Surface Engineering - Applied Research and Industrial Applications

Room Grand Hall - Session GP

Symposium G Poster Session

GP-2 Laser-clad Induced Reaction Synthesis of TiC/WC Reinforced Co-based Composite Coatings on Copper Alloy, ***Hua Yan***, *P Zhang, Z Yu,* Shanghai University of Engineering Science, China

Co-based composite coatings reinforced by nickel coated WC (Ni/WC) and in-situ synthesized TiC particles has been fabricated from precursor mixtures of HG-Co01(Co-based alloy), Ni/WC, graphite and pure titanium powders by laser cladding on Cr-Zr-Cu alloy substrate. The microstructure, phase and wear properties were investigated by means of optical microscopy (OM), X-ray diffraction (XRD) and scanning electron microscopy (SEM), as well as dry sliding wear test. Results show that reinforcements dispersed uniformly in the Co-based matrix. TiC showed the morphology of dendritic and particle. During laser-clad processing, the laser heating effect caused inter-diffusion action between the precursor mixtures and generated TixCy and some Ti element diffused into Ni/WC particles formation of TiWC2 alloyed layer. The laser-clad TiC/WC reinforced Co-based composite coatings exhibited higher microhardness and better wear resistance than copper alloy. The highest microhardness was up to 1007 HV0.2 which was improved 8 times comparing to the Cr-Zr-Cu substrate. The friction coefficients of the laser-clad composite coatings were reduced significantly to about 0.15 and relatively smooth wear surface could be observed.

GP-5 The Study of Mechanical Strength on the Injection Molding Parameters of PMMA/TG Composite Bipolar Plates, ***Ai-Huei Chiou***, National Formosa University, Taiwan

Recently, green energy technology is developing in the world and fuel cell is one potential energy resource of renewable energy technologies. Now fuel cell is facing the challenges of popularization and miniaturization. The bipolar plate is a key component in this device, so to develop highly conductive, lightweight, and low cost bipolar plate for fuel cell is important goal. Besides, the design of fuel cell assembly plays an important role in the performance. Therefore, the primary goal of this study is improving process, material selection and mechanical properties of bipolar plate. To make a breakthrough the bottleneck of science and technology in fuel cell and create more economic value in the future.

Therefore, weight and cost of bipolar plates were important research project for improvement. In this study, light-weight composite bipolar plates were prepared by injection molding. The thickness of the lightweight composite bipolar plates were thinner in this study. After the injection molding bipolar plate may havepoor strength caused affection [to fuel cell assembly and battery efficiency. In order to make it have good strength, take the tea graphites(TG) as reinforcing materials that were made of recover tea leaves and mixed with Polymethylmethacrylate. The experimental parameters were planned by Taguchi method to improve strength and warping quality.

The experimental results showed that the increase of TG content decrease the PMMA flow and transmittance, but the bending strength and heat resistance increased in PMMA / TG composites.The Single quality optimization of bending strength of the PMMA / TG composite bipolar plate was about 35.64 ±1.9 Mpa, which was improved about 7.6% higher than the maximum bending strength of L_8 (33.13±1.4Mpa)in the orthogonal table.Results showed that the composite of interest qualified under the Department of Energy (DOE) requirements for weight and flexural strengthfor fuel cell bipolar plates.The study concludes that the process of PMMA/TG bipolar plates by injection mold may be used in fuel cell applications.

GP-6 Real-time Analysis of Neutral Species from Atmospheric Plasma, ***Peter Hatton***, *A Rees, C Greenwood, S Bort,* Hiden Analytical Ltd, UK

Electrical plasmas at atmospheric pressures find increasing application in materials processing and other fields. Generation of the plasmas is not necessarily more difficult than at low pressures, but the plasmas can involve a wider range of particle species, produced through an increase in interactions at the elevated pressures. Identification of the active species assists the characterisation of the plasmas and the evaluation of equilibrium pathways involved, thus aiding the optimisation of particular systems. The work reported here is for two simple RF atmospheric plasmas studied using a Hiden HPR20 EPIC quadrupole mass spectrometer. The measurements were made in real-time using the instrument's capillary inlet system to couple to the reactor. Test data for a mixture of helium and carbon dioxide clearly show the plasma dissociation of the carbon dioxide. The reaction was monitored either through observing the intensities of CO^+ and CO_2^+ ions produced in the source of the HPR20 EPIC from the sampled gas or the intensity of the negative oxygen ions produced by selecting the electron energies in the source to be those corresponding to the peaks in the dissociative electron attachment for the two gases.

Data from tests using a methane/helium plasma show clearly the wide range of high mass products produced by the plasma, and their rapid response to changes in plasma conditions. Negative ions such as H^- and $C_2H_2^-$ were monitored as well as high –mass positive ions. The data illustrate some of the potential of instruments such as the HPR20 for the study of high pressure plasmas, for example in the production of hydrophobic surfaces.

GP-8 Correlation of HPPMS Plasma and Coating Properties using Artificial Neural Networks, *K Bobzin, T Brögelmann, N Kruppe,* ***Martin Engels***, Surface Engineering Institute - RWTH Aachen University, Germany

The development of industrial coating processes for tool coatings by means of physical vapor deposition (PVD) is usually extremely complex. This is caused by the large number of necessary coating batches and associated coating analyses until suitable process parameters are found. Artificial neural networks (ANN) are basically capable of describing complex relationships between various characteristic process values. Hence, within the scope of this paper the capability of describing complex correlations was tested on the example of a reactive high power pulsed magnetron sputtering (HPPMS) (Cr,Al)ON process. Selected process parameters pulse frequency and process gas composition were chosen, since they exhibit strongly non-linear cause-effect relationships. The ANN was used in order to correlate selective results from efficient substrate-oriented plasma diagnostics and coating analyses. Regarding the plasma properties the Al/Cr ratio and the metal-to-gas ion flux ratio were considered. With respect to the coating properties the Al/Cr ratio and the universal hardness were examined. From the correlation of these results, conclusions on the process parameters for desired coating properties were deduced and successfully proven for the investigated HPPMS (Cr,Al)ON process. Hence, the ANN exhibits a great potential to supplement the fundamental understanding of PVD processes in order to contribute to a simplification of the development of industrial coating processes.

