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ESEM Characterization of Grafoil® Flow Field Plates

F.P. Orfino

Ballard Power Systems Inc., 4343 North Fraser Way, Burnaby, BC, V5J 5J9, Canada

Environmental scanning electron microscopy (ESEM) has allowed the examination of specimens in a gaseous environment [1]. ESEM has been used to study hydration of pharmaceuticals [2] as well as, imaging of biological specimens [3, 4]. A research field in which ESEM imaging would be beneficial is that of proton exchange membrane (PEM) fuel cell (FC) components. PEMFCs produce water as a product of the electrochemical reaction of hydrogen and oxygen, and as a consequence, in-situ hydration properties of component materials are important.

A PEMFC is a sandwich structure comprised of two outer gas diffusion layers (GDLs; usually carbon fiber paper), two inner catalyst layers, and a PEM between them. An electrical circuit is formed when the two GDLs are externally connected to a load while electrochemical reactions ultimately producing water are simultaneously occurring at the catalyst/PEM interfaces. Reactant gases are supplied to the outside of the GDLs through the flow field (FF) pattern [5] imprinted on the FF plate (FFP); H_2 is supplied to the anode and air to the cathode. These reactants diffuse to the catalyst layers where dissociation to their constituent ions takes place. Protons travel from the anode, through the membrane, to the cathode and the resulting electrochemical reaction produces water at the cathode (see figure 1).

The excess water produced at the cathode catalyst layer diffuses out the back of the GDL where it is removed through the FFP. The water removal efficiency of the FFP differs depending on the chosen plate material since a film or droplets may form from the excess water and produce varying pressure drops. As a consequence, surface hydrophobic properties of the FFP channels are important parameters when designing FC water management schemes. The ESEM has been utilized to measure in-situ contact angles within Grafoil® FFP channels of sub-mm dimension for droplet diameters in the range of 20 – 150 microns. An example of the images collected for analysis is shown in figure 2. The results obtained are shown in Table 1 where a comparison with ex-situ measured contact angles for droplets measuring ca. 5 mm in diameter are shown. The contact angle measured in-situ for Grafoil® FFP channels was found to be 50 ± 5 degrees [6].

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[6] The aid of the R&D and Product Development teams at Ballard is gratefully. acknowledged.

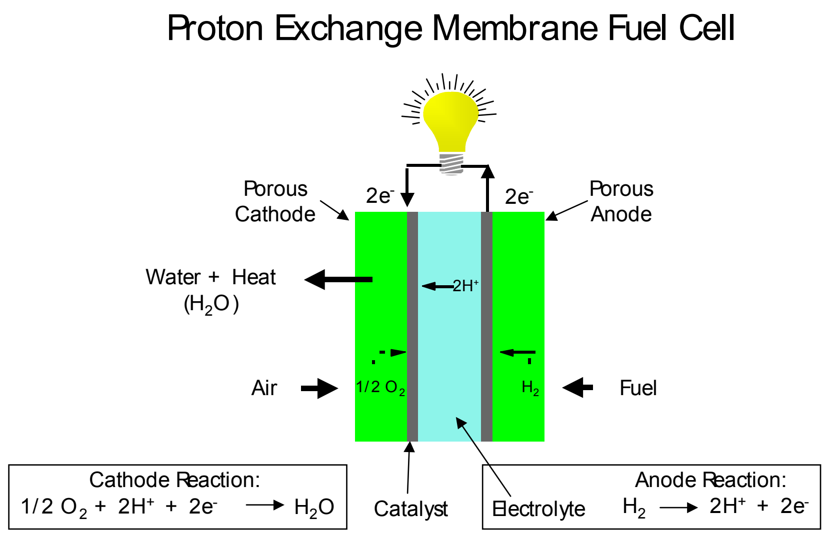

FIG. 1. Schematic representation of a Proton Exchange Membrane Fuel Cell (PEMFC).

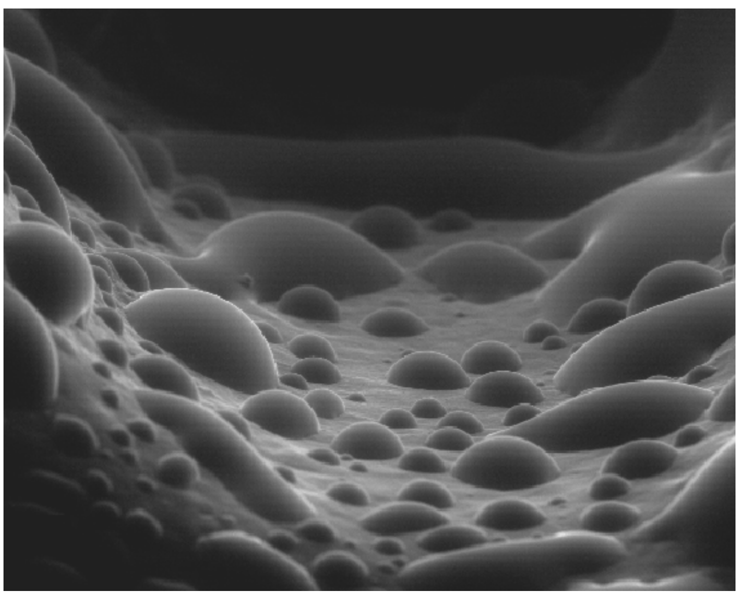

FIG. 2. Representative ESEM image of humidified Grafoil® FFP hemispherical channel at 400x.

TABLE 1. Contact angle values for Grafoil® Flow Field Plates.

Sample Identifier	Contact Angle (Degrees)	Comment
Grafoil® FFP channel	50 ± 5	In-situ
Back of Grafoil® FFP (flat)	64 ± 5	In-situ
Back of Grafoil® FFP (flat)	75 ± 4	Ex-situ

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