THE HYDROGEN AND FUEL CELL CENTER

Development of graphitic bipolar plate foils for fuel cell application

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Motivation

Within the project "InduRex" metallic and graphitic bipolar plate foils are being tested in PEM fuel cell stacks. The production of graphite-polymer compounds and their shaping into thin-walled foils, that can be processed into structured bipolar plates as an alternative to metallic bipolar plates, is one goal of the project. The focus is on highly filled compound materials and process techniques to produce thin-walled foils. The entire process chain is considered, starting from the selection of material components, foil production, to the forming of structured graphitic bipolar plates. The specifications for the physical and chemical properties of the graphitic bipolar plates are based on the target values of the Department of Energy for bipolar plates in mobile stack applications. The final foils should have a maximum thickness of 0.7 mm and meet the high requirements for fuel cell applications.

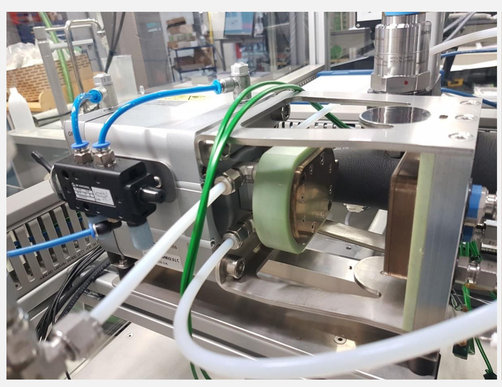
Consortium

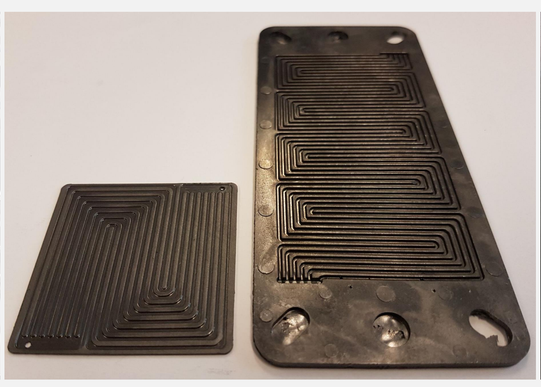
ZBT · Fraunhofer IPT · e.GO:REX · WZL | RWTH AACHEN UNIVERSITY

Content

Graphitic bipolar plates for fuel cell applications are usually injection- or compression molded. Both production methods are discontinuous and therefore time consuming and expensive. In contrast, the described thin walled bipolar plate foils are produced continuously by extrusion and calandering. A wide slot die with optionally 250 mm or 350 mm width is attached to the extruder outlet followed by a two-roll calander. The distance between the rolls can be set between 0.2 mm and 20 mm, accordingly the thickness of the foils is also within this range. The produced foils are subsequently embossed with a stamp to form the flow field. In the next step, the foils are ex-situ characterized whether the flow field imprint corresponds to the stamp, its area specific resistance, H2-tightness, heat deflection temperature under load and chemical resistance. If a foil passes the tests, the final bipolar plates are tested in a single cell fuel cell.
Several polymers, graphites and carbon blacks have been tested with different weight percentages until the final recipe was found.

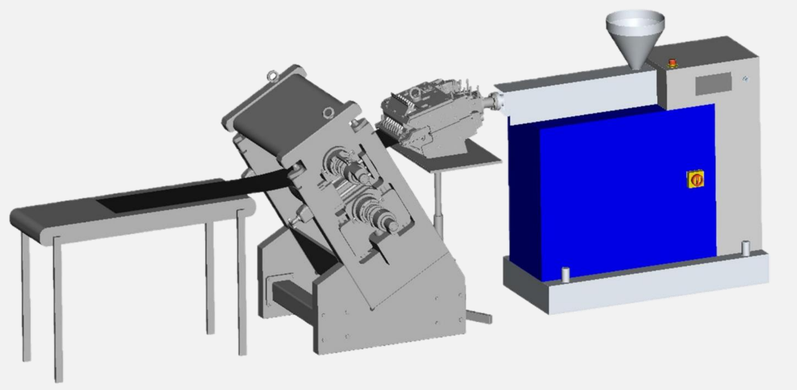
Conductive compound


Test chamber for single cell (Baltic Fuel Cell ™)

