The Next Generation of Lithium Batteries *for Marine Autonomous Systems*

Introduction

Current Lithium batteries used in marine applications are reaching maturity and predictions are that further performance improvements will be small due to the limitations of the chemistry. By contrast, Li-Sulfur (Li-S) has the potential to surpass Li-ion by being able to store more capacity than many other battery storage systems without any safety issues.

Autonomous Underwater Vehicles are energy limited; this restricts their operational envelope, and so speeds are usually low (2-4 knots) and endurance is restricted. By significantly increasing the energy available within the vehicle, the operational envelope can be expanded, thereby increasing the speed and range.

Lithium Sulfur (Li-S) cells have five times the theoretical maximum specific energy of lithium ion. The increased specific energy and improved lower density of the cells means that they could be an excellent replacement for the current lithium rechargeable cells used in Marine Autonomous Systems. Li-S is predicted to have a 'neutrally buoyant' specific energy up to 3-4 times that of the current Lithium ion cells used by state-of-the-art deep-diving underwater systems, thus reducing or eliminating the need for highly expensive buoyancy material in the vehicle, and increasing endurance, speed and payload.

It was thought that the availability of such technology was many years' away, yet innovative technology companies such as OXIS Energy are proving that the chemistry is far nearer than anticipated. Working with an experienced battery assembly partner such as Steatite means that Lithium Sulfur battery packs are progressing development beyond proof of concept. Steatite and OXIS are well placed to deliver battery packs designed for the most challenging environments. Lithium Sulfur batteries offer distinct advantages over conventional lithium rechargeable technologies, they are considerably lighter and safer. Steatite are developing battery packs complete with a Battery Management System that will not require the heavy and bulky pressure housings that are currently used in many Underwater Autonomous Systems . This modular battery design offers a scalable high energy solution that can be utilised in a variety of Marine applications, including, Sea floor systems, Nodes and Underwater Vehicles.

Benefits of Li-S Lithium Sulfur Batteries :

- **Higher Energy Density** - enabling longer operations
- **Lighter** - Improved buoyancy and greater payload capacity
- **Safer** - Tolerant to short circuiting and puncture.
- **Cost** - Improvement to mass density provides significant cost saving by dramatically reducing the need for expensive Syntactic foam required as buoyancy.
- **Scalability** - modular design complete with battery management system (BMS).

Overview: The Chemistry

A traditional Lithium ion cell contains graphite mixture in the anode and a combination of lithium and other choice metals in the cathode. However, in an Li-S cell, the anode consists of pure Lithium metal, while the cathode uses Sulfur as its active material. But, Sulfur has a low conductivity, and so carbon is added to alleviate this, and lastly, a polymer is used to bind them to the aluminium current collector.

For a safe cell, it is important to formulate an electrolyte which has a high flash point. The OXIS Li-S electrolyte has a very high flash point, over 100°C. Further to this, the OXIS Li-S chemistry forms a protective Lithium Sulfide (Li_2S) layer on the anode, which has a high melting point of 938°C which acts as a perfect insulator to prevent thermal run away. Conventional Lithium ion batteries have alkyl carbonate-based electrolyte that have unresolved safety issues. The beginning of thermal energy and flammability of the solvent vapour will start to occur at around 160°C which is likely to result in venting and cell disassembly.

The OXIS Lithium Sulfur technology is safer than Li-ion due to a higher flash point of electrolyte and the protective Lithium sulphide layer on the anode.

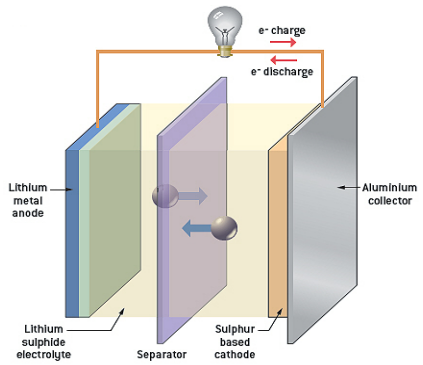

Fig1. The Chemistry of Li-S extracted from OXIS Energy

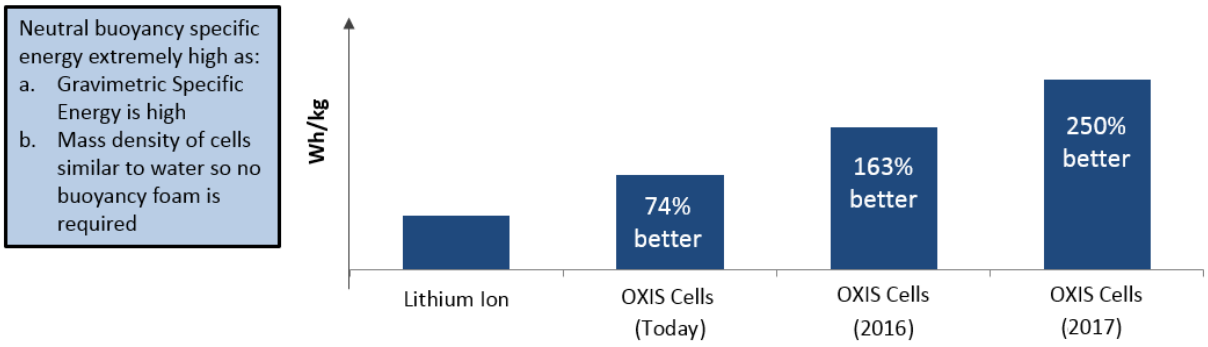

Figure 2 — Improved range and performance through increased neutral buoyancy specific energy

OXIS cells today, offer a significant improvement over the best performing Lithium Ion solution available. At a research and development level with long life cells, they are already achieving 220 Wh/kg . Current projections for the Ultra light cells predict a gravimetric energy density of 400 Wh/Kg early in 2017.

