STAMPEM

STAMPEM - STAble and low cost Manufactured bipolar plates for PEM Fuel Cells

STAMPEM FLYER 3rd YEAR

Project overview

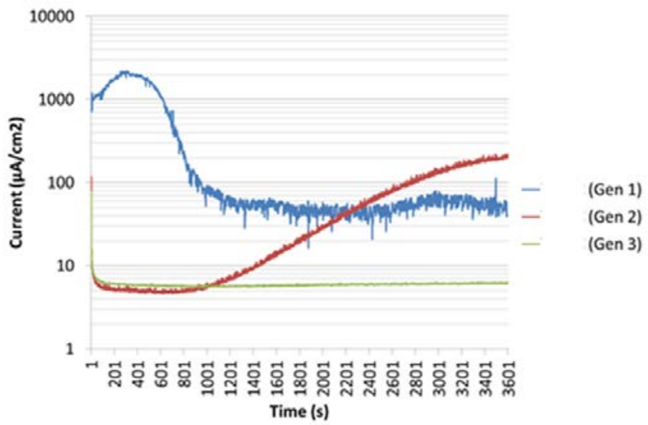
The FCH JU funded project "*STAble and low cost Manufactured bipolar plates for PEM Fuel Cells*" - STAMPEM, project reference 303449, was a cooperation project between SINTEF (Norway), MIBA Teer Coatings Limited (UK), ElringKlinger (Germany), Fraunhofer Institute for Solar Energy Systems (Germany), University of Birmingham (UK) and Fronius (Austria). It was dedicated to the goal of developing coatings for PEM fuel cell metallic bipolar plates.

Recent developments have showed that metallic bipolar plates for PEMFCs have many advantages over composite plates including their high strength, mechanical durability, electrical conductivity, and minimum thickness. The main objective of the STAMPEM project was to develop durable coating materials for metal based bipolar plates, that could be mass produced for less than € 2.5 /kW of rated stack power at mass production volumes of 500 000 stacks annually. Properties after extrapolated 10 000 hours from AST single cell testing should still be within the AIP specifications. The main parameters were interfacial contact resistance (ICR) (< 25 hm cm^2) and corrosion resistance (< 10 µA/cm^2).

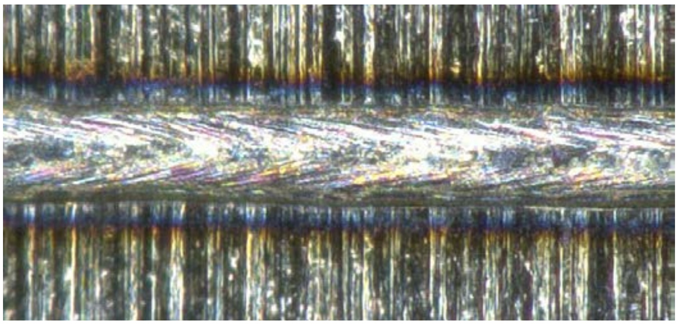
Coating development

Development of coatings for stainless steel bipolar plates was investigated using four different approaches within this project. These were 1) PVD coatings, investigated by TCL; 2) electrochemically prepared polymer based coatings investigated by UoB; 3) combined GDL-BPP concept and 4) carbon-based coatings investigated by SINTEF. Each of these was developed independently throughout the project, but improvements were achieved in all areas: Great improvements were achieved in corrosion resistance of the new generations PVD coatings.

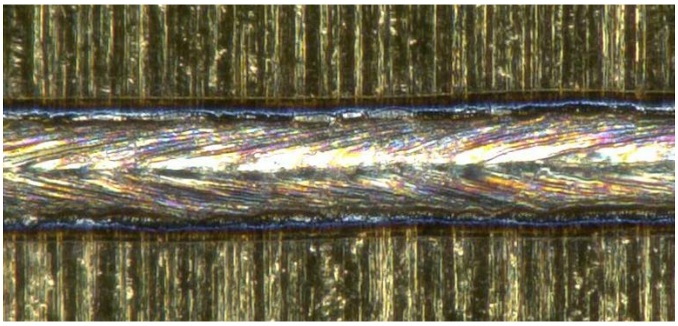
A significant reduction in ICR of the polymer-based coatings was achieved by hybridisation with/addition of TiN particles. A reduction in ICR of the carbon composite coatings was obtained due to an improved application process. The concept of a combined GDL and BPP was also validated in small scale in-situ testing.



