Live Session

Room Live - Session LI-TuM2

Tribology and Mechanical Behavior of Coatings and Engineered Surfaces Live Session

Moderators: Dr. Michael Chandross, Sandia National Laboratories, USA, Dr. Giovanni Ramirez, Oxford Instruments , USA

11:00am **LI-TuM2-1 Welcome, Announcements, & Thank You to Sponsors**, ***Giovanni Ramirez (Giovanni.Ramirez@outlook.com)***, Oxford Instruments , USA

Welcome to the ICMCTF 2021 Virtual Conference! We hope you will enjoy our Live and On Demand Sessions

11:15am **LI-TuM2-2 PVD Coatings Interaction with the Environment and Influence of Substrate on Coating Performance**, ***Bojan Podgornik (bojan.podgornik@imt.si)***, Institute of Metals and Technologies, Slovenia **INVITED**

In the past, the development of tools, engines and transmissions would have been impossible without improved steel performance, advanced lubricant additive chemistry and proper lubricant formulation. In order to meet demanding durability and performance requirements forming, engine and transmission oils contain a wide range of additives. Especially anti-wear and extreme-pressure additives are crucial in minimizing friction and wear and protecting contact surfaces under severe contact conditions. The mechanism by which AW and EP additives reduce friction and wear of metallic surfaces under boundary lubrication is well known and described in detail. It is due to formation of tribofilms, activated by tribochemical reactions between additive molecules and metallic surface.

By improving tribological properties hard coatings provide great opportunity for further improving performance, durability and efficiency of forming tools and components, which can no longer be achieved only by steel and lubricant design. However, although DLC and CrN coatings show low friction and wear under dry sliding conditions the majority of automotive components and forming tools will remain lubricated, at least for the near future. Therefore, for successful application of coated components aimed for further performance enhancement in forming and automotive industry (lower friction and energy consumption, higher load bearing capacity,...) coatings will have to perform adequately also under oil-lubricated conditions. Investigations so far indicate that in certain cases even coated surfaces may show improved tribological properties when lubricated by additivated oil. However, the mechanism responsible is not yet fully understood, especially when it comes to the influence of additive type, contact conditions and environment in general. Another important parameter when considering coated components is the substrate. Without proper support even the most superior coatings will fail.

With the aim to add some further understanding to this important area and to be able to fulfil future requirements in automotive and forming industry, the talk will focus on the influence of substrate preparation on the tribological performance of PVD coatings as well as on the reactions between lubricants and typical PVD coatings. Results from investigations on common coatings found in forming and automotive applications will be presented. Furthermore the influence of substrate properties including roughness, hardness and toughness, additive type, additive concentration and contact conditions, including load, sliding speed and temperature on the tribological behaviour of PVD coatings will be discussed.

11:45am **LI-TuM2-4 Insights into Indentation-Induced Cracking via 3D-FIB Tomography and HR-EBSD**, ***Bo-Shiuan Li (spring46515@gmail.com)***, University of Oxford, UK **INVITED**

Indentation-induced cracking has been a topic of interest to the coating community since the late 70s, as it provides a convenient measure for evaluating fracture properties of the coated layer. The fracture toughness (K_c) calculation based on indentation-induced cracking simply relies on three parameters: fracture load, crack length, and an empirical coefficient which depends on the indenter geometry. Due to the complicated stress state around the indent and subsurface crack geometry, it is difficult to perform conventional stress analysis for obtaining the stress-intensity factor (SIF) used in fracture mechanical analysis. Alternatively, a pre-defined crack geometry (often half-penny or Palmqvist shape) is assumed to simplify the stress analysis. For ideally brittle material, the method generally shows good agreement with macroscopic values, but will starts to deviate when plasticity is significant.

In this work, nanoindentation up to 700 °C was performed on the monolithic 6H-SiC, a promising ceramic for high-temperature structural applications. High-resolution electron backscatter diffraction (HR-EBSD) and 3D-FIB tomography were used to examine the stress state and crack geometry around the nanoindent. Results from both analysis will provide physical validation of the indentation-based fracture toughness model, and gain insights into the brittle-to-ductile (BDT) transition at elevated temperatures.

12:15pm **LI-TuM2-6 Photon Beam and Plasma Cloud – Programmable Surfaces**, ***Anna Buling (buling@ceranod.de)***, *J. Zerrer,* ELB Eloxalwerk Ludwigsburg GmbH, Germany **INVITED**

How to face the incessantly growing demands on sustainability, efficiently and endurance, which are made on components in automotive, aerospace and machinery applications? We are sure that intelligent lightweight, which enables the multi-material mix, accompanied by the right solutions for the surfaces is the answer.

Since the application of lightweight metals leads to a fuel consumption reduction and, thus, an environmental shielding, it is necessary to unveil the whole potential of e.g. Al and Mg alloys in high-loaded applications. In this talk we will focus on innovative surface technologies, which can be adopted to different application cases to fulfill ambitious demands. With adaptable process parameters the plasma electrolytical oxidation (PEO), which is known to give hard and dense coatings on lightweight metals, could be optimized to form homogeneous nanocrystalline surfaces on Al casting alloys with high Si content. This Ultraceramic® process results in a very wear-resistant protection, unfolding the whole potential of the casting component in action with novel low-viscosity oil, which is developed for innovative engine applications, leading to low friction and also low wear. Special improvement was achieved by structuring the PEO surfaces using the direct laser interference patterning (DLIP) method. Here, the advanced micro structuring technique leads to a further reduction of friction and wear, especially on the counter body side.

A further approach to meet increasing requirements is function integration, which enablesthe application of different functions on one component. Here, a data mining process was utilized to develop an additive laser-based coating process, whereas poly-ether-ether-ketone (PEEK) can be selectively applied on lightweight metals. The employment of different nano and microscale dopants in the PEEK dispersion, their interaction within the laser process and the resulting tribological and anticorrosion performance were studied. Based on tribological findings of the single-layer coatings – collected and evaluated by data mining - a multi-layer system was preprogrammed, which provided 3 orders of magnitude increased life-time, 10 times lower wear of the coating and the counter body part and a stable and reduced friction by solid lubrication.

Special knowledge of the nanoscale phenomena of plasma, dopants and laser processes in combination with extensive analysis of the resulting surface properties utilizing tribological measurements, nanoindentation and SEM characterization give us the possibility to find right position of the “screws” to tune the surface properties in such a way to improve their macroscopic sliding and wear behavior in orders of magnitude.

12:45pm **LI-TuM2-8 Closing Remarks & Thank You's**, ***Michael Chandross (mechand@sandia.gov)***, Sandia National Laboratories, USA

Thank you for attending the Session. Please join us for our Post-Session discussion and Q & A opportunities with our invited speakers.

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