

Advanced 18650 Battery Cells for Extreme Space Environments

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Space Power Workshop,
Torrance Marriott Redondo Beach, Torrance, CA



Purpose

Provide industry-leading energy storage solutions

Vision

Electrify Earth and Beyond

Mission

Design and manufacture the world's best & safest batteries and license our unique technologies





Our Vision: Electrify Earth and Beyond

We will power the energy ecosystem of the future with our batteries and unique patented technologies. Our products will lead the industry in safety and energy density, without compromising cycle life. We will treat our suppliers as trusted partners, provide employees with high-quality jobs, and our customers will recognize us for delivering on our promises.

Our societal impact is measured in lives improved and saved, reduced emissions and an unparalleled safety record.

MARKETS WE SERVE



ELECTRIC
VEHICLES



DEFENSE



AEROSPACE



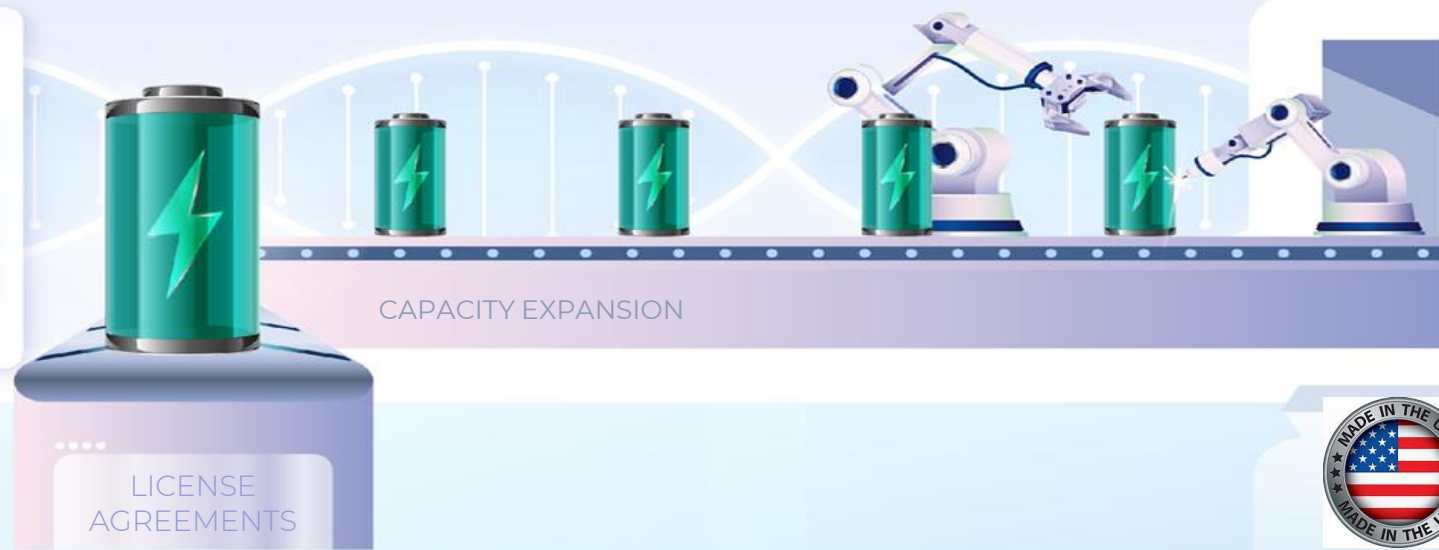
MEDTECH



ENERGY
STORAGE



ROBOTICS
& AI

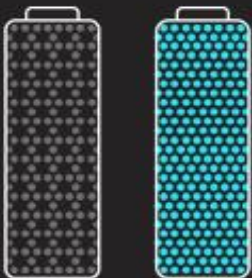




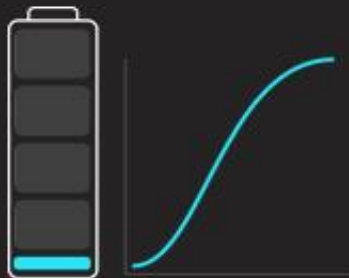
Shipping the World's Highest Energy Density Silicon Anode Lithium-ion Batteries

18650, Pouch, Prismatic and Medical Device

Energy
Density



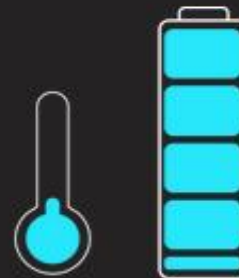
Zero-Volt
Technology



Unparalleled
Safety



Extreme Low
Temperatures



American Lithium Energy Corp.

Advanced Battery Solutions



- **Company Name:** American Lithium Energy (ALE)
- **Date:** Jan. 22, 2025
- **Contact Information:** William Hadala, VP of Business Development
 - Email: william.hadala@americanlithiumenergy.com
 - Phone: 202-860-9444

AOI: Energy Battery Technology and Supply Chain- Supplying Safe and Reliable Batteries

- **Secondary alignment** by providing a domestic battery supply to DoD Industry & marketplace.

- **DUNS:** 782243096
- **CAGE Code:** 4GBA8
- **UEI:** C21AVSKSE7G9
- **Address:** 2261 Rutherford Road, Carlsbad, CA 92008
- **Principal Investigator:** Dr. Jiang Fan
 - CEO with 25+ years of experience in lithium-ion battery R&D and manufacturing
 - PhD in Solid State Chemistry from Arizona State University
 - Achievements include SafeCore® and Zero-Volt technologies, awarded over 99 US and international patents, and successful defense/aerospace collaborations.

- **Certifications:** AS 9100D Quality Management System since 2018

- **Facility:** Full-time operational facility (23,000 sq ft (RD+pilot line) + 81,000 sq ft in San Diego County for battery R&D, testing, and battery cell production.