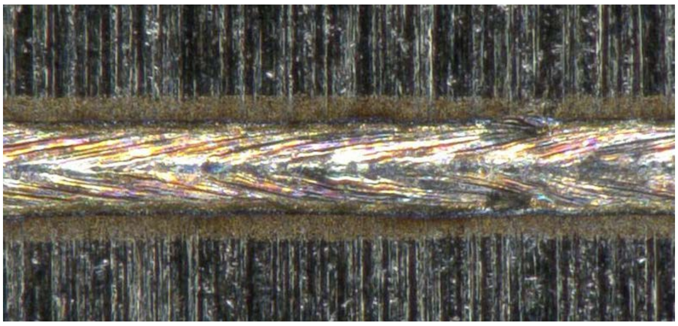
Potentiostatic corrosion tests at 1.4 V_{SHE} for three development generations of a PVD coating



Uncoated material:
The tempering colors occur directly adjacent to the melting zone



Galvanic gold:
Tempering colors occur only on a very narrow area adjacent to the melting zone



PVD coating:
A visible change in the coating occurs up to a distance of 40 µm away from the melting zone

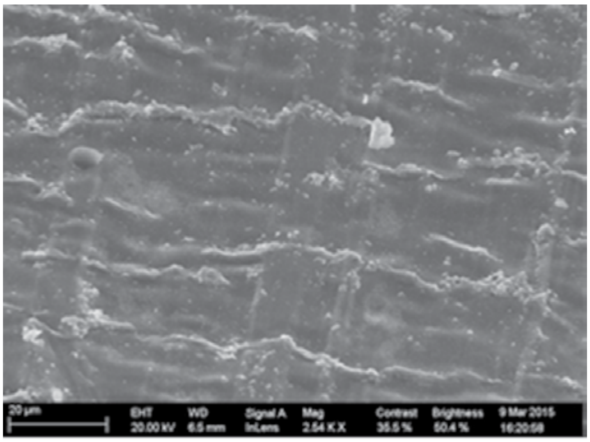
Effect of laser welding on coated stainless steels

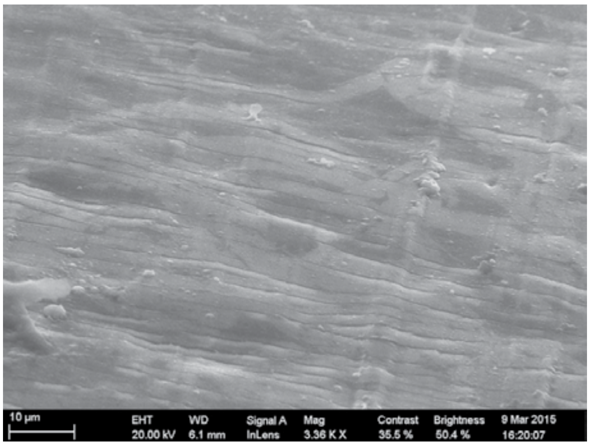
For coated materials, slightly different results were obtained with the same laser parameter variations. The welding results differ somewhat from those obtained with uncoated substrates. In the area of the welding seam the coating material mixes with the molten metal or evaporates/burns. In the areas showing tempering colors the coatings were expected to be changed in their composition or be entirely destroyed.

It was also observed that the width of the area affected by the welding process varies for different coatings. However, as this area was about 100 µm maximum, the potential lack of local conductivity was not envisaged to significantly influence the properties of the coated plate.

Stamping of bipolar plates – metal BPP stack

Coated flat metal plates were also stamped and characterized. From the figures below it can be seen that a PVD coating can withstand deformation very well.



