The Foundation for Science and Technology
Debate Record Note

Meeting the Battery Challenge

Date and Location: 16th October 2019 at The Royal Society

Chair: The Rt. Hon, the Lord Willetts FRS
Chair, The Foundation for Science and Technology

Speakers: Professor Clare Grey FRS
Department of Chemistry, University of Cambridge
Ian Ellerington
Head of Technology Transfer, Faraday Institution
Dr Christopher Lee
Technical Director, Ilika
Robert Millar
Head of Electrical, Williams Advanced Engineering

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Sponsors: The Faraday Institution

Audio/Video Files: www.foundation.org.uk

Hash tag: #fstbattery . Twitter Handle: @FoundSciTech .

LORD WILLETTS opened the meeting by saying this was an apt moment to discuss battery technology with the Nobel Prize for Chemistry recently being awarded to the researchers behind the lithium-ion battery. Lord Willetts hoped the discussion would cover whether the future would see improvements to lithium-ion batteries or new solid-state batteries, but also touch on other uses for batteries outside of the automotive sector such as off-shore wind renewable energy storage. He also expressed his delight that attending the evening's discussion were members of the new Foundation Future Leaders programme which aimed to tap into the next generation of researchers, industrialists and civil servants. He thanked the body leading this challenge, the Faraday Institution, who were kindly sponsoring the event.

PROFESSOR CLARE GREY, University of Cambridge, started by outlining the benefits that batteries will bring, from reducing CO2 emissions to helping provide cleaner air. The automotive sector is a major user, but batteries will also play a crucial role in grid storage as, at the moment, increased renewable energy usage reduces grid stability. She warned however, that the solution is not as simple as scaling up current batteries.

Providing an overview of battery technologies, Professor Grey reminded the audience that batteries contain metastable materials: as they heat up oxygen is released and the materials decay. This decay is reduced only due to the creation of a protective layer on the anode. We need to ensure we are developing materials that can last for 7 years in electric vehicles and up to 20 years for grid storage.

Since the original research, battery density has increased while battery price has decreased 10-fold. However, we are reaching the limits of possibilities as scaling batteries up causes safety issues.

Development of materials such as 811 (containing 80% nickel, 10% cobalt, 10% manganese) allows a good compromise between cobalt use (which is expensive) and battery stability. Professor Grey is working to fully understand how 811 degrades and to develop mitigating solutions. Other materials such as silicon can give 10 times more energy density but this causes the material to expand, thus creating a changing battery size and exposing fresh surfaces that react and degrade. In order to reduce material costs, options such as cheaper materials, thicker electrodes, dense materials that maximise ion transport and increased battery life are being explored. To produce this longevity we need lab experiments that will predict the degradation of batteries not just in days and months but 10 years into the future.

Professor Grey did not believe that the overall supply of lithium was an issue but that security of supply and recycling lithium from used batteries were concerns.

In order to meet 2050 CO2 reduction targets, we need radical thinking to create a step-change in our thinking about batteries with a need to find more abundant and cheaper materials. Batteries need to be made sustainably, and we must consider that mining, metals reduction and manufacturing processes all produce CO2 emissions.

In Professor Grey's view, the ultimate aim would to be to develop a lithium air battery which would have the same energy density as gasoline. There were many challenges to the development of this type of battery and continued research was needed including research into other technologies such as solid-state batteries. She concluded by highlighting the need for systems thinking to join up each element's development and their interactions.

IAN ELLERINGTON, Head of Technology Transfer at the Faraday Institution, started by saying that though batteries have few components, they are very complex items. The Faraday Battery Challenge has three strands – a research programme run by the Faraday Institution, an innovation programme for SMEs and a Battery Industrialisation Centre. The aim is to make a compelling offer to UK business and to make the UK a world-leading place for the battery industry.

Ian spoke about learning from the 1980s when Japanese businesses licensed UK research and used it in consumer electronics. At that time the UK had minimal consumer electronics demand and could not justify large investments - unlike Japan who became the world's leading consumer electronics industry. The UK has an opportunity to become a world leader in battery technology if we invest in its development now. Ian had searched on the FST website for 'batteries' and came across a 2009 event in which a presenter concluded that building an electric vehicle was too expensive as a number of technologies needed developing before they would become widespread. Since that event, the cost of batteries had reduced by 90% and continues to reduce. Batteries will be fundamental to meeting our carbon reduction challenges and developing the next generation of vehicles, so we need to develop the battery industry within the UK.

There is a large automotive industry within the UK that could and should be at the forefront of the change to battery technology, by developing our own battery industry and attracting overseas companies to the UK. Electric vehicle usage will only be widespread when they become cost effective for consumers. Cost competitiveness continues to get closer, from initial dates of 2025, to 2022 and some forecasts putting 2020 as the date when buying an electric vehicle will be a cost-neutral decision for consumers.

Ian outlined that battery technology is not just important for the automotive sector but also for the consumer electronics sector. For example, Dyson has spoken publicly about battery technology in its latest range of cordless vacuum cleaners.

To be able to take advantage of this increased move to batteries we need to develop a strong research base within the UK. The Faraday Institution remit is application-inspired research for specific impacts. To this end it has a number of research programmes looking at current technologies such as lithium-ion batteries, extending battery life and smarter manufacturing as well as future technology such as sodium batteries and solid-state batteries. It aims to understand the main challenges to commercialisation of this technology.

