Tribology and Mechanical Behavior of Coatings and Engineered Surfaces
Room Grand Hall - Session EP
Symposium E Poster Session

EP-2 Effect of Power on Soft Magnetic and Tribological Properties of Fe-Co based Coating by Laser Cladding, ***Xiaoshan Yang***, *X Cui, G Jin, J Liu,* Harbin Engineering University, China

Fe-Co based coatings which have a broad application in improving the surface properties have excellent wear resistance and soft magnetic properties. In this study, (FeCoNi) Si B Cu Mo coatings with high saturation magnetization and good tribological properties were prepared using lasers cladding.The different process parameters effect on the microstructure, mechanical properties of the cladding layer wereinvestigated. It was found that laser power P, scanning speed V and laser remelting technology which had a significant effect on the magnetic properties and tribological properties. The optimum process parameters were determined and the coatings showed bcc dominated microstructures. The average microhardness and friction coefficient of the coatingsreached 1032 $HV_{0.5}$ and 0.291 respectively. With the decrease of grain size, wear resistance and microhardness of coatings improved significantly. In addition, the coatings exhibited higher saturation magnetization (212emu/g), comparable magnetic properties to those of their conventionally processed counterparts.

Acknowledgements

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EP-3 Tribological Behavior of the FeB Phase in Boron Coating Formed on an AISI L6 Steel using Ball On Disc with Dry Conditions, ***Daniel Sanchez Huerta***, CBI, Universidad Autónoma Metropolitana unidad Azcapotzalco, Mexico*; I Hilerio Cruz,* Universidad Autonoma Metropolitana unidad Azcapotzalco, Mexico*; N Lopez Perrusquia,* Universidad Politecnica Del Valle De Mexico, Mexico*; E García Bustos,* Catedras CONACYT, Mexico, México*; M Doñu Ruiz,* Universidad Politecnica del Valle de Mexico, Mexico*; M Flores Martinez,* Universidad de Guadalajara, CUCEI, Mexico

The coefficient of friction (CoF) and wear behavior in a boron coating was studied at different temperatures of 1173, 1223 and 1273 K, with residence times of 0.5, 2 and 3 h for each temperature. The boron coating was obtained by powdered box technique on AISI L6 steel (DIN 1.2714). The roughness of each treatment was studied by roughness profile (2D) measurements, obtained an increase in R_a between 0.352 (1173 K with 0.5 h) to 0.965 µm (1273 K with 3 h) for the FeB phase. The reciprocating tribometer tests were studied at normal loads of 7 and 10 N with humidity and temperature controlled in dry conditions. For the FeB phase, we obtained CoF values from 0.49 to 0.64 at 36 m of displacement. The topography of the wear traces, were analyzed by optical profilometer (3D). The wear in the FeB phase obtained in the sliding tests, suggested a resistance wear of the treatment at high thicknesses; in the Fe_2B phase the wear was not obtained, because the thickness wear is around from 0.44 to 0.98 µm. The wear behavior are two bodies with an adhesive behavior in the FeB phase.

EP-4 Tribocorrosion Behavior of Boronized AISI 4140 Steel, ***Steffen Aichholz***, *R Torres, M Meruvia, P Soares,* PUCPR, Brazil

In this study, AISI 4140 steel was boronized using solid state thermochemical boriding technique, producing a monophasic iron boride (Fe_2B) layer with a mean thickness of 49,5 µm. The microstructural and chemical characteristics were evaluated by Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS) and X-ray Diffraction (XRD). To investigate the tribocorrosion behavior samples were immersed in 3,5% NaCl solution subjected to a pin-on-disk wear test and connected to a potentiostat monitoring the open circuit potential (OCP).

The results obtained show that boronized samples have an improved tribological behavior compared to unboronized samples and the evaluation of the OCP curve indicates the formation of a passivation layer during de wear test. These results can be explained by the high hardness and chemical inertness of iron boride layer.

