



ION⁺



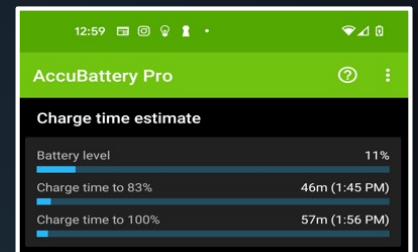
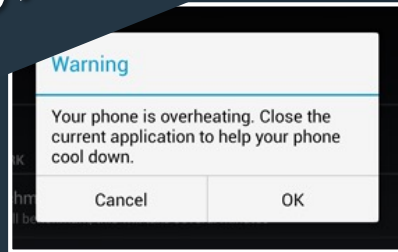
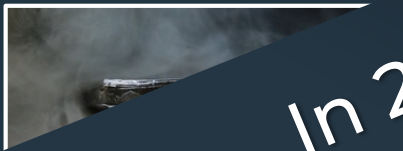
NASA Aerospace Battery Workshop
November 2022

Traditional Li-ion batteries have been pushed to their limits

Safety

Operational

Time



In 2022 Experts agree:
“Solid-State is the next big step”
in the evolution of battery technology



Material instability



Low current density



Volume change



Requires heating



Requires compression



Complex manufacturing



High cost



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Solid-state batteries had significant technological barriers to becoming a viable solution.

ION⁺ patented core technology
overcomes these technological barriers

Ion Storage Systems technology protected by 40 patents and applications
Patent US10622666: Ion-conducting batteries with solid state electrolyte materials

Better strategy, better batteries, no compromise

Solid-state material choices come with limitations

Technology	Oxide	Sulfide	Solid polymer
Battery Cell			
Lithium Metal	✓	✓	X
Energy	✓	✓	X
Power	✓	X	✓
RT Performance	✓	X	✓
Integrated Pack			
Pressure Free	X	X	✓
No Expansion	X	X	X
Safety	✓	X	✓
Cost	✓	✓	X
Low Integration Risk	X	X	✓
			

Our 3D structure unlocks their true potential

ION ⁺ - Oxide Structure
✓
✓
✓
✓
✓
✓
✓
✓
✓
✓






"The need was apparent, and the solution required a different perspective."



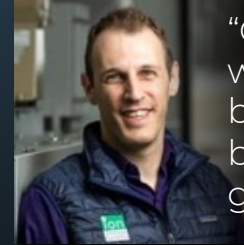
+ Eric Wachsman *Exec Chair & Founder*



"For the first time in 22 years of making batteries, I can offer customers high performance and safety with no compromise."



+ Ricky Hanna *CEO*



"Our design is the right way to build solid state batteries and will be the benchmark for future generations."



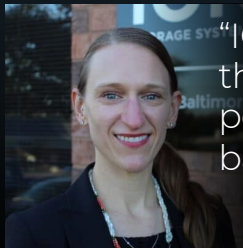
+ Greg Hitz *CTO*



"Our core technology and manufacturing plan sets us apart from our competitors."



+ Ben Chiu *CFO*



"ION's innovation breaks the ceiling of what was possible with traditional batteries."



+ Elizabeth Santori *VP, R&D*



"Our transformative technology will have a global impact on how we think about energy."










+ Neil Ovadia *VP, Operations*



Our uniquely qualified team created a manufacturable, flexible, and extensible platform



ION⁺

						
Inc. Founded	Employees	Facility	Funding	Active Partners	Patents	Cells produced
2019	50	20k sqft (MD, USA)	\$8M Seed \$30M Series A	8 <u>\$8M Nondilutive</u>	12 Issued 32 Pending	1000's of pouch cells

ION is commercializing its low cost, energy dense, fast charging, safe, and versatile solid-state batteries with a goal of sustained GWh-scale production.



Our Patented Technology

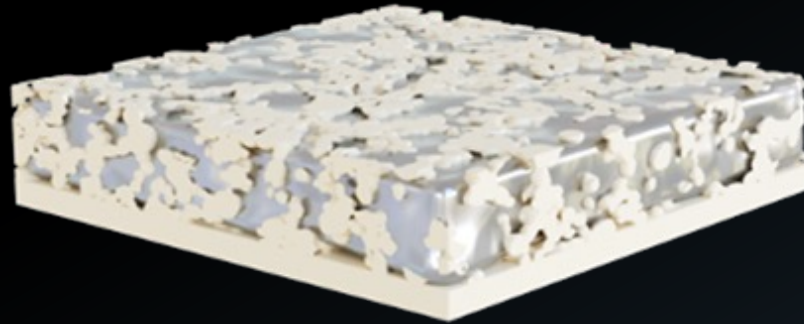


Ceramic Electrolyte Structure

- Nonflammable and low-cost materials.
- Porous scaffold provides mechanical support for thin dense layer.
 - Porous layer is ~50X surface area of a planar interface.



