Topical Symposium on Sustainable Surface Engineering
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Coatings for Batteries and Hydrogen Applications - TS1 Poster Session

TS1-ThP-2 Corrosion Stability and Electrical Conductivity of PVD Coated Electrolyzer Bipolar Plates, ***Martin Welters (welters@kcs-europe.com),*** KCS Europe GmbH, Germany*; N. Kruppe,* Schaeffler Technologies AG & Co. KG, Germany*; R. Cremer,* KCS Europe GmbH, Germany*; M. Öte, N. Bagcivan,* Schaeffler Technologies AG & Co. KG, Germany

Bipolar plates (BPP) are one of the essential components of electrolyzer stacks for the generation of pure hydrogen by water electrolysis. In order to replace conventional and expensive titanium based BPP, stainless steel becomes more and more important against the background of increasing production volume due to cost and functional reasons. On the other hand, some requirements exist, which limit the use of stainless steel BPP in electrolyzers. Firstly, due to harsh corrosive conditions, the application of the stainless steel BPP requires the protection against corrosion. Secondly, the electrical conductivity of BPP must remain constantly low over the entire service life.

As part of the H2Giga StacIE joint project, KCS Europe developed titanium-based PVD protection layers for stainless steel BPP in order to fulfill the demanding requirements of water electrolysis. In addition to the functional suitability of the coatings, the economic viability and suitability for large-scale production was kept in mind. Therefore, the coatings were deposited by means of a tailored inline coating system, applying PVD technology. The coating system enables an easy scale up to larger production quantities in future. Measurement of Interfacial Contact Resistance at 10 bar and Linear Sweep Voltammetrie of the coatings revealed promising results regarding corrosion stability and electrical conductivity prior and after electrochemical cell tests on laboratory scale adapting electrolyzer cell conditions.

TS1-ThP-3 PVD Core-Shell-Catalysts for Water Electrolysis, ***Jan-Ole Achenbach (achenbach@kcs-europe.com),*** KCS Europe GmbH, Germany*; M. Berger,* Institute of Technical and Macromolecular Chemistry, Germany*; M. Pilaski,* The Hydrogen and Fuel Cell Center - ZBT, Germany*; R. Cremer,* KCS Europe GmbH, Germany

The expected increasing demand of hydrogen in the upcoming years requires adequate electrolysis capacities in order to be able to serve the market. One technology for mass production of hydrogen is the alkaline polymer membrane water electrolysis (AEM-WE). Heart of AEM-WE are the catalysts, which enable the decomposition of water at low energy input. Therefore, the availability of sufficient and suitable catalysts is a limiting factor for high H_2 production volumes.

Within the research project H2Giga AlFaKat, KCS Europe follows up the approach of replacing the usual expensive catalysts containing precious metals by cheaper core-shell particles. Therefore, particles of a suitable low-cost material are activated by the deposition of a more expensive catalyst material by means of physical vapor deposition (PVD). For the realization, a coating demonstrator was developed and validated in the project. Thereby, the basic suitability, the efficiency and useability for mass production of the concept as well as the coating growth, homogeneity and properties were investigated. Analyses of the core-shell-particles showed a homogeneous coating of the core particles after processing by PVD coating demonstrator. Further investigations regarding catalytic activity revealed high activity of new PVD catalyst. In this context, a comparison confirmed similar activity of PVD core-shell-catalyst and pure catalyst. Thereby, only the top layer of the core-shell-catalyst is active, meaning the same performance at significantly less material input. The results prove, that a reduction of catalyst material by Core-Shell-concept is possible.

TS1-ThP-4 Production of Cost-Effective Precious Metal Free Bipolar Plates for Future High Demand, ***Sijia Yang (yang@kcs-europe.de),*** KCS Europe GmbH, Germany*; J. Kapp, V. Lukassek,* The hydrogen and fuel cell center ZBT GmbH, Germany*; R. Cremer,* KCS Europe GmbH, Germany

Objective of the R&D project “BipolarPilot” was the economic mass production of bipolar plates, which form the heart of fuel cells and represent around 30% of the total system costs. Together with its research partner The hydrogen and fuel cell center ZBT GmbH, KCS Europe has both developed appropriate PVD coatings as well as an inline PVD pilot coating system in order to enable mass production of cheap and corrosion stable stainless steel Bipolar plates.

While batch coaters are coating units with only one cycle-time limiting coating chamber, inline systems are coating units that enable a continuous processing and coating with short cycle times. Thus, the pilot coating unit has been designed with a future high demand for bipolar plates in mind.

KCS Europe’s coatings for bipolar plates have been tested based on DoE specifications. The deposited coatings were investigated in detail by ZBT. Both, the electrical properties and the corrosion behavior under application conditions were investigated. KCS Europe’s coatings for bipolar plates are homogenous precious metal free coatings. Investigations at ZBT proved, that the coatings beat the various limitations given by the DOE (Department of Energy) of the United States to meet the stack conditions. The contact resistance of all investigated coatings was determined below 0.6 $m\Omega cm^2$ and thus well below the DOE limit of 10 $m\Omega cm^2$. Moreover, the corrosion current identified by polarization test of all coatings meet the target values for bipolar plates defined by the DOE (lower than 1 $\mu A/cm^2$).

TS1-ThP-5 Hydrogen Diffusion in Protective Coating Materials, *P. Rückeshäuser, A. Bahr, W. Zhao, R. Hahn, T. Wojcik,* Christian Doppler Laboratory for Surface Engineering of high-performance Components, TU Wien, Austria*; S. Kolozsvári, P. Polcik,* Plansee Composite Materials GmbH, D-86983 Lechbruck am See, Germany*; T. Stelzig, F. Rovere,* Oerlikon Balzers, Oerlikon Surface Solutions AG, 9496 Balzers, Liechtenstein*; **Helmut Riedl (helmut.riedl@tuwien.ac.at),*** Institute of Materials Science and Technology, TU Wien, Austria

Introducing hydrogen-based energy production, storage, and conversion technologies implies materials withstanding hydrogen's specific, reactive behavior. Durability-related issues such as hydrogen embrittlement in structural components or corrosion-induced phenomena in fuel cell or electrolyzer technologies are of significant interest in transitioning to green and sustainable energy supplies. In more detail, the stimulated interaction of hydrogen with the topmost micrometers and the microstructural features of materials will play a predominant role. Therefore, using physical vapor deposited (PVD) coating materials to protect and functionalize material surfaces will be critical in diverse future applications.

Degradation mechanisms related to hydrogen occur at multiple length scales, involving different strategies for exposure or treatments. These strategies are typically divided into the two hydrogen-related material research worlds: (i) electrochemical degradation setups and (ii) and non-electrochemical treatments as a collective term for pressure/gas-related setups. Nevertheless, the broad field of hydrogen-related applications is increasingly merging. Consequently, the different degradation strategies primarily focus on electrochemical test setups as they are highly versatile.

Therefore, in this study, the interaction of hydrogen with well-known protective coating materials such as TiN, CrN, ZrN, or TiAlN and AlCrN is described by an electrochemical Devanathan-Stachurski permeation setup. Different sets of these ceramic coating materials have been deposited on ferritic steel sheets through sputter and arc-evaporation technologies with varying deposition parameters. Subsequently, the coatings have been electrochemically loaded, and parameters such as diffusion coefficients, permeability, or permeation reduction factors are estimated. These results are correlated with the coatings’ microstructural appearance before and after hydrogen testing using a set of diverse high-resolution techniques such as SEM, TEM, XRD, and micro-mechanical testing methods.

Keywords: Protective coatings; Hydrogen; Electrochemical testing; PVD; Nitrides;

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