Hard Coatings and Vapor Deposition Technologies
Room Golden West - Session B1-4

PVD Coatings and Technologies

Moderators: Joerg Vetter, Oerlikon Balzers Coating Germany GmbH, Qi Yang, National Research Council of Canada, Jyh-Ming Ting, National Cheng Kung University

2:10pm **B1-4-3 Particles in PVD-Coatings: Imperfection or Functional Add-on Feature?**, ***Uwe Beck***, *J Baier, M Sahre, M Weise, G Hidde,* BAM Berlin, Germany

The application of PVD-coatings ranges from mechanical engineering, i.e. thicker tribological coatings, to precision optics, i.e. thinner optical coatings. For physical vapor deposition (PVD) technologies such as evaporation, sputtering, ion beam assisted/driven deposition, vacuum is a prerequisite for two reasons: at first process-related ones (evaporation source, plasma discharge, and mean free path) and at second coating-related ones (pure, perfect, and dense films). Usually, the goal is a homogenous coating of defined stoichiometry and micro-structure without any imperfection.

However, the implementation of micro- or nano-particles may occur accidentally or deliberately. Independent of the particle origin, there are two fundamental rules regarding coating functionality: at first, the larger the particle diameter to coating thickness ratio the more affected the functionality of the coating, and at second, the larger the material contrast in terms of the functional feature of interest the more affected the coating performance. Hence, embedded particles have to be avoided for the majority of thin films by all means. The unintended implementation of particles usually results in a malfunction of the coating from the beginning or is at least considered as a weak point of the coating creating a time-dependent defect under service conditions. The intended implementation of particles on surfaces and in coatings may create add-on features, topographic ones and functional ones, however, the facts mentioned hold true.

Examples of particle-initiated coating defects are demonstrated in dependence on the origin and the field of application. Strategies for deliberate attachment/embedding of particles on surfaces/in coatings are discussed regarding process compatibility and coating integrity. For industrial applications, both the validation of process compatibility of particle injection and the plasma resistance of particles under vacuum and plasma conditions have to be confirmed. Further points of interest are the homogeneity of particle distribution and the avoidance of particle agglomeration which is still a crucial point for dry dispersed particles. So far, technical applications are limited to PVD hybrid coatings, plasma dispersion coatings are still a challenge except for applications where homogeneity is not required as in case of product authentication.

2:30pm **B1-4-4 Gradient Coating for NIF Double Shell Targets**, ***Hongwei Xu***, General Atomics, USA

Double shell provides an alternative implosion platform for National ignition facilities (NIF). Double shell inner shell incorporates density graded layer to suppress Rayleigh-Taylor instability during implosion caused by inhomogeneity. We will report our efforts of fabricating density graded layers for double shell inner shell using magnetron sputtering and characterization of graded layers. The cold welding was observed for a lot of metals when deposited on a spherical mandrel, which seems correlated with material ductility. W-Be gradient layer was fabricated for double shell inner shell because of their large density difference and microstructure changes were revealed with varying composition. A W-Be amorphous phase was also discovered.

2:50pm **B1-4-5 Growth Morphology and Piezoelectric Properties of AlN Thin Films Deposited by Reactive DC Magnetron Sputtering**, ***Mathis Trant***, *M Fischer, K Thorwarth, H Hug,* Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland

The piezoelectric properties of aluminum nitride (AlN) make it a good candidate for many applications in microelectronics, electroacoustic and optoelectronics. Magnetron sputtering is widely used to prepare AlN thin films so that they can easily be integrated into, for example, MEMS devices. However, controlling the microstructure and microchemistry, especially at low deposition temperatures, is crucial for a good performance. Ions impacting on the growing film can be used advantageously in magnetron sputtering to address these needs. We investigate the effect of low energy ion bombardment on the AlN thin film growth morphology and its correlation to piezoelectric properties.

An electromagnetic coil is used to generate a variable magnetic field that allows varying the ratio of ions and neutrals impacting on the growing film by more than one order of magnitude. With an increasing ion flux, the residual stress of AlN thin films changes from tensile to compressive. This evolution is compatible with a change in the growth morphology from open grain boundaries towards dense films. The piezoelectric properties of AlN thin films in the different growth regimes are discussed and possible applications for scanning probe microscopy are presented.

