

Development and evaluation of a water-cooled fuel cell stack with porous rib GDL/MPL

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Background and objective

Fuel cell vehicles are an important option for achieving a carbon-neutral society. Improving fuel cell performance and reducing system cost require advances in both catalyst technology and cell design. In this study, we focus on the cell structure and bipolar-plate (BPP) design rather than catalyst performance. The separator is a key component that strongly influences gas supply, current collection, water management, heat rejection, and manufacturability.

Cell concept

A porous rib GDL/MPL was applied to the cathode. In this component, gas channels and rib structures are formed on the GDL side of an integrated gas diffusion layer (GDL) and microporous layer (MPL). The ribs remain porous, so oxygen and liquid water can move through regions that would normally be solid separator ribs. This improves oxygen transport and drainage, supports a thinner gas-transport layer, and enables the cathode bipolar plate to be a simple flat sheet [Fig. 1].

To use this concept in a water-cooled stack, the resin frame was also used for flow-field formation around the manifold area. This avoided the need to form cathode channels in the metal bipolar plate by high-precision stamping, while retaining hydrogen, air, and coolant distribution functions. The designed cell thickness was less than 1.0 mm; the prototype test cell used a resin-impregnated carbon anode bipolar plate with similar anode channels, giving an experimental cell thickness of approximately 2.2 mm.

Performance test

A seven-cell water-cooled stack was fabricated and evaluated. The average cell voltage of the stack was compared with a non-water-cooled reference single cell having a similar channel length. Both tests used a back pressure of 100 kPaG. Because different temperature-control methods were used, the results were compared under conditions expected to provide a similar average MEA temperature. Although the cathode stoichiometric ratios differed between the two tests, HFR measurements confirmed that neither condition exhibited a dry-out tendency.

Results and summary

The test stack showed stable polarization behavior up to 3.0 A/cm², with no clear voltage drop indicating a significant increase in concentration overvoltage. These results demonstrate that the porous rib GDL/MPL concept retained high oxygen-transport performance in the water-cooled stack configuration. Furthermore, the water-cooled stack exhibited higher average cell voltage than the reference single cell above 2.0 A/cm².

These results demonstrate the feasibility of a water-cooled fuel cell stack incorporating porous rib GDL/MPL and a flat cathode bipolar plate, providing a pathway toward thinner, higher-output, and lower-cost fuel cell stacks.

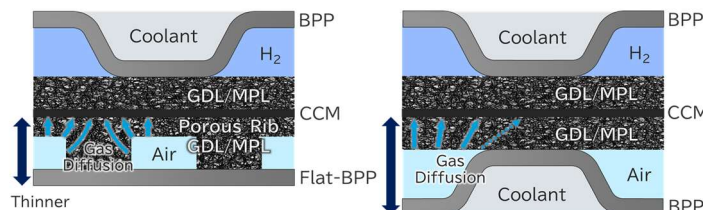


Fig. 1 Cross-sectional views of fuel cell unit cells with and without porous rib GDL/MPL.

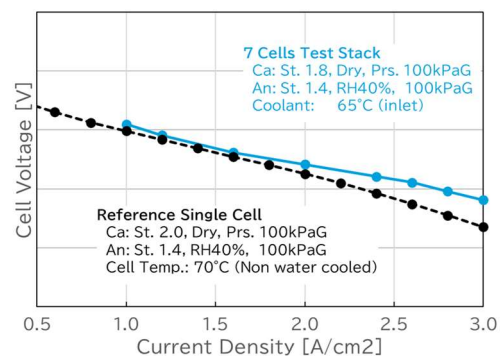


Fig. 2 Polarization curves of the seven-cell test stack and the reference single cell.