Recent Key Milestones:

- Series A funding in 2024 for an >81,000 sq ft MWh factory producing 5M cylindrical and pouch cells annually
- Funding to scale 18650 cell production
- STRATFI funding for aerospace batteries

a)



b)



a) ALE current headquarter 23,000 sq ft and b) MWh production line 81,000 sq ft



SSC CCT Tech Need 715, Zero-Volt Program Goals

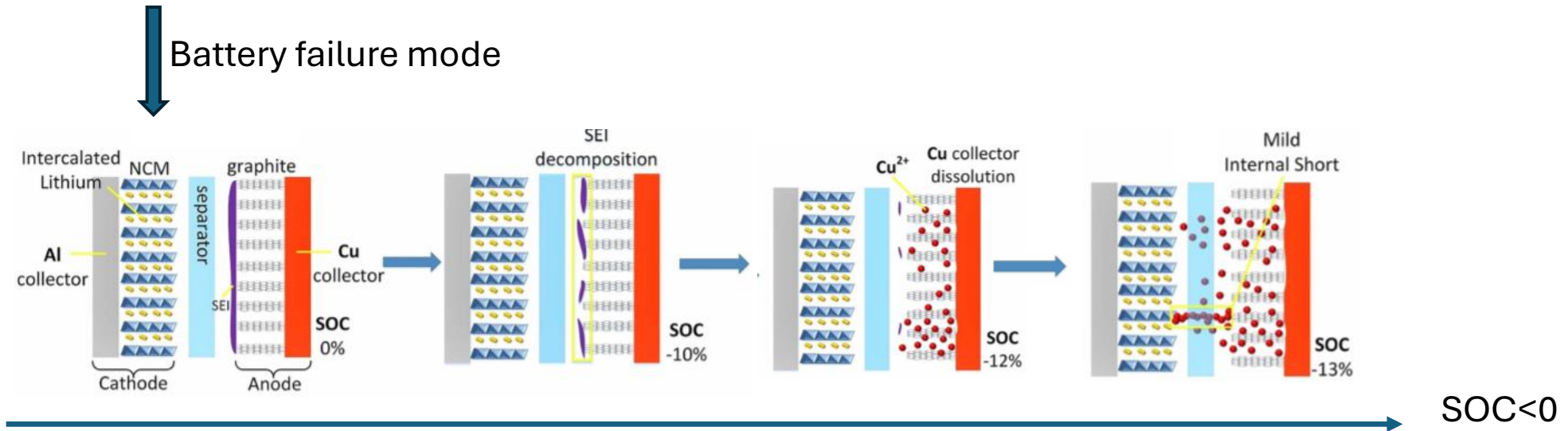
- **Problem Description:** Loss of energy storage capacity following full battery cell discharge (0.0 Volts) on orbit or on ground. Need for hard reset of the onboard computer. Spacecraft battery cell displays a high fade rate. Planned storage is required on the ground or on-orbit. Higher battery cell transportation, storage, range, and operations safety is required to mitigate requirements of UN 38.3.
- **Benefit:** The ability to fully discharge a battery cell allows hibernation modes, cybersecurity protection by fully clearing computer registers, dead bus recovery, ground recovery of short circuit, safety risk reductions. The resiliency of a zero-volt battery cell to high fade rates benefits systems by extending cycle life.

SSC CCT Tech Need 717, Production Equipment Goals

- **Problem Description:** The Space Force Architecture is moving from the present baseline of large, 5-7 ton GEO satellites replenished every 15 years, to small satellites, with reduced target signatures, in all orbits replenished every 3-5 years to utilize and sustain a technology lead over U.S. adversaries. The U.S. is developing military-grade battery cells for the first time, with limited current production capabilities. All U.S. satellite providers have standardized on 18650-sized and three other sized cells for hundreds of battery designs, but these cells are primarily foreign-sourced and represent a foreign-source risk. Technology has not been developed and is not entrenched in current U.S. battery cell providers to produce high-quality military-grade battery cells to satisfy the future Space Force goals for small satellite replenishment to Space Force Architecture Operational End State (OES) 3b, due by year 2028. Pre-qualified 18650 COTS cell stockpiles do not currently exist.
- **Benefit:** technology improvements to advance manufacturing capacities include, but are not be limited to, developing technologies that aid in automating equipment that produces raw materials, precursors, anode and cathode rolls, separators, terminals, and containers. Advanced processes, methods, designs, or equipment to improve material production or cell assembly throughput and yield as well as decreasing touch labor might include manufacturing, test, and inspections technologies.



Battery Complete Discharge → Battery Failure → Spacecraft Power failure → Dead Bus



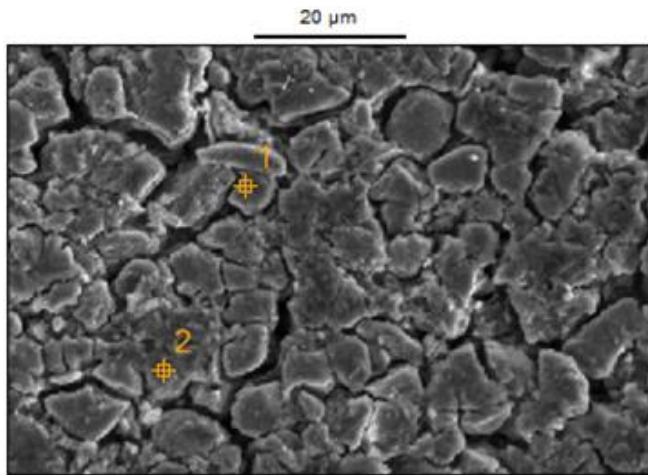
Overdischarge Process: Cu dissolution and dendrites, Internal short

