INTERNATIONAL CONFERENCE ON METALLURGICAL COATINGS AND THIN FILMS

PROGRAM AND ABSTRACTS

Town and Country Hotel
San Diego, California
May 1–5, 2006

Sponsored by:
Advanced Surface Engineering Division
of AVS

Tribology and Mechanical Behavior of Coatings and Thin Films
Room: Town & Country - Session EP

EP Poster

EP-1 Study on the Theory of Spectroscopic Graze Ellipsometry in Electrochemistry, *S.T. Zhang (stzhang@cqu.edu.cn), W.P. Li*, Chongqing University, PR China

The mathematical model of the graze ellipsometry has been put forward by combining the model of diffusion layer in electrochemical reaction with graze ellipsometrical experiment. The physical meaning of ellipsometrical parameters δ and ψ has been explained. The influence of the concentration of electroactive substance and the width of the incidence light on δ and ψ is discussed with reference to the experiment results. The results showed that (1) The reason why Graze Ellipsometry can sensitively detect the change of the property of the solution in diffusion layer near the electrode surface is that the change of the concentration of the particles in diffusion layer results in the change of the polarization status of incident light and the change of Ellipsometry parameter δ, ψ reflect that change. (2) Diffusion layer is similar to a phase retarder and an amplitude absorber. Ellipsometry parameter δ demonstrates its function as the phase retarder, and ψ shows its function as the amplitude absorber. (3) δ and ψ are related to the concentration of the electroactive substances and the width of incident light. δ is in linearity with bulk concentration C_0 and quadraticly linear with width l, while ψ is in exponential relation with C_0 and quadraticly linear with l.

EP-2 Surface Modification of $W9Cr_4V_2Mo$ High Temperature Bearing Steel by Rare Earth Ion Implantation, *F. Jin, P.K. Chu (paul.chu@cityu.edu.hk)*, City University of Hong Kong, PR China, *Z. Xu, H. Tong*, Southwestern Institute of Physics, PR China

Wear and corrosion are the main failure mechanisms of bearing steels and thus their properties must be improved to prolong their lifetime. Incorporation of rare earth elements have been investigated in processes such as plating, chemical heat treatment, and thermal spray. Ion implantation is an effective technique in the industry but there have been few reports about the use of rare earth ion implantation to improve the wear and corrosion resistance of bearing steels. In this work, rare earth ions including praseodymium, lanthanum and neodymium were implanted into $W9Cr_4V_2Mo$ high temperature bearing steel specimens using a metal vapor vacuum arc source. Pin-on-disk test, microhardness determination, and potentiodynamic polarization were employed to evaluate the mechanical properties and chemical stability of the treated specimens. The chemical composition and surface morphology of the implanted layers were characterized by X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), and scanning electron microscopy (SEM). The results show that the tribological properties and aqueous corrosion resistance of the treated samples were enhanced significantly. The improvement can be attributed to the oxide barriers and increasing cohesive strength of the oxide films. The mechanisms of the wear and corrosion behavior of the implanted specimens are also discussed.

EP-5 Dry Machinability of Ceramic-Coated, Cemented Carbide Tools with/without Self-Lubrication via Chlorine Implantation, *T.S. Sumitomo*, University of Tokyo, Japan, *S.Y. Yamamoto*, National Institute for Materials Science, Japan, ***T.A. Aizawa*** *(aizawa@asiaseed.org)*, University of Toronto, Canada

In order to attain low friction and wearing conditions in dry, self-lubrication mechanism must be accommodated to hard protective coating for cutting tools, forming tools and dies. Through our research and development, self-lubrication via chlorine implantation significantly improves the dry-formability and dry-machinability since lubricious titanium oxide films are in-situ formed on the surface of protective coating films. In the solid-lubricated abrasive dry wearing by this self-lubrication, duration of low friction and wear conditions in dry machining might be dependent on the amount of lubricious titanium oxides. In the present study, the effect of titanium resource amount in protective coating and work materials on dry machinability is investigated to describe the self-lubrication process. A turning test was employed to make on-line measurement on the variation of friction coefficient with cutting distance (L) and to evaluate the flank wear for various cutting speeds (v) up to 500 m/min. Two kinds of works materials were used: Al-deoxidized and Ti-deoxidized S45C steels. As a bare tool, WC (Co) with a content of TiC was used; TiCN-coating was also utilized as a titanium resource in coating films. These pairs of coated tools and work-materials with Cl-implantation directly evaluate the effect of titanium in coating and work materials on the dry machinability. Significant reduction of flank wear width (W_f) can be detected with increasing the amount of titanium in the dry cutting condition: e.g. when L = 500 m and v = 400 m/min, W_f = 90 μm for TiCN-WC tools against Al-deoxidized S45C, W_f = 65 μm for Cl-implanted, TiCN-WC tools against Al-deoxidized S45C, and, W_f = 55 μm for Cl-implanted TiCN-WC tools against Ti-deoxidized S45C.

