

Tuesday Evening Poster Sessions, October 23, 2018

Advanced Surface Engineering Division Room Hall B - Session SE-TuP

Advanced Surface Engineering Division Poster Session

SE-TuP-1 Deposition and Characterization of Ga-doped TaON Thin Films, *J Hsieh, Shi Jei Lin*, Ming Chi University of Technology, Taiwan, Republic of China

Recently, gallium ions have been studied for its multi-functional bio-activity. While gallium has no known function in human physiology, the chemical properties that it shares with iron allow it to bind to iron-containing proteins (Trojan Horse effect), including the iron transport protein transferrin. Thus, malignant cells and microorganisms may be tricked into incorporating gallium in place of iron for iron-dependent processes essential for bacterial viability and growth. Hence, rather than facilitate iron-dependent cellular function, gallium disrupts it. As a result, the interaction between gallium and iron-proteins can be exploited for therapeutic purposes in cancers and bactericidal treatments. Accordingly, it is of great interest to know how Ga can be doped into surface coatings.

In this study, the tunable TaOxNy-Ga thin film coatings were studied systematically on their interesting deposition process, as well as their mechanical, electrochemical, surface topology, antibacterial properties, in terms of O/N ratio and Ga contents. However, due to the low melting point of Ga (~29 °C), it is relatively difficult to sputter Ga into those oxynitride coatings. Therefore, Ga₂O₃ target was used in this study to provide oxygen and Ga. According to the results, it was learned that small amount of oxygen in the coatings may be beneficial to the improvement of mechanical and surface properties, and enhance the dissolution of Ga ions.

SE-TuP-2 Fabrication of Porous Membranes of Controlled Porosity and Chemical Functionality, *Golnaz Dianat, M Gupta, S Seidel, M Deluna*, University of Southern California

We present a modified initiated chemical vapor deposition (iCVD) technique to synthesize porous polymer membranes. We demonstrate that we can pattern the deposition of the porous polymer membranes by using poly(dimethylsiloxane) (PDMS) masks. The porosity and thickness of the membranes can be controlled by varying the substrate temperature during monomer deposition. The functionality of membrane can be tuned by addition of a cross-linker during polymerization and allow for the fabrication of robust free-standing shaped membranes. Our ability to control the shape, thickness, porosity, and functionality of the porous membranes allows for the design of new surfaces for a variety of applications in sensors, filtration, and microfluidics. Asymmetric polymer membranes, that are composed of a dense top layer and porous bottom layer, can be synthesized using a combination of conventional and nonconventional iCVD conditions in a one-pot process. This method allows for a high degree of control over the thickness of the dense layer by simply controlling the deposition time and paves the way to synthesize ultrathin dense layers with sub-50nm thickness that is difficult to attain using other methods. The functionality of the dense and porous layers can be independently tailored to be either hydrophobic or hydrophilic, resulting in membranes that are fully hydrophilic, fully hydrophobic, or asymmetric in both structure and chemical functionality.

SE-TuP-3 Plasma Treatment of Thiol-Carborane Self-Assembled Monolayers on Copper, *Michelle Paquette, R Thapa, L Dorsett, S Malik, S Wagner, A Caruso*, University of Missouri-Kansas City; *D Merrill, J Bielefeld, S King*, Intel Corporation

Thiol-carborane self-assembled monolayers (SAMs) have been used to modify the properties of metal surfaces. Not only do the symmetric twelve-vertex icosahedral carborane molecules provide a unique and appealing geometry for SAM formation, but boron carbide materials are notorious for their chemical, thermal, and mechanical robustness. Carborane-based SAMs have been shown to provide superior corrosion resistance on silver as well as the ability to modify the electronic properties (e.g., work function) of gold and silver surfaces. One of the noteworthy properties of carboranes is their ability to cross-link via labile hydrogen bonds under the influence of heat, plasma, and various energetic particles. Here, we investigate the influence of various plasma treatments on carborane monolayers on copper and show how these can be used to both further tune their properties as well as influence their stability.

