Technology Strategy Board
Driving Innovation

Collaboration Nation

Fuel cell manufacturing

September
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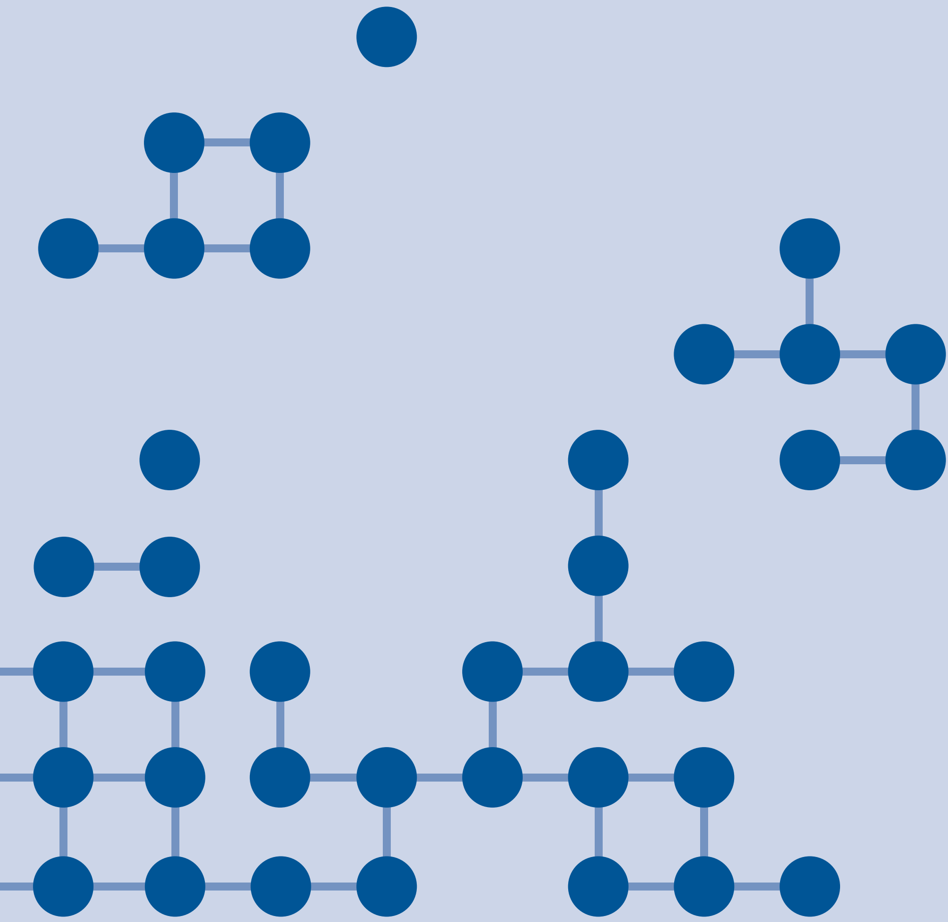

The development and use of new technologies drive economic growth, but early-stage innovation can be too high-risk for many small and medium-sized businesses to undertake without support.

Our feasibility study funding enables new ideas to be transformed into demonstrable technologies and techniques that can attract the partners, investors and future customers needed for successful and timely commercialisation.

This directory showcases some of the feasibility studies we have funded in our energy programme.

Introduction

Energy is one of the priority areas for the Technology Strategy Board. We aim to help UK business to address the 'trilemma' of energy security, affordability and sustainability, and to profit from the changes the world will have to make to its energy system. Global markets for fuel cells are expected to grow significantly over the next five to 10 years, including in transport, energy, consumer and industrial applications.

A number of UK companies have developed innovative products for these markets. However, as markets for these technologies develop, business will need to massively scale up production to meet expected demand, while reducing costs and continuing to increase performance.

To encourage the development of these production capabilities, along with novel supply-chain partnerships, the Technology Strategy Board awarded £1m for innovative feasibility studies into fuel cell manufacturing.

Our aim is to help businesses make the necessary step changes in production volumes and in reducing lifetime costs by using innovative ways of applying knowledge and capabilities from other business sectors or the academic community.

The further success of these projects rests on their ability to commercialise their innovations, often with others as industrial or academic partners or investors. That might include you.

