Topical Symposia
Room Golden State Ballroom - Session TS1P-ThP

Coatings for Energy Storage and Conversion - Batteries and Hydrogen Applications - TS1 Poster Session

TS1P-ThP-1 Bacezryybo$_{3-\delta}$ Coatings Deposited by Colloidal Coating Process for Sustainable Energy Application*, **Chien-Ming Lei**, P. Lin, Y. Chen,* Department of Chemical and Materials Engineering, Chinese Culture University, Taiwan

$BaCeZrYYbO_{3-\delta}$ (BCZYYb) is one of the high temperature proton-conductive materials, which widely applied in protonic ceramic fuel cell, alkane and alkene reforming, water-gas shifting, ammonia synthesis, CO_2 reduction, etc. The main purpose of this research is to fabricate the BCZYYb coatings on NiO/yttria stablished zirconia (YSZ) substrate via a colloidal coating process. The BCZYYb powders were prepared by solid-state reaction method. The powders were well-dispersed in de-ionic water to prepare the BCZYYb colloidal suspensions. The suspensions were spin-coated on a pre-sintered NiO/YSZ substrate to obtain BCZYYb coating samples for the sequent sintering processes. Several properties of the as-prepared coating samples were analyzed including the crystal phases by X-ray diffractometer (XRD), microstructures by scanning electron microscopy (SEM), electrical properties by electrochemical impedance spectra (EIS). The results show that the main crystalline phase of BCZYYb powders are a single-phase perovskite structure, when the calcination temperature is higher than 1500^{o}C. According to the observation results of SEM microstructures, the BCZYYb coating sample were formed a dense layer on the substrate when the sintering temperature higher is than 1500 ^{o}C. But there are still a few pores found from the surface of the coating layer. The average thickness of the coating layer is around 3.3 µm. After the second coating cycle, the pores on the surface were obviously eliminated, and the average thickness of the coating layer is around 5.7 µm. The results of electrical analysis show that the conductivity of BCZYYb single-coating samples are 0.0134 and 0.11261 S/m tested at 500 ^{o}C and 800 ^{o}C, respectively, and the activation energies are 0.299 eV and 0.292 eV, respectively. The conductivity of the double-coated samples is similar with that of the single-coating sample.

TS1P-ThP-2 PVD Core-Shell-Catalysts for Use in Electrolyzers*, **Jan-Ole Achenbach**, S. Cremer, R. Cremer,* KCS Europe GmbH, Germany

Up-scaling of electrolyzers is necessary to provide sufficient quantities of hydrogen for fuel cells in the future. Alkaline polymer membrane water electrolysis (APM-WE) in particular offers promising potential for the production of hydrogen. However, a requirement for the widespread use of this technology is the cost-effective production of suitable quantities of catalyst.

KCS Europe is pursuing the approach of replacing the usual expensive catalysts containing precious metals with cheaper core-shell particles within the research project AlFaKat. In this approach, 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). To realize this, various PVD technologies were evaluated at the beginning of the project with regard to the aspects of ‘basic suitability’, ’deposition rate’ and ‘homogeneity’. In a feasibility study on a commercially available batch coater, it was demonstrated that a homogeneous coating of the core particles is possible by PVD process. Furthermore, an economical production of core-shell particles appears possible. The gained knowledge was transferred to a demonstrator, aiming mass production of core-shell catalyst powders on an industrial scale in the future.

Keywords: PVD, Core-shell, Electrolyser, Hydrogen, Catalyst

TS1P-ThP-3 Repressing Noble Metal Ruthenium Target to Reduce the Cost of Bipolar Plate Manufacture in Fuel Cells*, **Jing Yang**,* SCI Engineered Materials, inc, USA

Bipolar plates, as the key component, contribute up to 60% of cost in a proton exchange membrane fuel cell. The most expensive part in bipolar plates is the noble metal coating for catalyst layers. Although there is research and development work done on non-noble metal catalyst, the noble metal coating on stainless steel, is still one of the most widely used combinations due to its good electrical and phonon conductivity, and corrosion resistance.

Sputtering is a preferred coating technique for bipolar plates catalyst layer due to its uniformity, as well as little chance to introduce impurity. However, due to the high price of the noble metal powder and the low usage of a planar sputtering target (15%-30%), the target is one of the costly factors for the process. At SCI, we have developed a process for adding a small portion of the metal powder on top of a spent target to fill in the sputtered area. SCI’s process produces a high-density target with an interface between the original target and additional powder that doesn’t interfere with the sputtering process. Depending on the target geometry, a spent target backer can be repressed up to ten times before the noble metal backer would need to be fully reclaimed. The repressing process can have a cost reduction on a noble metal powder costs up to 50%.

