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NexTech's FlexCell Planar SOFC Technology

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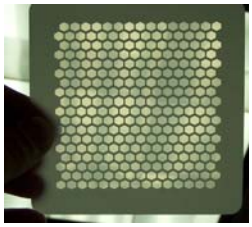
NexTech's FlexCell ™ Membrane Architecture

The *FlexCell* is a patent-pending electrolyte-supported planar SOFC cell design comprising a thin electrolyte membrane layer that is mechanically supported by a "honeycomb" mesh layer of electrolyte material. With the *FlexCell*, more than 70 percent of the electrolyte membrane within the active cell area is thin (less than 40 microns). After the bi-layer element is sintered, anode and cathode layers are separately deposited onto the major faces to define the active cell regions. The *FlexCell* combines the attributes of anode-supported and electrolyte supported cell designs, with a thin electrolyte layer for high performance, and the dense periphery for ease of sealing.

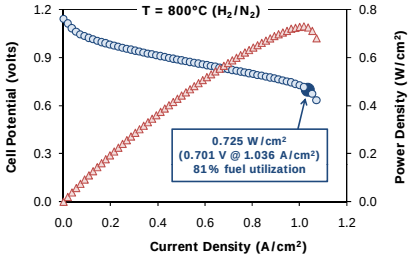


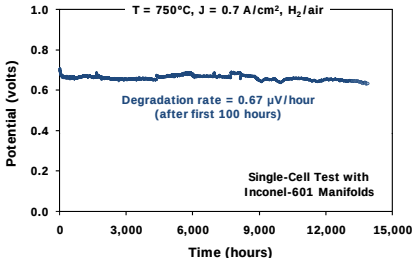
FlexCell Manufacturing

The *FlexCell* membrane is manufactured using inexpensive and scalable manufacturing processes of tape casting, lamination and sintering. A key advantage of the *FlexCell* is that the sintering step is not complicated by differential thermal expansion and sintering shrinkages of component layers. Thus, *FlexCell* membranes can be manufactured at high yields and without curvature or residual stress. Anode and cathode coatings are applied to the *FlexCell* membrane using spray deposition methods that also are scalable to high volume manufacturing.

High Performance & Efficiency

An important advantage of the *FlexCell* is that thin anode layers (less than 50 microns) are not prone to gas diffusion limitations (fuel in and reactants out). This allows *FlexCells* to achieve high power density and high efficiency simultaneously (as shown in the figure to the right). This capability provides system designers with the option of eliminating the anode recycling step, which simplifies the system.



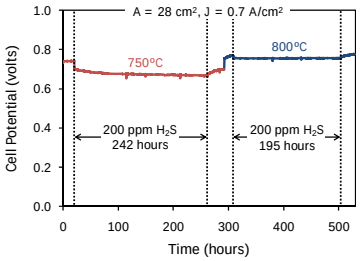


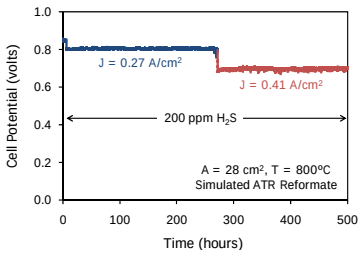
Long-Term Stability

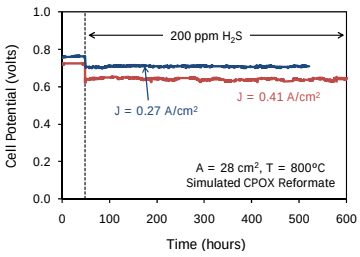
Electrode materials flexibility is an important attribute of the *FlexCell*, since electrodes are deposited in separate steps. Thus, new and improved anode and cathode materials can be incorporated without re-design of the manufacturing process. NexTech's *FlexCell* features a chromium-resistant cathode that has enabled the demonstration of extremely low degradation rates in single-cell tests performed with Inconel-601 manifolds (see figure to the left).

Sulfur Tolerant Anodes

NexTech has demonstrated SOFC anodes that are resistant to degradation by sulfur at temperatures above about 750°C. This capability has significant implications for design of solid oxide fuel cell power systems operating with common hydrocarbon fuels, such as natural gas, propane, LPG, diesel, and coal, all of which contain sulfur in varying amounts. For example, one can design a system with built-in robustness in the event that sulfur removal systems fail. This capability also allows system designers to relax the specifications (and reduce the cost) of desulfurization components.