Recovery Battery from Deep Discharge even Zero voltage Exposure

ALE Solutions: Prevent Cu dissolution at low Voltage

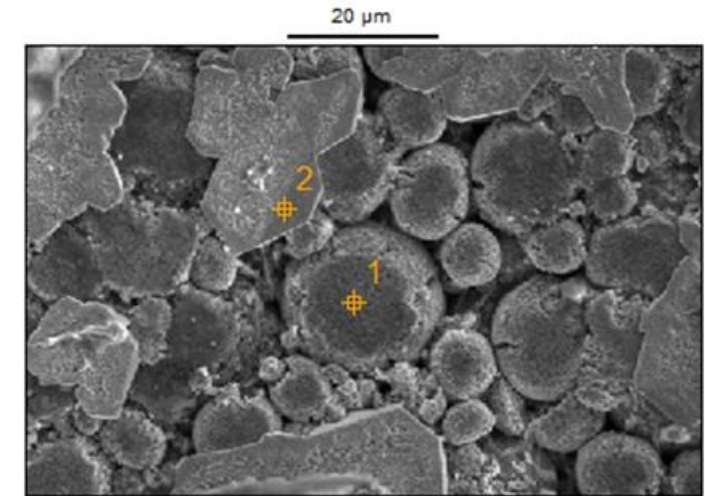
Microscopy: Non-Sacrificial Design

Negative
Electrode



Si/C negative electrode
Cu foil severely corroded

Positive
Electrode



High Ni content positive electrode
Cu plate deposited on the positive electrode

ALE Patented Zero Voltage Technology

Challenge: When U is close 0 voltage, the potential of negative electrode increase to 3.56 V vs Li^+/Li , the corrosion of negative collector Cu foil occur (Cu oxidization to Cu^+)

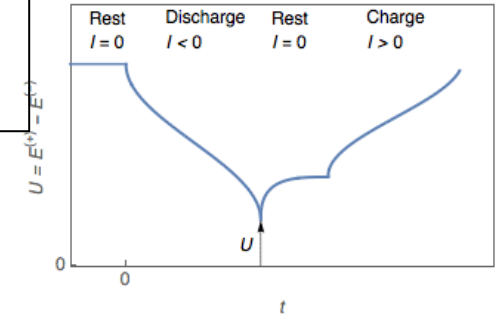
Negative Impact:

- Li-ion batteries without Cu protection are dead or damaged if discharged to zero volt
- Dead bus issues caused by the failure of the batteries
- To avoid the dead bus issue, some low energy density batteries such as Ni-metal Hydride batteries (50 to 75 Wh/kg) were used for space application

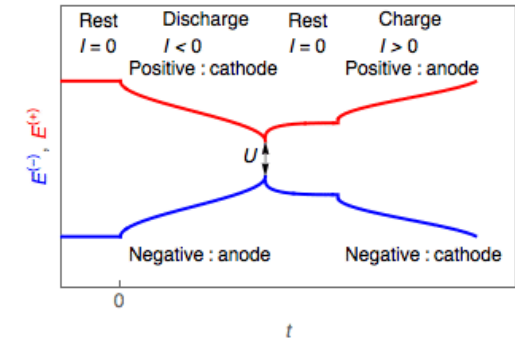
Solution: When a sacrificial electrode applied, whose corrosion occurs first so as to protect Cu foil from corrosion.

ALE Patented ZVT:

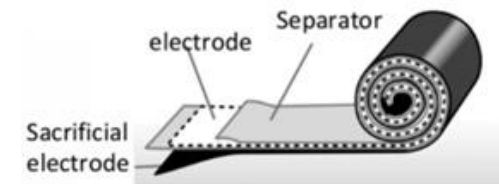
- Materials is low cost and not moisture sensitive or air sensitive
- Not participate in the normal electrochemical reaction
- The protection starts when the cell is assembled (close to zero voltage)
- Improved cycle life due to the protection in the wetting period before the formation
- Applicable to any lithium-ion battery cells when Cu foil is the current collector
 - Very useful in the battery logistics, battery shelf life, and battery safety