EP-5 Influence of Sputter Power Ratio on Microstructure, Mechanical and Tribological Properties of Ti-B-C Coatings Deposited onto AISI M2 Steel, ***Elbert Contreras***, *M Gómez,* Universidad de Antioquia, Colombia

Despite being a ceramic material widely known for its high hardness, chemical resistance and high thermal stability; TiB_2 coatings using in industrial conditions has been really limited due to the high residual stresses associated with the reduction of adhesion. Recently, several investigations have shown that the incorporation of carbon within TiB_2 coatings reduces the residual stresses, increasing the adhesion and becoming Ti-B-C coatings in excellent candidates for applications at high temperatures. In this research, Ti-B-C coatings were deposited onto M2 steel substrates by DC UBMS. Prior to the coatings deposition a plasma cleaning process was carried out both substrates and targets with a 40 sccm flow of Ar and a pressure of 3 Pa for 0.5 h. For the deposition, two targets of TiB_2 (99.9%) and graphite (99.9%) opposite each other was used. The power density of TiB_2 was fixed to 2.4 W/cm^2 and four different power ratio W_{TiB2}/W_C was made in order to varied the carbon content in the Ti-B-C coatings. Microstructural analysis by X-ray diffraction (XRD) showed h-TiB_2 crystal structure with preferential orientation (001), increasing the carbon content, the intensity of (001) peak decrease becoming the crystalline coatings in amorphous coatings. Using AFM technique, an increase in roughness and grain size was observed with higher carbon content, except for coatings with ~20%. SEM images revealed columnar, dense and homogenous structure for all coatings. A progressive decreasing in hardness and Young modulus was observed with the increasing in carbon content, hardness up to 27 GPa was reached with lower carbon content and a decreasing under 5 GPa with the higher carbon content. The Young modulus exhibited the same featured. Tribological properties of the coatings were investigated using Pin-on-disk, all coatings showed COF higher tan AISI H13 substrate, only the coatings with 36% of carbon showed COF over 0.30. respecting to the wear rate it was keep almost constant for all Ti-B-C coatings.

EP-6 Structural and Mechanical Properties of W-doped HfO_2 Thin Films, *A Uribe, M Garcia, R Chintalapalle,* ***Cristian Orozco***, University of Texas at El Paso, USA

Hafnium oxide (HfO_2) is a high temperature ceramic with interesting mechanical properties. HfO2 is distinguished by its wide band gap (~5.7 eV), high dielectric constant (20-25), and high chemical stability. In an effort to tune and enhance the structural and mechanical properties, this work was focused on doping tungsten (W) into HfO_2 thin films. While the doping effects of other metals have been studied, there is a lack of knowledge on the effects of W doping into HfO_2. On the other hand, refractory metal incorporated dielectrics are expected to meet the functional requirements of high-temperature device applications. W-doped HfO_2 thin films were deposited on silicon and quartz substrates via radio frequency magnetron sputtering. The W content was varied by changing the sputtering power from 0-100 W. The films were characterized by performing x-ray diffraction (XRD), nanoindentation, scanning electron microscopy (SEM), and contact angle measurements. Nanoindentation studies revealed increases in hardness and elasticity with increasing W content. XRD displayed the predominant (-111) peak of monoclinic HfO_2 and revealed amorphization induced by increasing W concentration. SEM data also showed gradual amorphization in the samples with increasing W-content. Finally, contact angle measurements showed all the samples were hydrophilic. Based on the experimental data, a structural-mechanical-property relationship is established.

EP-7 Tribological Studies on Self-Lubricating (Cr,Al)N/MoS_x Coatings at Elevated Temperature, *K Bobzin, T Brögelmann,* ***Nathan Kruppe***, *D Hoffmann,* Surface Engineering Institute - RWTH Aachen University, Germany*; F Klocke, P Mattfeld, D Trauth, R Hild,* Laboratory for Machine Tools and Production - RWTH Aachen University, Germany

Due to the high material utilization and the associated resource and energy efficiency, production processes from the field of cold forging of steel are of great importance. At present, environmentally harmful lubricants have to be used to ensure process stability as well as low wear and friction. Due to environmental, economic and legislative aspects, there is an increased research potential to reduce or to completely substitute lubricants. To achieve the goal of lubricant free dry cold forging of steel, physical vapor deposition (PVD) coatings with self-lubricating properties are applied on forming tools. Promising for this application are PVD coatings on the basis of a (Cr,Al)N hard phase with embedded MoS_x which simultaneously meet the requirements of high wear resistance and friction reduction. Furthermore, a sufficient compound adhesion is needed to withstand high

