Surface Engineering - Applied Research and Industrial Applications
Room Town & Country D - Session IA2-3-FrM
Surface Modification of Components in Automotive, Aerospace and Manufacturing Applications III

Moderator: Ta-Chin Wei, Yuan Christian University, Taiwan

8:00am **IA2-3-FrM-1 Study of Piezo-photocatalytic Performance of p-CoS-n-$NaNbO_3$ Junction Composite**, ***Man-Yu Hsiao* *(n56121288@gs.ncku.edu.tw)***, *T. Nguyen, K. Chang,* National Cheng Kung University (NCKU), Taiwan

Piezoelectric materials have been applied to the application of photocatalysis, photoelectrochemical cells, and pressure sensors. Furthermore, their heterojunction composites can enhance the photocarrier separation through a built-in electric field, and induced piezoelectric potentials can also minimize photocarrier recombination, improving photocatalytic efficiencies. In this talk, detailed studies on piezoelectric $NaNbO_3$, CoS-$NaNbO_3$ composites, and their associated piezo-related applications will be discussed. Various morphologies of $NaNbO_3$ were tuned via facile hydrothermal methods by the adjustments of heating times and temperatures, solution concentrations, and precursor types (Fig. 1-3, Supplement). Crystal phases of the samples were determined using XRD. Morphology and microstructures of $NaNbO_3$ and their composites were examined by SEM and TEM. Optical properties of the samples were investigated using UV–Vis spectroscopy. The sample's conductivity types were determined through Mott-Schottky measurement. Piezoelectric properties were directly measured via piezoresponse force microscopy (PFM). Furthermore, piezo-photocatalytic applications of $NaNbO_3$ and CoS-$NaNbO_3$composites were also explored, and the performance was elucidated using a constructed energy band diagram. Our results reveal that the photocatalytic effectiveness of the CoS-$NaNbO_3$ composite is attributable to the robust formation of p–n junctions, piezoelectric potentials, substantial amounts of active surface areas, and band positions.

8:20am **IA2-3-FrM-2 Enhanced Metal Surface Finishing with EPPo: Innovative Strategies for Ti 6Al-4V Alloys**, ***Nicolas Laugel (nicolas.laugel@manchester.ac.uk)***, *A. Matthews, A. Yerokhin,* The University of Manchester, UK

Electrolytic plasma polishing (EPPo) emerges as a promising technique for the precision removal and refinement of metals' surface layers. Its applications are experiencing growing interest, particularly in improving the finishing of lightweight alloys produced through additive manufacturing (AM). While the AM of metals holds immense potential to revolutionize global production, it faces a persistent challenge of achieving satisfactory final surface quality. To tackle this challenge, effective post-treatment methods are crucial, and EPPo emerges as an ideal solution.

The EPPo process involves placing the workpiece as the anode in an electrolytic cell and applying DC voltages in the hundreds of volts. The resultant energy release at the interface induces various physical and chemical reactions, ultimately influencing the processes governing the working surface's dissolution and allowing more precise control. EPPo employs electrolyte compositions that are safer for the workplace and the environment compared to traditional electropolishing methods, albeit with a slower material removal rate. Nevertheless, it preserves the advantages of contactless and geometry-independent polishing, aligning ideally with the advantages of additive manufacturing.

EPPo holds particular significance in its application on titanium and its alloys, a class of materials highly valued across various industries for their exceptional strength-to-weight ratio, corrosion resistance, and biocompatibility. They also present a valuable testing ground for EPPo due to their challenging electrodissolution characteristics, particularly the interference caused by the formation of insoluble oxides that create passivation layers, hindering the EPPo process itself in a positive feedback loop. This investigation specifically focuses on the impact of electrolyte on the surfaces generated through the EPPo of Ti 6Al4V alloy.

As EPPo has been transitioning from laboratory to industrial scales in recent years, electrolyte replacement has emerged as a significant and unexpected obstacle to cost-effective implementation. Notably, considerable downtime arises with the associated waste management tasks and inertia in temperature change of larger volumes. This study explores novel, environmentally friendly, non-aqueous electrolytes with deep eutectic solvents and their unique advantages in the application of EPPo to valve metals such as titanium and aluminium. Furthermore, it examines the ageing process in conventional fluoride-based aqueous electrolytes, providing insights from both chemical and surface science perspectives, along with proposed mitigations.

