Surface Engineering - Applied Research and Industrial Applications
Room Sunset - Session G5

Hybrid Coatings and Hybrid System Processes

Moderators: Hana Barankova, Uppsala University, Sweden, Sang-Yul Lee, Korea Aerospace University

1:50pm **G5-2 Propagation of Electric Field Waves in a DC Magnetron Plasma**, ***Rachel Broughton***, *S Kirkpatrick,* Rose-Hulman Institute of Technolgy, USA

Arcing is an issue that extends throughout the field of plasmas that can cause expensive damage to industrial equipment. In magnetron plasmas, arcing is usually avoided by employing a preventative method, such as pulsed DC sputtering. This work superimposes a small AC signal onto the high voltage supplied to the DC cathode to observe the effects within a magnetron plasma. A Langmuir probe was inserted into an argon DC plasma formed by a two-inch magnetron gun. The voltage from the probe was read on an oscilloscope not only in the time domain to obtain the appropriate IV-curve, but also in the frequency domain to observe if the driven frequencies were able to propagate through the plasma. An 8 mm by 8 mm square probe was employed both parallel and perpendicular to the surface of the cathode. Variations depending on orientation were noted in the measured plasma temperature and density where typical density values of the observed plasmas were on the order of 10^{10} cm^{-3}. The applied AC signal was detected in the time domain measurements of the Langmuir probes only from probes oriented perpendicular to the surface of the cathode.

2:10pm **G5-3 From Surface to Coating - Tools for Surface Engineering**, ***Frank Papa***, Gencoa Ltd, USA, Spain; *V Bellido-Gonzalez,* Gencoa Ltd, UK; *I Fernandez Martinez,* Nano4energy SLNE, Spain; *F Meyer, H Li, D Monaghan, T Sgrilli,* Gencoa Ltd, UK **INVITED**

Surface engineering has been an area of interest for many decades. Initially, hybrid processes such as nitriding, anodizing and plating were applied to improve the surface properties of engineering materials such as steels and aluminum. Today, we are faced with many surface engineering challenges as the number of advanced materials increases and the "functionality" requirements of surfaces become more demanding. From metals to plastics to ceramics, the types of surface treatments and coatings are varied. For surface preparation, the energy and type of ion needed (etching/functionalization/cleaning) will vary with the application. Likewise, the properties of coatings and surface coating interfaces depend strongly on the type of impinging particles and their energies and reactivity. Several tools are available for "hybrid" processes where the energy and type of ions reaching a surface need to be controlled. Ion sources are typically used for pre-treatment of substrates, but sputtering magnetrons themselves can also be turned into sources of ions. Conversely, both can be used for depositing coatings. Advanced tools for surface engineering in today's world involve an understanding of how sources can be driven (power supplies) and how combinations of technologies, both active (anode layer ion sources) and passive (anodes), allow us to change interfaces and coating properties. In this talk, we'll explore such applications in the areas of glass coating, hard coatings and on polymers. We'll discuss the combined used of secondary sources to boost and to decrease plasma density as well as the effects of adding positive pulses to traditional HIPIMS processes. With such positive pulses, the ion flux and energy can be controlled to the growing film after each negative pulse (deposition). The successful implementation of hybrid processes for coatings such as AlCrN, ITO, DLC and functionalized Ag will be presented.

2:50pm **G5-5 Nb – Doped TiO_2 Deposited by Hybrid HIPIMS – CVD Process**, ***Justyna Kulczyk-Malecka,*** Manchester Metropolitan University, UK; *D Donaghy,* University of Liverpool, UK; *B Delfour-Peyrethon,* Manchester Metropolitan University, UK; *P Chalker, J Bradley,* University of Liverpool, UK; *P Kelly,* Manchester Metropolitan University, UK

Novel methods for the deposition of thin functional coatings, such as hybrid CVD – PVD technologies have the potential to become an important means of overcoming the limitations of current processes, such as low deposition rates, associated with some sputtering processes or limited material/precursor choices, associated with CVD processes.