contact stresses up to σ = 3,000 MPa during cold forging of steel. In addition to the mechanical stresses, a thermal load up to T = 250 °C occurs during cold forging. In the presented work, three self-lubricating coatings (Cr,Al)N/MoS_x deposited with varying bias voltage were investigated. The hybrid PVD technology, consisting of direct current and high power pulse magnetron sputtering dcMS/HPPMS, was used for the coating deposition in an industrial coating unit. Two different steels AISI D2 (X155CrMoV12, 1.2379) and AISI M2 (HS6–5–3C, 1.3343) were used as substrate materials. The influences of the substrate material and heat treatments at T = 250 °C on mechanical, compound adhesion and tribological properties were investigated. The samples were analyzed with respect to the universal hardness HU and modulus of indentation E_{IT} using nanoindentation. To determine the interfacial adhesion of the compound coating/substrate, Rockwell indentation and scratch tests were carried out dependent on the heat-treatment. For the analysis of the tribological behavior, AISI 5115 (16MnCr5, DIN 1.7131) and AISI 4140 (42CrMo4, DIN 1.7225) were used as counterpart materials, since these are widely used as forming material. As closed tribometer, a Pin-on-Disc (PoD) was used at varying temperatures. In this case, the coated substrate is continuously loaded with the worn pin on the same track. As open tribometer, a newly developed Pin-on-Cylinder (PoC) was used. The particular feature of the PoC is that the pins (AISI D2) are coated and pressed by means of a defined feed along a rotating cylinder (AISI 5115 and AISI 4140). Thus, the coated pin is permanently in contact with an unworn surface of the cylinder. The contact region was studied by Raman spectroscopy before and after the tribological tests.

EP-8 Role of Carbon Nanotubes in Reducing Friction between Steel/Steel Contacts, ***Zaixiu Yang**, S Bhowmick,* University of Windsor, Canada*; F Sen,* Argonne National Laboratory, USA*; A Alpas,* University of Windsor, Canada

Carbon materials such as graphene and carbon nanotubes (CNT) are increasingly used to reduce the friction. By performing sliding tests on steel against steel immersed in ethanol solutions with 0.005 mg/ml of CNT added, the coefficient of friction (COF) was reduced from 0.27 (in absolute ethanol) to 0.16. Once the CNTs were oxidized, the partially unzipped CNT showed reduced agglomeration in ethanol. Moreover, the partially unzipped CNT in ethanol led to the elimination of the running-in stage of friction and more stable COF curves. Examination of the worn surfaces indicated that the deposition of CNT to the steel surfaces, which was confirmed by the micro-Raman spectroscopy, was responsible for the reduced COF. Density Functional Theory simulation results were used to reveal the effect of the partially unzipped structure of CNT on the improved friction properties as will be discussed in the presentation.

EP-11 Microstructure Change, Element Diffusion and Tribological Properties of Chromium Oxide from RT to 1000 °C, ***Huidi Zhou**, N He, X Liu,* Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, China

The demands of reusable solid lubricants with continuous lubricating properties from room temperature (RT) to 1000 °C or even higher temperatures become increasingly urgent with the development of high-tech industries, especially that of aerospace industry. In our work, chromium oxide was investigated as a primary coating because it possesses high melting point and excellent thermal stability. The chromium oxide coatings were deposited on Ni-based high-temperature alloy substrates through an arc ion plating system and then annealed at 1000 °C in air for 2 h. The effects of annealing on the structure and tribological properties in wide temperature range of Cr_2O_3 coating were researched in detail. The phase change and elements diffusion behavior of Cr_2O_3 coating annealed at 1000 °C were also discussed. Main results and conclusions are as-followed:

Ti and Cr atoms in the Inconel 718 alloy matrix diffuse to the coating surface and react with oxygen in atmosphere, thereby generating the mesh-like heave structure that endues the annealed coating an excellent self-lubricating behavior in wide temperature range. The friction coefficients are all lower than 0.3, and the wear rates maintain at a magnitude of 10^{-7} mm^3/Nm from RT to 1000 °C. Particularly, the excellent self-lubricating performance could be maintained even in five-thermal-cycles test. Moreover, while the mesh-like heave structure damaged by friction, Ti and Cr atoms in the matrix tend to diffuse to the damaged locations and react with oxygen in air. This phenomenon results in the reproduction of composite-phase heave structure of Cr_2O_3 and $Cr_2Ti_4O_{17}$ at the damaged locations. Consequently, the self-supplement ability of the mesh-like heave structure could prolong the wear life in wide temperature range.

