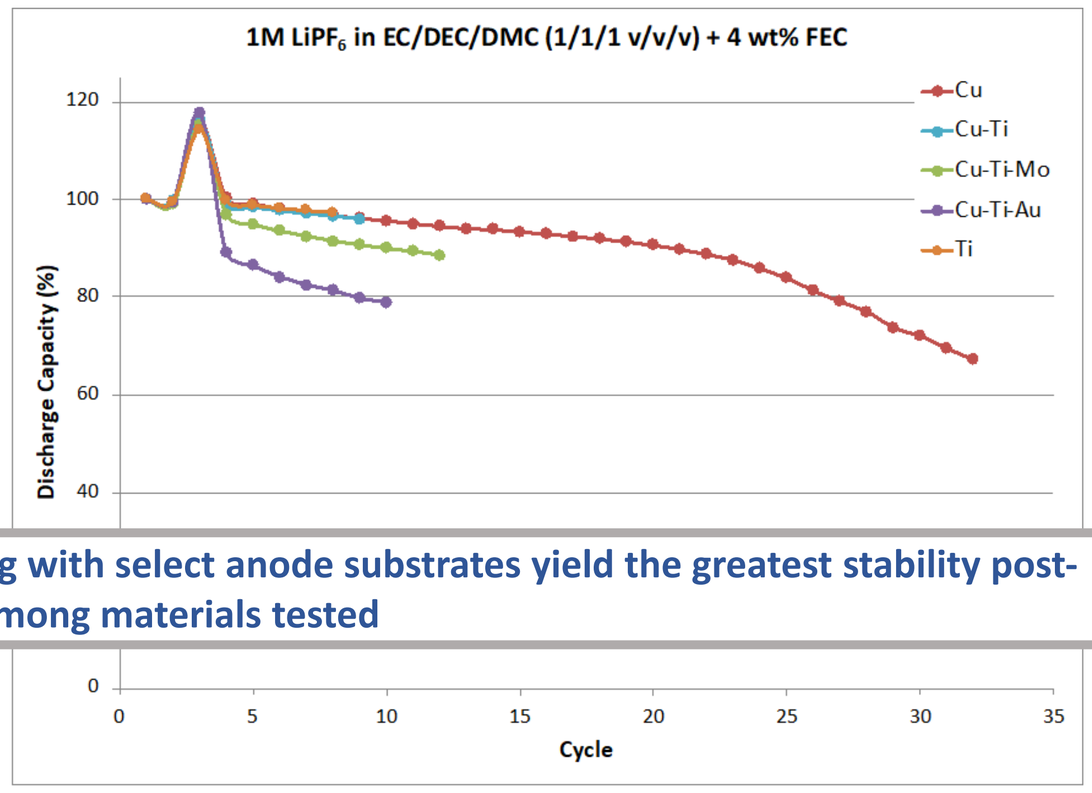
1. Use **magnetron sputtering** to develop layered coatings of corrosion-resistant gold, titanium, and molybdenum on copper substrates at the anode of lithium-ion batteries.
2. Investigate **electrolyte additives** that can stabilize the solid electrolyte interface (SEI) at low voltages. Fluoroethylene carbonate (FEC) and lithium bis(triufluorosulfonyl) imide (FSI) were tested.
3. Test each combination of substrate and electrolyte in prototype coin cells.



Blue plasma is produced as a thin titanium layer is deposited onto copper foil via magnetron sputtering



Fluorinated electrolyte additives significantly improve capacity retention after deep discharge



FEC additive along with select anode substrates yield the greatest stability post-deep discharge among materials tested

Significance to NASA/JPL:

The availability of efficient lithium-ion batteries that can withstand low voltage and dead bus scenarios will **improve mission safety** and eliminate the need for engineering controls to mitigate risk of failure. Cells in a fully de-energized state would be safer to handle and launch.

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