Lithium Sulfur cells offer wider benefits for marine autonomous systems, the cells have increased specific energy compared to current lithium cells used in AUV applications, and the cells are significantly less dense compared to the conventional lithium polymer cells, with a density of 900 kg/m3 compared to 2100 kg/m3. This decrease in density produces a substantial benefit for AUV applications, as it is necessary to float the batteries. It is considered the specific energy of a battery pack for an AUV must include the mass of the foam required to float the batteries. Assuming that the batteries are floated with one of the best available 6000m rated syntactic foams and taking the nominal density, we can calculate the amount of foam required to float a 1kg pack and hence calculate the specific energy of a neutrally buoyant battery system. Reducing or eliminating the need for expensive Syntactic foam, will greatly reduce the overall cost compared with other solutions. This benefit of the lithium sulfur battery pack facilitates additional research equipment, longer deployment time and increased speed.

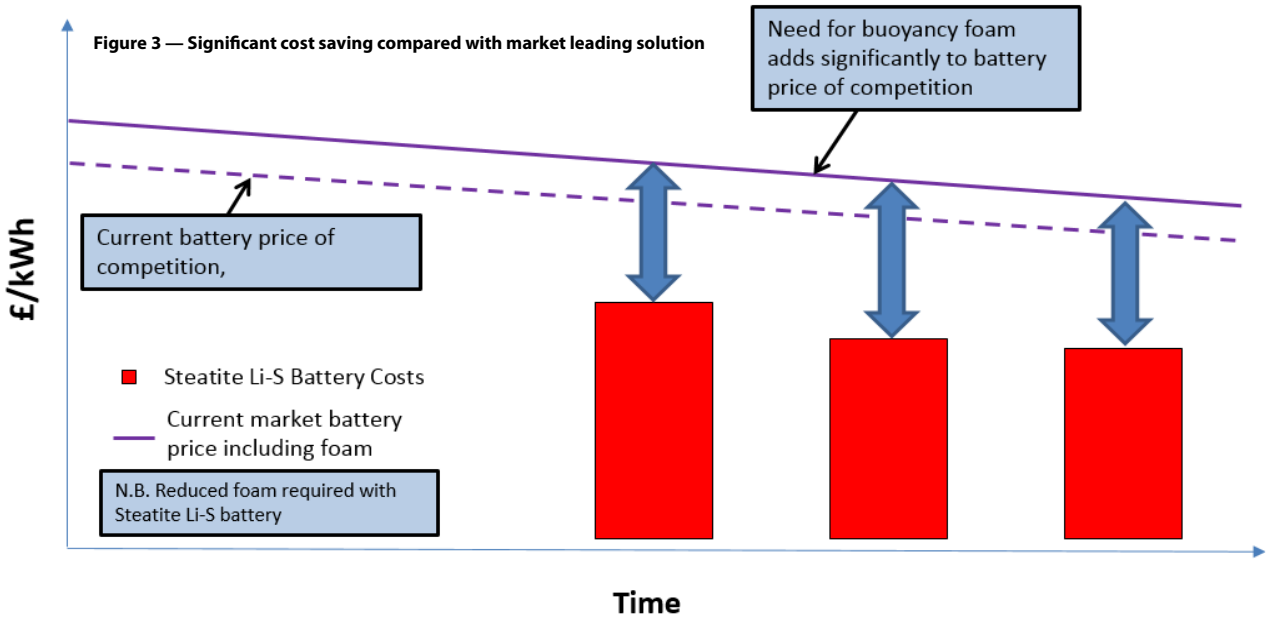

Figure 3 — Significant cost saving compared with market leading solution

The Way Forward

Steatite has specialist industry skills in Oil and Gas, Oceanography, Security and Defence applications. Our dedicated in-house teams support customers by designing, building and supplying the most advanced range of battery systems tailored to their application needs supported by the reassurance of first class quality standards.

Li-S performance has rapidly growing potential and many more enhancements are expected. There will certainly be major gains in technology advances now that the manufacture of the cells is moving to large scale production, and the OXIS team continues to implement development programmes the technology. With the continuous developments of new polymer binders, carbon materials, electrode substrates and Lithium salts, we will see many improvements to the Li-S technology. Li-S will offer significant benefits in harsh operating environments such as, unmanned vehicle systems, portable power, energy storage and defence applications.

For more information on the latest developments and product updates contact Steatite today...

STEATITE LIMITED
RAVENSBANK BUSINESS PARK
ACANTHUS ROAD
REDDITCH
WORCESTERSHIRE
B98 9EX

TEL: +44 (0)1527 512400
FAX: +44 (0)1527 512419
EMAIL: sales@steatite.co.uk

www.steatite.co.uk
PART OF SOLID STATE PLC