Advanced Surface Engineering
Room: Hall 3 - Session SE-TuP

Advanced Surface Engineering Poster Session

SE-TuP1 Surface and Tribological Properties of CFx-doped TaN Thin Films With and Without CFx Top Layer, *W.C. Say, **ShangLun Liu***, National Taipei University of Technology, Taiwan, Republic of China, *J.H. Hsieh*, Ming Chi University of Technology, Taiwan, Republic of China

TaN thin film coatings are known to have good mechanical properties, impact toughness, as well as good biocompatibility. However, the friction coefficient of these films is sometimes too high, or the hemocompatibility is poor. The purpose of this study is to reduce the friction coefficient and lower the surface energy of TaN coating by introducing CF_x into/onto the nitride coatings. CF_x–doped TaN films, with and without CF_x top layer, were deposited on silicon and tool steel substrates by magnetron sputtering. During the deposition process, C_2F_6 gas with various flow rates was added. During the deposition of 30 nm CF_x top layer on some samples, the power to Ta target was shut off. After deposition, these films were then characterized using XRD, XPS, FTIR, FESEM, as well as a tribometer. The tribo-tests were carried out with and without argon flow. Surface energies of the films were also analyzed with contact angle measurement system. According to structural analysis, TaN phase would transform to Ta(FCN) with the increase of the fluoride gas flow rate, which would cause the decrease of friction coefficient and surface energy. According to the results obtained from tribotesting, it is found the increase of CFx would reduce the effects of moisture and oxygen on friction coefficient. The prepared films may have good hemocompatibility and wear-resistance.

SE-TuP2 Biocompatibility of Porous TaOxNy Films with Various O/N Ratio, *J.H. Hsieh, **YiChih Lin**, S.J. Liao*, Ming Chi University of Technology, Taiwan, Republic of China, *C. Li*, National Yang Ming University, Taiwan, Republic of China, *Y.H. Lai*, Ming Chi University of Technology, Taiwan, Republic of China

The oxynitride of a transition metal is able to form a new grade of functional thin film. Controlling oxygen-to-nitrogen ratio allows one to tune the film properties. The tunable properties include optical and mechanical properties, and biocompatibility, etc. In this study, TaOxNy-Cu films were first prepared using reactive co-sputtering, with the variation of O/N flow ratios. After deposition, the films were annealed, and Cu was etched away to form porous oxynitride structures with various O/N ratio. The films were characterized using nano-indentation, XRD, and SEM. The results showed that the porosity of these films could be varied depending on Cu contents and O/N ratios. The samples were then tested for their biocompatibility and viability using 3-T-3 fibroblast cells. According to the results obtained from biocompatibility and MTT assay testing, it was found that the O/N ratio should be near the transition of semiconductor to conductor. Furthermore, the pore size played a major role in terms of biocompatibility and cell viability. An optimal pore size was found around 200 um.

SE-TuP3 Nanopatterned ZnO on PDMS via Decoupled Ion Beam Modification and Metal Co-Deposition, ***Zachariah Koyn**, B. Holybee, A. Shetty, K. Nash, J. Pachicano*, University of Illinois at Urbana-Champaign, *S. Srivastava*, Illinois Applied Research Institute, *J.P. Allain*, University of Illinois at Urbana-Champaign

Ion beams have been shown to create nano-scale surface patterning on polycrystalline thin metal films, including ripples and dots [1,2]. Additionally, oxygen ion beams have been shown to induce fluence-dependent surface oxidation on metal surfaces [3]. This work seeks to unravel the directed irradiation synthesis of metal oxide thin-films, specifically ZnO, with irradiation-driven mechanisms on dissimilar, polymer-based substrates. This examines the dual effects of oxygen irradiation as a method of both oxidizing and patterning metal thin-films at ambient temperatures. This represents a scalable process in growing and functionalizing metal-oxide thin-films on polymers, which are sensitive to the high temperatures required in thermal oxidation processes. Recent work utilized a single ion beam to simultaneous irradiate and sputter deposit metal impurities on Si, creating nanostructures [4]. The work here decouples these processes by using two ion beams to independently control the metal deposition and surface modification fluxes. The ratio of these is the primary tool used to explore the creation and control over size and shape of nanostructures. Beam energies of 100-2000 eV are used at ambient temperatures to protect the substrate, with an inert beam used for metal deposition and both inert and reactive (O_2^+) normal incidence beams used for surface modification. Both Si and PDMS substrates are explored with fluences of ~5E16–2E17 ions/cm^2. Surface patterning and chemistry are analyzed with AFM and XPS, respectively. The ability to functionalize flexible, transparent substrates with metal-oxide nanostructures offers exciting applications in areas such as flexible and wearable electronics, gas sensors, biosensors, and photonics [5].

