Li-S Energy

MARCH 2022

MULTI-LAYER CELL TESTS SHOW STRONG PERFORMANCE

An essential step toward the commercialisation of Li-S Energy batteries has been achieved over the last three months as lithium sulphur (Li-S) cell testing has been scaled up from single layer pouch cells to multi-layer pouch cells — which share the same physical architecture as commercial cells.

Comparative tests were conducted on a series of identical 4-layer Li-S cells, with a "lean" electrolyte loading typically used in high energy density cells. Some cells were treated with our unique BNNT and Li-nanomesh protection, while the other baseline control cells were not.

The test objective was to subject the cells to sufficient charge and discharge cycles to identify a marked difference in performance between the protected cells and the unprotected control cells, this being the "gate" to trigger a scale up to 10-layer cell testing.

Taking a rapid-prototyping comparative testing approach is more effective during scale up, as full cycle testing to failure can take many months, if not years on protected cells.

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We are pleased to report the 4-layer comparative cell test results provided by our Deakin University team show marked improvement in performance between the protected cells and the control cells.

The specific capacity was 24% higher in the protected cells compared to the control cells, capacity retention was above 95% in the protected cells compared to 74% in the control cells, and in the protected cells the coulombic efficiency was 18% higher than in the control cells.

Based on these positive results we have now commenced building a series of 10-layer pouch cells to commence further BNNT and Li-nanomesh comparative performance testing in larger capacity cells.

The Li-S Energy difference

Traditionally Li-S cells have a very high energy density and offer significant potential for enhancing performance by extending the operational range of electric aviation platforms, drones and EVs.

However, they suffer from very poor cycle life, making them unsuitable for most applications.

Li-S Energy has developed unique technology to protect the cell electrodes and extend the cycle life of Li-S batteries by using Boron Nitride Nanotubes (BNNT) and a unique nano-material composite called Li-nanomesh, offering the potential to solve the most significant issue facing Li-S battery adoption.

CELL PRODUCTION SCALE UP ON TRACK

December marked another important step in our acceleration towards commercialisation with the ordering of two automated roll-to-roll coating machines.

Playing a vital role in our ability to scale the production of multi-layer test cells, these coating machines can be used to prepare cathodes and coat our patented BNNT materials. Other machinery ordered includes additional machines for cathode material preparation, automated electrode cutting, cell stacking/pouching and electrolyte filling/sealing.

These machines will ship from the manufacturer in mid-April, with an expected arrival in Australia in early May. Meanwhile, we continue to prepare our facility at Deakin University Manufutures to be ready for the machines' arrival.

LI-NANOMESH TESTING EXPANDED TO ZINC AND ALUMINIUM ANODES

We have commenced symmetric testing on zinc and aluminium half-cells using Li-nanomesh protection to explore the wider potential of Li-nanomesh as a dendrite inhibitor.

If successful, this exploratory research could point to the potential for even broader applications for our unique Li-nanomesh nano-composite as a key ingredient in other battery chemistries.

Li-S Energy ManuFutures labs

WORLD RENOWNED EXPERTS ADDED TO OUR DEVELOPMENT TEAM

Central to our success is our ability to leverage the best scientific teams — both in Australia and internationally — to drive the company forward to commercialisation.

With that in mind, we have engaged Professor Maria Forsyth, Professor Patrick Howlett, and their team at Deakin University's BatTRI-Hub research facility on key projects worth $1.6M.

The projects focus on exploiting Li-nanomesh anode protection in lithium-metal batteries, and the development of solid state and polymer electrolytes.

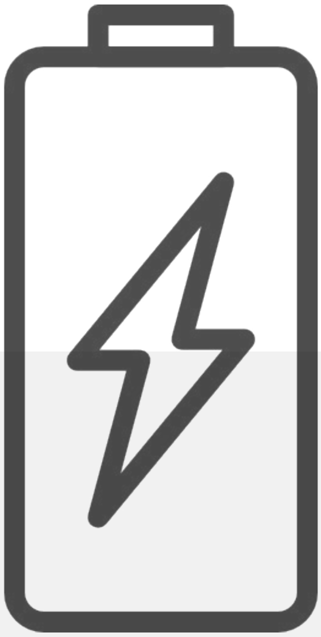
This work complements the extensive ongoing R&D being carried out by our current Deakin scientific team lead by Professor Ian Chen, which is focused on lithium sulphur batteries, BNNT and nano-material composites.

The partnership also provides access to additional researchers and cell production capability, enhancing schedule and risk mitigation across the development process.

Professor Forsyth

Professor Maria Forsyth is world renowned for her contribution to advanced battery chemistry, and her knowledge of lithium metal batteries, advanced solid state and polymer electrolytes will be of tremendous benefit to the company in demonstrating its technology at a commercial scale.

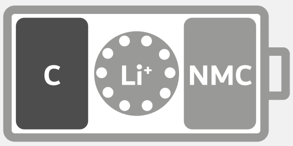
Batteries 101



NEW TO THE INDUSTRY OR NEED TO BRUSH UP ON YOUR KNOWLEDGE? THERE'S A LOT OF 'TECH TALK' IN THE BATTERY WORLD, SO WE'RE INTRODUCING A NEW REGULAR COLUMN **BATTERIES 101** WHICH WILL HELP US ALL BY DETAILING KEY COMMON BATTERY TERMINOLOGY AND CONCEPTS.

LITHIUM SULPHUR VS LITHIUM METAL VS LITHIUM-ION BATTERIES

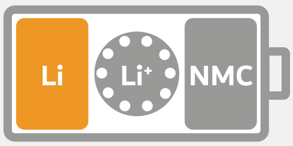
At Li-S Energy we are developing two key battery technologies – lithium sulphur and lithium metal. Here is a brief explanation of what they are, how they compare to conventional lithium-ion batteries, and why we are excited about them.



Lithium ion batteries have been around for a long time. Most use a lithium metal oxide as a cathode (e.g. NMC), and carbon, in the form of graphite as the anode. During charging, positively charged lithium ions flow into the pores of the graphite anode, rather like water entering a sponge. It's a process called "intercalation". During discharge these ions flow back out of the anode toward the cathode, at the same time driving electrons out of the battery terminals to create an electric current.

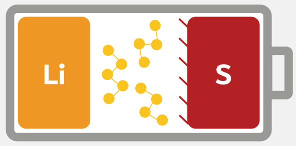
The problem with graphite intercalation is that it is not very efficient from a mass point of view, meaning that lithium-ion batteries are reaching their maximum gravimetric energy density.

This is why the race is on to discover and build better batteries.



Lithium metal batteries replace the graphite anode with a thin film of pure lithium. Instead of hiding in the pores of graphite, lithium ions deposit as pure lithium metal at the anode during charging (a process called "plating"), then deplating back into the electrolyte on discharge (a process called "stripping"). This can potentially double the gravimetric energy density of the cell while also reducing its overall size, thus increasing its volumetric energy density. However, when plating, the lithium deposits unevenly in mossy or spiky structures called dendrites, which can cause short-circuits and rapid failure.

In recent tests on symmetric lithium cells, we have shown that our unique Li-nanomesh nano-composite suppressed dendrite formation for over 1000 charge/discharge cycles.



Lithium sulphur batteries are a type of lithium metal battery where, in addition to a lithium metal anode, the lithium metal oxide cathode is replaced with a sulphur/carbon cathode. This results in even higher energy density than conventional lithium metal cells, but adds additional challenges in terms of the cathode stability during extended cycling.

Recent tests have shown that our BNNT cathode protection can improve cathode stability during extended cycling, while the li-nanomesh suppresses dendrite formation on the lithium anode.