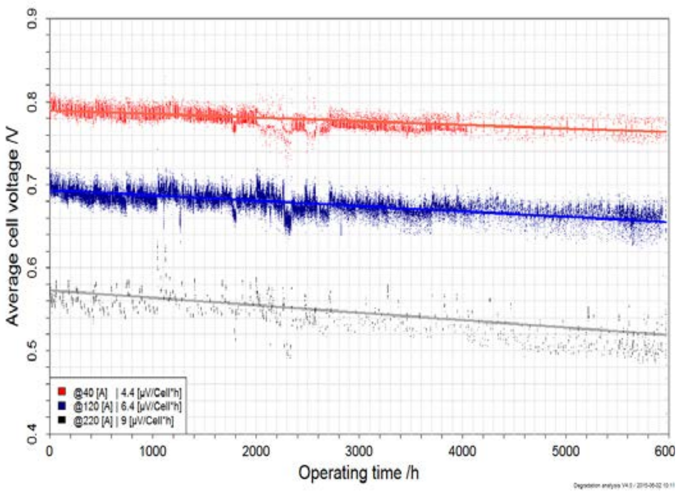


SEM image of a PVD pre-coated substrate after stamping, land top (at the top) and edge of land (at the bottom).

The area at the top of the land, which does not experience major elongation and also the side of the land, where major elongation occurs both showed an intact surface.

Looking in more detail at the lower figure, it can be seen that cracks did occur but the electric contact of the coating to the substrate seemed to be still very good with no white areas which would indicate poor electrical contact. Thus it could be seen that this coating could withstand deformation very well.

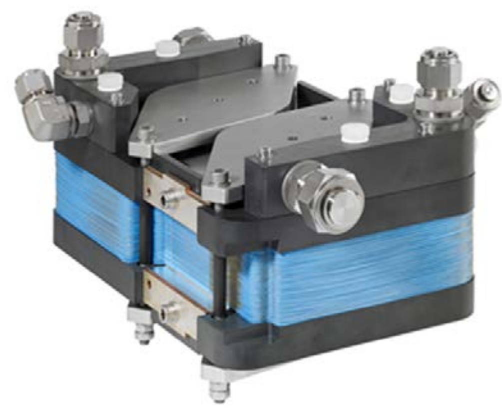
A stack with gold coated BPPs was operated for a prolonged period of time following different proprietary load cycles at ElringKlinger. The voltage behaviour of the stack for three different current levels (extracted from the load cycle) shows the performance and degradation behavior extracted from a long term test. It can be seen that the degradation rate is less than 10 µV/h per cell for all load levels, which is in the range that MEA-suppliers name as intrinsic degradation rate for their products. Thus, this result clearly shows that no additional degradation occurs due to any effects connected to the metallic plate or the production process. As the gold layer was so thin and these plates were produced by stamping of coated platines a full coverage of the surface by the gold coating is not expected. This data clearly shows that no protection of the surface is necessary for the material used – stainless steel 1.4404 – and the laser-welding used for joining the two plate halves.



Voltage behaviour of the stack for three different current levels (extrapolated from the load cycle).

Stack testing

A metal BPP stack was subjected to a lifetime test in a harsh industrial load cycle over 1000 hours with about 1800 start / stop cycles. The industrial load cycle test was followed by accelerated stress testing over 250 hours with a further 1800 start / stop cycles. The gold coated metal BPP reference stack showed a degradation rate of 32 µV/h in the industrial load cycle and 40-60 µV/h during the AST. ThePVD coated metal BPP stack showed reduced initial performance, probably due to the higher ICR of the bipolar plates. The degradation rate during industrial load cycling was in the range of 56 and 80µV/h. The lifetime test confirms that start / stop cycling is an important parameter for stack degradation and a low ICR is a key parameter in determining overall stack performance.



Cost reductions from applying metal coated BPPs

The contribution of coated metal BPPs for fuel cell system cost reduction was analysed in detail and was subsequently found to be considerable compared to moulded graphite BPP originally used. The cost reduction potential at the BPP level was found to be in the range of 62 - 93% for 50 000 stacks per year. For the high volume automotive market with 300 000 stacks per year (representing 150 million BPPs per year), a projected 98% cost reduction potential was identified for the PVD coating system developed within the STAMPEM project.

A further cost reduction of the bipolar plate could be achieved if active area welding is applied in the future. This would eliminate the need for a conductive coating on the inner surfaces of the BPP assembly, thus further reducing the coated area per assembly by a factor of 2. This manufacturing route is not yet fully established, but could be developed in the near future to provide further added value.

Fronius HyLOG Fleet 26F hybrid fuel cell system for Class 3 material handling trucks

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New Energy World JU fuel cells & hydrogen for sustainability

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