3:10pm **B1-4-6 Plasma Generation and Coating Composition from Ti-C, Ti-Al, and Ti-W Cathodes used in DC Vacuum Arc**, ***Igor Zhirkov***, Linköping University, Sweden; *P Polcik, S Kolozsvári,* Plansee Composite Materials GmbH, Germany; *J Rosen,* Linköping University, Sweden

Arc deposition from composite cathodes is a common method for synthesis of a wide range of functional coatings. A commonly used cathode element is Ti, which combined with different elements can deliver properties of coatings requiring in various applications. To understand the plasma generation from these cathodes is of importance for controlling the structural and compositional evolution of the coating of interest. In this work, we present the correlation between cathode, plasma and film composition for Ti-C, Ti-Al, and Ti-W composite cathodes of various stoichiometry used for DC vacuum arc depositions. The generated plasmas are characterized with respect to plasma chemistry and charge-state-resolved ion energy, and the intensity of the macroparticle flux is evaluated. The obtained results are compared to corresponding evaluation of elemental Ti, Al, C and W cathodes. We show that the plasma and film composition are in good agreement for the Ti-Al and the Ti-W cathodes, while for the Ti-C cathodes, there is a significant loss (~ 50%) of the light element. We also show, that the kinetic energies of ions from the Ti-Al and Ti-W cathodes are slightly different from those from the elemental cathodes, while the difference between the Ti-C and Ti cathode is more pronounced (Ti^{1+} average ion energy; ~ 90 eV and ~ 50 eV, respectively). The ion charge states are also found to be sensitive to cathode composition. The overall observations are explained by the cohesive energies and melting temperatures of the phases present at the cathode surface during arcing, while also considering transportation of ions of different mass within the generated plasmas. The systematic evaluation of general trends in properties of the generated material fluxes accompanying the addition of elements of different masses and chemical reactivity (C, Al, W) to a Ti cathode, contributes to an increased understanding of plasma generation from a two element cathode, which in turn may provide guidance for selection of cathodes and experimental conditions for other material systems.

3:30pm **B1-4-7 Improved Adhesion Strength of the Gradient Zn-Mg Coating on TRIP Steel**, ***MyeonKyu Song***, *J La, H Kim, S Lee,* Korea Aerospace University, Republic of Korea

The high-strength steels (HSS) such as dual phase (DP) steel, transformation-induced plasticity (TRIP) steel, and twinning-induced plasticity (TWIP) steel have been used extensively in automotive industries to reduce the weight and to improve the safety of automobiles. To ensure the corrosion resistance of HSS, advanced coating material and process to replace conventional galvanizing coating and process are necessary. Zn-Mg coating is a strong candidate for the corrosion protective coating of HSS, and physical vapor deposition (PVD) process is a promising process for deposition of Zn-Mg coating on HSS. As reported in previous works, however, the Zn-Mg coating showed the insufficient adhesion strength compared to Zn coating due to the high brittleness of the Zn-Mg coating.

In this study, to improve the adhesion strength of the Zn-Mg coating, the Zn-Mg/Zn coatings were synthesized on TRIP steel substrate using evaporation deposition process, and the annealing heat treatment at 200°C in vacuum led to the gradient Mg content along the cross-section of Zn-Mg coatings. Microstructure, chemical composition depth profile, and adhesion strength of gradient Zn-Mg coatings were investigated by field emission scanning electron microscopy (FE-SEM), glow discharge optical emission spectroscopy (GDOES), and punch test, respectively. The gradient Zn-Mg coating was synthesized successfully by heat treatment of Zn-Mg/Zn coating. The gradient Zn-Mg coatings showed an improved adhesion of the coatings during adhesion test, and this indicated that the adhesion strength of Zn-Mg coating could be improved by the gradient Mg content. Detailed expereimental results will be presented.

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Author Index

Bold page numbers indicate presenter