TS1P-ThP-4 Corrosion Protection of Bipolar Plates in Electrolysers*, M. Welters,* KCS Europe GmbH, Germany*; N. Kruppe,* Schaeffler Technologies GmbH & Co. KG, Germany*; **Peter Jaschinski**, T. Breuer, S. Yang, R. Cremer,* KCS Europe GmbH, Germany*; M. Öte, N. Bagcivan,* Schaeffler Technologies GmbH & Co. KG, Germany

By 2050, 80% of the total energy supply in Germany is to be converted to renewable energies. Since renewable energy generation fluctuates significantly, possibilities for storage and cross-sectoral use must be developed. The direct conversion of regeneratively generated electricity into a secondary energy medium such as hydrogen represents an elementary solution for the technical implementation of the energy transition.

Bipolar plates (BPP), which are combined into stacks, are an essential component of electrolysers in terms of functionality and service life. Currently, both untreated and coated steel and titanium BPP are used. Thereby, a coating can extend the operating conditions and increase the service life. Two main approaches are currently being pursued with regard to corrosion protecting coating systems: carbon-based and metal-based coatings. With regard to the technologies utilized for the production of coatings, there has only been little experience in order to be able to specifically assess the advantages and disadvantages of individual process variants. In addition to the functional suitability of the coatings, in this context the economic process efficiency and suitability for large-scale production are essential aspects. Corresponding aspects often correlate with the coating system to be synthesized.

For this reason, KCS Europe carried out fundamental analyses as part of the StacIE joint project, in which physical vapor deposition (PVD) processes, were compared. Both, the layer morphology and the deposition rate of metallic and non-metallic coatings were investigated and compared. The coated samples were provided to Schaeffler and analyzed with regard to the interfacial contact resistivity using through plane voltage (TPV) measurements. The corrosion stability was investigated using electrochemical cell tests in laboratory scale adapting electrolyzer cell conditions. These findings provide the basis for the development of new concepts, which can be used in the environment of industrial coating of bipolar plates by PVD technology.

Keywords: PVD, Electrolyser, Hydrogen, Corrosion, Protection

TS1P-ThP-5 MOF-Derived Molybdenum Carbide-Copper as an Electrocatalyst for The Hydrogen Evolution Reaction*, W. Chen, **Yu-Chin Shen**, J. Huang,* National Cheng Kung University (NCKU), Taiwan*; S. Wang,* Southern Taiwan University of Science and Technology, Taiwan*; Y. Shen,* National Cheng Kung University (NCKU), Taiwan

The only side product of water electrolysis for hydrogen production is water, which is a clean and environmentally friendly process. However, the HER efficiency is quite low, and the electrocatalyst is required to improve the reaction efficiency. Molybdenum carbide has good catalytic activity and acid resistance. However, high temperature is generally required to prepare molybdenum carbide and the high temperature process leads to excessive growth of nanoparticles. To solve this problem, one of the solution is to combine it with conductive substrates to avoid excessive growth and agglomeration of nanoparticles, and to improve the conductivity of electrons.

In this study,Mo-Cu-MOF was used to confine the growth of molybdenum carbide nanoparticles, and Cu with high conductivity in Mo-Cu-MOF served as the electron transporter through the change of the gas flow (nitrogen → 20% CH_4/H_2) during the annealing process, MoO_2-Cu transformed to η-MoC-Cu. And then with the increase of temperature(800°C→1000°C), η-MoC phase disappeared and β-Mo_2C phase appeared, leading to the transformation from η-MoC-Cu to β-Mo_2C-Cu. Electrochemical performance results show that the overpotential at -10 mA/cm^2 of η-MoC-Cu carbonized at 800°C is -233 mV and the Tafel slope is 73 mV/dec. Finally, some analysis were taken by XRD, TEM, XPS and BET.

TS1P-ThP-7 rGo-SiOx Nanocomposite as Anode Material in Lithium Ion Battery*, **Sheng Hsu**, J. Huang,* National Cheng Kung University (NCKU), Taiwan*; B. Sanjaya,* National Cheng Kung University (NCKU), Taiwan, India

Research to develop negative electrode materials in lithium ion batteries is an emerging topic. Graphite, the most commonly used anode in LIBs, may be useful to operate typical electronic equipment but the theoretically capacity(372mAhg^{-1}) is quite low for applications in advaced devices such as electric hybrid vehicles. Recently, silicon has been leading as a key material of choice owing to its easy availability, low discharge voltage vs. Li/Li+, and outstanding capacity(3580mAhg-1). However, challenges remain due to the significantly high volume change(~400%) which leads electrode degradation and a quick decline in capacity. Recently, SiOx have emerged as one of the promising high capacity anode materials due to lower cost, less volume expansion(~200%), high cyclic stability and rate performance than pure Si making it more suitable material for applications in power batteries. However, SiOx has lower electrical conductivity that requires a high-level conductive agent to fabricate the anode. So far, top-down approach and complicated synthesis procedure at high temperature is usually used to prepare SiOx-C composite. We have expertise in the synthesis of metal oxide and reduced graphene oxide nanocomposite at room temperature that delivered very good reversible capacity, cyclic stability and rate capability when used as anode in LIB. Therefore, we explore a room temperature, low temperature and bottom-up approach for the synthesis SiOx-rGO, Si/SiOx-rGO nanocomposite and apply them as anode material in LIB.

Author Index

Bold page numbers indicate presenter