Hard Coatings and Vapor Deposition Technologies
Room California - Session B5-2-FrM

Hard and Multifunctional Nanostructured Coatings II
Moderators: Tomas Kozak, University of West Bohemia, **Helmut Riedl**, TU Wien, Institute of Materials Science and Technology

9:00am **B5-2-FrM-4 Microstructural and Mechanical Stability of TaCu Composite Coatings***, A Bahrami, C Onofre, A Delgado,* Universidad Nacional Autonoma de México, México*; T Huminiuc, T Polcar,* University of Southampton, UK*; **Sandra Rodil**,* Universidad Nacional Autonoma de México, México

In this study, binary Cu-Ta alloys with Ta content between 0 and 100 % were prepared by co-magnetron sputtering. The effect of elevated temperature vacuum annealing on the morphological stability and mechanical properties of Cu–Ta films was studied. Their structural and mechanical properties were characterized by X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and nanoindentation methods. The XRD results show that a Ta-rich CuTa amorphous phase is formed in the coatings with 15-67 at. % Ta along with nanocrystalline Cu. TEM analyses of two selected samples with 25 and 67 at. % Ta depict formation of crystalline Cu islands in an amorphous CuTa matrix in both as-deposited and annealed coatings. XPS profiles show that the coatings are mainly metallic, with a thin oxide layer. Moreover, analysis of the oxide layer, indicated that Cu nanocrystals are protected against oxidation by the Ta-rich CuTa amorphous layer. A significant increase in hardness values from 0.9 for pure annealed Cu to 11.89 GPa for the samples with 98 at. % Ta, is observed. Also, it was observed that the coatings preserve their microstructural and mechanical stability after vacuum annealing at 550 °C.

9:40am **B5-2-FrM-6 Tantalum Alloying - Improvement of Thermal Stability and Mechanical Properties of Ternary and Quaternary Transition Metal Nitrides***, **Branislav Grancic**,* Comenius University in Bratislava, Slovakia*; D Sangiovanni,* Linköping University, Sweden, Ruhr-Universität Bochum, Germany*; T Roch, M Truchlý, M Mikula,* Comenius University in Bratislava, Slovakia **INVITED**

Combining the high hot-hardness to enhanced toughness and good oxidation resistance is one of the greatest challenges in material-design of transition metal nitride (TMN) ceramics, which are widely employed as protective coatings in machining industry.

In Ti-Al-N and Cr-Al-N, well-known Al-containing TMNs, the thermally-induced decomposition of the cubic solid solution via spinodal mechanism or precipitation leads to the formation of fine-grained nanostructures and the associated age hardening. However, continuous thermal load/unload cycling during industrial machining cause transformation into thermodynamically more stable coarse-grained structures containing hexagonal AlN and cubic TiN or hexagonal CrN_x phases resulting in degradation of mechanical properties. In addition, brittleness limits the use of TMN-AlN alloys in applications demanding a high fracture-resistance.

The concept of multicomponent alloying with elements from groups IIIB – VIB (Y, Zr, Hf V, Nb, Ta, Mo, and W) represents a suitable way to improve the properties of Al-containing TMNs. From this group, pentavalent tantalum is a very attractive substitutional element which is used, for example, in Ti-Al superalloys to improve ductility, and to reduce oxidation at high temperatures. Moreover, the Ta-N phase diagram exhibits a large variety of Ta_yN_x structures, characterized by different electronic properties.

Here, the role of tantalum as a substitution atom improving thermal stability and mechanical properties is presented in several ternary and quaternary systems. In the first case, we combine experiments and *ab initio* calculations to investigate thermally induced age hardening in tough Ta-Al-N coatings via spinodal decomposition. The increase in hardness from 29 GPa to 35 GPa was observed during early stages of phases separations when temperature exceeded 1000°C. In the next case, a significant improvement in toughness of nitride coatings was observed in highly TaN-alloyed Ti-Al-N. While the hardness of $Ti_{0.46}Al_{0.54}N$ (32.5 GPa) is not significantly affected by alloying with TaN, the elastic stiffness monotonically decreases from 442 to 354 GPa with increasing Ta contents indicating enhanced toughness in TiAlTaN. In the last presented Cr-Al-Ta-Y-N system, the presence of Ta in the solid solution shifts the decomposition process to higher temperatures (>1000°C) compared to Cr-Al-Y-N (~900°C), thus enhancing the alloy thermal stability. The improved thermal stability may be attributed to increased cohesive energie, as revealed from *ab initio* calculations.

This work was supported by the Slovak Research and Development Agency [Grant No. APVV-17-0320]

10:20am **B5-2-FrM-8 Interface Characteristics Between PVD- AlTiN and Electroplated Hard Chrome by Duplex Process***, D Wang,* MingDao University, Taiwan*; **Li-Chi Hsu**, J Hung,* Aurora Scientiftic Corp., Canada*; C Chen, H Liu,* Surftech Corp., Taiwan*; W Ho,* MingDao University, Taiwan

Most of the hard coatings have good corrosion resistance on certain applications. The traditional way for corrosion resistance accepted by industries are electroplated hard chrome. However, in some severe environment, hard chrome can not pass corrosion tests, as a result, PVD hard coatings are applied on hard chrome to even further enhance corrosion resistance in some special applications. In this research, we are investigating the unique application of cathodic arc technology in depositing AlTiN hard coating film onto electroplated hard chrome PH17-4 stainless steel 1-inch OD shafts. The requirement for the AlTiN multi-layer coating is to take into consideration of residual stress between the hard chrome layer and AlTiN coating to ensure great adhesion between two materials. Also, the residual chemicals from hard chroming process will be analyzed and the removal of chromium oxide will be addressed in both pre-coating cleaning and in-chamber cleaning processes. This research will reveals the effect of coating process on the sensitive to temperature of the duplex coatings which related to the residual stress. Meanwhile, it is critical to monitor whether any released on the hard chrome surface, causing contamination of chrome surface in the coating process. Results of this research will enhance corrosion resistance by applying both hard chrome and hard coating by PVD cathodic arc process.

10:40am **B5-2-FrM-9 Manipulation of Bimodal Matrix in Plasma Sprayed Nanostructured YSZ Coating and Its Effect on the Microstructure***, **Pavan Bijalwan**,* Tata Steel Limited, India*; A Islam, K Pandey,* Indian Institute of Technology, India*; A Pathak, M Dutta,* Tata Steel Limited, India*; A Keshri,* Indian Institute of Technology, India

Nanostructured YSZ (n-YSZ) based ceramic TBCs have attracted widespread attention because of the exceptionally higher toughness, bond strength and thermal cycling life compared to the conventional YSZ. However, the primary concern is to control the melting of nanostructured powders in the plasma jet by adjusting the plasma spray parameters, resulting the formation of the bimodal structured coatings. Further, by controlling the size, shape, and morphology of the nanozones, it is possible to engineer coatings with enhanced properties. There is a complete scarcity in correlating the effect of the content of nanostructured zone on the performance of the coating. In this work, attempts have been made to control the melting states of nanoparticles by changing the plasma process parameters and to manipulate the different contents of nanozones in the coating. Temperature and velocity profile of the in-flight particle was captured at several plasma process parameters using Accuraspray in-flight particle diagnostic sensor. Free standing coating will be synthesized after analyzing the temperature and velocity profile of the in-flight particle. These free-standing coating will be evaluated in detail for the porosity and the bimodal matrix. At the optimized parameter, final coating will be fabricated and various abovementioned properties will be evaluated.

Author Index

Bold page numbers indicate presenter