Our Patented Technology

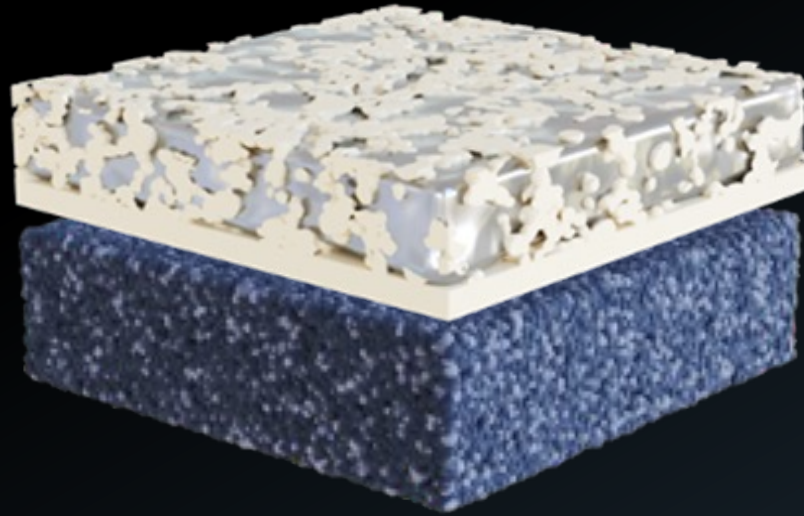


Lithium Metal Anode

- Lithium plates within porous scaffold for no external volume change.
 - No pressure required.
- High rate & low resistance cycling at room temperature meeting DOE Vehicle Technologies Office 10 mA/cm² goal.



Our Patented Technology

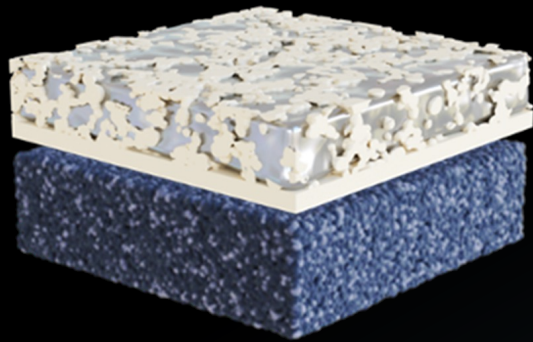


Cathode-flexible platform

- Compatible with off-the-shelf cathodes
- Enables next generation HV and S cathodes.



Our Patented Technology



Cathode-flexible platform

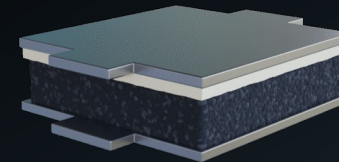
- Compatible with off-the-shelf cathodes
- Enables next generation HV and S cathodes.



Simplified cell functioning

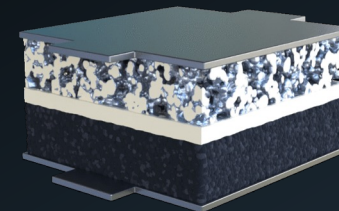
No volume expansion or compression requirement.

Other
Solid-State



vs

ION⁺

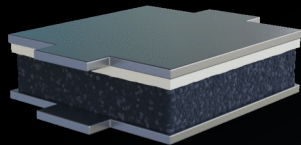


Our Patented Technology

Simplified cell functioning

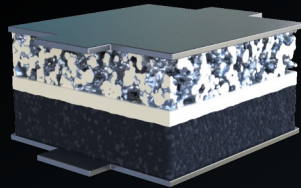
No volume expansion or compression requirement.

Other
Solid-State



vs

ION⁺



Important for pack & product integration

- Unlocks applications which can't accommodate engineered packs
- Efficient EV pack integration
- Simpler manufacturing



ION⁺ Innovation: A true platform for solid-state

Safe

Nonflammable bill of materials based on intrinsically safe ceramic structure



Fast Charging

Only solid-state technology to achieve ARPA-E and DOE VTO Fast-Charge goals for Li-cycling current density at room temperature.