To find out more about our energy strategy, go to **www.Innovateuk.org** and look under Our Priorities. To meet people working in your area go to **http://connect.innovateuk.org**

Liz Flint
Lead Technologist – Energy Generation and Supply

Collaboration Nation

Fuel cell manufacturing

ACAL Energy Ltd

Partner:
Thomas Swan & Co Ltd

Low-cost catalyst manufacturing for FlowCath® fuel cells

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ACAL Energy develops novel chemistry for use in fuel cells, a platinum-free liquid catalyst, FlowCath. Thomas Swan provides contract manufacturing for outsourced chemicals.

What was the business need that motivated the project?

FlowCath has been developed in the lab by ACAL Energy. We now need to make large volumes of the chemicals to support the development of larger systems and to meet the requirements of customers. Thomas Swan has the facilities to scale up the processes used in the lab from hundreds of litres to 10,000 litres and more.

What approach did you take to address the challenge?

We need to assess which lab-based methods used to synthesise the FlowCath can be transferred to the scale-up process and also to identify ways of keeping energy costs low and yields high during synthesis. Materials are being produced in the pilot plant at Thomas Swan and then evaluated by ACAL Energy.

What are the potential benefits?

The benefits are: larger quantities of FlowCath to speed up system development; being able to provide FlowCath chemicals to customers and partners for further evaluation; validation of scale-up methods and processes for very large quantities of chemicals that can meet the target cost.

What are the next steps?

The plan is to ‘freeze’ the chemical formulation and then to seek REACH certification. Once that is achieved we will then be able to supply large quantities of FlowCath to our developing customer base.

ACAL Energy Ltd

Partner:
TATA Steel

Stainless steel and steel components for FlowCath fuel cells

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ACAL Energy develops novel chemistry for use in fuel cells, namely a platinum-free liquid catalyst, FlowCath. We are looking at long-term compatibility of coatings and steel with FlowCath chemicals for use in proton exchange membrane (PEM) fuel cells.

What was the business need that motivated the project?

We want to develop a range of approved materials that offer long-term durability when exposed to the acidic FlowCath chemicals. These materials will be part of an approved list for licensees of the technology to use in designing fuel cell systems.

What approach did you take to address the challenge?

The challenge was to identify materials that would be corrosion-resistant in the long-term. Our tests were based on inductively coupled plasma (ICP) analysis of the liquors after exposure and also weight loss or gain from the exposed materials. Our aim was to identify a range of suitable low-cost materials and coatings.

What are the potential benefits?

As well as identifying a range of approved coatings and substrate steels, we would be able to deliver the low-cost benefits of FlowCath chemistry and provide long-term stable operating conditions. We could also identify assembly methods to meet tolerance requirements.

What are the next steps?

The coating materials are currently being developed before being released for testing in FlowCath solutions.

Amalyst Ltd

Utilising next generation fuel cell catalysts

Partners:
PV3 Technologies
and ACAL Energy

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Amalyst is a recent spin-out from University College London with patents in highly active, platinum-free electrocatalysts for water electrolysers and fuel cells. Amalyst is managed by Dave Hodgson and Chris Gibbs. PV3 Technologies and ACAL Energy are our project partners.

What was the business need that motivated the project?

We are a catalyst development company and will rely on toll manufacturing, in this case PV3 Technologies, to supply customers. Before the project we could supply only small samples to customers from our R&D laboratories. In order to meet customer demand, we needed to assess the feasibility of a production line capable of producing much larger quantities of catalyst.

What approach did you take to address the challenge?

Working with PV3 Technologies, we designed a pilot production line to scale-up our laboratory process. After speaking with original equipment manufacturers (OEMs) to inform the design, we tested equipment to investigate new ways of fabricating our materials. We then commissioned the line at PV3 Technologies and fabricated a catalyst batch. ACAL Energy tested electrodes made from our laboratory catalyst side-by-side with electrodes made from our batch in the pilot line.

What are the potential benefits?

We have commissioned a pilot line capable of producing 250g of Amalyst catalyst per run. This not only enables us to effectively meet early customer demand but also to purchase precursor materials at scale. The pilot line enables us to focus on our core R&D activities. Amalyst offers significant savings to water electrolyser and fuel cells which could accelerate take-up of these technologies, with immense environmental benefits.

