DTU Achieves 5X Power-to-Weight Gain in Hydrogen Engines Using Ceramic 3D Printing

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Researchers at the Technical University of Denmark (Department of Energy Conversion and Storage / DTU Energy) have achieved a major breakthrough in power density in the race for future lightweight hydrogen energy systems.
“Escape Flatland” – Instead of conventionally stacking flat layers, the team has overturned this prevailing paradigm by printing single, three-dimensional monolithic fuel cells with nature-inspired, thin-walled gyroid geometry on their Lithoz CeraFab System.
Using Lithoz Yttria fully Stabilized Zirconia (8YSZ) as electrolyte membrane material, the specific power-to-weight ratio at the device level was increased fivefold compared to current flat SOFCs.

Qualifying LCM as a key enabling technology, DTU now plans to scale the project to an industrial level.

Copenhagen / Vienna: A DTU research team led by Prof. Vincenzo Esposito of the Department of Energy Conversion and Storage (DTU Energy) has demonstrated a paradigm-changing architectural approach to SOFC design in the context of worldwide efforts to accelerate the energy transition in transportation by implementing more efficient fuel cell engines. Defining the power-to-weight ratio as the key parameter for SOFCs to push the performance and long-range qualities of hydrogen-powered transportation to the next level, the team developed monolithic SOFCs with nature-inspired, thin-walled gyroid geometries made from yttria-stabilized zirconia (8YSZ) and printed on their recently acquired Lithoz CeraFab unit. The work was carried out in collaboration with researchers from DTU Construct, with Associate Professor Venkata Karthik Nadimpalli contributing expertise in mechanical behaviour and the structural optimization of architected ceramic materials. The collaboration helped assess the structural stability of the thin-walled gyroid architecture under thermal and operational conditions.

At the device level, the architecture demonstrates power-to-weight ratios approaching around 1 W g^{-1}, compared to around 0.2 W g^{-1} typical of conventional planar SOFC architectures. “This innovation is a real paradigm shift from planar stacking to monolithic architectures.” as Prof. Esposito explains.

This departure from stacking planar items has a strong disruptive impact on the search for further power-density potentials in hydrogen propulsion, as the combination of thin inner walls with the elimination of interconnects and sealants results in a drastic loss of weight, reduced thermal mismatch and mechanical stress, all while significantly improving the utilization of the available volume. The remarkably compact, lightweight SOFCs created now allow for a complete rethinking of both long-range and ultra-compact hydrogen engine designs for all kinds of transportation on water, on land, and particularly in the air.

Prof. Esposito states: “Our motto, ‚Escaping Flatland, , sounds like a logical step, but it has long been impossible to achieve. The particular arrangement of materials and microstructures requires a significantly elevated level of complexity – but until recently, we simply lacked the tool to make this concept a reality. 8YSZ remains one of the most widely used and technologically mature electrolyte materials for SOFCs. With its mature precision and scalability, Lithoz LCM technology has demonstrated the highest repeatability for these bio-inspired TPMS geometries with the thinnest possible inner walls, which inherently meet the gas supply requirements. The monolithic concept could only be achieved by precisely replicating those gyroid units and adding a sealed shell frame to maintain gastight conditions.”

Johannes Homa, Lithoz CEO adds: “By realizing 8YSZ monolithic fuel cells with intricate gyroid geometries on their Lithoz CeraFab printer, DTU was able to reduce the dependence on conventional interconnect and sealing architectures inherent to stacked flat items. These elements have traditionally been the Achilles heel in the search for better power density in commercial planar SOFC stacks and, therefore, the traditional focus of attention in the quest for a more advantageous power-to-weight ratio. With their revolutionary monolithic concept, these elements eliminate the need to gradually optimize exit points, paving the way for a complete rethinking of fuel cell design. Of course, we are extremely excited about the impact this will have on the worldwide hydrogen-based industry.”

As the design and test phase at DTU Energy has now concluded, the team around Professor Esposito plans to scale the project to an industrial level.

About DTU Energy

DTU Energy – the Department of Energy Conversion and Storage at the Technical University of Denmark – conducts research on materials, devices, and systems for sustainable energy technologies. The department focuses on electrochemical energy conversion and storage, including fuel cells, electrolysers, batteries, and advanced materials for next-generation energy systems. By combining fundamental materials science with device engineering and system integration, DTU Energy develops technologies that support the transition to reliable, sustainable energy infrastructure. DTU Energy works closely with industrial partners and international research institutions to translate scientific discoveries into practical energy solutions for sectors such as transportation, power generation, and energy storage.