CARBONACEOUS BIPOLAR PLATES IN FUEL CELLS

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Introduction

Companies world-wide are currently developing solid polymer electrolyte fuel cells (SPFCs) as replacements for conventional internal combustion engines in automotive applications. A few prototype vehicles based on this technology have already been produced [1,2], however several components of this system need further development before this becomes a commercially viable power source.

Fuel cells are devices that carry out a combustion reaction electrochemically. In theory, they have the capability of producing electrical energy for as long as reactants are fed into the device. Assembly of cells in series as a *stack*, enables high power densities to be achieved.

In a typical polymer electrolyte cell, gaseous reactants are fed in to the electrodes, hydrogen to the anode, and air or oxygen to the cathode. Reactions take place at the electrodes to produce a current and a by-product, water. Figure 1 shows the basic construction.

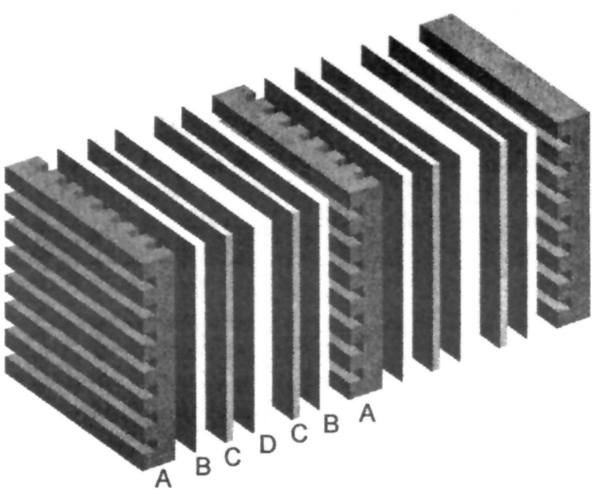

Figure 1. Construction of 2 cells in a simple fuel cell stack. A – bipolar plates; B – diffusion media; C – electrodes; D – polymer electrolyte.

The main role of the bipolar plate is to distribute the fuel and oxidant gases with embedded gas tracks in the fuel cells with, whilst maintaining a high conductivity electrical path for the current passing through the stack. It must also withstand the corrosive environment of polysulphonic acid-based polymer electrolytes in a fuel cell, exhibit low cost and density together with impermeability to the H_2 fuel. A possible solution being investigated is that of using carbon-carbon composite materials. Carbon materials are of low density (<2g/cm^3), and can possess high electrical conductivities, together with excellent resistance to chemical attack. A supplied carbon-carbon composite material has been evaluated for this study. This is a CVI-densified carbon felt, infiltrated at 1100°C, followed by graphitisation at 2600°C.

Experimental

Test bipolar plates were machined from the composite material to produce 5cm^2 x 5mm thick plates, containing the required gas tracks, for evaluation in a test cell.

Bulk resistivity measurements were carried out using a 4-electrode set-up. The measuring electrodes were set up with a guard ring configuration, so as to minimise ir losses.

Interfacial resistances were measured by sandwiching two gas diffuser cloths between two test plates at a known compaction pressure in order to simulate a test fuel cell arrangement. A known current was passed through whilst measuring the potential difference across the plates, giving relative measures of resistance.

Apparent densities were measured by calculations from weights and dimensions.

Endurance testing of bipolar plates in a fuel cell was carried out maintaining a compaction force of 220Ncm^{-2}, air and hydrogen gases at 3bar, at a temperature of 50°C, for up to 30 weeks. The cell potential was recorded, whilst maintaining a constant current density of 0.7A. A reference cell containing bipolar plates machined from a commercially available Poco graphite (EDM3) was evaluated alongside the test cell.

Results and Discussion

The carbon material was found to be highly porous, and hence allowed the permeation of hydrogen. To solve this, it was vacuum impregnated with a low viscosity epoxy resin. Test plates of the C-C/Epoxy material were then linished to restore the high conductivity carbon surface, and to remove excess resin. The apparent densities of the material before, and after resin impregnation are given in Table 1.

The bulk resistivities of the carbonaceous materials are significantly larger than that of 316 stainless steel (Table 1). However, of more importance for a bipolar plate, is that their interfacial resistances are much lower.

Three different plates have been tested in the evaluation cell and the long-term results are shown in Fig. 2. The lower performance of the metallic plates is related the higher interfacial resistances measured (Table 1).

This shows the great potential for these materials in electrochemical applications in comparison to conventional metallic plates. Composite structures also have the advantage of improved mechanical properties, which will ease the assembly of commercial plates which will need to be approximately 200cm^2 and 2mm or less in thickness.

References

1. Panik F. Fuel cells for vehicle applications in cars – brining the future closer. Journal of Power Sources 1998;71(1-2):36-38.

2. Kawatsu S, Advanced PEFC development for fuel cell powered vehicles. 5th Grove Fuel Cell Symposium on Fuel Cells. (London, England) 1997.

Acknowledgements

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Table 1. Physical properties

Material	Density (g/cm^3)	Interfacial Resistance (mΩcm^2)	Bulk Resistivity (mΩcm)
C-C	1.85	-	1.95
C-C/Epoxy	1.98	18	2.22
Poco Graphite	1.75	10	4.47
AISI 316	7.96	37	0.07

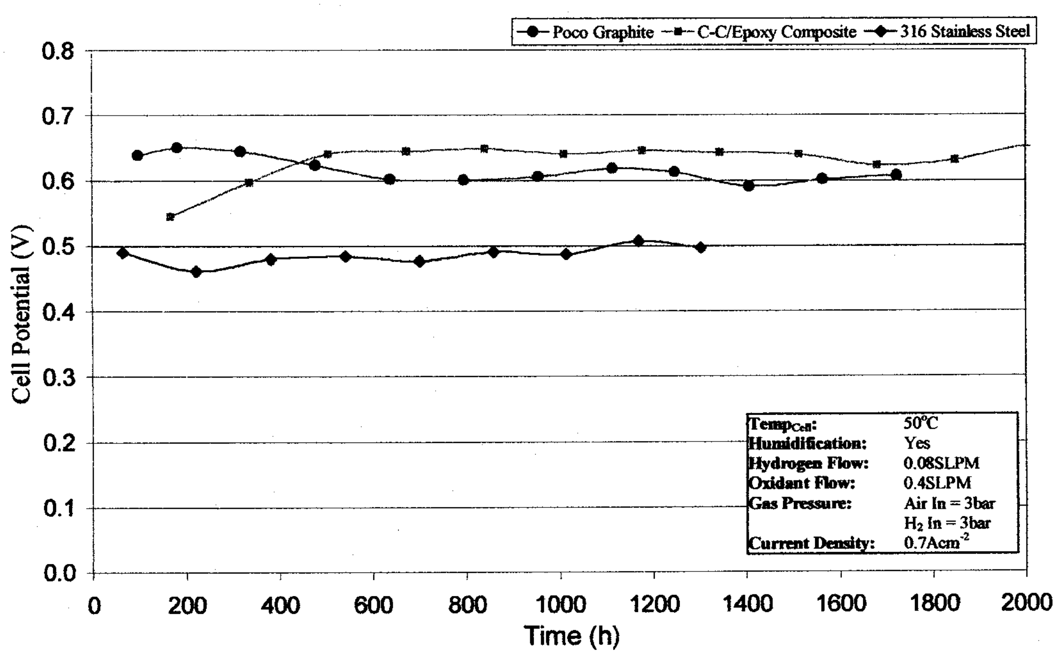

Figure 2. Average weekly cell potential at constant current density (0.7A/cm^2)