8:40am **IA2-3-FrM-3 Optimization of Plasma Electrolytic Polishing for 304 Stainless Steel Using Taguchi Method**, ***Chun-Wei Chang (yiwenz988@gmail.com)***, *N. Zheng, C. Tseng,* Ming Chi University of Technology, Taiwan, Republic of China

Plasma electrolytic polishing (PEP) is an advanced and efficient surface treatment technique widely employed across various industries. These particles induce chemical reactions on the material surface, thereby achieving fine polishing and enhancement of surface properties. In this study, we focused on utilizing a low concentration of ammonium sulfate ($(NH_4)_2SO_4$) aqueous solution to perform plasma electrolytic polishing on 304 stainless steel surfaces. The Taguchi experimental method was employed to assess the effects of different PEP parameters such as process time, voltage, electrolyte concentration, and temperature on the surface roughness,wettability and corrosion resistance of the PEP-treated stainless steels. Optical microscopy (OM) and scanning electron microscopy (SEM) were utilized to capture the changes in surface defects on 304 stainless steels after PEP processes, while a white light interferometer was used to evaluate surface roughness and flatness. Water contact angle measurements were conducted to assess the hydrophilicity/hydrophobicity of the PEP-treated 304 stainless steels. Additionally, the corrosion resistance properties were evaluated by using potentiodynamic polarization curve measurements in 3.5 wt% NaCl solutions. The experimental results performed by Taguchi analysis reveal that the electrolyte concentration is the most significant parameter affecting the effectiveness of plasma electrolytic polishing for 304 stainless steels, and followed by process time, voltage, and temperature. The OM and SEM images indicate that the removal of surface defects is increasing by increasing the process time, maximum voltage, and electrolyte concentration. The experimental data measured by the white light interferometer reveal that the lowest surface roughness of 0.061 μm and optimal surface flatness are achieved at PEP parameters of 6 minutes, 320 volts, and 5 wt% ammonium sulfate concentration. However, the wettability of PEP-treated 304 stainless steels obtained by water contact angle measurements indicates that an enhancement in hydrophobicity for PEP-treated surfaces, with the contact angle increasing from 73.8° before PEP to a maximum of 96.6° after PEP in 5 wt% ammonium sulfate solution. Furthermore, the pitting resistance for PEP-treated 304 stainless steels evaluated by potentiodynamic polarization curves measured in 3.5 wt% NaCl solution demonstrates that the highest pitting nucleation potential (E_{np}) and the largest passive region, indicating superior corrosion resistance properties, achieve on PEP-treated surface after PEP in 5 wt% ammonium sulfate solution.

9:00am **IA2-3-FrM-4 Structure Design and Degradation Mechanism of Amorphous Carbon Coatings on Metallic Bipolar Plates**, ***Hao Li (lh@nimte.ac.cn)***, *P. Guo, A. Wang,* Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, China

Proton exchange membrane fuel cell (PEMFC) is important on the development of hydrogen energy and fuel cell technology. However, in the acidic working environment of the PEMFC, the metallic bipolar plates (BPs), as a core component in PEMFC, will face to the problems of dissolution and corrosion, which directly determines the output power and service life of the PEMFC. Therefore, improving the conductivity and corrosion resistance of the metallic BPs is one of the key technologies that need to be tackled in the PEMFC field, affecting the competitiveness of the hydrogen energy and fuel cell industry.

The amorphous carbon (a-C) coating can endow metallic BPs with excellent corrosion resistance and conductivity. Besides, the scale cost advantage of a-C coating is significant. It can be prepared by physical vapor deposition technology, and has great application potential in metallic BPs of PEMFC. However, the preparation of a-C coating with excellent performance and the realization of stable low interface contact resistance (ICR) are still great challenges in this field. In addition, the degradation mechanism of a-C/metallic BPs after long-term operation is not clear, which seriously limits the development of corrosion-resistant and conductive a-C materials and technologies.

In view of the above problems, this paper fabricated a series of a-C coatings for the surface modification of metallic BPs under PEMFC conditions, and explored the relationship between the microstructure and bonding composition of coatings and corrosion resistance and conductivity, revealed the failure mechanism of the coatings modified metallic BPs, prepared a-C coating with high conductivity and corrosion resistance, and put forward a new idea of interface optimization of the coating modified metallic BPs.

9:20am **IA2-3-FrM-5 Automated Laser Cleaning/Ablation as a Novel Tool in Aerospace Manufacturing**, ***Dmitri Novikov (dnovikov@ipgphotonics.com)***, IPG Photonics, USA

This presentation will explore the progress in laser technology that has made them the tool of choice for mass manufacturing, with a focus on laser cleaning/ablation. Laser technology has revolutionized the way we manufacture, maintain, repair, and overhaul aerospace components. Thorough cleaning is a critical step in these processes, whether before coating, surface polishing or roughening, or any joining operations like welding or brazing. Currently, three main technologies are used for coating stripping and surface preparation for coating: abrasive grit blasting, abrasive water jetting, and chemical cleaning/stripping. However, these technologies negatively impact the environment and health and are slow and expensive. This presentation aims to introduce a laser cleaning solution that can replace these legacy technologies. Although laser cleaning/ablation is known in the industry, its use is limited due to the limited access to correct laser sources and concerns of part damage by laser heat. The presentation will showcase successful laser cleaning applications for different cleaning/ablation tasks, resulting in improved productivity, repeatability, direct cost savings, and part performance improvements in quality. Laser technology has proven to be a game-changer in the manufacturing industry.

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