Tribology and Mechanical Behavior of Coatings and Engineered Surfaces
Room Royal Palm 4-6 - Session E2-1

Mechanical Properties and Adhesion

Moderators: Gerhard Dehm, Max-Planck Institut für Eisenforschung, Megan Cordill, Erich Schmid Institute of Materials Science, Ming-Tzer Lin, National Chung Hsing University, Taiwan

10:00am **E2-1-1 In-situ Mechanical Testing of Hierarchical and Gradient Nanostructures***, J Wardini, O Donaldson,* ***Timothy Rupert****,* University of California, Irvine, USA **INVITED**

Recent innovations in materials processing have enabled the creation of nanostructured materials with unique microstructures. In this work, we focus on two promising examples: (1) nanocrystalline metals with amorphous intergranular films and (2) gradient nanograined materials, where grains size is varied near a specimen's surface. Due to the limited volumes of materials that can be made on lab scales or the geometry of typical parts, it is difficult to accurately probe the mechanical properties of these materials. In this talk, we describe the use of in-situ mechanical testing in the scanning electron microscope, with the goal of measuring important properties only from the regions of interest. We focus on properties of fundamental importance, such as yield strength, strain hardening rate, ductility, and rate sensitivity, with measurements made by microtension and microcompression of very small samples. Using these results, we revisit the design of these materials, to suggest paths for improvement in the future.

10:40am **E2-1-3 Mechanical Properties of Molybdenum Incorporated β-Ga_2O_3 Nanocrystalline Films for Extreme Environment Applications***,* ***Anil Krishna Battu****, S Manandhar, R Chintalapalle,* University of Texas at El Paso, USA

The mechanical properties of the metal-oxide nano films are important to utilize them in extreme environmental applications. The fundamental knowledge about the mechanical behavior in relation to the microstructure and grain growth is required to predict the component life as well as performance in high temperature applications. Thin films and coatings of β-Ga-$_2O_3$, a stable oxide of Ga, are widely used in high temperature sensors, anti-reflection coatings, and solar cells. We recently proposed and demonstrated that the life and performance of Ga coatings can be in high temperature applications by the addition of refractory metals. In this work, we performed a systematic study of the optical and mechanical properties of Mo co-doped β-Ga_2O_3 thin films. A comparative study of as-deposited and annealed samples will be presented and results will be compared to understand the effect of crystal structure, grain growth and oxidation states and how these parameters will affect the mechanical properties, such as hardness, young's modulus and durability.

11:00am **E2-1-4 Experimental Characterization and Finite Element Simulation of Damage in Thin Hard DLC Coatings***, A Choleridis,* Ecole Nationale Supérieure des Mines de St-Etienne, France*; C Héau, M Leroy,* Institut de Recherche en Ingénierie des Surfaces, Groupe HEF, France*; S Sao-Joao, G Kermouche,* Ecole Nationale Supérieure des Mines de St-Etienne, France*; C Donnet,* Université de Lyon, Université Jean Monnet, France*;* ***Helmut Klöcker****,* Ecole Nationale Supérieure des Mines de St-Etienne, France

While DLC coated components exhibit very little wear having a reduced friction coefficient [1], under severe conditions blistering driven in service delamination can sometimes be observed.

In the present work, first perfectly adherent DLC coatings with high compressive process induced residual stresses were deposited on a M2 steel substrate and a thin under layer.

In a second step, the coated samples were tested under severe loading conditions in a novel friction test facility. The damage induced by these conditions has been characterized by post mortem SEM and FIB observations.

Finally, the novel experimental insight in coating damage allowed modeling coating delamination at a scale defined by the substrate microstructure.

Coating delamination is preceded by intense blistering. FIB cross sections on particular blisters allow analyzing blister nucleation. Blistering occurs close to the under-layer/steel interface, inside steel. After blistering, a thin layer of substrate material is attached to the under-layer. Its thickness is maximal in the center of the blister and decreases moving to its borders. EDX analyses through several zones of this film confirmed the presence of a thin iron-layer. Cracks initiate inside the M2 steel substrate, several nanometers beneath the (M2)-(under-layer) interface. The cracks then propagate towards this interface and propagation ends with interfacial failure. Carbides lead to local crack kinking.

The influence of the local microstructure (grain size, carbide distribution) on the delamination behavior has been analyzed by a mechanical (fe-based) model. This model highlights the blister interaction.

References

[1] Christophe Donnet , Ali Erdemir Editors Tribology of Diamond-Like Carbon Films, Fundamentals and Applications, 2008, Springer, ISBN 978-0-3 G.G.

[2] S. Massl, J. Keckes, R. Pippan, Acta Materialia 55 (2007) 4835–4844

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[4] R. Treml, D. Kozic, J. Zechner, X. Maeder, B. Sartory, H.-P. Gänser, R. Schöngrundner, J. Michler, R. Brunner, D. Kiener, Acta Materialia 103 (2016) 616–623.

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