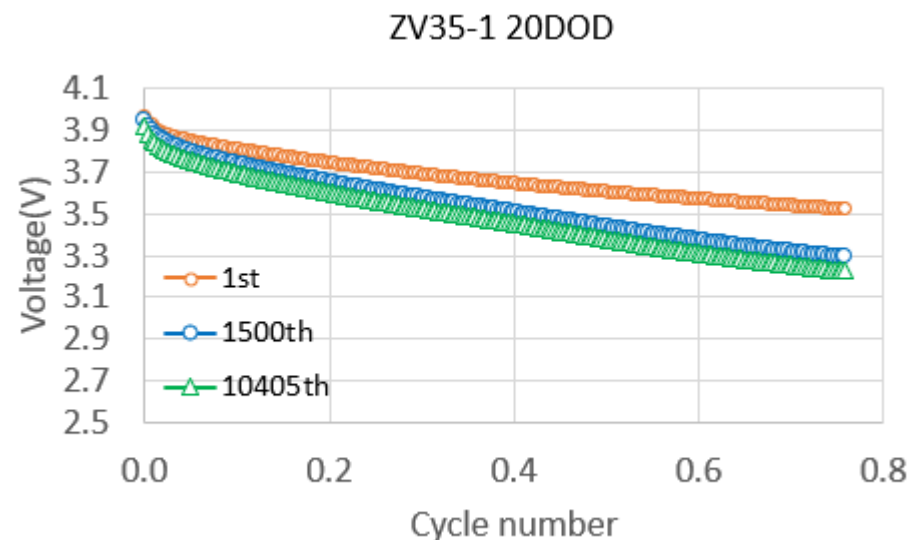
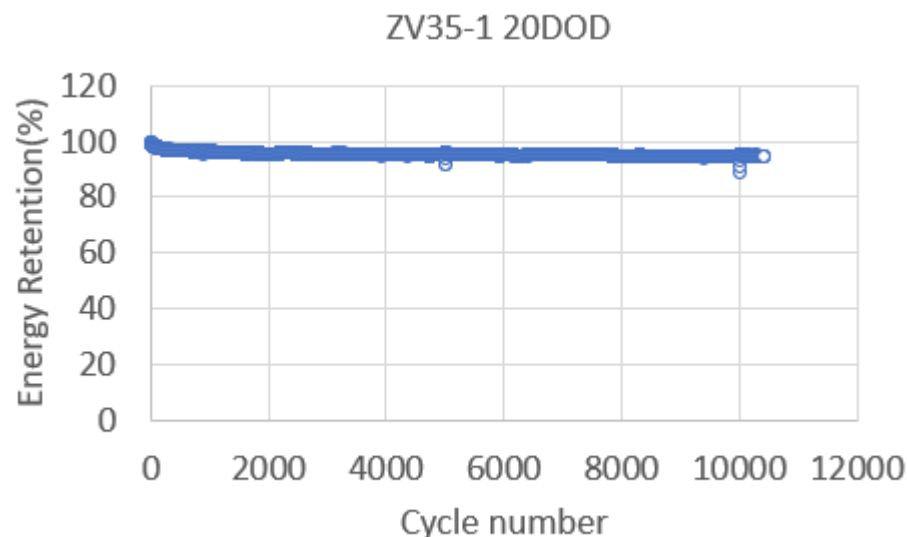


Battery voltage



Potential of Negative and Positive electrodes





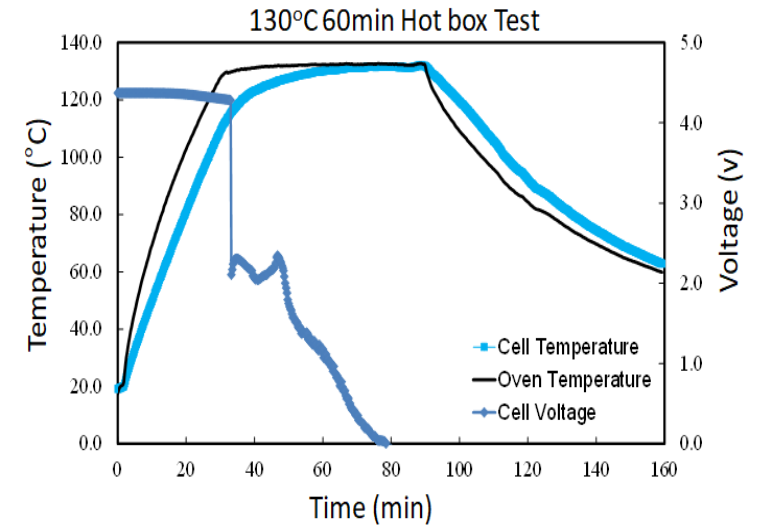
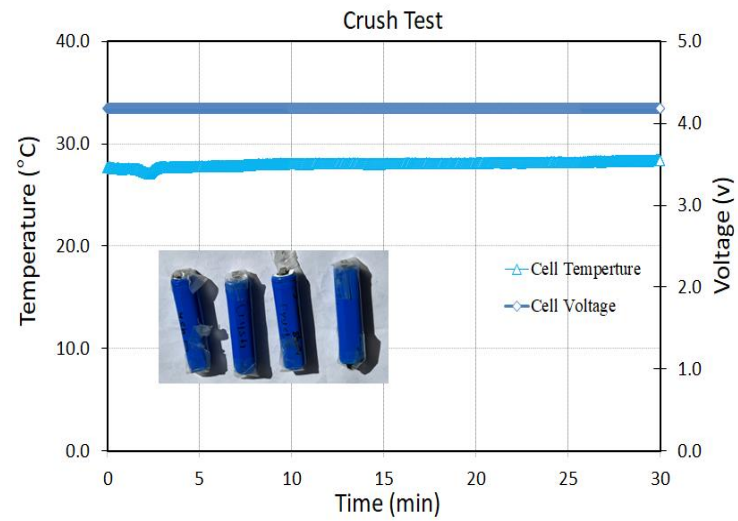
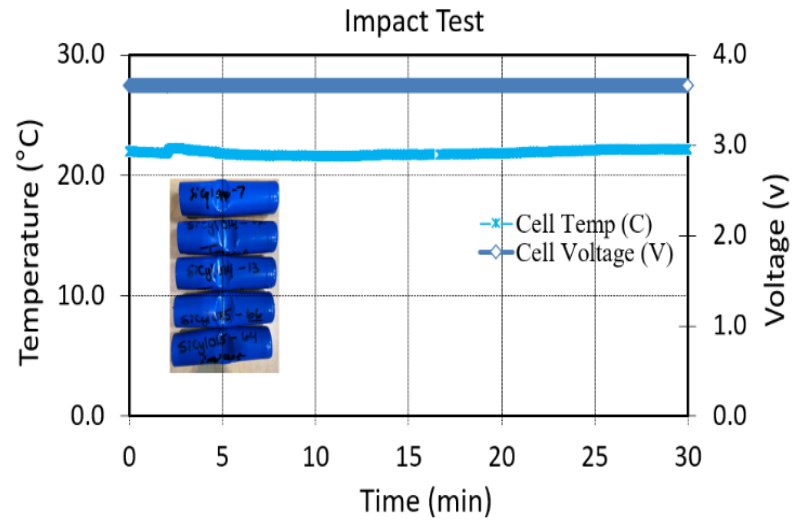
- 3.76% loss
- Polarization cumulation
- Decrease in SoC
- Cell degradation
- 1.56% loss
- Cell degradation