What are the next steps?

We plan to optimise the fabrication process at scale to ensure quality, reduce cost, and increase yield. We will continue to investigate each process stage, envisaging a production line able to produce 1kg batches. This will enable us to supply large customer orders with our highly active, platinum-free electrocatalyst.

ITM Power

Membrane-compatible fuel cell bipolar plates

Partners:
Advanced Chemical Etchings Ltd and Teer Coatings Ltd

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ITM Power is an AIM-listed-company which designs and makes hydrogen energy systems for energy storage and clean fuel. Advanced Chemical Etching specialises in manufacturing precision photo-etched metal components. Teer Coatings has a strong track record in coatings.

What was the business need that motivated the project?

Bipolar plates for PEM fuel cells typically constitute more than half of a fuel cell stack's weight and 15-30% of its cost. The materials need to have low electrical resistivity, be corrosion-resistant and lightweight, as well as low-cost and suitable for volume manufacture.

What approach did you take to address the challenge?

Our project investigated the application of precision, photo-chemical etching of low-cost conventional metal substrates, combined with established nitride and/or carbon-based coatings. The aim was to achieve a step change in production volumes and lifetime cost reductions for metallic fuel cell bipolar plates.

What are the potential benefits?

Combining the coated, metallic, bipolar plate material with ITM's high performance membrane materials provides an opportunity to capture technological advantage. Benefits include: low cost – the photo tool is more efficient and less expensive than typical hard tooling; no hard tooling required, so no metal stress or deformation – etched parts remain flat since metal removal is chemical, not mechanical; secondary de-burring operations are eliminated, so material properties remain unchanged; excellent repeatability and accuracy.

What are the next steps?

After identifying promising low-cost metal substrates and corrosion resistant coatings, we will take these forward for further development. This will include a proposed volume manufacturing process and cost model(s) necessary for the production of coated etched metal substrates at volume.

Johnson Matthey Fuel Cells Ltd

Continuous processes for high-precision unitisation of membrane electrode assemblies

Partner:
Huxley Bertram Engineering Ltd

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JMFC is a leading manufacturer of membrane electrode assemblies (MEAs), which determine the power density and efficiency of PEM fuel cells. Huxley Bertram is an engineering automation company, providing consultancy, prototypes/ demonstrators through to fully automated production machines.

What was the business need that motivated the project?

As fuel cell vehicles are deployed in ever-increasing numbers, it is vital to implement high volume MEA manufacturing processes, with a single manufacturing line capable of operating at up to around 100 linear metres per minute. Our strategy is to identify bottlenecks in such a process and to evaluate improved process options.

What approach did you take to address the challenge?

We investigated processes for rapid and accurate placement and attachment of gas diffusion layers (GDLs) to catalyst-coated membranes (CCMs) to produce fully-integrated seven-layer MEAs. Following trials to identify sealing materials and processes that could work in fractions of a second, we are preparing a full manufacturing design study to review the methodologies and conduct cycle time simulations for accurate placement of GDLs.

What are the potential benefits?

Successfully identifying processes for attaching the GDL at volume will contribute to higher integrated MEA manufacturing output, capable of matching the future volumes required by the automotive market. The manufacturing processes and adhesive materials we have identified should allow for rapid placement and bonding of fuel cell components. If further developed and exploited to demonstrate the manufacture of MEAs, this will provide a step-change in manufacturing volumes.

What are the next steps?

After successfully demonstrating the positioning system, we would combine this with the bonding system to produce seven-layer MEAs for cell testing validation. We would then progress to designing and building a system that could be integrated into a high volume continuous manufacturing line for seven-layer MEA mass production.

Johnson Matthey Fuel Cells Ltd

Partner:
Actinic Technology

In-line spectroscopic defect detection in catalyst-coated membranes

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JMFC is a world-leading developer and manufacturer of MEAs, the critical component that determines the power density and efficiency of the PEM fuel cell. Actinic Technology provides consultancy in the application of lasers and spectroscopy for chemical process monitoring.

What was the business need that motivated the project?

