Development of metal supported PCFCs using wet chemical methods

Editorial

The 1st of December 2011 marked the start of the METPROCELL project: **Innovative fabrication routes and materials for METal and anode supported PROton conducting fuel CELLs.** It is a collaborative project funded by the Fuel Cell and Hydrogen Joint Undertaking (FCH JU) where 8 partners work together to develop a new generation of intermediate temperature fuel cells based on the Proton Conducting Fuel Cell technology.

This report summarizes the activities performed in the frame of METPROCELL in relation to the development of metal supported Proton Conducting Fuel Cells (PCFCs) by means of wet chemical techniques like screen printing.

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1. Introduction

The deposition of anode and electrolyte layer on metal supports has been assessed by using thermally stable metal substrate from METPROCELL partner HOGANAS. Two strategies have been developed in order to investigate as much as possible the metal-supported configuration. A first approach is based specifically on wet-chemical routes, with the depostion of the anode and electrolyte layers by screen-printing. The most critical step for this configuration is the sintering of the electrolyte, which requires a too high temperature for the metal substrate. Different sintering parameters have been evaluated and no efficient and sufficient operating condition has been defined.

The second investigated approach consisted on a combination of wet chemical and physical routes: It is based on the deposition of the anode layer by screen-printing and the deposition of the electrolyte layer by a plasma-Electron Vapor Deposition (EVD) technique. Here, the innovative plasma EVD technique should enable the deposition of dense electrolyte layers at a temperature close to 600°C (EIFER). The results obtained were very promising, but the optimization needed for the development of such samples requires too much time, which is not compatible with the time frame of the project.

2. Wet Chemical Routes

The main difficulty in combining metal-supported cell configurations with wet-chemical routes remains to avoid the oxidation of the metal, which can lead to irreversible formation of undesirable phases. Elaboration of metal-supported cells by wet chemical routes implies one or two high temperature sintering steps. The best sintering conditions have thus to be well defined, according to the desired microstructure and the tolerance of materials.

Different parameters have to be carefully controlled in order to get a gas-tight electrolyte:

- gas conditions (Argon, Hydrogen),
- composition of the electrolyte layer (addition of sintering additive like that could contribute to decrease the sintering temperature like Zinc Oxide, solid loading),
- sintering temperature (1200°C), and
- substrate (crude metal tape).

Unfortunately, the best combination was not efficient enough to lead to the elaboration of a good quality metal supported protonic fuel cell. The anode layer was always spread inside the metal support and the electrolyte layer was not dense enough to ensure a gas-tight membrane. The main conclusion of this activity is that the manufacturing procedure and cell

architecture must still be optimized to successfully obtain a homogenous and gas tight electrolyte layer. It was concluded that too many resources and time are still needed to complete this optimization process, which are not available within the project.

3. Metal-supported cells by plasma-EVD method

The target of this activity was to evaluate the feasibility of an electrolyte layer by EVD technique, in order to lower the temperature sintering of metal-supported cells. In this technique, the deposition of a dense layer is achieved via electron beam thermo-ionically emitted from a hot filament, accelerated by a grounded electrode and focused into the hearth by magnetic lens. Evaporation from an electron beam device is mostly identical to evaporation from a resistance or induction heated source. This technique is expected to enable the deposition of thin electrolyte layers at temperatures close to 600°C and thus be beneficial for the manufacture of metal supported cells.

The main bottleneck identified in an initial stage of the work was the roughness of the substrate. Preliminary results showed that the electrolyte deposited on a metal substrate only covers the metallic particles, without the formation of a complete layer. Based on this result, several studies have been performed to get a flat and homogeneous screen printed anode layer in order to possibly the deposition of a thin electrolyte layer by EVD. The surface quality and roughness have been improved with an increased amount of anode layers (until 4 screen printed layers). It seems that four anode layers is the minimum amount to get a continuous electrolyte layer, instead of only a cover on the anode grains. Further experiments have been performed: metal-supported substrates have been coated with more than four anode layers, and then the electrolyte membrane has been deposited. It results in a columnar structured electrolyte layer with a thickness of 1 - 2 µm.

A huge improvement of the deposition of the electrolyte layer by Plasma-EVD has been obtained. Unfortunately, the unexpected difficulty to get such quality of layer was too time-consuming to consider further experiment and tests. It has been decided at this stage that, considering the great progress achieved in the anode-supported configuration, the metal-supported technology by wet chemical and EVD routes doesn't represent the most strategic way to follow within the frame of METPROCELL. Nonetheless, based on the promising results obtained so far, EIFER foresees the follow-up of this activity beyond METPROCELL.

Project details
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