Topical Symposium on Sustainable Surface Engineering
Room Town & Country B - Session TS1-1-MoM

Coatings for Batteries and Hydrogen Applications I

Moderators: Martin Welters, KCS Europe GmbH, Germany, **Chen-Hao Wang**, National Taiwan University of Science and Technology, Taiwan , **Fan-Bean Wu**, National United University, Taiwan

10:00am **TS1-1-MoM-1 Coating Innovations for Green Energy: Enabling Hydrogen Technologies**, ***Mehmet Öte [oetemhm@schaeffler.com]***, Schaeffler Technologies AG & Co. KG, Germany **INVITED**

In light of urgent climate challenges, the transition from fossil fuels to green energy sources necessitates significant advancements in hydrogen technologies. This keynote presentation will emphasize the crucial role of innovative coatings across all components of electrolyzers and fuel cells, including bipolar plate coatings, transport layer coatings, and catalyst-coated membranes. We will provide a comprehensive review of the evolving requirements for these coatings, assessing their impact on both performance and sustainability.

Key focus areas will include advancements in anti-corrosion and electrically conductive coatings designed to enhance the efficiency and lifespan of components within hydrogen systems. These innovations not only achieve exceptional electrical conductivity and corrosion resistance but also play a pivotal role in significantly reducing the CO2 footprint of critical components. Ultimately, this talk aims to contribute to the ongoing discourse in the energy sector, demonstrating how advanced materials and coatings can facilitate the widespread adoption of hydrogen as a clean energy carrier.

10:40am **TS1-1-MoM-3 Intermediate-Temperature Proton-Conducting Solid Oxide Fuel Cells and Electrolyzers for Clean Energy**, ***Sheng-Wei Lee [swlee@ncu.edu.tw]***, *Chung-Jen Tseng, Szu-Yuan Chen,* National Central University, Taiwan **INVITED**

The solid oxide cells (SOCs), which can operate in fuel cell or electrolyzer mode, is a promising technology to store electrical energy as chemical energy and to reconvert it into electricity upon demand. In recent years, extensive efforts have been devoted to developing proton-conducting SOCs (P-SOCs) that operate in the low-to-intermediate temperature range (400-800 ℃). Compared to the conventional oxygen ion-conducting SOCs (O-SOCs) that require high operating temperature (800- 1000 ℃), this scheme enables more reliable sealing, use of cheaper materials for interconnect, and a better control of electrode/electrolyte interactions, thus prolonging the operational lifetime of SOCs.

In this presentation, a variety of nanostructured electrode for P-SOCs is demonstrated via nano-engineering and have demonstrated their excellent cell performance. For example, we present a nanofiber-derived functional anode and cathode for proton-conducting SOFCs. The significantly lower polarization resistance elements indicate that the nano-fibrous electrode has superior catalytic activity for HOR and ORR. We also use PS nanospheres as pore former to fabricate an LSCF cathode with graded porosity, thus greatly improving the cell performance. In addition, we employ spin-coating technique and pulsed laser deposition (PLD) with doping strategy to fabricate thin-film electrolyte for P-SOCs. A bulk heterojunction GCCCO-BCZY layer with a domain width of ~5 nm by PLD via spontaneous phase separation is demonstrated as an electrolyte/cathode interlayer, which effectively increases the interfacial area between the two distinct phases and facilitates proton transport across the interface. Finally, we also discuss the SOC performance when fed with a variety of fuels and in the electrolysis mode.

11:20am **TS1-1-MoM-5 Development of Anode Electrodes for Water Electrolysis by Electroplating**, *Pei-Chi Lin, Chieh-Fu Huang,* ***Yong-Song Chen [imeysc@ccu.edu.tw]***, National Chung Cheng University, Taiwan **INVITED**

Anion exchange membrane water electrolysis (AEMWE) has drawn much attention recently as a sustainable and cost-effective method for hydrogen production. Unlike proton exchange membrane water electrolysis, AEMWE employs non-precious metal as catalysts, which can significantly reduce material costs. However, it remains challenging to develop efficient and durable anode electrodes that can withstand alkaline environments while maintaining high performance in the oxygen evolution reaction (OER). In this study, stainless steel paper (SSP) is employed as the porous transport layer (PTL) of the anode in AEMWE. The effects of various surface modifications on SSP are investigated to assess their impact on electrochemical performance, including heat treatment, acid treatment, and electroplating.

Surface morphology, Brunauer–Emmett–Teller (BET) surface area, and current-voltage (I-V) characteristics are analyzed across treatments to evaluate their impact on catalytic activity. Results indicate that electroplating nickel (Ni) onto acid-treated SSP significantly enhances anode performance, achieving over a 10% increase in efficiency compared to untreated SSP. This enhancement is attributed to the increased specific surface area provided by acid treatment, combined with the catalytic benefits of Ni from electroplating. BET analysis supports that acid treatment creates a rough surface on the SSP fibers, thereby increasing active surface area. Additionally, I-V curves demonstrate that Ni-electroplated, acid-treated SSP exhibits lower overpotentials and higher current densities. This approach utilizes low-cost, commercially available stainless steel, supporting the potential for mass production and enhancing the economic feasibility of AEMWE in hydrogen production applications.

12:00pm **TS1-1-MoM-7 Development of Three-Dimensional Lithium Metal Composite Electrode with Lithiophilic ALD Coating**, *Yu-Lun Cheng,* ***Chih-Liang Wang [wangcl@mx.nthu.edu.tw]***, National Tsing Hua University, Taiwan

Lithium (Li) metal is widely regarded as an ideal anode material for lithium-ion batteries thanks to its high theoretical capacity (3860 mAh/g) and low electrochemical potential (-3.04 V vs. standard hydrogen electrode). However, practical use is limited by challenges such as lithium dendrite growth, volume expansion, and dead lithium, which degrade performance. This study addresses these issues by applying atomic layer deposition (ALD) of zinc oxide (ZnO) onto electrospun carbon nanofibers (CNFs) to create a high-performance, three-dimensional (3D) lithium metal composite anode. Polyacrylonitrile (PAN) was first electrospun to form the CNF framework. The lithiophilic properties of CNFs were systematically explored by adjusting the number of ALD ZnO cycles. The 3D lithium metal composite anodes were then produced by infusing molten lithium into the ZnO-coated CNFs. These composite electrodes showed excellent electrochemical performance, including low overpotential and extended cycle life in symmetric cell tests. In full-cell tests with $LiFePO_4$, the 3D Li composite anode delivered higher capacity than traditional Li metal foil. Overall, the combination of electrospinning and ALD techniques demonstrates substantial potential in creating 3D lithium metal composite electrodes, offering improved lithium diffusion, current distribution, battery stability, cycle life, and rate performance.

Author Index

Bold page numbers indicate presenter