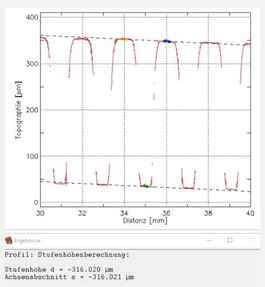

Embossed foil in 700 µm with flow field depth of ~ 320 µm vs. injection molded plate in 2500 µm thickness

Embossing stamp

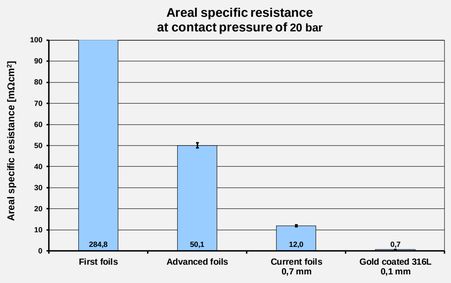
Calandered foil


Scheme of the foil production line

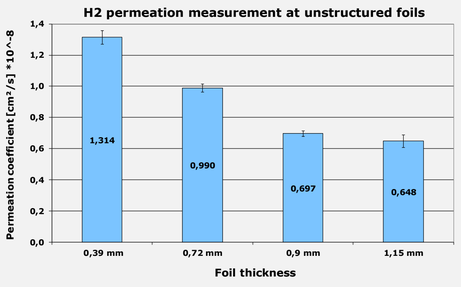
Ex-situ characterization of graphitic bipolar plate foils



Flow field depth of 316 µm remains stable after 20 h by 4 MPa at 90 °C *1



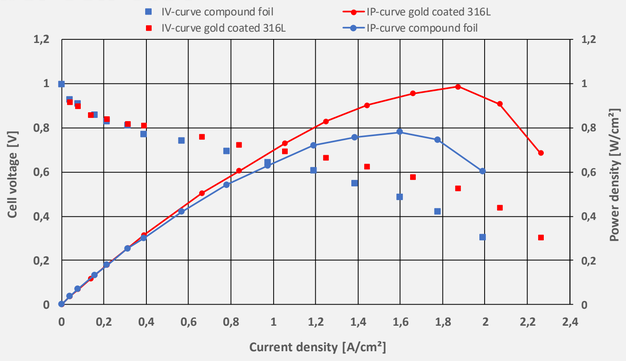
Areal specific resistance *2



H2 permeation coefficient for different thicknesses *3

In-situ characterization: baltic fuel cell test

- Up to a current density of 0,8 A/cm² similar increase in power density for compound foil and gold coated 316L plate with same flowfield design.
- Due to higher resistivity of the foil (x 17) the curves diverge for higher current densities.



IV- and IP-curves of compound foils compared to gold coated 316L plates

Summary

- Continuous production of highly filled foils with a min. thickness of 0.3 mm is possible
- Structured foils with a total thickness of 0.7 mm are mechanically stable and heat resistant for low temperature fuel cell application (tested with 4 MPa at 90 °C for 20 h)
- The electrical resistivity is close to the specifications of the Department of Energy
- Foils with a residual thickness of 0.38 mm within the flow field are gas-tight against H_2
- Performance within a single cell test stack up to a current density of 0,8 A/cm² is close to gold coated 316L plates with same flow field
- Foils with 1/3 thickness compared to injection molded bipolar plates have similar resistivities
- Save up to 65 % weight, volume and material costs compared to injection molded bipolar plates with more than 2 mm thickness
- Initial tests of flow field insertion into the films during calandering look promising and will be done in the next steps

Footnotes:

1: Measured with MicroProf by FRT

2: Measured with BePPel test rig at ZBT

3: Measured with ZBT test rig, values < 10 * 10^{-8} are useful

Acknowledgements:

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