initiatives in the industrial packaging business, and started a successful global brokerage firm and a packaging components company. He is a graduate of Fairmont State University, West Virginia with degrees in business and political science.

Earlier this year Nexceris was awarded $2.2 million by the Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E), to develop a pressurised SOFC stack for hybrid power applications [*April 2018, p14*], and some $150 000 under DOE's SBIR/STTR programme to develop improved SOFC seals [*June 2018, p12*].

Nexceris: www.nexceris.com

RESEARCH

Danish 4M project leads to better fuel cell lifetime, performance

A consortium of Danish universities and fuel cell companies, working with researchers in Germany and South Korea, have completed the 4M (Mechanisms, Materials, Manufacturing and Management) development project, which has resulted in improved fuel cell lifetime and performance.

'The 4M project has helped [with] maturing the fuel cell technology significantly. The increased research in the fuel cell materials has provided us with a better understanding of the properties of polymers and membranes, and the interaction between the membrane and electrode,' says Thomas Steenberg, Technical Director of Danish Power Systems, as reported by *StateofGreen.com*. 'This has paved the way for a very long lifetime and high performance, which is a major step towards a commercialisation of the fuel cell.'

The five-year project, led by DTU Energy (the Department of Energy Conversion and Storage at the Technical University of Denmark) [*see also item below*], also included Aalborg University (Department of Energy Technology), University of Southern Denmark (Department of Chemical Engineering, Biotechnology and Environmental Technology), and University of Copenhagen (Department of Chemistry). These groups worked alongside industrial partners Danish Power Systems, SerEnergy, and EWII (formerly IRD Fuel Cells). The consortium also succeeded in bringing on board the Forschungszentrum Jülich Research Centre in Germany, one of the world's largest fuel cell institutes, as well as the Korea Institute of Science and Technology (KIST) and Sangmyung University in Korea.

'We expect more collaboration with Korea in the coming years,' says Professor Qingfeng Li at DTU Energy. 'Together with Danish Power Systems, we entered into an agreement with KOGAS [Korea Gas] from Korea last year [*FCB, August 2016, p11*], and that collaboration has already started.'

The 4M project was financed with a DKK31 million (US$4.8 million) grant from Innovation Fund Denmark towards the total project budget of DKK43.7 million ($6.8 million).

4M Centre: www.4m-centre.dk

DTU Energy: www.energy.dtu.dk/english

Danish Power Systems: www.daposy.com

SerEnergy: www.serenergy.com

EWII Fuel Cells: www.ewii.com/en/international/fuel-cells

CARB funding awards for fuel cell powered cargo handling, ferry

The California Air Resources Board has awarded $20 million in grants to accelerate the state's transition to zero-emission off-road equipment in the freight, agriculture and waterborne mass transit sectors. The successful projects include fuel cell powered cargo-handling equipment at the Ports of Los Angeles and Long Beach, and a hydrogen-powered passenger ferry in San Francisco Bay.

Two of the projects will demonstrate fuel cell powered, cargo handling equipment. A **fuel cell range-extended top loader** (for moving freight containers) with wireless inductive charging will be developed and deployed by Hyster-Yale Group, Nuvera Fuel Cells and other partners for a demonstration project at the Port of Los Angeles, coordinated by the Atlanta-based Center for Transportation and the Environment. The CARB grant will cover $6.5 million of the $8.8 million project cost.

And three battery-electric top handlers and two **yard trucks** (fuel cell and battery-electric) will be deployed at the Port of Long Beach. The City of Long Beach Harbor Department has been awarded a $5.3 million grant towards the $8.3 million project cost. The fuel cell electric yard truck will utilise Loop Energy's eFlow hydrogen fuel cell [*see the PowerDisc eFlow feature in FCB, March 2014*].

In addition, a **hydrogen fuel cell powered ferry** will provide a passenger service between the Ports of San Francisco, Oakland, Redwood City and Martinez in the San Francisco Bay Area. The Bay Area Air Quality Management District will receive a $3 million grant towards the $5.5 million project cost for this first high-speed, hydrogen-powered fuel cell marine vessel in the US.

The 70 ft (21 m) aluminium hull catamaran, designed by Incat Crowther and built by Bay Ship and Yacht, will be operated as part of the Red and White fleet. Power for the vessel – which has a 22 knot (41 km/h) top speed – will be generated by 360 kW of Hydrogenics PEM fuel cell power modules in combination with lithium-ion battery packs. The powertrain integration will be managed by Golden Gate Zero Emission Marine (GGZEM), which was set up by Dr Joe Pratt when he left Sandia National Laboratories – where he led the SF-BREEZE project [*FCB, August 2017, p12*].

There will be a three-month study period after the vessel is launched in San Francisco Bay, during which Sandia will independently gather and assess performance data. CARB will then use the real-world data to verify the suitability of the technology for marine use.

The projects – to be completed by March 2020 – are part of California Climate Investments, a statewide programme that puts billions of cap-and-trade (emissions trading) dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment, in particular in disadvantaged communities.

California Air Resources Board: www.arb.ca.gov

Center for Transportation and the Environment: www.cte.tv

Hyster-Yale Group: www.hyster-yale.com

Nuvera Fuel Cells: www.nuvera.com

Loop Energy: www.loopenergy.com

Bay Area Air Quality Management District: www.baaqmd.gov

Hydrogenics Corporation: www.hydrogenics.com

Golden Gate Zero Emission Marine: http://ggzeromarine.com

Sandia, Maritime Hydrogen: http://maritime.sandia.gov

Cell3Ditor progressing towards 3D printing of industrial SOFC stacks

The European Cell3Ditor project is making steady progress towards the development of an innovative 3D printing technology for the industrial production of solid oxide fuel cell stacks. The project is funded by the Fuel

Cells and Hydrogen Joint Undertaking (FCH JU), and involves eight partners from across Europe [*see the News Feature in FCB, October 2016*].

