Monday Morning, November 3, 2003

Advanced Surface Engineering
Room 323 - Session SE-MoM

Modern Challenges in Surface Engineering

Moderator: A.A. Voevodin, Air Force Research Laboratory

8:20am **SE-MoM1 Nanomechanical Testing of Films and Coatings*, I. Robertson,*** University of Illinois **INVITED**

The fundamental deformation and fracture processes of thin metallic films with a nanograined microstructure and of thin hard coatings with a composite nanocrystalline- amorphous structure will be investigated by using the in situ TEM straining technique. For the nanograined materials, a novel uniaxial tensile test device has been fabricated using microelectronic fabrication processes to integrate MEMS force sensors with metallic films on a silicon wafer. The device permits direct correlation of the measured mechanical properties with the observed deformation mechanisms. The importance of grain boundaries as sources and sinks for dislocations will be demonstrated for a 200-nanometer thick freestanding aluminum film. For the hard coatings, a TiC coating supported on a stainless steel substrate was fabricated. Preliminary results suggest that the failure mode for coatings with the same C/Ti ratio is dependent on the percentage of crystalline TiC and the oxygen content, demonstrating the importance optimizing the composition and structure. Results from these studies will be compared with model predictions.

9:00am **SE-MoM3 Molecular-Scale Tribology in Model SAMs and Amorphous Carbon Films*, J.A. Harrison*,** *G.M. Chateauneuf, P.T. Mikulski, G.T. Gao,* US Naval Academy **INVITED**

With the rapid development of MEMs and NEMs, protection of the surfaces of these devices has become an urgent issue. In recent years, much effort has been devoted to methods for passivating the surfaces of MEMs. Amorphous carbon films (a-C) and self-assembled monolayers (SAMs) are both possible candidates for the passivation and lubrication of MEMs. The fundamental problem associated with minimizing friction and wear mechanisms is to gain a better understanding of the underlying chemical and physical processes at the atomic scale. Over the past several years, we have done extensive molecular dynamics (MD) simulations that examine the compression and friction of model hydrocarbon SAMs attached to diamond and amorphous carbon films attached to diamond. Recently, compression and shear-induced polymerization have been modeled in unsaturated hydrocarbon films. The effects of polymerization on friction will be discussed. In addition, we have also done extensive simulations that analyze the structure and friction of a-C and a-CH films. These results will also be discussed. @FootnoteText@ **Supported by The Office of Naval Research & The Air Force Office of Scientific Research.

10:20am **SE-MoM7 Thin Film Growth by PVD in the Presence of Residual Gas*, J.M. Schneider,*** RWTH-Aachen, Germany **INVITED**

Vacuum based synthesis techniques are characterized by the presence of residual gas. It is well known that the residual gas in high vacuum mainly consists of water. Depending on the affinity of the residual gas to the growing film material, incorporation during thin film growth has recently been reported.@footnote 1@ Here, a review on residual gas - growing film interactions is presented. Sources@footnote 2@ for residual gas incorporation as well as incorporation mechanisms@footnote 1@ are described. Furthermore the effect of impurity incorporation on the film structure and film properties is discussed.@footnote 3@ @FootnoteText@ @footnote 1@ J. M. Schneider, A. Anders, I. G. Brown, B. Hjorvarsson, and L. Hultman, Applied Physics Letters 75, 612 (1999). @footnote 2@J. M. Schneider, A. Anders, G. Yushkov, Applied Physics Letters 78, 150 (2001). @footnote 3@J.M. Schneider, K. Larsson, J. Lu, E. Olsson and B. Hjorvarsson, Applied Physics Letters 80, (2002) 1144.

11:00am **SE-MoM9 John A. Thornton Memorial Award Address: Advances in Reactive Sputtering Processing Technology*, W.D. Sproul*[1]*,*** Advanced Energy Industries **INVITED**

Reactive sputtering is the sputtering of an elemental target in the presence of a gas that is purposely added to the system to react with the sputtered species to form a compound film. Although simple in theory, reactive sputtering can be difficult to carry out if one wants to obtain high deposition rates and good properties in the deposited films. The classic problem with reactive sputtering when the flow control of the reactive gas is used to regulate the inlet of the reactive gas into the chamber is that the surface of the target will suddenly change from the elemental state to a compound state when the flow of the gas is increased beyond a certain point. When this happens, the target becomes covered with the compound ("poisoned state"), and the sputtering rate drops precipitously while the composition and properties of the deposited film change. To avoid the problems associated with flow control of the reactive gas, it is possible to increase the pumping speed of the system, which will prevent avalanching from the metallic state to the poisoned state for most materials. However, this technique will not prevent the loss in deposition rate. To avoid the loss of rate from target poisoning and a degradation of film properties, it is necessary to control the partial pressure of the reactive gas. Partial pressure control is more involved than flow control of the reactive gas, but it does provide high deposition rates, good composition control, and excellent film properties. For partial pressure control to be effective, a feedback signal that varies as the partial pressure changes is required. Common feedback signals are the cathode voltage, a partial pressure signal from a mass spectrometer, or an optical emission signal from the sputtering plasma. Each has its advantages and disadvantages. Signal acquisition, processing, and response times are all very important for partial pressure control. If the update time of the feedback signal or if the response to a change in the control signal are too long, it may not be possible to maintain a stable reactive gas partial pressure. The feedback signal must be obtained and processed quickly, and the response to any change must also be quick. If this is done, it is possible to operate at any point along the transition from the metallic state to the poisoned state of the target, which means that it is now possible to achieve both high deposition rates and good film properties. Reactive sputtering of insulating films presents special problems because arcing can occur on the target surface, which leads to instabilities in the process. Fortunately, arcing can be eliminated by using a power supply that can suppress or prevent arcing. For deposition of insulating films, it is necessary to combine the correct type of power and with partial pressure control of the reactive gas to generate a stable, high-rate reactive sputtering process. One without the other will not produce the optimum results

---

[1] **John A. Thornton Memorial Award Winner**

Author Index

Bold page numbers indicate presenter