Cycle number	1	1500	10405
End voltage	3.5663	3.2912	3.2240
Energy retention	100%	96.24	94.68

Test Procedure:
Discharge C/3: 35 minutes
Charge C/4.5 to 4.1V cut off C/20:
60minutes

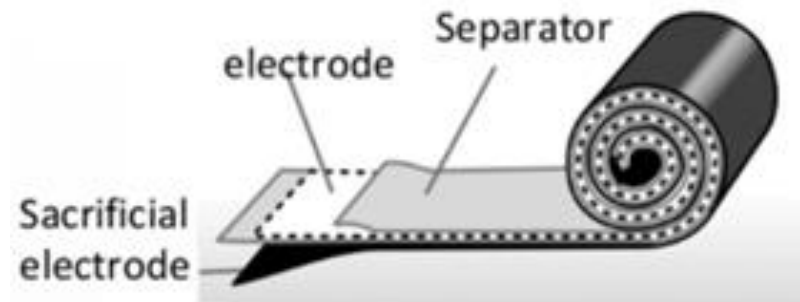
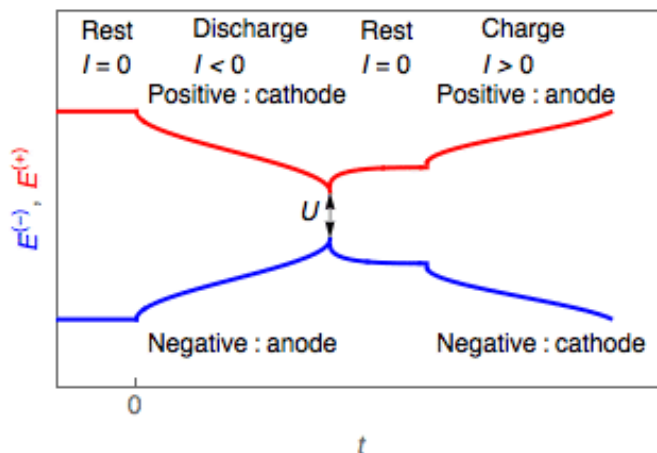
- ~3.76% reversible discharge polarization energy reduction from 1st to 1500th cycle (equilibrium state to steady state)
- ~1.56% discharge loss from 1500th to 10405th cycle (2.5 years data, the cycle life is still on going).
- Projected cycle life: >92,703 cycles (18 years); longer than the 75,000 cycles (15 years).

Safety – UN 38.3 Certified



➤ 18650 4Ah passed Impact, Crush, and Hotbox test per UN 38.3 standard

Zero Voltage Technology



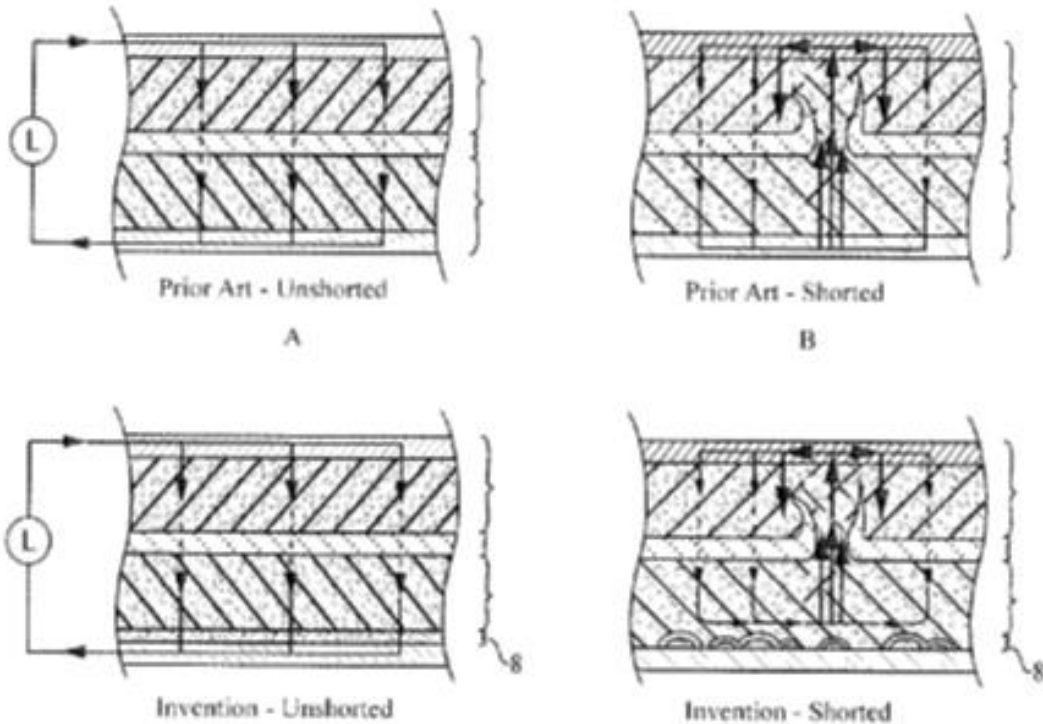
ALE Patented ZVT:

- No cell damage when discharged to zero volts
- Zero-energy tolerant for exceptional safety during mfg and transport
- Eliminates maintenance concerns during long term storage
- Improved cycle life due to the protection in the wetting period
- Applicable to any lithium-ion battery cells with Cu foil current collector
- Improves battery logistics, battery shelf life, and battery handling safety

SafeCore Technology

ALE Patented SafeCore:

