## Advanced Surface Engineering
## Room 2007a - Session SE2-ThM

### Hard and Nanocomposite Coatings: Synthesis, Structure, and Properties

**Moderator:** J.M. Schneider, RWTH Aachen, Germany

9:40am **SE2-ThM6 Surface Engineering for Improved Resistance to Contact Damage***, S. Suresh, **M. Dao**,* MIT **INVITED**

The tribological resistance of materials and surfaces during monotonic and repeated contact with other objects depends on a wide variety of complex interactions among material microstructure/properties, contact geometry, loading conditions, initial surface roughness, surrounding environment and lubricants. This presentation will provide a broad overview of our recent work on strategies to enhance the contact-damage resistance of surfaces. For this purpose, depth sensing, instrumented, continuous contact measurements are obtained over multiple length scales, from nm to macro-scale, using nanoindentation, quantitative frictional sliding measurements, cyclic normal indentation, repeated frictional sliding, as well as fretting fatigue. For material properties, a broad spectrum of microstructural conditions spanning nanocrystalline materials to commercial alloys are studied experimentally. These experimental studies are also accompanied by detailed, multi-scale computational modeling. In addition, strategies for improved in tribological properties by the introduction of controlled gradients in elastic and plastic properties, either through reinforcements or through grain size gradations, are explored. The presentation will conclude a summary of key advances in the area of instrumented contact mechanics and in the engineering of surfaces for improved contact-damage resistance.

10:20am **SE2-ThM8 Cr-B-N Coatings Deposited by Cathodic Arc Evaporation***, **K. Polychronopoulou**, J. Neidhardt, B. Sartory, R. Kaindl, R. Tessardi,* Christian Doppler Laboratory for Advanced Hard Coatings*; C. Rebholz,* University of Cyprus*; M. O Sullivan,* Plansee SE*; A.E. Reiter,* Balzers AG*; C. Mitterer,* Christian Doppler Laboratory for Advanced Hard Coatings

Transition metal boron nitride (Me-B-N) coatings receive increasing attention for their excellent combination of mechanical, chemical and tribological properties. Thus, this study presents nanocomposite Cr-B-N coatings deposited onto various substrates by high-rate reactive cathodic arc evaporation from Cr/B (80/20 at%) targets at 500°C using a commercial Balzers RCS system. The total pressure (Ar+N@sub 2@) was kept constant at 2 Pa, while the N@sub 2@ fraction was varied between 0 and 1. The coating composition and microstructure and mechanical as well as tribological properties were determined. X-ray diffraction studies revealed that Cr-B-N coatings deposited in a range of N@sub 2@ fractions from 1/8 - 1 contain randomly orientated CrN crystallites. No crystalline BN or Cr@sub 2@N phases were identified, whereas after vacuum annealing at 700°C during stress-temperature measurements peaks attributable to the Cr@sub 2@N phase emerged. The as-deposited coatings are with 2-3 GPa in a compressive stress state for higher N@sub 2@ fractions, while the hardness and elastic modulus values range from 18 to 23 GPa and 210 to 240 GPa, respectively. During ball-on-disc tests, these coatings revealed a coefficient of friction decreasing from 0.8 to 0.4; values between 0.5-0.6 were observed at an elevated testing temperature of 500°C. Raman investigations after tribological experiments revealed mainly chromium oxide suggesting a predominantly oxidative wear mechanism.

10:40am **SE2-ThM9 Growth and Characterization of Diamond/CNT Nanocomposites using Hot-Filament Assisted Chemical Vapor Deposition***, **N. Shankar**, N.G. Glumac, M.-F. Yu, S.P. Vanka,* University of Illinois Urbana-Champaign

Superhard materials are characterized by a bulk hardness of 40 GPa or more. However this extreme hardness is often offset by their inherent brittleness. In wear application where hard materials are typically used, it may be necessary to improve the toughness of the hard coatings for improved reliability, performance and durability. Reinforcing these hard materials with a tough second phase would possibly produce hard and tough composites which have the potential to outperform conventional hard coatings. We have developed a superhard-supertough composite from diamond and carbon nanotubes (CNT) by Hot Filament assisted Chemical Vapor Deposition (HFCVD). The growth was achieved by initially pre-dispersing commercially available multiwalled CNT onto a Si(100) surface and then subsequently growing diamond over this layer. The diamond/CNT composites were characterized using SEM, TEM, and Raman Spectroscopy. It was found that at 1% CH@sub 4@ in H@sub 2@ (a typical condition for diamond growth using HFCVD) most of the CNT are destroyed by the harsh growth conditions. A parametric study of growth phase-space revealed a selective window between 2-5% of CH@sub 4@ in H@sub 2@ wherein the CNT are not destroyed and the resulting diamond film still retained a high percentage of its sp@super 3@ structure. The TEM analyses showed that nanometer sized diamond particles nucleate on the surface of the CNT and grow radially outward. Based on the detailed characterization of the composites, a growth mechanism for diamond onto the CNT has been proposed. To the best of our knowledge, this is the first time that a successful composite of diamond and multiwalled CNT has been produced with direct bonding between the diamond and CNT resulting in good load transfer at the interface between the matrix and reinforcement.

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