GP-9 Linking Erosion and Sputter Performance of a Rotatable Target to Microstructure and Properties of Mo Thin Films, *A Hofer-Roblyek, K Pichler,* Montanuniversität Leoben, Austria*; C Linke,* Plansee SE, Austria*; R Franz,* Montanuniversität Leoben, Austria*; J Winkler,* Plansee SE, Austria*;* ***Christian Mitterer***, Montanuniversität Leoben, Austria

The use of molybdenum in large area thin film deposition includes back contact layers for thin film solar cells as well as diffusion barriers and source/drain electrodes in microelectronics and relies on its excellent thermal stability and chemical inertness as well as low electrical resistivity. A constant high quality of sputter deposited thin films during the entire target lifetime is of vital importance for these applications. Thus, this study addresses the sputter performance, i.e. changes of current, voltage and arc rate, recorded during erosion of a rotatable Mo target as well as the quality of thin films deposited at different erosion stages. The enhanced target erosion and the thus reduced target wall thickness cause an increase of the magnetic field strength in front of the target and yield a slightly reduced voltage and increased current. Increased arc rates could be related to venting the vacuum chamber during interruptions in target erosion which were needed for thin film depositions. Both, microstructure and electrical resistivity of the films deposited are widely unaffected by the progressing target erosion. In contrast, the different substrate carrier oscillation modes determine film topography, stress and electrical resistivity. The end of target life is determined by the pronounced sputter grooves formed at both ends of the rotatable target due to the shape of the permanent magnetic field at the turnarounds rather than changes in the quality of the films deposited.

GP-10 Surface Profile Analysis as an Investigative Tool for Electrolytic Plasma Polishing, ***Nicolas Laugel***, *A Matthews, A Yerokhin,* University of Manchester, UK

Electrolytic Plasma Polishing (EPPo) is a finishing method for the smoothing of conductive workpieces. Based on the electrodissolution of metals at electrical potentials lying in the hundreds of volts range, it presents the advantages of electropolishing. The absence of a tool, for example, means

independence from macroscopic surface geometry as well as the avoidance of tool wear. Yet in contrast with traditional electropolishing, it requires lower material removal for a given target roughness and makes uses of mild electrolytes, for a very low negative environmental impact.

In EPPo, just like in electropolishing, material is typically thought to be removed through anodic dissolution. The high energy discharge at the interface leads however to several simultaneous phenomena limiting the rate of material removal. A gaseous vapour hull enveloping the treated surface, hallmark of plasma electrolytic processes, is an example as it limits drastically the current flowing through the cell. So is the production of soluble ions and oxides significantly modifying the effective electrolyte composition at the surface's immediate vicinity. The eventual topological properties of the treated surface are a direct result of these competing phenomena.

Careful characterisation of interfacial features thus allows to gather information on the process itself. Power spectral density analysis of height maps, obtained by laser confocal profilometry over wide areas and with varying resolutions, underline the characteristic lengths of surface features of a given surface. Comparing its results before and after EPPo, on pieces made of different materials and with varying original roughness distributions, sheds a unique light on the material removal process. Contrasting them with the results form other characterisation techniques, both *in* and *ex situ,* builds on a picture showing EPPo as a chain of processes each indispensable to the whole and to a large extent independent of one another.

GP-11 Evaluation of the Oxidation of Cr-W-N Coating on Ferritic Steel as Bipolar Plates for Solid Oxide Fuel Cell*, S Yang,* ***Chi-Ju Tsan****,* National University of Kaohsiung, Taiwan*; Y Chang,* National Formosa University, Taiwan*; Y Pan,* China Steel Corporation, Taiwan*; D Lin,* National University of Kaohsiung, Taiwan

Ferritic stainless steel is the one of materials of choice for SOFCs bipolar plates, because of high electrical conductivity, suitable thermal expansion compatibility, excellent mechanical properties and oxidation resistance. It has been reported that Crofer 22 H has excellent electrical conductivity and oxidation resistance with additions of Nb and W, whcih are better than those of Crofer 22 APU. Even though Laves phase in Crofer 22 H improves creep property, the oxidation rate is not sufficiently low to enable uncoated Crofer 22 H interconnects to meet the current 40,000 h SOFC lifetime requirement. Therefore, Crofer 22 H also requires a protective coating both to retard the oxidation rate and to prevent the volatile chromium species.

In this study, Cr-W-N coating was deposited on high-chromium ferritic stainless steel as protective coatings by using cathodic arc evaporation. Oxidation kinetics of the Cr-W-N -coated sample was evaluated through isothermal tests in an atmospheric furnace at 800 °C for 1000 h. Morphology and cross sections of scales were examined under a field-emission scanning electron microscope in both backscattered and secondary electron modes. Coating phase assemblies were assessed using X-ray diffraction. High resolution transmission electron microscopy was utilized for a close examination of the coating/alloy interfacial chemistry. After oxidation at 800 °C for 1000 h, the results showed that the dominant oxidation mechanism transfer is the growth of Cr_2O_3 and $(Mn,Cr)_3O_4$ spinel. Moreover, the doping of W benefited the formation of a χ phase to precipitate at the oxide/coating interface, which acted as a diffusion barrier retarding the reaction rate between Cr and O.

Author Index

Bold page numbers indicate presenter