In this work we are combining PECVD with a magnetron sputtering source driven by a HIPIMS power supply to assist the deposition of functional oxides for TCO applications. Although, other PVD – CVD hybrid systems have been developed, each process requires its own power supply. However, combining the processes in this way means that only one power supply is required. Thus, niobium – doped titania coatings were deposited on glass and Si wafer substrates by this hybrid HIPIMS – CVD technique. The TiO_2 coatings were deposited by CVD from a TTIP precursor via the vapour drawn method. The HIPIMS process provided not only the source of Nb metal dopant to the functional films, but sustained the low temperature CVD process by the means of a highly energetic plasma. Furthermore, since HIPIMS deposition rates are very sensitive to magnetic field strength and the degree of unbalance, by using a magnetron with variable magnetic field strength, it was possible to adjust the dopant content of the film without adjusting the power applied to the magnetron target.

The effect of processing parameters (pulse frequency, peak powers, precursor flow rates, operating pressure, etc.) on generating a stable HIPIMS plasma across the process envelope has been studied in this work. The composition, microstructure and electrical properties of the deposited coatings have been investigated, in respect to variable process parameters, such as substrate temperature and operating pressure.

3:10pm **G5-6 Potential of Sequent and Simultaneous PVD PeCVD Hybrid Technology Combination. Investigations Aside Well-known Technologies in Duplex DLC and Co-deposition by Simultaneous Arc, Sputtering Evaporation**, ***Pierre Collignon***, *R Scheibe,* PD2i Europe GmbH, Germany

As Hybrid technology , the Combinations of different PVD and PeCVD technologies like WC/C or Cr-DLC are state of the art technologies that are well established and industrialized but there are more possible idle technological combinations . Research was concentrated on two specific technology combinations:

1) Further investigations in DUPLEX DLC, an upstream NITRATION to increase surface hardness and increased resistance against plastic deformation with a subsequent tribological DLC coating reducing the coefficient of friction in one batch (INSITU). Goal of the study is discovering the properties (adhesion , friction coeff , corrosion) but also the potential to what extent existing sequent processes can be substituted and further, the feasibility of substituting used material / surface treatment combinations.

2) Co-deposition a simultaneous ARC and sputtering evaporation to combine the advantage of high adhesive hard coatings with embedded lubricant / tribiological nanoparticles. Today's weakness in multi layered lubricant thin films are the limited working temperature of 300 °C and the fast elimination of the weak functional trobological layers by wear. Target of the test series is to figure out if lifetime can be increased significant by embedding lubricant particles into the hard coating by simultaneous evaporation of a different hard coatings (e.g. AlTiN) via ARC and materials with low friction coefficient (e.g. WC/C) via sputtering evaporation.

3:30pm **G5-7 TiN Deposition using the Magnetized Hollow Cathode Activated Magnetron**, *H Barankova,* ***Ladislav Bardos,*** Uppsala University, Sweden

A new type of the magnetron, Magnetized Hollow Cathode Activated Magnetron with the target coupled with the hollow cathode magnetized by the magnetic field of the magnetron was tested in the reactive process of TiN deposition. Increased deposition rate compared to the Ti metal deposition rate was confirmed. The depositions as well as optical measurements were performed at several pressures in the reactor. The results of the TiN reactive deposition are presented and discussed, including the TiN deposition in pure nitrogen.

3:50pm **G5-8 Structural and Tribological Properties of Mixed Iron-titanium Borides Produced with Cathodic Arc Assisted Alloying and Electrochemical Boriding**, ***Erkan Kacar***, *C Yelkarasi, S Timur, M Urgen,* Istanbul Technical University, Turkey

Borides of transition metals are very promising materials for a wide range of applications due to their high hardness, excellent wear, high temperature oxidation resistance and high thermal/electrical conductivity. Most widely used borides are iron and titanium borides. Iron borides are produced with diffusion based processes applied to iron and steel alloys. On the other hand titanium borides are produced either by boriding titanium or as coatings on different substrates using PVD or CVD methods. In this study we aimed to produce complex borides composed of Fe and Ti borides using hybrid process. For achieving this aim, low carbon steel substrates are alloyed with titanium using cathodic arc assisted process to produce iron-titanium alloy on the surface. This alloy is then borided using electrochemical boriding method. Produced mixed boride is characterized with respect to its structure, morphology and mechanical properties using XRD, SEM, FIB and ultra microhardness measurements. Tribological properties of the layers are determined using reciprocating wear tests against alumina balls. Results of the investigation revealed that it is possible to produce ultra hard surface layers (hardness above 40 GPa) by this hybrid method with excellent wear resistance.

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