A Novel Battery Chemistry, From Russia with Love

OXIS Energy Ltd

Key Data Fact File
Technology: Polymer Lithium-Sulphur battery
Established: 2004
Type: Start up company
Location: Abingdon, Oxford
Employees: 20
Funding: Seed and venture capital
CEO: Huw Hampson-Jones
Bio: Joined OXIS in January 2010. Previously based in Sweden for 10 years supporting the management of high tech companies for European VCs. Early career with Siemens AG.

Lithium-Ion (Li-Ion) is usually cited as the battery for future electric vehicles, but it still needs to overcome safety, price and capacity constraints. We introduced Oxford-based Nexeon in the previous issue of *Technology: Inside* because it promises solutions to improve many of these constraints.

On the same research park as Nexeon is OXIS Energy, which is proposing another approach to solve these issues. Its approach is based not only on the improvement of the cathode material, but the electrochemical system as well – in this case, Polymer Lithium-Sulphur (Poly Li-S). The new system incorporates a new kind of cathode and anode along with the new electrolyte and battery design. In OXIS's view, this is the only battery chemistry which can deliver the low weight and high energy storage that will make the electric vehicle a final reality.

GENESIS

OXIS has been working on lithium-sulphur battery technology since 2004 when it began to exploit research from the Ufa Research Institute in the Urals, a region at the geographical edge of Europe which is known as a centre of excellence in sulphur and electrochemistry. More recently, OXIS has been collaborating as well with the Materials Departments of Oxford and Cambridge Universities.

The three primary functional components of a lithium-ion battery are the anode, cathode and electrolyte. Both the anode and the cathode of a lithium-ion cell are made from a type of intercalation material (typically carbon or in the case of Nexeon silicon) which means that Lithium ions must insert into the electrode 'host' matrix when charged (anode) or when discharged (cathode). The weight of the host material however accounts for its inherent weight overhead. OXIS's Polymer Li-S system does not have such host materials and therefore it says is inherently lighter.

Around this new electro-chemistry OXIS has filed 9 families of patents, over half of which have been granted, covering the UK, USA, Europe, Japan, South Korea, India, Russia and

China. Patents cover the use of a metallic lithium negative electrode with carbon/sulphur positive electrode in the proprietary polymer electrolyte system.

ADVANTAGES

As OXIS points out there is an inherent limit on the gravimetric energy density of Li-Ion batteries which comes from the nature of the host material. According to OXIS, the theoretical gravimetric energy density of its Polymer Li-S is 5 times higher than that of the optimum currently achievably by a Li-Ion battery. In other words Polymer Li-S has the potential to deliver 5 times the run times for the same battery weight. In lab tests OXIS's Li-S has a gravimetric energy density of 250-350 Wh/kg (Watt hours per kilogram) which compares with 140 Wh/kg for current lithium-ion. Its aim is to improve this to five times the current levels of Lithium-ion batteries.

Another advantage claimed by Oxis for Polymer Li-S batteries is that polymer is stable under extreme temperature conditions: this is because the inner battery pressure does not rise due to the high electrolyte stability. OXIS has fabricated several hundred prototype cells and carried out key tests for thermal stability, nail penetration, short circuit and overcharge tests. According to OXIS says the cells have passed the tests with a high margin of safety.

THE TECHNOLOGY

The particular safety features of the OXIS technology are due to the fact that the Li sulphide forms a passivation layer to protect the Li electrode. The passivation layer is formed during cell assembly and is intrinsic to OXIS's chemistry. It is non electron conductive and also supports the high thermal stability of the Polymer Li-Sulphur battery technology up to temperatures of nearly 1000 degrees centigrade.

ELECTRIC VEHICLE MARKET

OXIS Energy therefore believes the higher performance of its proprietary battery system compared with existing rechargeable battery technologies will be critical in the transportation sector, where the weight of the battery (its energy weight ratio) is the key to performance.

Li-Ion batteries used in Electric Vehicles are costly ($1,200 per kWh according to OXIS), contain cobalt (carcinogenic), and do not comply with the safety requirements of the car industry without being encased in a steel vessel. OXIS says its Polymer Li-S chemistry addresses all of these issues, and therefore has the potential to be the major breakthrough needed in electric vehicles.

For Li-Ion batteries, the area of most technical difficulty is cycle life (the number of complete charge - discharge cycles a battery can perform before its nominal capacity falls below 80% of its initial rated capacity). The current level of 200-350 cycles is below the usual life-time of a battery (between 500 to 1200 cycles). OXIS expects to improve this to

500 cycles over the next 18 months. To achieve this it has initiated a new funding programme for new production equipment, and has set a goal to achieve 2000 cycles within 3 years.

Besides this it needs to demonstrate the ability to maintain the performance of the battery scaled up in volume production. Having recently raised further funding, OXIS is now recruiting process and test engineers in order to develop a volume manufacturing process. In two years it hopes to reach the point where it is able to provide pre-production cells, ready for mass production. The requirement is to ensure that the pre-production cells achieve the same safety and performance features as the lab prototypes.

OXIS says that the Polymer Li-S manufacturing process is relatively close to the processes used in the Lithium industry and, in theory, existing Li-Ion and Li metal production plants could be re-equipped to manufacture Polymer Li-S batteries, using between 70% to 80% of their existing manufacturing processes. According to OXIS, the battery chemistry is cheaper than competing chemistries because sulphur is plentiful as a waste product of petroleum production. A further cost saving arises from not having to use the expensive anode host materials in Li-Ion. OXIS now has partners in China and Europe who are assisting it to source these low cost materials.

TO BE NUMBER ONE

OXIS says its goal is to be the “Number One Centre in the world for the design, architecture and development of lightweight rechargeable battery technology”. To progress in this direction it has started discussions with leading battery and automotive manufacturing companies on technology licensing. Car companies often have their own battery development operations, so are highly influential in deciding the battery chemistry adopted, and their response will therefore be critical.

Although OXIS believes the Polymer Lithium-Sulphur battery chemistry is unique to OXIS, others such as Idemitsu Kosan Co Ltd of Japan have exhibited a Li-Ion battery using a variation of lithium sulphide .The battery generated significant press attention and interest when it was showcased at the 1st International Rechargeable Battery Expo, which took place from March 3 to 5, 2010, in Tokyo. Oxis however says there is the possibility of a patent infringement, since OXIS owns the fundamental patent for Lithium-sulphide electrochemistry.

There is also now an element of competition now between the US and the UK to prove the technology. OXIS is backed by the UK government’s Technology Strategy Board, which is funding a one-year research program to confirm the potential of the OXIS battery. In the US corner, so to speak, the US Department of Energy is providing Sion Power - the leading developer in Li-S chemistry in the US - with a three year funding grant to support the development of a new electrolyte. OXIS believes its own electrolyte already has the necessary performance and better safety features. This “battery race”, however, will be healthy to draw attention to the benefits of sulphide. OXIS, with some “Love” from Russia intends this to be one “Race” that the Americans won’t win.