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Bipolar plate materials development using Fe-based alloys for solid polymer fuel cells

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Abstract

Due to its high efficiency and the relatively low working temperature of 80°C, the solid polymer fuel cell (SPFC) is mainly intended for transport applications. In this work the authors present results on bipolar plate materials development using economical Fe-based alloys. The construction materials are exposed to very different potentials by electrochemical contact with the electrodes. Great demands are made on the bipolar plates with regard to the corrosion behaviour and contact resistance. Electrochemical investigations regarding corrosion behaviour showed that, in principle, Fe-based alloys can be employed. Future work will concentrate on reduction of the contact resistance between the construction material and the current collector ensuring a high efficiency of SPFC.

Keywords: Solid polymer fuel cell; Bipolar plate material; Fe-based alloy

1. Introduction

The development of alternative electricity generator technologies, such as fuel cells, has been stimulated by the discussion about the reduction of pollutant and CO_2 emissions. Due to its high efficiency and the relatively low working temperature of 80°C, the solid polymer fuel cell (SPFC) is mainly intended for transport applications. Within the design of the SPFC [1,2], one can distinguish between the functional materials (membrane, Pt-catalyst, and current collector) and the construction materials for the bipolar plates (Fig. 1). At the moment, an Au-plated Ni-based alloy (NiB) is used for the bipolar plates. The Au-coating is applied in order to reduce the contact resistance between the construction material and the current collector.

The general objective of this investigation is to examine the suitability of economical corrosion resistant Fe-based alloys (FeBs) for construction of the bipolar plates, avoiding cost-intensive surface coating. The problem to be solved is that on the surface of corrosion-resistant FeBs a passivating oxide-layer (mainly Cr_2O_3) is generated that does protect from corrosion, but does cause a high contact resistance.

The construction materials are exposed to very different potentials (0–1000 mV/RHE) by the electrochemical contact with the electrodes. Great demands are made on the bipolar plates with regard to the corrosion behaviour and the minimisation of the contact resistance between the

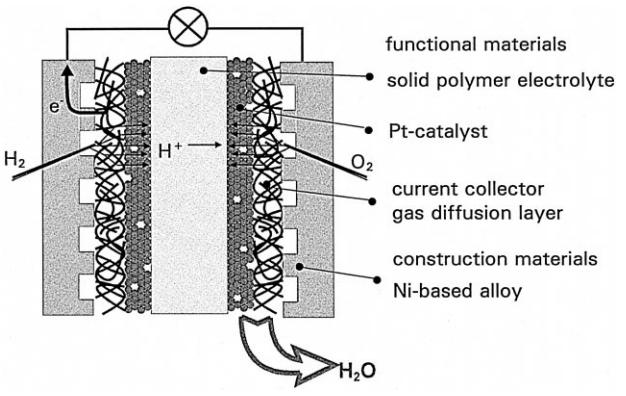

Fig. 1. Design of solid polymer fuel cell.

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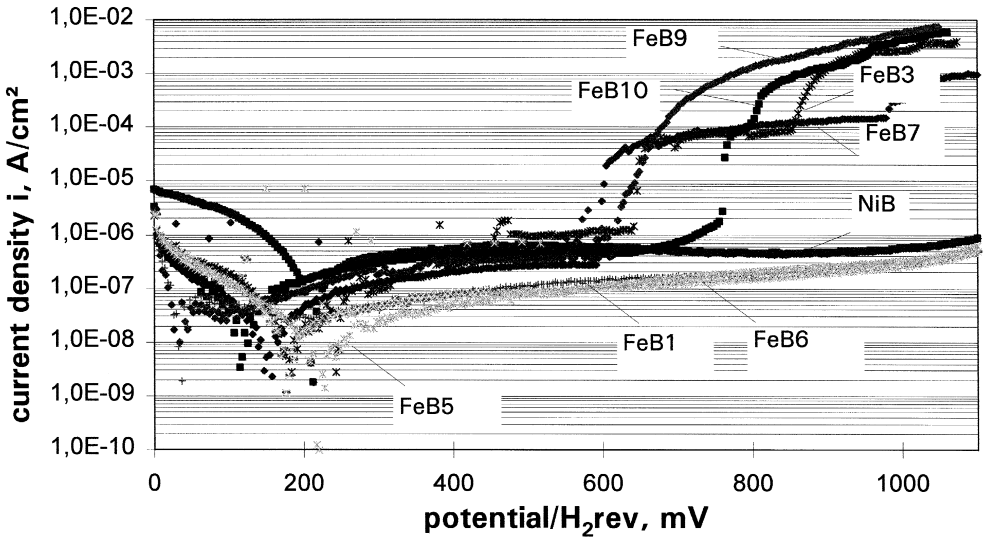

Fig. 2. Polarization curve of Fe-based alloys in HCl (0.1 mol/l).

construction material and the current collector. An increased contact resistance influences the cell performance negatively by decreasing the efficiency of the fuel cell.

2. Experimental work and results

The selection criteria for FeBs were mainly the Cr, Mo and N content in accordance with the pitting resistance equivalent (PRE = %Cr + 3.3% Mo + 30% N), combined with a relatively high Ni content. The selected FeBs were electrochemically investigated in different electrolytes. According to the analysis of the product water of a running SPFC test station, a SPFC model electrolyte was defined containing F^-, Cl^-, NO_3^-, SO_4^{2-} ions (ppm). The polarization curves indicated that most of the FeBs exhibited a characteristic comparable to that of the Ni-based alloy. The measurements in HCl (0.1 mol/l) showed that some FeBs are susceptible to pitting corrosion, because at a potential of 600 mV/RHE the current densities increase gradually by 3–4 orders of magnitude (Fig. 2). The resistant FeBs stand out due to a higher pitting corrosion resistance PRE ≥ 25. Long-term tests (load condition 0.3 A/cm^2, 350 h, H_2/O_2 pressure 2 bar, membrane Nafion 117) were performed in 3 cm^2 SPFC cells. Regarding aging, these experiments showed that some FeBs performed comparably with the NiB.

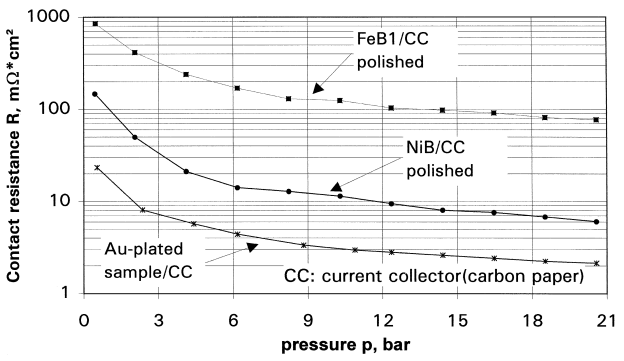

Fig. 3. Pressure dependence of the contact resistance.

The pressure dependence of the contact resistance NiB/current collector is shown in comparison with that of FeB/current collector and Au-coated sample/current collector in Fig. 3. From here it is to be seen that, at present, only the contact resistance of the coated sample is low enough.

In principle, production of low-cost SPFCs could be accomplished using FeBs bipolar plates. Future work will concentrate on economical methods for decreasing the contact resistance FeB/current collector down to an acceptably low value.

References

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