Atomic Force Microscopy Detection of Electronic Short Circuits in Solid Polymer Electrolytes Fuel Cell Membranes after Accelerated Degradation

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Polymer electrolyte fuel cells represent an environmental friendly way of power generation for many applications since no harmful substances are produced and if hydrogen is produced from renewable sources. Important for the function of the fuel cell is a durable solid polymer electrolyte.

In this work we investigated Nafion polymer electrolyte membranes after 1600 h operation under open circuit conditions as accelerated degradations test. To enable ex situ analysis of the inner membrane surfaces they were manufactured from two identical half cells in a short stack of 4 cells assembles from differently thick membranes. By means of scanning electron microscope platinum deposition was identified on the inner interfaces of the membranes and inside the membranes mainly as bands [1].

By investigation of cross sections of the Nafion 211 with material sensitive atomic force microscopy agglomerated platinum particles were identified all across the membrane [2] as shown in Figure 1. To exclude electrochemical reactions current measurements were performed with gold-coated AFM tip in dry Ar atmosphere. Under these dry conditions no ionic current could be detected at any site of the bare membrane surfaces. At a few sites associated to Pt that was present at the surface a steady state electronic current measured through the half cell membranes was detected. A short-circuit electric connection through the membrane was formed by platinum deposition which can be considered as a failure mechanisms for the fuel cell. Current-voltage curves were measured to ensure ohmic (Figure 2) instead of electrochemical current. In humid ambient environment or without extended purging electrochemical reactions were observed at larger Pt agglomerations, where water droplets condensed easily [3].

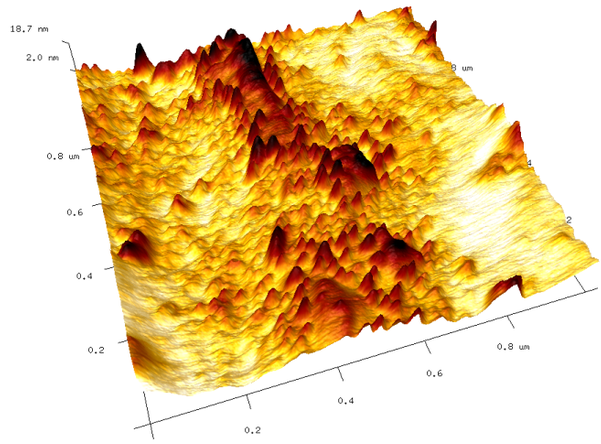

Figure 1: Height image of cross section of Nafion® 211 overlaid with adhesion data. Low adhesion marked with dark colors indicated platinum particles.

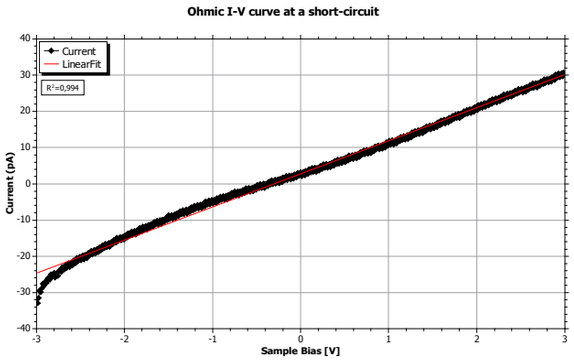

Figure 2: Ohmic current-voltage curve through the membrane at an electronic short-circuit.

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