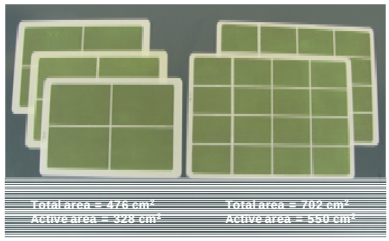


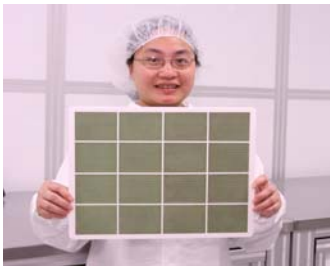




Fabrication of Large-Area FlexCells

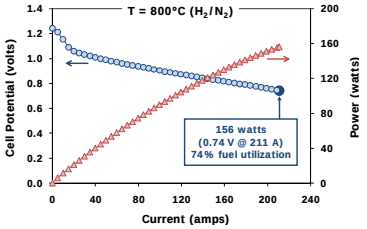
One of the key advantages of the *FlexCell* design is that there is no intrinsic limitation to the size of cells that can be made. Scalability is important to the design of stacks when power outputs of 5-kW and larger are being targeted, because these stacks can be produced with a lesser number of cells. This reduces cost associated with stack repeat units and simplifies stacking. NexTech routinely manufactures *FlexCells* with 500 to 700-cm² total areas targeting 150 to 250 watts per cell (as shown in the lower left figure), and 1200-cm² area targeting 400 watts per cell (as shown in the lower right figure).

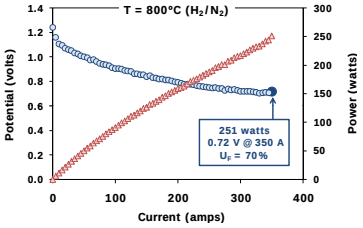


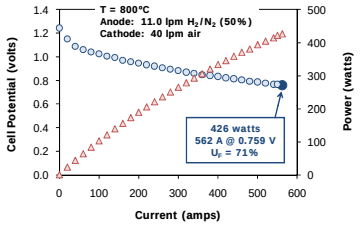


Testing of Large-Area FlexCells

Large-area *FlexCells* of the three sizes shown above (with active areas of 328, 550 and 800 cm²) were tested at 800°C with diluted hydrogen as fuel. At a temperature of 800°C. As shown in the figure to the right, the 328-cm² active area *FlexCell* achieved 156 watts at 0.74 volts and 74 percent fuel utilization. As shown in the figures below, power outputs of 251 and 425 watts were achieved with *FlexCells* having active areas of 550 and 800 cm², respectively, at relatively high voltages and fuel utilizations.

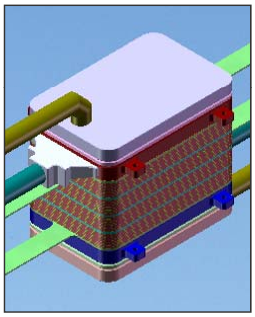


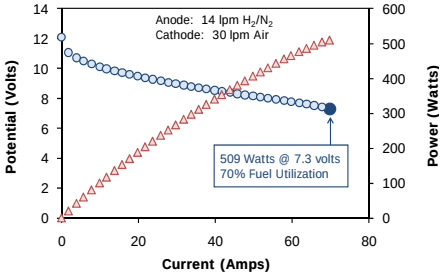




SOFC Stack Development at NexTech

A current focus of work at NexTech is on stack design, fabrication and testing. NexTech's modular stack design exploits the attributes of the *FlexCell* architecture and provides a path to achieving high gravimetric and volumetric power densities. The stack design capitalizes on the mechanical flexibility and strength of the *FlexCell* and the gasket sealing approach afforded by the dense cell perimeter. A solid model of NexTech's internally manifolded (co-flow) stack design is shown to the right. Data obtained on a 10-cell stack (160-cm² active area) is shown below. The stack achieved 509 watts of power at 0.73 volts per cell and 70 percent fuel utilization.





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