EP-6 Effect of Ni Interlayer on the Adhesion Characterization of Mo-Ru Thin Film, ***C.-Y. Kang***, *C.-H. Lin*, National Tsing Hua University, Taiwan, *Y.-I. Chen*, National United University, Taiwan, *F.-B. Wu*, National Tsing Hua University, Taiwan, *J.G. Duh (jgd@mx.nthu.edu.tw)*, National Tsing Hua Univerisity, Taiwan

Noble metal coatings usually increase lifetime and modify properties of glass molding die. In this study, Mo-Ru coatings with and without Ni interlayer were deposited on tungsten carbide by DC sputtering processes at an elevated temperature of 550 in order to improve the qualities of molding die material. Phase identification was investigated by X-ray diffractometry (XRD).The surface morphology and surface composition were evaluated by atomic force microscopy (AFM) and field emission electron probe microanalyzer (FE-EPMA), respectively. Mechanical characteristic, such as surface hardness of the Mo-Ru films, was measured by nanoindentation testing. In the aspects of adhesion mechanism, failure modes with and without interlayer appeared comparable. Nevertheless, the different thickness of interlayer resulted in various kinds of fracture configurations during scratch. Besides, conventional scratch test exhibited chipping failure between substrate and layer at load as low as 3N.However, nanoscratch technique showed only ductile scratch because the channel depth was so shallow such that the scratch was merely affected by top layer's intrinsic behavior.

EP-7 Wear Behavior of Several PVD Coatings Against Stainless Steel, ***A.E. Reiter*** *(andreas.reiter@balzers.com)*, Balzers Ltd., Liechtenstein, *M. Rebelo de Figueiredo, C. Mitterer*, University of Leoben, Austria

During the last ten years, the usage of stainless steel materials increased continuously in various industrial applications. However, the machineability of these materials is difficult, especially austenitic stainless steels. Tools like blind hole taps, punches or deep drawing molds are often exposed to severe wear by machining these materials, mainly due to their tendency of cold-welding. Additional to the intensive abrasive wear, the material build-up causes adhesive wear which results in a distinctive reduced tool life. In this study, ball-on-disc experiments were carried out in ambient air at room temperature, 150°C and 250°C. The high-speed steel (HSS) discs were coated with TiN, CrN, TiAlN, AlCrN with three different compositions, CrC, TiCN, WC/C and DLC. The coatings were worn against an austenitic stainless steel ball (DIN 1.4301). Characterization of the wear track was done by SEM, Raman spectroscopy and an optical 3d profiling system. Emphasis of the analysis was to achieve a comparison regarding the abrasive wear behavior and the tendency to material build-up. Especially AlCrN based coatings, TiCN and DLC are demonstrating sufficient abrasive wear resistance whereas the results obtained on DLC suffer due to increased sticking of counter part material. This build-up was found to be lowest for CrN and also minor for AlCrN based coatings. However, the abrasive wear for CrN and CrC was severe for all tested coatings. Increasing test temperature entails increasing abrasive and adhesive wear.

EP-8 Measurement of Friction and Wear of PVD Coated Pistons, ***K. Bobzin***, *E. Lugscheider*, RWTH Aachen University, Germany, *H. Murrenhoff*, Institute of Fluid Power Drives and Controls (IFAS), Germany, *N. Bagcivan*, RWTH Aachen University, Germany, *S. Scharf*, Institute of Fluid Power Drives and Controls (IFAS), Germany, *N. Goebbels (goebbels@iot.rwth-aachen.de)*, Surface Engineering Institute, Germany

Hydrostatic displacement units have a sophisticated design that enables a high level performance in combination with specially developed mineral oil based fluids. In order to use biologically degradable fluids based on native esters, fluids based on mineral oil have to be replaced. That means that functions, which had been realised with mineral oil based fluids by adding chemical substances, have to be substituted. The reason is that these chemical substances are mainly environmentally toxic and thus have to be avoided. Within the Collaborative Research Center 442 at Aachen University the aim is to replace these functions by providing components of tribological contacts with PVD coatings, that hydrostatic displacement units, bearings and gears can perform with biologically fast degradable fluids based on native ester. The pistons are coated with a carbon based PVD coating. Graded zirconium carbide (ZrCg) has shown a big potential for reduction of wear and friction. Due to its graded hardness and carbon distribution along coating thickness ZrCg enables self adjustment tribological systems. This paper deals mainly with the research of wear and friction of coated pistons in axial piston units on the one hand and with the investigation of the mutual influence of biologically degradable fluids and coatings on the other hand. For this purpose contact angle measurements with different fluids and materials are performed in order to conclude on wetting behaviour and surface energy of coatings and fluids. Furthermore