Tribology and Mechanical Behavior of Coatings and Engineered Surfaces
Room San Diego - Session E1-4-WeA

Friction, Wear, Lubrication Effects, and Modeling I

Moderators: Nazlim Bagcivan, Schaeffler Technologies GmbH & Co. KG, Germany, **Carsten Gachot**, Vienna University of Technology

2:20pm **E1-4-WeA-2 Surface Characteristics of the Chameleon/PEO Coating after Fretting Wear Tests*, Mengyu Lin,* *A Nemcova,* University of Manchester, UK*; A Voevodin,* University of North Texas, USA*; T Liskiewicz,* University of Leeds, UK*; A Matthews, A Yerokhin,* University of Manchester, UK

A duplex MoS_2/Sb_2O_3/graphite chameleon and PEO coating deposited on 6082 series Al alloy substrate have been established using burnishing process and plasma electrolytic oxidation (PEO) technique, respectively. A series of fretting wear tests were then applied on the surface of the chameleon/PEO coating sample under various amplitudes and environment (ambient humid air or nitrogen atmosphere) with two different counterpart materials. The X-ray diffraction (XRD), nano indentation, scanning electron microscopy (SEM), energy dispersive spectrometer (EDS), laser confocal microscope and Raman spectroscopy were employed to examine the phase composition, nanohardness, surface microstructure, element distribution and 3D surface topographies of the wear scars. It was found that the wear scars on the chameleon coating were mainly composed of MoS_2, Sb_2O_3 and Al_2O_3 phases while the underneath PEO coating was consisted of crystalline α/γ-Al_2O_3 mixtures. This study demonstrated the efficient wear properties enhancement of the chameleon/PEO coating against alumina counterpart by reducing friction coefficient from 0.88-0.92 to 0.07-0.09 in N_2 and 0.58-0.62 to 0.10-0.12 in air . The specific stick sliding (~3 µm amplitude), partial slip (5-10 µm amplitude) and gross slip (>10 µm amplitude) regimes were observed at the fretting wear with the amplitudes increase from 3 µm to 100 µm. The steel counterpart and oxidized atmosphere were proved could seriously affect the performance of the duplex coating, resulted in the mass generation of the metal oxides/hydroxides in the contact region, long penetration micro-cracks in the PEO coating and gradually severely oxidation in the aluminium substrate.

2:40pm **E1-4-WeA-3 Characterization of W Alloyed DLC Coatings Deposited by a Hybrid DC / HIPIMS Magnetron Sputtering Process*, Manuel Evaristo,*** *A Cavaleiro,* SEG-CEMMPRE - University of Coimbra, Portugal

Tribology is a key feature to sustainable and environmental friendly engineering as it is directly related to energy consumption, wear and component failures across all industries. Energy losses worldwide due to friction and wear have a significant impact on the economy, reduction of friction and wear can reduce economic losses by energy saving and increase time between maintenance stops. One of the most efficient way to reach those objectives is modifying the surfaces in contact by means of thin films in dry and lubricated conditions. DLC coatings provide low friction and good wear resistance in dry sliding; however in lubricated conditions the efficiency is not so good due to inertness of the surface. Therefore, to maintain a good performance in both situations, improving the reactivity of the surface, by doping the coating with a metal, is necessary.

W-DLC coatings were deposited in a four magnetron semi-industrial PVD TEER Coatings deposition chamber with HIPIMS and DC power supplies connected to the W target and C/Cr (used for the deposition of the interlayer) targets, respectively. The depositions were set to have a W content close to 10 at. % for all coatings. The coatings were deposited with two peak power levels, high 140 kW and low 55 kW. For both powers the substrate bias voltage was varied from 0 to -110V. The mechanical properties are influenced by both peak power and bias voltage with the lowest value of 9.7 GPa achieved for the lower peak power and 0 substrate bias and the highest of 14.1 GPa for the higher peak power and 110 V of substrate bias. A coating deposited in a reactive atmosphere (Ar +CH_4) with the latter conditions, with same W content, also showed a similar hardness value 14.9 GPa. The adhesion of the coatings was similar for all coatings tested. The XRD analysis showed typical diffraction patterns of an amorphous structure without visible differences among the coatings. However, both bias and peak power influenced the coatings morphology, with a more compactness columnar aspect with their increase. In the case of the coatings deposited in a reactive atmosphere, a dense and featureless morphology was produced.

Two coatings were selected for the tribological characterization, the ones deposited high peak power and -110V substrate bias, with and without CH4 as reactive gas. The coatings were tested in different conditions with wear rates and coefficient of friction values lower than 0.15×10^{-6} mm^3/Nm and 0.25 respectively.

3:40pm **E1-4-WeA-6 Analysis of Tribomechanical Behavior of Low-Temperature Plasma Blued Tool Steels*, Fernando Santiago,*** ITESM Estado de México, Mexico*; R Meza,* Termoinnova, S.A. de C.V., Mexico*; J Oseguera-Peña,* Tecnológico de Monterrey, México

The tribomechanical behavior of tool steels AISI 4140T and AISI 8620 steel treated by the novel low-temperature plasma blued (LTPB) process. An amorphous solid carbon film (Diamond-like Carbon, DLC) layer is obtained using an atmosphere of methane (CH_4) and molecular hydrogen (H_2) at low-temperature and a short period of time. The microstructure of treated samples was characterized using XPS spectroscopy, Raman spectroscopy, and X-ray diffraction, and the compound layer thickness was measured by optical microscopy. Raman spectroscopy finds D and G bands, and XPS spectroscopy shows a mixture of sp2 and sp3 hybridized bonds of a typical DLC coating. Vickers microhardness profiles were correlated with a reduction of friction coefficient in the treated samples. Wear test was performed on a pin-on-disc tribometer in dry-sliding conditions using a counter-face of WC-Co ball. Wear tracks on the ball and surface of the treated sample were analyzed by optical micrograph and SEM.

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