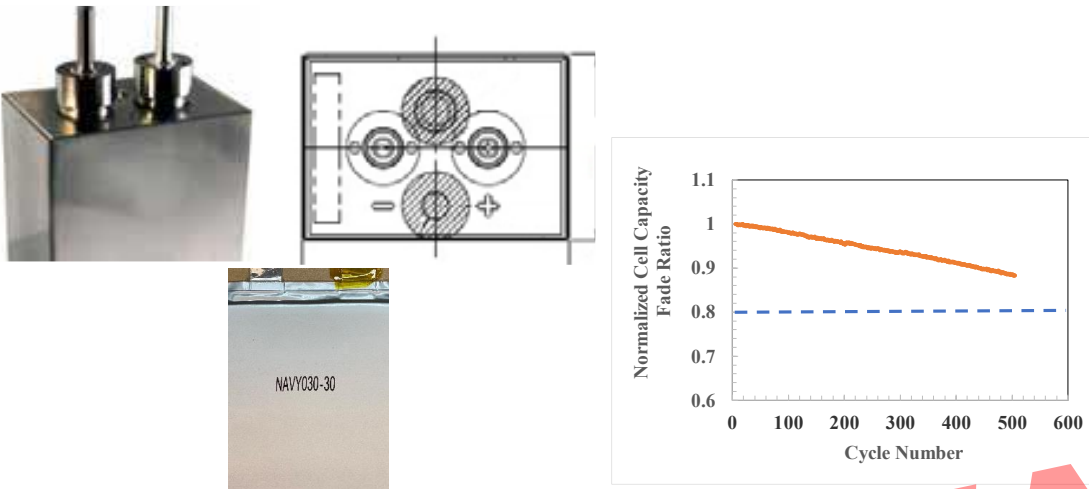
- Activated by chemical decomposition of a thin layer (SafeCore) between the current collector and electrode active layers under abnormal conditions such as overcharge, internal short, or high temperature.
- The layer decomposition or shrinkage will result in a gap between the electrode layer and current collector nearly instantaneously stopping or greatly impeding an overcharge or internal short current.
- Excellent cell safety and significantly reduced risk of hazardous events



SafeCore working mechanism during internal short.

PY24.2 Space Force STRATFI | SBIR

Advanced 5781173 Nano Si/C Prismatic Cell with Superior Safety, High Energy Density and Zero Volt (ZV) Stability



Zero Volt is Safe, Survivable, and Resilient

Technology Area: Space
Mission Area(s): Pervasive through (1) Space Domain Awareness, (2) Space Control, (3) Satellite Communications, (4) Position, Navigation & Timing, and (5) Space Sensing

Stakeholders			
Customer	SSIO	TPOC	Dan Romm
End User	SSIO	Transition Partner	All SSC Satellite Contractors
SBC	American Lithium Energy	SBC Website	www.americanlithiumenergy.com

Transition Strategy
Integrate up to 36 SSC satellite Prime Contractors into the productization and technology development program

STRATFI Scope

- ❑ Build capability to produce drop-in ZV solution with >50% more specific energy
- ❑ Develop and qualify 5781173 ZV cell with >100Ah per AIAA S-144 standard; build 500 cells inventory
- ❑ Qualify 4Ah ZV 18650 cells per S144 standard; build 10,000 cell inventory
- ❑ Improve Non-Sacrificial ZV technologies
- ❑ Develop configurable 5781173 (4.1, 8.2, 12.3, 16.4, 20.5, 24.6, or 28.7 Volts)
- ❑ Achieve >75000 cycles @20%DOD and >1500 cycles @ 50% DOD

Innovation

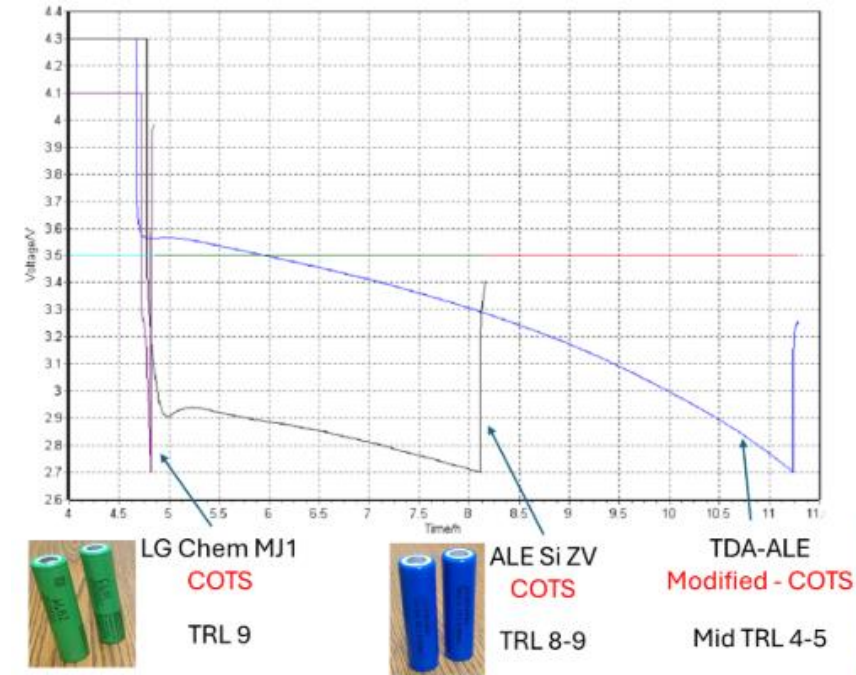
- ❑ Next generation Nano Si/C battery technologies
- ❑ Patented low cost ZV technologies
- ❑ Hermetically-sealed prismatic cell consisting of high performance ZV pouches
- ❑ Configurable 5781173 prismatic case for varying ESPA Grande Bus voltages
- ❑ Non-Sacrificial Zero-Volt technologies