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SE-TuP4 Investigation of Tungsten-YttriumBased Structural Materials for Nuclear Reactor Applications, ***Gustavo Martinez**, J. Chessa*, University of Texas at El Paso, *M. Lerche*, Mcclellan Nuclear Research Center, *R.V. Chintalapalle*, University of Texas at El Paso

Material failure is one of the most considerable setbacks needed to be addressed by the materials research community to develop the next generation of nuclear energy systems that demand materials to serve under extreme conditions. We report on the enhanced irradiation tolerance and phase stability of nanocrystalline Tungsten-Yttrium (W-Y) coatings produced by radio-frequency sputter deposition. The W-Y coatings were produced under variable sputtering pressure and Y-content. The coatings were characterized by studying their structure and mechanical properties. The W-Y coatings were then subjected to heavy ion-irradiation at high fluence levels. The addition of Y atoms into the W matrix has shown to improve the irradiation bombardment of heavy Au+3 and yielding improved young's modulus and hardness when compared to pure W alone. It is believed that the addition of Y creates grain boundaries that are capturing interstitial ions and recombining to eliminate vacancies. The results will be presented and discussed.

SE-TuP6 The Influence of Mo Content and Bias Potential on the Structure, Mechanical Properties, and Tribological Behaviour of Cathodic Arc Evaporated Ti-Al-N Hard Coatings, ***Stefan A. Glatz***, TU Wien, Austria, *C.M. Koller, H. Riedl*, CDL AOS, TU Wien, Austria, *R. Rachbauer*, Oerlikon Balzers, Oerlikon Surface Solutions AG, Liechtenstein, *S. Kolozsvári*, Plansee Composite Materials GmbH, Germany, *P.H. Mayrhofer*, CDL AOS, TU Wien, Austria

Today's industrial processes, i.e. forming and shaping of various materials, require efficiency and precision. Therefore, wear and friction are core topics in the continuous improvement process. Coating either one of the counter-bodies or both of them with, for example, Ti-Al-N can be a feasible solution for fitting these certain requirements of the tribological conditions within industrial processes. Powder metallurgical manufacturing is ideal to produce materials with a broad composition and/or to alloy further elements to a standard target composition—i.e. to alter the properties of $Ti_{1-x}Al_xN$ thin films. This study focuses on the influence of bias potential and alloying element content on phase formation, mechanical properties, and tribological behaviour of cathodic arc evaporated $(Ti_{0.5}Al_{0.5})_{1-x}Mo_xN$ hard protective coatings. The tribological behaviour of the coatings obtained by using this physical vapour deposition (PVD) technique were evaluated by means of pin-on-disc tests and by non-contact optical profilometry—where the development of the wear tracks and counter-bodies is investigated. Scanning electron microscopy in combination with energy dispersive x-ray spectroscopy and x-ray diffraction experiments are performed to establish the chemical and structure evolution of our $(Ti_{0.5}Al_{0.5})_{1-x}Mo_xN$ thin films deposited with various bias potentials. It can be shown that the tribological behaviour of Ti-Al-N coatings can significantly be enhanced by the development of $(Ti_{0.5}Al_{0.5})_{1-x}Mo_xN$ thin films.

SE-TuP7 High-temperature Tribological Investigations of CrAlN and CrAlSiN in Ambient and Inert Atmospheres, ***Marisa Rebelo de Figueiredo**, A. Xia*, Montanuniversität Leoben, Austria, *S. Kolozsvári*, Plansee Composite Materials GmbH, Germany, *R. Franz*, Montanuniversität Leoben, Austria

CrAlN-based hard coatings are nowadays widely used in industrial cutting applications to protect the base material of the tools against wear and oxidation. Due to alloying of the binary CrN with Al, enhanced mechanical properties of CrAlN could be achieved as a result of solid solution hardening, if the face-centered cubic structure of CrN is retained, i.e. Al atoms substitute Cr in the crystal lattice. An improved oxidation resistance is based on the formation of thin oxide layers on the coating's surface hindering further oxidation. With the addition of Si, a nanocomposite of crystalline CrAl(Si)N grains and an amorphous SiNx grain boundary phase can be formed resulting in a further enhancement of the mechanical properties. The oxidation resistance could also be further improved due to the formation of an additional SiOx phase on the coating surface. The tribological properties of these coatings at high temperature have already been studied in detail [1, 2]. However, these experiments were performed in ambient atmosphere impeding a clear identification of the main wear mechanism like abrasive or oxidative wear. Even though CrAlN and CrAlSiN are oxidation resistant at the test temperatures up to 700 °C, oxidation in the tribological contact zone might still play an important role if the protective oxide layer on the surface is removed and freshly exposed coating material can rapidly oxidize.

Therefore, CrAlN and CrAlSiN coatings were analyzed in ball-on-disk tests in ambient and inert Ar (+ N_2) atmosphere at temperatures ranging from room temperature up to 700 °C. The coatings were synthesized by DC magnetron sputter deposition in an industrial-scale system using composite $Cr_{50}Al_{50}$ and $Cr_{45}Al_{45}Si_{10}$ targets. The tribological tests against alumina counterparts revealed a coefficient of friction independent of the used atmosphere. The wear coefficient as determined by 3D optical profilometry, however, showed a non-uniform behavior. At medium temperature of about 400 °C higher wear in inert than oxidative atmosphere was noticed, whereas the opposite trend was observed at high temperatures of up to 700 °C. A subsequent analysis of the wear scars and the wear debris by scanning electron microscopy and Raman spectroscopy revealed further details about the wear mechanisms.

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Authors Index

Bold page numbers indicate the presenter