As fuel cell vehicles are deployed in ever-increasing numbers, it is vital to implement high volume MEA manufacturing processes. It also becomes imperative to develop rapid in-line tests for monitoring and controlling the quality of the MEAs produced. Defects can lead to early failure of the stack and need to be removed prior to stack assembly.

What approach did you take to address the challenge?

Our aim has been to evaluate the application of spectroscopic and thermography techniques to detect membrane defects inside manufactured catalyst-coated membranes (CCMs) and quantify the spatial resolution and time-resolved sensitivity of such measurements. We also assessed the feasibility of developing such techniques for application as an in-line measurement technique during continuous CCM manufacture.

What are the potential benefits?

A successful outcome from the project will be to enable the continuing growth of the fuel cell vehicle market. It will provide confidence to the vehicle manufacturers that fuel cell engines can be made with a consistently long life and will help to consolidate Johnson Matthey Fuel Cells' position as a major global manufacturer and supplier to this market.

What are the next steps?

We have identified several techniques capable of detecting faults on the surface and within CCMs at the required resolution. The next stage is to identify partner companies who can develop an in-line inspection system capable of monitoring CCMs at the line speeds needed for high volume manufacture of MEAs.

Johnson Matthey Fuel Cells Ltd

Partner:
Telsonic UK Ltd

Use of ultrasonic processes for catalyst layer transfer in CCM manufacture

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JMFC is a world-leading developer and manufacturer of MEAs, the critical component that determines the power density and efficiency of the PEM fuel cell. Telsonic UK Ltd specialises in industrial ultrasonic technology for a wide range of applications.

What was the business need that motivated the project?

As fuel cell vehicles are deployed in ever-increasing numbers, it is vital to implement high volume MEA manufacturing processes, with a single manufacturing line capable of operating at up to around 100 linear metres per minute. Our strategy is to identify bottlenecks in such a process and to evaluate improved process options.

What approach did you take to address the challenge?

We investigated using ultrasonic energy as an alternative heat source for an innovative, faster and more efficient process for the transfer of the catalyst layer to the membrane in CCM manufacture. We analysed the CCMs produced to relate ultrasonic process parameters to CCM characteristics and fuel cell performance. We also assessed the application of this process to continuous roll-good manufacturing.

What are the potential benefits?

Successfully applying an ultrasonic energy-based process in CCM manufacture would contribute to higher CCM manufacturing output, capable of matching the future volumes required by the automotive market. It would also offer energy savings, as the selective focusing of ultrasonic energy means that its use can be optimised. That minimises energy losses and would allow production cost reductions associated with reduced process times.

What are the next steps?

We have demonstrated the concept of using ultrasonic energy to transfer the catalyst layer to the membrane. However, the work has highlighted a number of challenges concerning sonotrode design and operational parameters that need greater understanding before the process can be scaled to high volumes, delivering high-performance CCMs.

Sustainable Engine Systems Ltd

Partner:
Arcola Energy

Improved thermal and water management of PEM fuel cells

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SES develops compact heat exchangers using selective laser melting (SLM), a version of additive powder layer manufacturing. Arcola Energy develops PEM fuel cells for education, portable power, transport and stationary markets. Imperial College's Fuel Cell Research Group is a subcontractor.

What was the business need that motivated the project?

Self-humidifying, air-cooled PEM fuel cells are cheaper, lighter and easier to integrate than water cooled systems employing active management of humidity. Unfortunately, they generally have lower power density and shorter life. This project aimed to develop an SLM passive heat and humidity exchange system which provided many of the benefits of active management with lower complexity, cost and weight.

What approach did you take to address the challenge?

SLM allows complex designs for heat and mass transfer not previously feasible. Taking as reference application the Arcola Energy lightweight automotive fuel cell system, we identified the exchanger requirements. Challenges included determining appropriate duct sizes and shapes, selecting an appropriate metal alloy (considering potential for poisoning of fuel cells versus manufacturing practicality and cost) and devising a representative lab test for small material samples.

What are the potential benefits?

If significant performance increases can be achieved with a passive thermal and water management unit, then the usefulness of simple PEM fuel cell systems will be greatly improved, enabling lower-cost fuel cell products for more demanding applications. For example, there could be improved fuel cell power systems for lightweight automotive such as ultra-efficient urban vehicles (boosting UK leadership in this area) and longer run-time back-up power systems.