EP-12 Sliding Wear Behaviour of Infiltrated Self-lubricating Polymer Matrix Composites Studied by in-situ Tribometry, ***Yinyin Zhang**,* McGill University, Canada*; R Schulz,* Hydro-Québec Research Institute (IREQ), Canada*; R Chromik,* McGill University, Canada

The hydropower industry routinely makes use of thermally sprayed coatings and solid lubricating polymer coatings in their operations to enhance the lifetime of their infrastructure, especially those components subjected to sliding wear. Often these two coating systems are used independent of one another but in this study, we examine the feasibility of a duplex coating where a self-lubricating polymer composite was infiltrated into a porous SS316 substrate. This resulted in coatings consisting of a top layer made of a self-lubricating polymer composite and a bottom layer made of a polymer composite infiltrated into a porous metallic structure. This paper presents the tribological behaviour of the polymer composite and the transition when wearing reaches the infiltrated metallic porous substrate.

Addition of graphite (Gr) to a thermoset bismaleimide (BMI) significantly reduced coefficient of friction and wear rate. An in-situ tribometer that uses a transparent sapphire hemisphere as counterfaces permits microscopic observation and video recording of the sliding contact. Interfacial sliding dynamics such as material transfer, formation of transferfilms and wear debris were examined and therefore wear mechanisms of BMI + Gr and BMI + Gr + SS316 were observed. A stable transfer film that was rich in Gr was formed when sliding on the top layer of BMI + Gr, while participation of metallic material in the sliding contact contributed to deposition of transfer film onto wear tracks and transfer film reformation. Raman spectroscopy was used to detect formation of Gr-containing tribofilms and transferfilms in the running-in and steady-state regimes. X-ray photoelectron spectroscopy (XPS) testing on the wear tracks and transferfilms revealed possible tribochemical reactions such as polymer decomposition and interaction with Gr and/or SS316 induced by sliding wear. Mechanical properties of the as-received polymer composites and worn materials were also investigated using nanoindentation.

EP-13 Sputtered B-C-W-Coatings: Composition – Properties – Stability, ***Heidrun Klostermann**,* Fraunhofer FEP, Germany*; J Poetschke,* Fraunhofer IKTS, Germany*; O Zywitzki,* Fraunhofer FEP, Germany

Coatings in the material system B-C-W have been synthesized by pulsed magnetron co-sputtering of a boron carbide and a tungsten target. The bipolar co-sputtering process enables fine tuning of the composition through variation of sputtering pulse times. In the range of composition from pure boron carbide to 70 at-% tungsten content, the hardness of the coatings as determined by nanoindentation changes only little, typically in the range of 24 GPa to 28 GPa. However, in contrast to completely amorphous pure boron carbide, the x-ray diffraction pattern of B-C-W coatings exhibit broad peaks, indicative of extremely small crystalline domains that cannot clearly be attributed to a single phase for tungsten content below 50 at-%. Corresponding to a smooth transition in structure, scanning electron microscopy investigation reveals very homogeneous coatings with extremely smooth surfaces, even at a thickness of several microns. Consistently, EDX mapping reveals a very homogeneous element distribution. Thermal stability has been tested up to a temperature of 600°C in vacuum and in air. While no degradation is observed in vacuum, the oxidation rate in air depends on the tungsten content of the coatings.

In contrast to many other hard coatings, the stress level of the B-C-W layers is very low and the material seems to be rather resistant to crack propagation, as far as scratch test analysis can reveal. The coatings have been tested on cutting tools for cemented carbide cutting, where they abrade rather rapidly. However, the combination of properties still makes them interesting as hard and tough coatings.