The technology allows the fabrication of SOFC stacks with unique features such as monolithic architecture, thinner elements and embedded fluidics, and current collection in only two production steps (printing and sintering). This simplification of the fabrication process reduces the operational cost and the initial investment required, increasing SOFC design flexibility and manufacturing reliability.

The achievements attained so far in this project, which include multi-material 3D printing of ceramics and the fabrication of hollow pieces, are bringing closer the highly desirable fabrication of joint-free and all-ceramic SOFC stacks. The outcomes of the Cell3Ditor project are expected to revolutionise the SOFC industry by bringing down the high manufacturing cost, increasing durability, reducing the time-to-market, and allowing easy customisation. Moreover, the advances accomplished in the hybridisation of 3D printing technologies (also known as additive manufacturing) will expand the scope of the project to other fields, opening the door to future breakthroughs.

The project is being coordinated by the Institut de Recerca en Energia de Catalunya (IREC, Catalonia Institute for Energy Research) in Spain, and also involves Barcelona-based automotive electronics manufacturer Francisco Albero SA (FAE) and the Inorganic Chemistry Department at the Universidad de La Laguna (ULL) in Tenerife. The other partners include the Department of Energy Conversion and Storage (DTU Energy) at the Technical University of Denmark [*see also page 14*], Promethean Particles Ltd in the UK, and 3DCeram in France. The stack design guidelines and the required quality control and standards are being led by Saan Energy in Sweden and HyGear Fuel Cell Systems in the Netherlands.

Cell3Ditor project: www.cell3ditor.eu

Video of 3D printer in action: www.youtube.com/channel/UCLBjbtdeN454YYsftZPkKQw

IREC: www.irec.cat/en

Fuel Cells and Hydrogen Joint Undertaking: www.fch.europa.eu

FuelCell Energy wins DOE project awards

Connecticut-based FuelCell Energy has been awarded some $10 million in new funding support by the US Department of Energy, for three projects to advance commercialisation of the company's solid oxide fuel cell platform for energy storage applications.

FuelCell Energy has now been awarded two projects aimed at advancing commercialisation of the company's energy storage solution, in addition to the recently announced $3.1 million DOE Advanced Research Projects Agency-Energy (ARPA-E) project for the development of ultra-high efficiency SOFC systems for distributed generation [*FCB, April 2018, p14*]. FCE will also receive $1.5 million for materials R&D aimed at reducing the operating temperature of solid oxide high-temperature electrolysis to levels compatible with advanced nuclear energy heat sources [*June 2018, p9*].

'These projects and the progress made on our existing projects demonstrate the readiness of our SOFC to advance to larger scale,' says Chip Bottone, CEO of FuelCell Energy. 'Utility companies are recognising the fast-growing need for cost-effective, financeable, long-duration energy storage, which is becoming increasingly urgent as more and more intermittent sources are placed into the electric grid.'

'Based on reversible solid oxide fuel cell technology, our solution converts excess power during periods of low power demand into hydrogen. An energy carrier stores our hydrogen onsite for long periods of time, and then uses this as a fuel source to generate clean power when needed during times of high power demand,' continues Bottone. 'This MW-scalable solution provides a long-duration storage, which compares very favourably against other technologies. We are ready to prove our application at a customer site, increase the scale of the technology, and demonstrate our efficient hydrogen-based storage.'

FuelCell Energy has also just been chosen to supply two SureSource™ molten carbonate fuel cell systems for new installations in Connecticut, funded by the state's Department of Energy & Environmental Protection [*see page 7*].

FuelCell Energy: www.fuelcellenergy.com

Autostack-Industrie partners talking to German automotive and supplier industry

The Autostack-Industrie project is a joint initiative of the German automotive and supplier industry, to create the technological and production technology preconditions required for the commercial introduction of fuel cell electric vehicles in Germany and Europe by around 2020. The project partners are now beginning a dialogue with suppliers on participation opportunities for fuel cells for automotive applications.

The project was announced last summer [*FCB, July 2017, p11 and January 2018, p12*], and is receiving €21.3 million (US$24.9 million) in funding within the scope of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP), coordinated by NOW GmbH. It involves automakers BMW (coordinator), Daimler (through its NuCellSys subsidiary), Ford and Volkswagen, as well as component suppliers Reinz-Dichtungs GmbH (part of US-based Dana), Freudenberg Performance Materials, Greenerity (part of Toray), stack developer PowerCell Sweden [*see also page 6*], Umicore, and the ZSW Centre for Solar Energy and Hydrogen Research Baden-Württemberg.

Autostack-Industrie aims to develop and share a stack technology for automotive applications, based on manufacturing processes and procedures that meet the functional, qualitative, and cost objectives of the automotive industry for industrial series production of stacks and components. This is underpinned by common design and quality guidelines for components and stacks that aim to maximise economies of scale in development and production, and the common use of key components.

An important aspect is the scaling up of stack performance for different vehicles and vehicle platforms. The project partners held a workshop in Frankfurt am Main on 26 June, to inform developers and suppliers about relevant aspects of component and stack design, important system interfaces and main components, the processes and development thereof required for mass production, as well as government funding opportunities. The event also provided an outlook on participation opportunities in development and production preparation, within the framework of supplier management.

NOW GmbH: www.now-gmbh.de/en

Autostack-Industrie workshop presentations [in German]: https://tinyurl.com/autostack-industrie-workshop