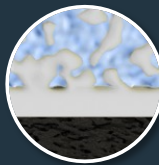
Simple

No compression required
No need for fire barriers
No need for swelling allowance
Reduced system overhead and cost



Energy dense

Accesses Lithium metal anode enables maximum energy density, compatibility with multiple cathode technologies.



Cost effective

Enables low-cost cathode materials
“Lithium free” anode
Leverages existing scaled manufacturing processes



Versatile

Performs well at low, ambient and high temp with no cooling system required.

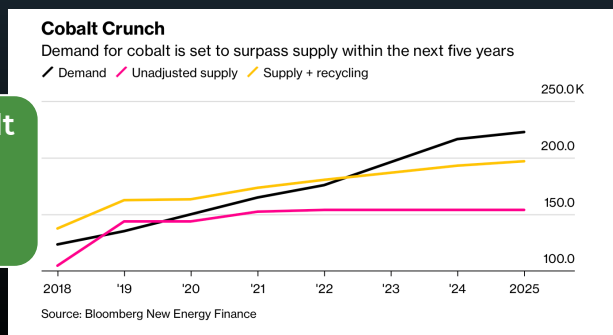


Reuse/recyclable at end-of-life

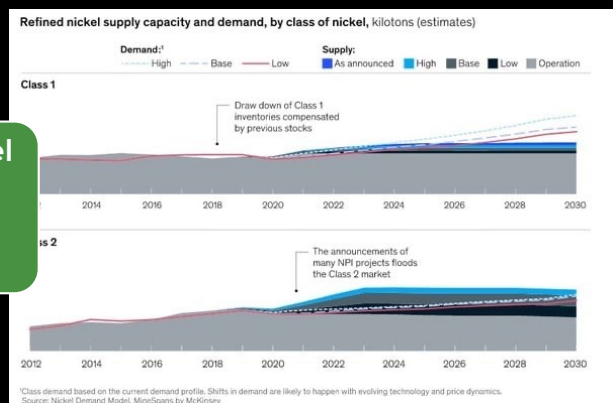


Our extensible platform allows for supply chain flexibility and latest cathode technology integration

Cobalt
27
Co
58.933



Nickel
28
Ni
58.693



Move to next generation cathodes

Higher energy density
Lower cost

ION+

Only oxide electrolyte & 3D structure enables high voltage cathodes which are Ni- and Co-free

Stay with Ni- and Co-based cathodes

Sourcing constraints
Rising prices

Switch to LFP

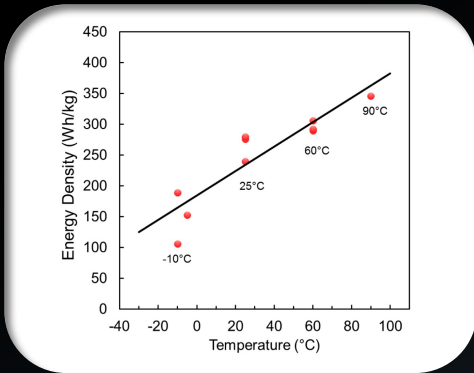
Lower energy density

Traditional Li-Ion has limited options in response to growing supply chain concerns



Unprecedented Performance

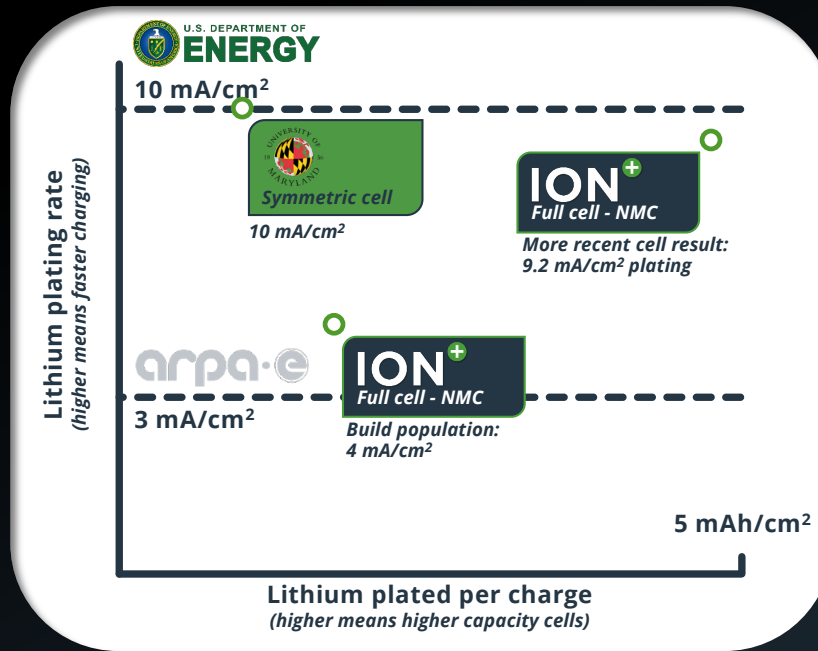
EV-level performance
Highest solid-state Li-metal cycling rate
Dimensional stability
No compression