EP-14 Comparison of Tribological and Electrochemical Properties of Titanium Oxided Films Produced on Cp-Ti by Sol-Gel and Silar Methods, *O Çomaklı,* Erzincan University, Turkey*; M Yazıcı,* Erzurum Technical University, Turkey*; **Halim Kovacı,*** Atatürk University, Turkey*; T Yetim,* Erzurum Technical University, Turkey*; A Yetim,* Erzurum Teknik University, Turkey*; A Çelik,* Atatürk University, Turkey

Cp-Ti is commonly used in different applications because of its good structural properties but its low mechanical and tribological properties restricts its usage areas. Therefore, different surface modifications based on TiO_2 formation on material surface are applied to enhance its surface properties. In this study, TiO_2 films were produced on Cp-Ti substrates by sol-gel and successive ionic layer adsorption and reaction (SILAR) methods in order to compare the performance of different coating methods. The structural, morphological and mechanical features of TiO_2 films were

investigated by XRD, SEM and microhardness tester. The tribological properties of films were characterized using a pin-on-disc tribotester. The electrochemical behavior of TiO_2 films were determined by potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) analyses. The structural and mechanical analyses showed sol-gel method caused the formation of more stable and hard film structures with good adhesion in comparison to SILAR method. For that reason, TiO_2 films produced by sol–gel method exhibited better wear and corrosion resistance than the films produced by SILAR.

EP-18 Mechanical and Tribological Properties of W–C–N Films Using Unbalanced Magnetron Sputtering Assisted by Linear Ion Source, ***Hyundong Kim,*** *S Heo, E An, I Park,* Korea Institute of Industrial Technology (KITECH), Republic of Korea

Ternary W–C–N films were deposited on 2618 aluminum alloy and 304 stainless steel substrates by a hybrid deposition process combining d.c. unbalanced magnetron sputtering and linear ion source system using pure tungsten targets in an $N_2/(N_2+Ar)$ gas mixture for diesel engine pistons applications. The influence of the carbon content and deposition conditions, i.e. substrate bias voltage and temperature, on the microstructure, mechanical properties and tribological properties of the W–C–N films was systematically investigated in this study. The microstructure for the films was characterized by X-ray diffractometer (XRD), scanning electron microscope (SEM), X-ray photoelectron spectroscope (XPS), and high-resolution transmission electron microscope (HRTEM). Nano-indentaion was conducted to assess the nanohardness and Young's modulus of the W–C–N films. Wear resistance and tribological behavior of these films also were evaluated using a micro-tribometer with wear debris analyses and coefficient of frictions. Moreover, morphological analysis with surface roughness was calculated by using atomic force microscope (AFM).

EP-19 The Influence of Feedstock Powders on Microstructure and Tribological Properties of WC-Co-Cr HVAF Coatings, *K Szymański, G Moskal, D Niemiec,* ***Aleksander Iwaniak,*** *J Wieczorek,* Silesian University of Technology, Poland

The basic goal of presented investigations is comparison of feedstock powders of WC-Co-Cr type in area of its chemical and phase compositions as well as morphological parameters, size distribution and shape. Those parameters have direct transfer on technological properties of powders such as followability etc., what is essential form high velocity spraying process point of view. In this part of article the X-ray and EDS analysis of powders were made, additionally scanning electron microscopy observation was carried out too. The size distribution was analysed by laser diffraction method. Obtained data gives the possibility to comparison of powders from different sources from technological properties point of view.

The second part of paper related with microstructural characterization of coatings deposited by high velocity air fuel (HVAF) method. The standard procedure for those kind of powders was used. The gun of Kermetico of K5 type was used. The range of investigations included characterization of coatings top surface with descriptions of roughness, as well as the stress state was analysed by X-ray method. Phase analysis was made after deposition and obtained data were compared to initial phase composition of powders as well as theirs chemical compositions. In area of mechanical properties basic parameters such as hardness and fracture toughness were measured and analysed. The final part of investigations is related with characterization of tribological properties of coatings with the same chemical and phases constituent buy deposited from different feedstock materials

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EP-20 Microstructure and Mechanical Properties of CuSn10 Alloy Coating Manufactured by Cold Spraying, ***Weihuang Liu,*** *J Cao, Z Yin, H Li, G Gao,* Shanghai Jiao Tong University, China

In order to achieve compact and low oxidation of Cu-10wt.% Sn (CuSn10) alloy coating, the cold spraying is used to deposit a coating on the bearing material substrate. The coating is analyzed by its morphology, hardness, metallographic, porosity and finite element analysis. Results show the mechanical performances of CuSn10 coating that are excellent. The microstructure of coating is compact and its hardness is appropriate for the requirement of embeddability and machinability. The sizes of grains of CuSn10 are uniform. There are no obviously grain boundary cracks. The porosity ratio is 0.07 %. Stress and deformation show that coating has excellent ability of reducing vibration and absorbing energy. With coating protection, results of fatigue life show that life is improved 173.32 %. The microstructure and mechanical properties of CuSn10 are outstanding that the cold spraying coating is very suitable for bearings.