Extreme Low Temperate Performance

RT Charge C/5 w C/50 taper & C/10 discharge 2.7V cutoff

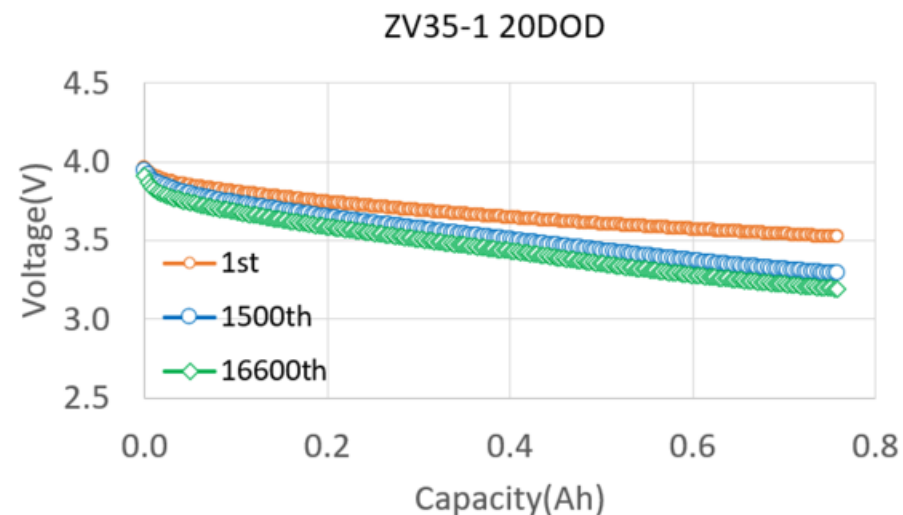
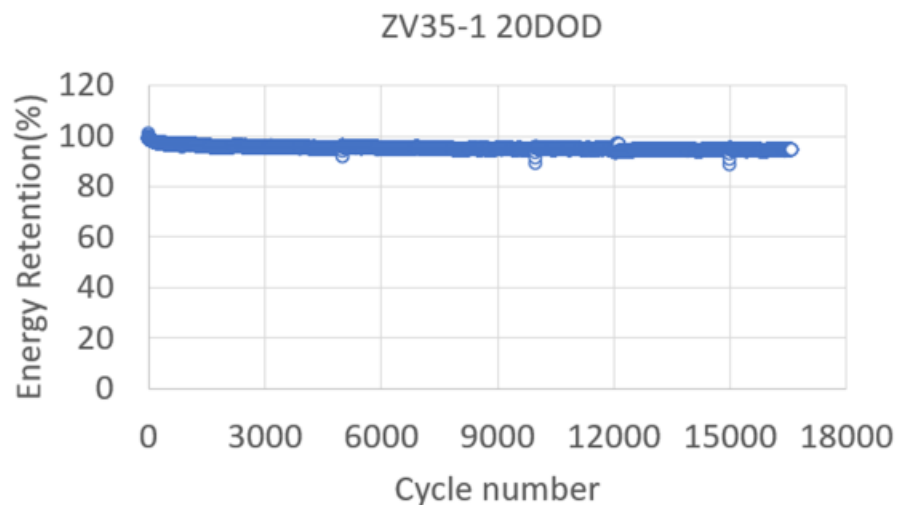
	Yardney Mars InSight	LG Chem MJ1	ALE Si ZV	NEW ALE Si ZV
	TRL9	TRL9	TRL8-9	Mid TRL 4-5
+60degC		234 Wh/kg	290 Wh/kg	289 Wh/kg
+40degC		234 Wh/kg	291 Wh/kg	290 Wh/kg
+22degC	273Wh/kg	231 Wh/kg	276 Wh/kg	289 Wh/kg
-40degC	100Wh/kg	2 Wh/kg	100 Wh/kg	182 Wh/kg
-60degC	78Wh/kg	0 Wh/kg	0 Wh/kg	137 Wh/kg



ALE modified vs. two Commercial-Off-The-Shelf 18650 cells
 -40degC discharge profile (C/10)
Electrolytes with -100degC Freeze Point



20%DOD



- 3.76% loss
 - Polarization cumulation
 - Decrease in SoC
 - Cell degradation
- 2.08% loss
 - Cell degradation

Cycle number	1	1500	16600
End voltage	3.5663	3.2912	3.1934
Energy retention	100%	96.24	94.16

Test Procedure:
Discharge C/3: 35 minutes
Charge C/4.5 to 4.1V cut off C/20:
60minutes

- ~3.76% reversible discharge polarization energy reduction from 1st to 1500th cycle (equilibrium state to steady state)
- ~2.08% discharge loss from 1500th to 16600th cycle.
- Projected cycle life: >107,058 cycles (21 years); larger than the 75,000 cycles (15 years).

American Lithium Energy (ALE) – Advanced Battery Testing Capabilities for Space Applications

Comprehensive Testing Capabilities

- **Full UN38.3 Certification**
 - Transportation testing for space-bound and terrestrial applications
- **Full UL Certification Support**
 - (Safety standards compliance for aerospace and critical platforms)
- **AIAA S-144 Compliance**
 - (Space Systems – Battery Qualification for Crew and Cargo Vehicles)

Space-Specific Focus

- **Shock & Vibration Testing**
 - (Critical for launch survivability, orbital operations, and planetary entry missions)
- **Thermal Vacuum Cycling**
 - (Simulating space environments: extreme cold, heat, vacuum conditions)

Advanced Analysis

- **Decomposition Gas Testing & Analysis**
 - (Identify and quantify toxic fumes during thermal runaway and venting events – vital for crew and payload safety)