The Faraday Institution takes a risk-balanced, portfolio approach with 20 university partners, research published in leading journals and the creation of patent applications on new materials. It works closely with industrial partners from small SMEs, like Ilika Technologies, to large multinationals, like Nissan, partnering with these companies to look across the research programme and identify short-term research programmes to answer pressing questions from industry.

Ian warned that research alone is not enough to develop the UK battery industry and highlighted how the Faraday Institution is investing in skills and education to develop the talent pipeline for the future of this industry. He concluded that this battery challenge is a long-term programme and we need to support the researchers and the nascent industry over the next 10 years.

DR CHRISTOPHER LEE introduced Ilika Technologies, formed in 2004 from a Southampton University spin out. Since then it had been a pioneer in solid-state batteries and is now listed on the London Stock Exchange. Ilika aims to position the UK as a world leader in solid-state lithium-ion batteries by developing the necessary materials and manufacturing capabilities.

One of a small number of UK companies developing next generation batteries, since 2008 Ilika had been developing solid-state micro-batteries using their proprietary High Throughput Technologies. These micro-batteries are small capacity, long-life devices that have applications ranging from the Internet of Things to biomedical devices. Recently they had been supported by the Faraday Challenge and Innovate UK to build a facility outside Southampton consisting of purpose-built pre-pilot development lines to develop the manufacturing processes needed for larger solid-state lithium batteries.

While solid-state batteries have chemistry very similar to that of lithium-ion batteries, they offer several advantages over incumbent lithium-ion technology. Solid state batteries do not contain any volatile or flammable electrolytes nor contain any dangerous liquid or polymer parts which are the main causes of safety issues such as outgassing, swelling and, in rare cases, explosions.

Solid state batteries could play a crucial role as an enabling technology for widespread electric vehicle uptake as their higher energy density increases driving ranges and reduced vehicle charging time due to faster charging and discharging cycles.

Despite these advantages there are various manufacturing challenges that need to be overcome before widespread adoption. Material properties need to be better understood to mitigate cell resistance, ensure appropriate capacities and voltage windows and minimise the stresses and strains within ceramic materials that can lead to cracking or delamination.

Ilika's Goliath development programme has developed a solid-state lithium battery which looks to transform the performance and safety of electric vehicles. Ilika is developing the manufacturing processes needed to commercialise at scale its micro-battery technology with £5m of support from Innovate UK.

Other research programmes, such as PowerDrive Line project, which aims to develop the solid-state batteries materials supply chain, and the Granite project, which aims to understand the transition between lithium-ion and solid state battery manufacturing, are priorities for Ilika Technologies. Chris concluded by looking forward to successful project completion and sustained support for the challenge by the UK Government.

ROBERT MILLAR, Head of Electrical at Williams Advanced Engineering, started by saying that Williams Advanced Engineering were fundamentally dependent on the other speakers' work. The Williams Group is best known for its F1 team but less well known for commercialising the technology developed for its racing team. Williams were ahead of the competition, having developed batteries in 2009 to take advantage of the kinetic energy recovery technology introduced into F1 at that time.

Williams Advanced Engineering's focus is high performance applications and Rob's team work on turning commercially available cells into modules and modules into batteries. Most cells on the market have either high power density or high energy density. The challenge was how to get the best compromise between the two, or to deliver both qualities at the same time.

To meet this challenge Williams Advanced Engineering has developed a hybrid module, a mixture of high-power density and high-energy density cells with power electronics which transfers energy between the two. Whilst the concept is simple, the solution is not deliverable economically at scale, but it should become scalable as more very high energy cells, such as solid state cells, come to the market.

Rob and his team also work with researchers on battery management algorithms to gain more power and capability from current cells. The benefit is that even though a cell has its performance limits, more accurately calculating those limits allows you to get closer to them and maximise the full cell capability. This allows for improved results from the current cell technology.

Rob noted that Williams Advanced Engineering is also developing the mechanical and thermal aspects of batteries, allowing them to deliver the most weight and volume efficient module possible through new materials and new techniques.

In the debate that followed, recycling was a major topic of concern - ensuring that this was taken into account during the design stage. The panel also spoke of the importance of recycling here in the UK so that we did not need to ship material abroad. Comparison was made between the 99% recycling rate for lead-acid batteries, and lithium ion batteries where the recycling figure was closer to 10%.

The panel had mixed views on the route to a solid-state battery future, with some feeling that 2025 was too optimistic due to the significant material challenges that still needed to be overcome and challenges of scaling up the technology.

Discussions on implications for the national grid and whether battery technology would lead to a decentralised model were highlighted. This was an area where the automotive use of batteries may overlap with energy storage as consumers may use their car batteries to power their homes whilst parked; though there was an opinion that having energy storage closer to the production of energy would be more feasible in the short term due to costs of producing grid-scale storage. There was also a point on charging infrastructure but it was seen that this will be independent of which battery technology is taken forward and that a universal connection standard will be the way to ensure the interoperability of different manufactures and technologies.

Discussion of where the UK can learn from abroad noted that the USA was investing significant sums into research and there was more risk appetite to allow for failure. Long term investment was also an area where the UK could learn from abroad.

There was also discussion on the future of the STEM talent pipeline for this new industry and the work that the Faraday Institution was doing to encourage all STEM disciplines, especially to young women.

Tom Grant