EP-22 Scratch Induced Thin Film Buckling for Quantitative Adhesion Measurements, *A Kleinbichler,* KAI – Kompetenzzentrum Automobil- und Industrieelektronik GmbH, Austria*; J Zechner,* KAI - Kompetenzzentrum Automobil- und Industrieelektronik GmbH, Austria*;* ***Megan Cordill,*** Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, Austria

The adhesion of thin films is one of the most important factors for the reliability of microelectronic devices and the semiconductor industry requires quantitative testing methods to effectively compare these interfaces. Several techniques have been developed over the last decades such as four point bending, budge testing, micro cantilever tests, spontaneous buckling and scratch induced delamination. For compressively stressed films on rigid substrates the scratching can cause buckling failure ideal to be used to determine the adhesion quantitatively by modeling the delaminations according to the Huchinson and Suo model. Two different sample systems, a tungsten-titanium film on a silicate glass and a silicon nitride film on a silicate glass with a tungsten-titanium overlayer, have been tested using a ramp load method in the range of 100-500mN. This study demonstrates that the scratch induced delaminations resulted in parallel and spontaneous buckles. The parallel buckles developed directly beside the scratch trace and were the result of fracture events at the interface and deformation left by the passing indenter tip. The spontaneous buckles, on the other hand, originated from the parallel buckles and propagated according to the stress distribution in the film forming telephone cord delaminations. Using the geometric dimensions of the induced buckles the adhesion energies of the interfaces were quantitatively calculated. It was shown that the adhesion energy of the tungsten-titanium film increased with annealing time from 2.7 J/m² for the as-deposited to 4.7 J/m² for the 2 hour annealed film at 400°C. The adhesion of the silicon nitride film was determined to be 1.4 J/m² and was in good agreement with previous nanoindentation experiments. The results illustrated that the scratch test can be utilized for quantitative adhesion testing of thin films in cases where other methods are not applicable or sample preparation would change the nature of the interface and suggest that scratch induced delamination is a valuable addition to established adhesion measurement techniques.

EP-23 Study of the Mechanisms of Built-up Edge Formation during Machining of Super Duplex Stainless Steel, ***Yassmin Seid Ahmed,*** *G Fox-Rabinovich, B Bose, D Covelli, J Paiva, G Dosbaeva, S Veldhuis,* McMaster University, Canada

Tool wear is a very important factor determining tool life and surface quality of a machined workpiece surface. So, it is necessary to minimize tool wear to maximize tool life and to optimize the manufacturing performance. Different mechanisms can cause the tool wear in a specific machining process, adhesion onto the cutting tool frequently observed during machining of stainless steels, generate damage on the tool rake face. Adhesion of the workpiece material causing built-up edge (BUE) formation tends to promote tool chipping, since BUE is never completely stable, but it periodically breaks off leading to tool failure. The phenomenon of BUE formation can lead to poor machined surface texture and accelerated tool wear, subsequently leading to increased manufacturing costs. An experimental study was undertaken in order to study the formation and the cutting mechanism of the BUE. In this paper, the mechanisms that trigger the formation of BUE during the machining of super duplex stainless steel alloys—Grade UNS S32750 with PVD AlTiN/TiSiN coated carbide tool has been investigated. The process parameters were chosen so that the BUE formation was provoked. The BUE formation and tool wear was evaluated throughout the cutting tests using an Alicona Infinite Focus microscope and a scanning electron microscope (SEM) equipped with energy dispersive spectroscopy (EDS). Tribo-film formation on the worn rake surface of the tool was analyzed using X-ray Photoelectron Spectroscopy (XPS). Comprehensive characterization of the BUE mechanisms of PVD AlTiN/TiSiN coated vs. uncoated cutting tool wear was performed using SEM, electron backscatter diffraction (EBSD) and nanohardness tester. This paper investigates the deformation mechanisms and plastic behavior of austenite and ferrite phases in BUE cross section. Nonohardrness distribution and EBSD phase mapping of BUE cross section samples revealed a built-up of austenite bands are collected at the tool-chip interface and ferrite bands collected on the top. Moreover, SEM

images of BUE cross section samples show micro-cracks which act as BUE initiators were identified in this region of austenite.

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