Key Takeaway

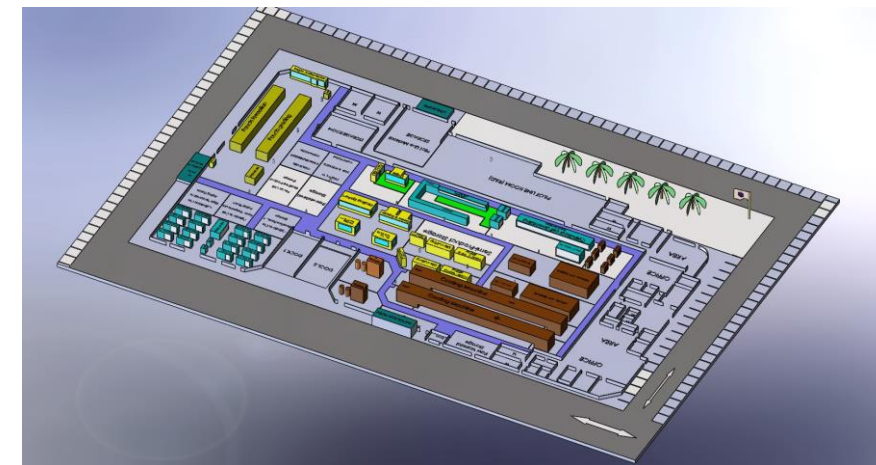
- ALE delivers end-to-end testing, qualification, and risk mitigation solutions for spaceflight battery systems – ensuring mission reliability and crew safety.



- **Business consideration:** Domestic growth and onshoring of cell and pack manufacturing **require consistent incentives** and support, especially given the critical role of electrified transportation in driving down costs and expanding the market. Aviation and uncrewed applications' stepping stone is an **early adopter** of next-generation, **high-specific-energy** battery technologies—technologies that may not yet fully meet the long-term cycle life or durability requirements for automotive use. Facilitating **early adoption** in electric aviation and uncrewed applications can, therefore, help **fast-track commercialization**, providing a vital steppingstone toward broader implementation of advanced battery solutions across the U.S. economy, which is why ALE has partnered with companies for aviation applications including magniX, Northrop Grumman, Raytheon, Teledyne, Lockheed, Ascent Aerospace and many others, all on separate projects to reduce supplier risk and to diversify our revenue sources.
- **Advantages of the Company's Solution Compared to Competing Products or Services:** safe and higher specific energy (>300 Wh/kg), wide operation temperature from -40 deg C to >60 deg C, long life, drop-in solution, reliable domestic cell and pack solutions
- **Advanced Technology:** ALE's nano Si, Zero Volt Technology (ZVT), and SafeCore/NTC electrode thermal fuse enhance safety and performance, particularly in extreme conditions.
- **Domestic Supply Chain:** Focus on domestic sourcing of raw materials mitigates risks associated with geopolitical tensions and supply chain disruptions.
- **Proven Safety Record:** Extensive testing and repeated orders demonstrate high safety levels, addressing reliability and performance concerns in military contexts.
- **Controlled cost:** ALE is good at managing its operation and manufacturing costs through its lean manufacturing practice, which is manifested by the fact that ALE has balanced its financial sheet for 10+ years. ALE will continue to improve its operation efficiency by introducing advanced manufacturing software from Siemens to digitize our MW production line to have real-time monitoring of our productivity and operation efficiency, including raw material, machine, and labor.



- **Site Production Capabilities:** ALE is committed to local production and is finalizing a second commercial site to manufacture the cells outlined in this grant; site designs (see picture on the right) are referenced. This approach minimizes the time spent on site selection and allows ALE to direct funding toward the machinery and equipment required for commercial-scale production. This enables domestic output with over 10 million electrodes/year and 5-7 million cells/year located in California, USA; the production electrode manufacturing line (including two 10 feet wide, 108 feet long coater; two 800 mm calendaring roll machines, two 400 Liter mixers) located and installed in our new 81000 sq ft building.
- **Production Lines:** Production line with >300 MWh/year (Single shift)
- **Cells to be produced:** ALE has two production lines in the MWh factory (81,000 sq ft)
 - Pouch cells: 2Ah, 7Ah, 14Ah and 19.5Ah for various kinds of markets
 - Cylindrical cells: 21700 cells with 5.7Ah and 4Ah 18650 cells
- **Automation:** Fully automated pouch and cylindrical cell assembly capable of 5-7 million cells.
- **Quality Control:** Robust analytics, including X-ray inspection, force gauge for welding strength, foil strength, electrode adhesion, moisture titration, impurity analyzer for the electrodes, impedance meter and analyzer, micro species, and many online sensors like loading, thickness gauges, and alignments.
- **Risk control:** To minimize the operation risk or production delay, we have signed the service agreement with the machine vendor for the on-site training for our operator, technician, and engineers for three to twelve months, depending on the complexity of the machine and operation.
- **Supply chain reliance:** ALE will reduce its dependence on Chinese supply chain items within the project deadline (within month 16) to only US and allies



Mixer



Coater



Calendaring machine

American Lithium Energy (ALE) – Space-Ready Battery Manufacturing and Testing

Key Highlights:

Mega Factory Expansion:

- ALE is building a new mega factory to scale production.
- NDAA-compliant and open for business to meet defense and space market demands.

Full Testing Capabilities:

- Certified testing for UN38.3, UL, and AIAA S-144 standards.
- Advanced Decomposition Gas Testing for toxic fume analysis.

Enhanced Performance:

- Improved cycle life for extended mission duration and reliability.

Extreme Environment Ready:

- Proprietary electrolyte with a freezing point at -100°C.
- Enables battery operation in extreme space conditions.

Key Takeaway:

- ALE delivers complete, space-qualified battery solutions from cell production to full mission assurance testing — powering the next generation of space exploration.





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