Tribology Focus Topic
Room: Hall D - Session TR-ThP

Tribology Poster Session

TR-ThP2 Nanocomposite Hf-B-C Hard Coatings by Low Temperature CVD, ***Elham Mohimi***, *J.R. Abelson, T. Ozkan, K. Walsh, S. Babar, P.J. Sempsrott, G.S. Girolami*, University of Illinois at Urbana Champaign, *A.A. Polycarpou*, Texas A&M University

Nanocomposite coating materials can afford an excellent combination of chemical, physical and mechanical properties, including high or super-hardness along with toughness. There is an extensive literature concerning the growth and properties of transition metal nitride, carbide and boride materials, as well as ternary (pseudo-binary) combinations. Our group previously reported the conformal growth and favorable mechanical properties of HfB2 and Hf-B-N hard coatings by chemical vapor deposition (CVD) using the high vapor pressure precursor hafnium borohydride, Hf(BH4)4, at substrate temperatures below 300°C. Our objective is to extend the use of the HfB2 system for tribological applications, for which a low coefficient of sliding friction is desirable. A useful analogue is C-alloyed TiB2, which exhibits super-hardness and good thermal stability. However, there have been no previous reports of the growth and properties of Hf-B-C alloys.

We report the CVD of Hf-B-C nanocomposite coatings on Si and on steel discs using hafnium borohydride precursor with a co-flow of dimethylbutene (DMB), (CH3)3CCH=CH2, as the carbon source. Depositions are performed in a high vacuum chamber with 0.1-0.5 mTorr of hafnium borohydride and 0.1-0.4 mTorr of DMB at a substrate temperature of 250-700 C. The resulting carbon contents are 10-33 at. %. DMB acts as growth inhibitor which reduces the film growth rate by a factor of 2-6 compared to growth using the precursor alone; for high temperature depositions, DMB also enhances the film density and decreases the surface roughness. XPS analysis indicates that Hf-B-C films consist of a mixture of HfB2, HfC and B4C phases. As-deposited films are XRD amorphous with hardness values of 8-10 GPa and reduced modulus of 92-120 GPa. Upon annealing at 700°C for 3 hrs, the films transform partially to a nanocrystalline structure, which increases the hardness and modulus. Multilayer films of (HfB2 / Hf-B-C)n afford a means to engineer the hardness and modulus to desirable values. The tribological properties of Hf-B-C films are superior to those of HfB2 films. This system affords conformal coating at low growth temperature, suitable for complex structures such as MEMS.

TR-ThP3 Stress Analysis of TiSiN and TiAlN Coatings using Scratch Testing and Raman Spectroscopy, ***Johans Restrepo***, Instituto de Investigaciones en Materiales - UNAM, Mexico, *E. Camps*, Instituto Nacional de Investigaciones Nucleares, Mexico, *S. Muhl*, Universidad Nacional Autónoma de México

The TiSiN and TiAlN coatings were deposited using Pulsed Laser Deposition. The films were characterized by SEM-EDS (chemical composition and surface morphology), X-ray diffraction (crystalline structure and grain size) and Nanoindentation (hardness and Young's modulus). The tribological properties of the coatings were evaluated using scratch testing, using two counter materials (1/16" balls of 100CR6 and Al2O3). To study the plastic deformation caused by the application of the load during the scratch measurements we used 3d profilometry. Finally, micro-Raman spectroscopy was employed to study any deformation-induced on the lattice and the chemical reactions produced, under the different loads, by the contact with the counterpart materials. The results show the TiSiN against alumina had the lower friction coefficient due to not showed reactive process on the surface for all load used just the movement of the Raman peak at lower wave numbers.

TR-ThP4 The Corrosion-Wear Mechanisms of CoCrMo Alloys Coated with TiAlN/TiAl Multilayer, ***Martin Flores***, *O. Jimenez, E. Rodriguez*, Universidad de Guadalajara, Mexico, *E. Andtade*, Universidad Nacional Autonoma de Mexico

The tribocorrosion phenomenon is present in biomedical alloys that are used in artificial implants to replace natural joints. This damage limits the service life of such implants, the hard coatings can improve the resistance to wear and corrosion. The multilayers of TiAlN/TiAl were deposited on CoCrMo alloys by magnetron sputtering. In this work we study the wear mechanism of the coated alloy and without multilayer in a simulated body fluid with an ion concentration similar to that in the human blood. The structure of coatings was studied by means of XRD and the composition by RBS and EDS techniques. The tribocorrosion behavior of CoCrMo alloys alone and coated with TiAlN/TiAl multilayers was studied in simulated body fluid and distilled water. The tribocorrosion was performed using a tribometer with an geometry of ball on plate and reciprocating movement. The tests were conducted at 36 ± 1 °C of temperature. The loads used were 1N, 1.5, and 2N, the oscillating frequencies was 1Hz. The corrosion and tribocorrosion were studied using open circuit potential (OCP) in wear-corrosion tests and potentiodynamic polarizations in corrosion tests. In order to study the wear mechanisms, the topography and composition of worn surfaces were analyzed by means of SEM, EDS and profilometry. In the case of CoCrMo alloy it was found a transition from smooth wear to abrasive wear when the load was increased.

TR-ThP5 Improving the Surface Hardness of Plasma Nitrided 316L Stainless Steel, ***Petros Abraha***, *S. Mikashima*, Meijo University, Japan

Stainless steels have very good corrosion resistance but the lower surface hardness poses marked limitation on the range of tribological applications that can be envisaged. Here plasma nitriding treatment was performed to modify the hardness without altering the corrosion resistance of austenitic 316L stainless steels.

In nitriding the 316L stainless steel, the passive CrO_2 layer that protects the surface from corrosion is removed first as it hinders the diffusion of nitrogen ions and atoms into the bulk of the stainless steel material. The removal of the passive layer was done by argon sputtering and the subsequent plasma nitriding was performed in electron beam excited plasma apparatus under nitrogen atmosphere for three hours. The apparatus was driven at an acceleration voltage of 100 volts and a beam current of 3 amperes. The sample temperature was held constant at 450 degree centigrade. Treated and untreated samples were characterized by means of morphological analysis, Vickers hardness measurements, and corrosion tests in NaCl solutions.

The results of our experiments show that nitriding treatments performed in primarily ion and neutral environs have increased hardness, slightly lower chrome concentration, and hence slightly higher quantity of rust. The measured hardness, chrome concentration, and quantity of rust for the non-treated samples were 230 Hv, 17 mass%, and 4 g/m^2, respectively. Ion nitriding in contrast largely increased the surface hardness of the stainless steel samples (more than 6 times), but decreased the corrosion resistance properties due to the CrN precipitation (15.8 mass %). Nevertheless nitriding treatments performed under neutral nitriding increased the surface hardness of the stainless steel samples (more than 3 times), avoid a large CrN precipitation (16.8 mass %) and rust quantity of 7.8 g/m^2 that is much lower than the 350 g/m^2 for ion nitriding. The above results indicate that stainless steels can be used as sliding or meshing mechanical parts in environments such as vacuum chambers and underwater machinery.

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