



**INTERNATIONAL CONFERENCE ON
METALLURGICAL COATINGS
AND THIN FILMS**

PROGRAM AND ABSTRACTS

**Town and Country Hotel
San Diego, California
April 10-14, 2000**

**Sponsored by:
Advanced Surface Engineering Division
of the
American Vacuum Society**



sputter-deposited hydrogenated carbon, respectively, as well as an average wear rate of 33%. No particulates have been observed even after performing depositions on 10000 discs while maintaining a deposition rate of 1.3 nm/sec. The PBS is compatible with the existing production line machines and, with slight modifications, can also provide protective overcoats of a thickness below 2 nm.

Coating and Thin Film Characterization

Room: Atlas Foyer - Session FP

F Poster

FP-1 A Quantum-Mechanical Model to Understand the Promotion of Tetrahedral Bonds by Carbon Subplantation in Diamond-like Carbon Films, *Hans J. Steffen*, Mannheim University of Applied Sciences, Germany

A simple self-consistent electronic structure calculation within the density-functional scheme reveals the electron-density dependent hybridization state for a carbon atom embedded in a homogeneous electron gas. It is shown that the p-like character of this quasiparticle exceeds the s-like state and a hybridization is naturally induced in an environment of high atomic density. Consequently, the mechanism for the formation of tetrahedrally coordinated carbon atoms in diamond-like films can be attributed to the rise of the average electron density owing to the enforced carbon subplantation and increased film density. The derived mechanism for promoting hybrid bonds is in accordance with experimental results which show a dose-dependent variation of the bond fractions within an evolving amorphous network during low-energy carbon ion deposition.

FP-2 Properties of Non-Stoichiometric Titanium Oxide Biomaterials Synthesized by PIII, *Y.X. Leng, P.K. Chu, B.Y. Tang*, City University of Hong Kong, *J.Y. Chen, P. Yang, Z.R. Zhou, N. Huang*, Southwest Jiaotong University, China

Ion implantation offers a large number of actual and potential applications in widely varying fields of modern biomedical technology, especially with regard to artificial internal organ research. However, conventional ion beam processes such as ion beam assisted deposition (IBAD) are "line-of-sight" techniques only suitable for flat substrates. Plasma immersion ion implantation (PIII) circumvents the line-of-sight restriction, and large, complex-shaped medical devices can be implanted. Non-stoichiometric titanium oxide (TiO_{2-x}) films are potentially useful as blood contacting materials such as heart valves and struts inside blood vessels, but the properties of TiO_{2-x} films prepared by PIII have seldom been shown. In this work, TiO_{2-x} films are synthesized on titanium substrates by PIII utilizing titanium metal plasma and reactive plasma oxidation. By controlling the deposition rate of titanium and the density of the oxygen plasma, TiO_{2-x} films with different Ti to O ratios can be fabricated. The chemical composition of the titanium oxide films is measured by Auger electron spectroscopy (AES), and the valence state of the elements is determined by x-ray photoelectron spectroscopy (XPS). X-ray glancing diffraction is employed to identify the structure of the films. The mechanical properties of the films are assessed by micro-hardness and pin-on-disk wear tests. The results show that the hardness of TiO_{2-x} films reaches 1000kg/mm^2 or above. The wear resistance of the TiO_{2-x} films is similar to that of titanium nitride films. The relationship between composition, structure, and surface mechanical properties is investigated systematically.

FP-3 The Effect of Cr Interlayer on the Microstructure of CrN Coatings on Steel, *S. Han*, National Chung Hsing University, Taiwan, *J.H. Lin*, National Tsing Hua University, Taiwan, *ROC, X.J. Guo*, National Chung Hsing University, Taiwan, *ROC, S.H. Tsai*, National Tsing Hua University, Taiwan, *ROC, F.H. Lu*, National Chung Hsing University, Taiwan, *ROC, H.C. Shih*, National Tsing Hua University, Taiwan, *ROC*

The effect of electroplated Cr on the microstructure and properties of CrN coatings on the steel was investigated. Two types of CrN-coated specimens by cathodic arc plasmas were prepared with and without an interlayer deposited by electroplated hard chrome. The microstructure and microchemistry of chromium nitride has been investigated using XRD, SEM, XTEM and SAD. The coatings are fairly dense with a microcolumnar morphology. The lattice fringes are continuous across the boundaries between the central thin layer of Cr and the surrounding darkish layers of CrN. The outermost layer of the coating is identified as CrN. The residual stresses in CrN caused the formation of dislocation networks and cell walls in the steel. From an estimation of the unrelaxed thermal stresses based on a bilayer model, it is demonstrated that the presence of a Cr

interlayer between CrN and steel can dramatically reduce the thermal stress in the CrN coating.