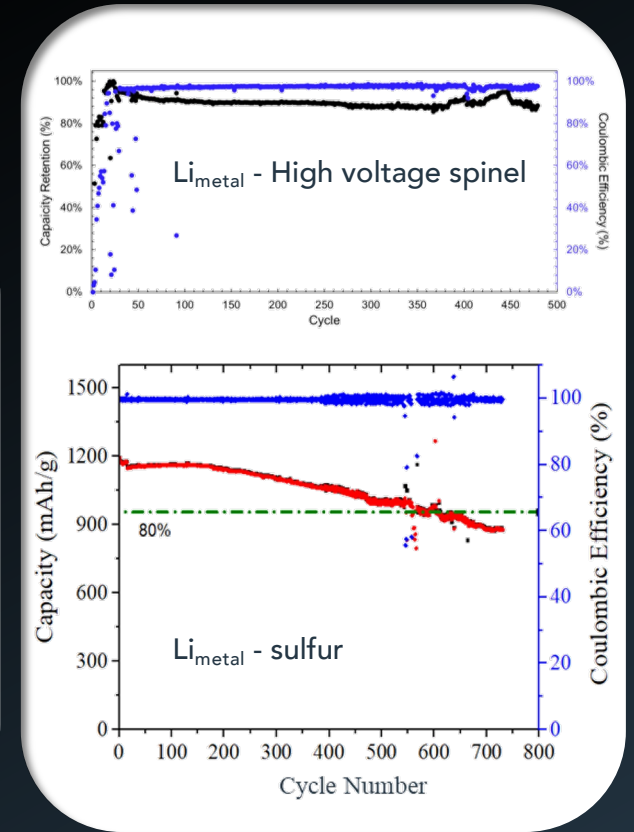
Wide operating temperature range



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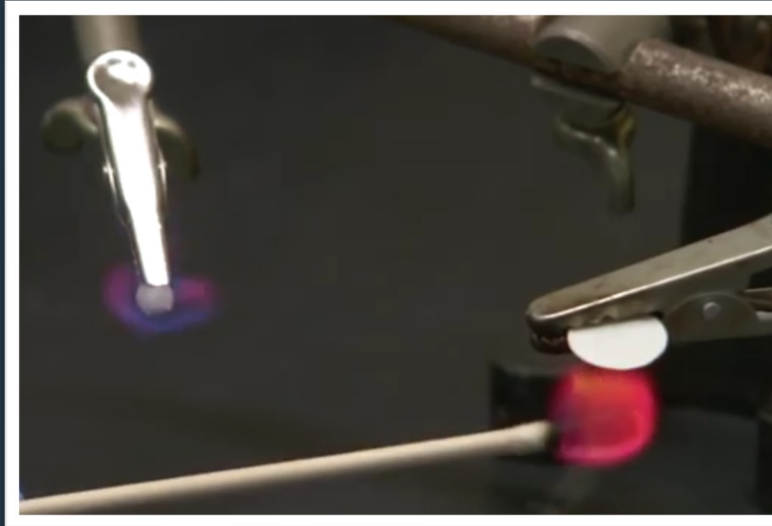
Rate performance meeting ARPA-E IONICS and DOE VTO Fast Charge goals



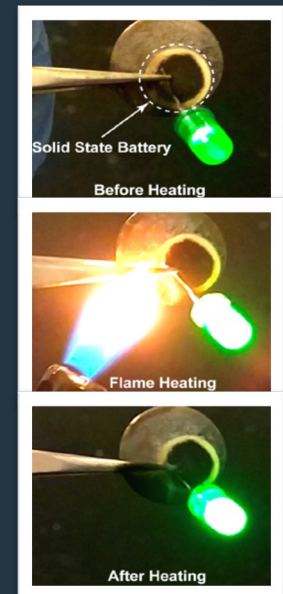
Elimination of anode cycling fatigue

Validating our built-in safety

Comparison of
Li-ion electrolyte (left)
&
ION⁺ Separator
(right)



Flammability
test of solid-
state battery



- Designed & built with nonflammable materials
- Cells have now reached meaningful capacity for safety testing & is ongoing

ION⁺ Ceramic Processing

>1,000X faster than conventional process



Mixing

Homogenous blending of input materials minimizing agglomerates in preparation for calcination.



