Surface Engineering - Applied Research and Industrial Applications
Room On Demand - Session G1
Advances in Industrial PVD, CVD and PCVD Processes and Equipment

G1-1 INVITED TALK: Deposition of Functional Nano-Coatings Using Atmospheric Pressure Plasmas*, **Daphne Pappas (daphne.pappas@plasmatreat.com)**, A. Aref, A. Sy,* Plasmatreat USA, Inc., USA **INVITED**

Plasma surface engineering has been employed for decades for the development of advanced materials and has offered a plethora of technological solutions. As an example, any microchip used in a computer, tablet or cell phone device, at some point during its production was subjected to a plasma etch or deposition process that took place in a vacuum environment. Over the last decade, plasma processing of materials has expanded, including the development of functional nanocoatings under atmospheric pressure and room temperature conditions. The motivation for this was the need for equipment and processes that could be incorporated in industrial production lines capable of producing large area inline coatings in a cost efficient way, negating the need for vacuum systems. In this talk, an overview of atmospheric pressure plasma jet processes for: i) the activation and cleaning of surfaces and ii) the deposition of polymer functional coatings will be presented. The surface cleaning step is important for surfaces that have residual contaminants or for materials that have low surface energy. This pre-treatment can be instrumental in improving the bonding to adhesives or coatings that are applied on the activated surfaces. Also, results from the deposition of polymer coatings with unique functionality will be presented. The coatings that were developed had a thickness that ranged from 50nm to 690 nm and can serve as anti-corrosion, water repellent, adhesion promoting or biocompatible surfaces. Due to these properties, they are applicable in several industries, including aerospace, automotive, biomedical and microelectronics.

G1-3 Parametric Analysis of the Selective GTAW Remelting Process for WC-10Co-4Cr Coating by HVOF*, **Hortencia Santos (hortencia.noronha@gmail.com)**,* Universidade Federal do Pampa, Brazil*; N. Mayhassen,* Instituto Tecnológico de Aeronáutica, Brazil*; A. Miranda, H. SVOBODA,* Universidad de Buenos Aires, Argentina*; A. Oliveira,* Universidade Federal do Pampa, Brazil

Thermal sprayed coatings containing tungsten carbide (WC) are widely used in different industrial applications due to its high hardness, high temperature and wear resistance. As sprayed coatings containing WC usually require a second stage of remelting, after application, to enhance the final properties, which can be made using different heat sources like laser, electric arc, oxi-gas flame or a furnace. Aspects of coating quality like adherence, dilution and level of defects are strongly affected by the heat source and procedure employed. Nevertheless, there is a lack of systematic studies related to these aspects. The objective of this work was to analyze different parameters using GTAW to produce the remelting of WC-Co thermal sprayed coatings obtained by High Velocity Oxi-Fuel (HVOF) process. Samples of carbon steel were coated by HVOF using a WC-Co powder obtaining a coating of 100 microns thickness with a hardness of 1250 HV. Then, the coated samples were remelted using GTAW processes. In each case, the effect of different parameters like power, travel speed and patterns were evaluated. On the refused samples microstructural characterization, microhardness profiles and electrochemical corrosion test were done. There were obtained procedures to remelt the WC-Co coatings with low dilution. The processes produced coatings with hardness values between 1600 and 1800 HV. The resistance to corrosion was similar than the as spray condition. Nevertheless, the integrity of the interphase was strongly improved in both cases.

Acknowledgments

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G1-4 HIPIMS –Ready on Industrial Scale for Modern Production*, **Philipp Immich (pimmich@hauzer.nl)**, G. Negrea, D. Doerwald, R. Jacobs, M. Eerden, R. Ganesan, L. Tegelaers,* IHI Hauzer Techno Coating B.V., Netherlands

Since HIPIMS enter the coating scene a lot of investigations on this topic had been carried out. Discovering new properties, different material behavior compared to convention sputtered coatings and better performance in cutting, forming and tribology applications. Most of the investigations were done on small scale deposition units. But bringing this technology to industry, larger units are needed and also process upscaling is needed.

Today real production of coated parts require not only good coating properties also production related topics like reliability, easy maintenance, cost per part and flexibility of the coating unit itself plays an important role.

In this regard different HIPIMS coatings from AlCrN-based, AlTiN-based and hydrogen free DLC such as ta-C systems were deposited on industrial scale units for tribology and tool applications. The applied coatings were investigated concerning mechanical film properties like hardness, Young´s Modulus, chemical properties like composition and phase formation. To verify the performance of the coating machine and the deposited coatings, industrial tests in automotive and tool applications are carried out. The obtained results shown, that the HIPIMS technology is ready for serial production in a modern production environment.