FP-4 The Effect of Intrinsic Parameters on the Critical Load as Measured with the Scratch Test Method, *N.X. Randall*, CSEM Instruments, Switzerland, *C. Frankel*, Penn State University

In the scratch test method, scratches are generated on the coated sample using a diamond indenter (usually a Rockwell C profile) which is drawn across the surface under either constant or progressively increasing load. The sample is displaced at constant speed and at a certain load damage occurs along the scratch path. This value of critical load, L_c , can be used to accurately characterise the adhesive strength of the coating-substrate system. With modern scratch testing instruments, the critical load can be determined by acoustic emission, optical microscopy, variation in penetration depth or variation in the tangential frictional force between tip and sample. However, it is difficult to express the adherence of a coating-substrate system in a quantitative way because the critical load depends on several parameters related to the testing conditions.

Experience in the scratch testing field has shown that various different radii of diamond indenter are often required in order to adequately characterise the adhesion of modern thin films and coatings. The constant reduction in thickness of coatings, as well as the increase in development of softer (polymeric) coatings has meant that a whole range of indenter geometries are needed to cover the scope of elastic and plastic properties measured by scratch testing. This paper considers the effect of intrinsic parameters such as scratching speed, loading rate and diamond indenter radius on the measured critical load for scratch tests performed on various different coating-substrate combinations (TiN, W, DLC, Al and Au). Results are presented which suggest definite correlations between critical load and indenter radius, and which should aid users in making the right choice of indenter for a given coating-substrate system.

FP-5 X-ray Fluorescence Characterization of Films at the Grazing Reflection of X-ray Beam Formed by the Slitless Collimation, *V.K. Egorov*, Ipmt Ras, Russia

The model of X-Ray fluorescence analysis at the total reflection of the exciting X-Ray beam (TXRF) is a fairly established technique for the quantity chemical diagnostic of surface layers with 2-5 nm thickness of polished targets today. There are the beautiful industrial TXRF spectrometers (for example, EXTRA II - Seifert, RUGAKU-3700) but cost of it's equipment is very high. The present work describes of TXRF spectrometer modified by using of the slitless collimator for the primary X-Ray beam. The prime cost of our spectrometer is not over 20000\$ at the excellent analytical characteristics and a simplicity of the using.

Standard TXRF spectrometer is complete by the monochromator for the forming of the exciting X-Ray beam with angle divergence near 0.001° . The primary X-Ray beam in our spectrometer is formed by the slitless collimator X-Ray radiation comprising two quartz polished plates intimate mated together. In a clearance between this plates the standing wave arises transported the beam on the distance near 100 mm without weakening. The beam divergence in output of the collimator is equal to double value of the total reflection critical angle for a quartz ($2\theta_c \sim 0.2^\circ$). Half of this beam is a source of X-Ray fluorescence excitation in the target studied. The X-Ray density on the surface layer of a target in our spectrometer is higher two orders in compared with a standard one.

It guarantees the reduction of the contamination detection levels for the TXRF spectrometer with slitless collimator no less then the order. The detection limits for the Fe group elements at the surface analysis of Si wafer are obtained better then 10^{10} atoms/cm² in measurements with the standard X-Ray tube (Mo, 2 kW) at the exposition time 600 sec.

FP-6 Numerical Interpretation of Reflectance/Transmittance Difference Spectroscopy of an-isotropic Multi-layer Thin Film, *D.T. Kwok, P.K. Chu*, City University of Hong Kong

Reflectance/Transmittance-difference (anisotropic) spectroscopy (RDS/TDS) is one of the few non-destructive optical techniques that one can use to study surface thin films and the interface of semiconductor materials under steady-state conditions. RDS spectra have been successfully acquired from various kinds of semiconductor layered structure, such as ZnSe/GaAs interfaces, (001) GaAs, etc. However, the spectra are hard to interpret when more than one layer is anisotropic. In this paper, a numerical method based on the 2×2 matrices established by Yeh is applied to simulate the non-normal-incident RDS and TDS spectra of biaxial anisotropic multi-layer systems with finite thickness. It is demonstrated that, when the principal axes of the anisotropy layer are at certain orientations, a RDS/TDS spectrum can be separated into two spectra, namely, an in-plane anisotropic spectrum and an out-of-plane anisotropic spectrum. It is shown that the