Calcination

Thermal treatment of precursor blend in batch or continuous furnace.



Milling

Milling of calcined powder targeting powder particle size.



Green Body

Ceramic green body formation via proprietary high speed casting method.

46,000 m²/year internal capability



Sintering

Oxide ceramic green body sintering via batch or continuous furnace.

Discussions with advanced sintering partners

1 MT/yr internal capacity w/ION formulation

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Partnership not yet announced

20-50 MT/yr 2023 capability

Partnership not yet announced

Partnership not yet announced





10 MWh/yr "R&D" capability

Positioning ION to compete in multiple market segments

ION 

Defense & Aerospace






Safe & reliable, always ready for use.

-  Safe chemistry enables battery deployment for extreme uses
-  Wide operating temperature allows for robust deployment
-  High energy density offers significant improvement over current tech
-  Made in the USA

ION 

Electric Vehicles






The range you need to get you home.

-  Low cost per kWh
-  Li Metal anode dramatically increases energy density extending EV range
-  Achieves DOE fast charge goals for shorter wait during charges
-  Wide temperature range reduces need for cooling, complexity, and mass
-  Simple design removes need for compression and reduces dead space

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Consumer Electronics





All day energy to keep you connected.

-  Higher energy density means more power in the same packaging
-  Nonflammable materials increases product safety
-  Wide operating temperature increases ability of use
-  No volume change allows for larger battery in same form factor
-  Full device charge time reduced dramatically

ION 

Grid Storage

The most efficient energy storage possible.





-  Low cost per kWh
-  No cooling required will increase roundtrip efficiency
-  Li Metal anode increases energy density reducing balance of plant & cost
-  Nonflammable materials increase product safety

Space & Military Applications - Markets

Battery Requirements	 LEO – MEO	 GEO	 Drones	 Jets	 Missiles	 Space Travel	 Orbiters
Critical to Missions	<ul style="list-style-type: none"> • Cycles • Lifetime • Fast charge • Wh/kg 	<ul style="list-style-type: none"> • Cycles • Lifetime • Fast charge 	<ul style="list-style-type: none"> • Power • Wh/kg • Wh/l 	<ul style="list-style-type: none"> • Safety • Reliability • Wh/kg • Wh/L 	<ul style="list-style-type: none"> • One cycle • Self-discharge • Wh/kg • Acceleration 	<ul style="list-style-type: none"> • Safety • Reliability • Wh/kg • Power 	<ul style="list-style-type: none"> • Power smoothness • Wh/kg • Fast charge
Price tolerance	\$\$	\$\$	\$	\$\$	\$	\$\$\$	\$\$\$
Market size	1,000	100	10,000	100	1,000	10	1
Fit for solid state electrolyte	Potential	Low	Likely	Potential	Likely	Potential	Low

What business strategy addresses these varied product requirements?

Enabling Electric Mobility - Aviation

Applications		Markets	Enabling Battery Specific Energy (Wh/kg)		
HAPS		Commercial High Altitude Platform Service and similar unmanned aircrafts / drones	250	+	Gen 1 2023 300Wh/kg
	eVTOL Urban Commuter	Commercial 4 passengers – 50 miles Electric Vertical Takeoff & Landing Vehicle	300		
eVTOL Regional Commuter		Commercial 10+ passengers – Regional Electric Vertical Takeoff & Landing Vehicle	400	+	Gen 2 2026 >500Wh/kg
	Fixed Wing Aircraft Short Range	Commercial 50+ passengers – All-electric & Hybrid-electric – Single aisle body	500		
Fixed Wing Aircraft Short Range		Commercial 150+ passengers – All-electric & Hybrid-electric – Single aisle body	600	+	Gen 3 2028 >600Wh/kg
	Fixed Wing Aircraft Long Range	Commercial 150+ passengers – All-electric	700		

Thank You



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