What are the next steps?

If final lab materials tests show positive results, our project team will create a full-scale prototype for an existing Arcola Energy product. If this is technically successful and commercially viable manufacturing processes can be developed, the technology would be deployed in Arcola Energy systems and manufactured/licensed for other systems integrators.

Tata Steel UK

Functional coated mild steel bipolar plates

Partners:
Teer Coatings,
Intelligent Energy

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The consortium consists of Tata Steel, a multi-national company that manufactures steel products, Teer Coatings, a specialist in PVD process and coating development, and Intelligent Energy, a leading UK and global competitor in the development of PEM fuel cell systems.

What was the business need that motivated the project?

Fuel cell stack costs remain a barrier to mass market commercialisation, with system costs far exceeding US Department of Energy targets. Gold-coated stainless steel is the current technology of choice for bipolar plates (BPP), a critical component within a fuel cell system. Mild steel with a base material cost significantly lower than stainless offers potential for meeting US DoE targets.

What approach did you take to address the challenge?

Criteria for assessing the potential of a coated mild steel BPP was based on a limited set of the US DoE's 2020 targets. Each of the partners undertook testing to characterise the performance of a combination of mild steel and coating options. For the cost analysis, US DoE cost data was used to develop a framework to cost the candidates being assessed for comparison against a stainless baseline.

What are the potential benefits?

Having a successful coated mild steel BPP will not only offer fuel cell manufacturers an alternative choice, but will also encourage further product innovation between different material suppliers. As a result it will help accelerate cost reduction, improve fuel cell performance and therefore encourage growth in the UK fuel cell supply chain.

What are the next steps?

This study has shown the potential for a coated mild steel BPP based on a limited set of technical criteria. The study now needs to consider a broader range of performance targets. Partnership with a component manufacturer will provide manufacturability and financial feasibility direction for the approach being proposed.

Versarien Technologies Ltd

Partner:
ACAL Energy Ltd

Low-cost, high performance metal foam cathodes for novel PEM fuel cells

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Versarien™ Technologies Ltd is a fast-growing, high technology, high-value materials manufacturer specialising in the commercialisation of porous metals. ACAL Energy is a globally innovative Fuel Cell technology company with more than 20 patents based around their 'FlowCath' cathode technology.

What was the business need that motivated the project?

We explored the potential of the patented, UK-invented lost carbon sintering manufacturing process to produce low-cost, high-performance cathodes for application in ACAL Energy's FlowCath technology. It was seen to potentially improve cell performance, reduce energy generation costs and cell electrical resistance. It addresses the needs identified in the International Energy Agency's hybrid and electric vehicle technology roadmap.

What approach did you take to address the challenge?

We developed the material specification and explored the capability of the process to achieve the required performance. Initial performance trials were carried out before assessment of the technical and commercial feasibility of the process. The innovation arises from the application of advances in metal foams being applied as a cathode.

What are the potential benefits?

The use of the developed cathodes could lead to improved fuel cell density, increased durability and reduced costs of production. All these have the potential for significant benefits for take-up and use in stationary and automotive power applications, if the feasibility study can be taken forward to a production level. Through the collaboration between the companies, we increased the capability of the UK supply chain in this area.

What are the next steps?

If the technical and commercial feasibility is proven, we will require significant further investment to develop a production solution. That investment will benefit from significantly reduced technology risk as a result of the foundations laid. The outcomes will also feed into Low Carbon Vehicles Integrated Delivery Programme 8 (IDP8) projects.

The Technology Strategy Board is the UK's innovation agency. Its goal is to accelerate economic growth by stimulating and supporting business-led innovation. Sponsored by the Department for Business, Innovation and Skills (BIS), the Technology Strategy Board brings together business, research and the public sector, supporting and accelerating the development of innovative products and services to meet market needs, tackle major societal challenges and help build the future economy. For more information please visit www.innovateuk.org

Disclaimer

Information for the entries in this directory was provided by the individual companies. The Technology Strategy Board cannot guarantee the accuracy or completeness of any of the information about the winning projects.

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