Cell3Ditor project on 3D printing tech for SOFC stacks

The new EU-funded Cell3Ditor project aims to develop a 3D printing technology for the industrial production of solid oxide fuel cell (SOFC) stacks. The seven partners anticipate cost-effective and flexible production of 3D printed SOFC stacks for commercial applications.

Stationary fuel cells based on SOFC technology operate at very high temperatures on a ceramic base substrate. Their market is highly varied in terms of the overall power and heat requirements, so that customisation of the final product is often necessary. Optimisation of manufacturing times and the need for design flexibility are a priority to facilitate their market deployment.

The fabrication of ceramic-based, multilayer solid oxide fuel cells (SOFCs) currently involves expensive and time-consuming multi-step manufacturing processes, including tape casting, screen printing, firing, shaping, and several high-temperature thermal treatments. In addition, these cells are manually assembled into stacks, resulting in extra steps for joining and sealing that challenge the standardisation and quality control of the final product, while introducing weak parts that are likely to fail.

Since current ceramic processing techniques present strong limitations in terms of shape and extremely complex design for manufacturing (for example, more than 100 steps), industrially fabricated SOFC cells and stacks are expensive, and suffer from low flexibility and long time to market. This is particularly relevant for the commercial segment of the stationary fuel cells market (5 kW to 400 kW), which is highly heterogeneous in terms of the overall power and heat requirements, and requires customisation of the final product.

The main goal of the **Cell3Ditor project** (Cost-effective and flexible 3D printed SOFC stacks for commercial applications) is to develop a 3D printing technology for the industrial production of SOFC stacks, by focusing on research and innovation in inks formulation, 3D printer development, ceramics consolidation, and system integration. All-ceramic, joint-free SOFC stacks with embedded fluidics and current collection will be fabricated in a two-step process (single-step printing and sintering) to reduce energy, materials and assembly costs, while simplifying the design for manufacturing and time to market.

Compared to traditional ceramic processing, the Cell3Ditor manufacturing process is expected to offer a significantly shorter time to market (reduced from years to months), and a 60% cost reduction, with an initial investment less than one-third of that for an equivalent conventional manufacturing plant (producing 1000 units per annum). The project is product-driven, and involves five European SMEs (small and medium-sized enterprises) with proven technologies in the entire value chain to ensure reaching Technology Readiness Level (TRL) 6 or better, i.e. technology demonstrated in a relevant environment.

The Cell3Ditor project began in July, and will run through December 2019. The project, funded with €2.2 million (US$2.4 million) from the FCH JU, is being coordinated by the **Institut de Recerca en Energia de Catalunya** (IREC, Catalonia Institute for Energy Research) in Spain. IREC's Nanoionics and Fuel Cells Group has experience in industrial fabrication and characterisation of solid oxide cells for electrolysis and power generation using conventional ceramic production techniques.

The other partners include Barcelona-based automotive electronics manufacturer **Francisco Albero SA** (FAE), whose expertise in industrial processing of devices based on advanced ceramics will be crucial for proper post-processing of the 3D printed objects, as well as better understanding the benefits of this new manufacturing technology. Also in Spain, the Inorganic Chemistry Department at the **Universidad de La Laguna** (ULL) in Tenerife specialises in inorganic synthesis and electrochemical characterisation. Its Nano and Microengineering of Materials Group has a track record in SOFC technology and materials engineering, and has been working on microstructural engineering of ceramics by different methods, including 3D printing.

The Department of Energy Conversion and Storage (DTU Energy) at the **Technical University of Denmark** has more than 20 years' experience in developing and scaling-up advanced functional ceramics, including expertise in sintering, deposition, printing, and synthesis of functional nanoceramics. DTU has developed one of the first proof-of-concepts for 3D printed SOFCs [*FCB*, June 2014, p10].

The French company **3DCeram**, which is focused on applying its proprietary laser stereolithography (SLA) technology to ceramics, will lead development of the 3D printer and SLA slurries for the project. The nanodispersions to be employed for inkjet printing will be mainly developed by UK-based **Promethean Particles Ltd** and DTU. Promethean designs and develops inorganic nanomaterials in liquid dispersions, using a patented reactor that allows continuous hydrothermal synthesis of inorganic nanoparticles, so the nanoparticles can be tailored to get the best functionality for a specific application.

The design guidelines for the Cell3Ditor SOFC stack for integration in real power generation systems, and the required quality control and standards, will be headed by **Saan Energy AB** in Sweden and **HyGear Fuel Cell Systems BV** in the Netherlands. Saan is developing fuel cell solutions for diversified energy segments, including decentralised power systems and combined heat and power units, building on previous SOFC integration experience at the DLR German Aerospace Center. HyGear is focused on developing and manufacturing fuel cell systems and reformer technology for onsite hydrogen supply. It has gained experience on kW-scale SOFC system integration and design in a collaboration between Plug Power and NexTech Materials.

More information

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Universidad de La Laguna: www.ull.es [in Spanish]

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

3DCeram: www.3dceram.com/en

Promethean Particles Ltd: www.prometheanparticles.co.uk

Saan Energi AB: www.saanenergi.se

HyGear Fuel Cell Systems BV: www.hygear.nl