G1-5 Carbon coating on Three-dimensional Anodically Oxidized Titanium Foam with Hierarchical Nanostructure for Capacitive Deionization Electrode*, J. Huang, **Ping-Yen Hsieh (pyhsieh@fcu.edu.tw)**, J. He,* Feng Chia University, Taiwan

Capacitive deionization (CDI) is one of the most promising technique for water treatment and purification. To meet the demand for pursuing high efficiency of desalination, the key component, CDI electrode, requires high chemical stability, high specific surface area, high water wetting ability, and suitable porous structure for ion electrosorption. As opposed to the conventional carbon nanomaterials for CDI electrode, a new design concept is proposed by using facile nanostructure engineering on titanium foam through anodically oxidization and hydrothermal treatment, followed by high-temperature glucose carbonization to develop a carbon film coated titanium dioxide nanostructured porous electrode (CTPE). Further, the feasibility of using such novel electrode for CDI performance was evaluated. The experimental results show that successful preparation of a carbon film coated titanium dioxide nanostructure on titanium foam can be facilitated to obtain CTPE. With the carbon film served to passivate surface and provide low impedance interface, it enhances ion transmission capacity and improves electrochemical stability. By taking the synergistic effect of abovementioned characteristics, the efficiency of salt electro-sorption/desorption performance was enhanced significantly based on the cyclic voltammetry results. Finally, under an optimal CDI cell operation condition, the CTPE can reduce sodium chloride water solution with its conductivity from 748 µS/cm to 627 µS/cm, corresponding to the adsorption NaCl amount of 0.54 mg/cm^3. Overall, the proposed CTPE can be considered a promising material for CDI application.

G1-6 Digital Twin PVD Coater Matsight - State-of-the-Art and Future Outlook*, **Adam Obrusnik (obrusnik@plasmasolve.com)**, P. Zikan, M. Kubecka,* PlasmaSolve s.r.o., Czechia

In most fields of industry, CAE (computer-aided engineering) is the go-to tool for designing a new system or a process. Recent scientific advancements and the evolution of high-performance computing also enabled predictive simulation of industrial PVD processes, substantially reducing the effort invested to trial-and-error. As a provider of industrial PVD CAE, we report on the development of MatSight - a user-friendly “digital twin” software that will enable in-house user-friendly CAE of PVD systems and processes. We discuss the numerical strategies and physical assumptions which enable the underlying simulation. The presentation aims to provide relevant use cases and success stories for PVD CAE but it also aims to discuss the challenges encountered during the development and present limitations of PVD simulation.

G1-7 Oxygen-Controlled Crystal Structures and Properties of SnO_2 Infrared Transparent Conducting Films*, **Liangge Xu (xuliangge@aliyun.com)**, L. Yang,* Harbin Institute of Technology, China*; J. Zhu,* Key Laboratory of Micro-systems and Micro-structures Manufacturing, China

Tin oxide (SnO_2) has been widely explored for various applications due to its excellent n-type semiconductor properties, low resistance, and high optical transparency in the visible range. However, few studies on the preparation of SnO_2 films using high power pulsed magnetron sputtering have been reported. Oxygen content is a critical parameter in the practice of SnO_2 thin films by high-power pulsed magnetron sputtering. the average free range of Sn atoms is usually much smaller than O atoms. SnO_2 films deposited in a pure Ar atmosphere are likely to be oxygen-deficient and form O vacancies. and such oxygen vacancies will cause lattice distortion, which will affect the mobility of charge carriers in the SnO_2 film. Therefore, oxygen is the main factor affecting the electrical conductivity of SnO_2 films.

In this paper, the reaction mode of high-power pulsed reactive magnetron sputtering at different oxygen partial pressures and the crystal structure and infrared transparent conductive properties of SnO_2 films prepared at 600°C were investigated. The crystal structures and properties of infrared transparent SnO_2 films deposited by high-power pulsed magnetron sputtering at different oxygen partial pressures from 10 to 24 sccm were investigated. For the SnO_2 films deposited with 10~14 sccm oxygen partial pressure, the reaction mode is dominated by the metallic mode, and the polar unsaturated (101) plane is the preferred orientation of the film crystals. For SnO_2 films deposited with oxygen partial pressures of 16 to 18 sccm, the reaction mode is dominated by the transition mode, and the (110) plane shows a preferred orientation. In the deposition process with oxygen partial pressure greater than 18 sccm, the reaction proceeds in the poisoning mode. As the oxygen partial pressure increases, the carrier concentration decreases to 2.335×10^{15} cm^{-3}; the mobility increases to ~15 cm^2/Vs, and the IR transmittance at 4 μm increases. At the same time, the electrical properties of the prepared SnO_2 films deteriorate due to the oversupply of O_2, with resistivity up to 5.029×10^2 $\Omega\bullet cm^2$.

G1-8 INVITED TALK: New Developments in Magnetron Sputtering Devices*, D. Monaghan,* ***Victor Bellido-Gonzalez (victor@gencoa.com)****, T. Sgrilli, R. Brown, J. Brindley, B. Daniel,* Gencoa Ltd, UK **INVITED**

Magnetron sputtering is a mature and well establish PVD deposition technique. Since the introduction of commercial planar magnetrons in the 1970s there are few vacuum coating sectors that haven't been touched by successful implementations of this deposition technique. In the 1970s the semiconductor industry was revolutinonized by the introduction of planar magnetron sputtering as an alternative to evaporation and diode sputtering. Nearly forty years later, still magnetron sputtering is at the heart of many of the manufacturing processes from small to large area, with different degrees of functionality, from decorative, to energy, transport, architectural, automotive, aerospace, display, photovoltaic, thermal solar, electronics, etc.

Different sectors have typically required adaptation of the basic concepts of magnetron sputtering for the specific functionality and purpose. There has been a need for a continuous development of sources and process solutions. Among those, the need for better controls, and better monitoring. This presentation will give an overview of magnetron sputtering with its main breakthroughs, the current status of the technology in important for some relevant PVD coating sectors and will look at the current and future challenges ahead.

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