SE-TuP-4 Improved Light Extraction Efficiency using Homeotropic Thin Films on SiO₂ Micro Pillars, *J.H. Lee, Y Lin, G Wu*, Chang Gung University, Taiwan

It has been known that high refractive index material such as gallium nitride film has been limited for light extraction by low total internal reflection angle. The external quantum efficiency for a light-emitting diode is thus low due to absorption by the semiconductor material and the substrate. In this paper, we proposed to use homeotropic, vertical alignment, liquid crystal polymer coatings on patterned SiO₂ micro - pillar arrays to improve the light extraction of nitride light-emitting diodes . A wet etching technique was firstly employed to create the patterned SiO₂ micro-pillar arrays on the surface. The pillar was nominally 3 μm in diameter, 200-600 nm in height, and the period was 6 μm for a triangular array. Then we coated 5 wt% liquid crystal polymer precursor uniformly on the surface of the etched structure. The results showed that the homeotropic optical thin-film improved light guiding, and the light escape cone angle increased from 26 to 50-60 degrees by the viewing angle test system at an injection current of 20 mA. The light extraction efficiency was also increased by 59% by using an integrating sphere.

Keywords: Liquid crystal polymer, Light-emitting diode, SiO₂ micro - pillar

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SE-TuP-5 Investigating the Influence of Substrate Cleaning on the Solution Stability of Plasma Polymer Films, *Karyn Jarvis*, Swinburne University of Technology, Australia; *S McArthur*, Swinburne University of Technology and CSIRO, Australia

Plasma polymerization modifies surfaces via the deposition of a thin film possessing specific functional groups. The organic monomer is introduced into the low pressure chamber as a vapour, fragmented via radio frequency and deposited onto all surfaces in contact with the plasma. Commonly used monomers such as octadiene, allylamine and acrylic acid enable the deposition of hydrocarbon, amine and carboxylic acid terminated surfaces respectively. Surface cleaning prior to the deposition of thin films is frequently carried out to improve film adhesion. The use of plasma polymer films in biomedical applications has increased the demand for coatings suitable for use in physiological conditions. Significant changes in film properties in aqueous conditions have serious implications on the incorporation of these films in biomedical technologies and devices.

In this study, silicon wafer substrates were cleaned by several different methods prior to the deposition of plasma polymerized thin films to investigate the influence of substrate cleaning on film stability in aqueous solutions. The substrates were used untreated or cleaned by liquid sonication, UV/ozone cleaning or air plasma. X-ray photoelectron spectroscopy (XPS) and contact angle measurements were undertaken to determine the effect of the cleaning method on surface chemistry and wettability. After cleaning, the substrates were coated by plasma polymerized octadiene, acrylic acid or allylamine thin films. The surface chemistries and film thicknesses of the plasma polymerised films were determined by XPS and variable angle spectroscopy ellipsometry respectively. The plasma polymerised films were immersed in both Milli-Q water and phosphate buffered saline for time periods of 1, 24 and 168 hours. Films were again analysed via XPS and ellipsometry to determine the influence of substrate cleaning, immersion solution and immersion duration on film stability. Substrate cleaning was shown to have an influence on film stability with visible pitting on some films, even after only 1 hour of immersion. Substrate cleaning is an important step prior to the deposition of thin films and can be used to extend the solution stability of plasma polymerised films, which has important implications for a variety of biomedical applications.

SE-TuP-6 Tribological Systems Solutions for Gas Turbine Engines, *Pantcho Stoyanov*, Pratt & Whitney

The advancement of durable gas turbine engine components depends heavily on the development of high-performance materials, which can withstand extreme environmental and contact conditions (e.g. large temperature ranges, high contact pressures, and continuous bombardment of abrasive particles, all of which degrade the physical properties). In particular, due to the large number of complex contacting and moving mechanical assemblies in the engine, the lifetime of certain structures is limited by the tribological performance of the employed materials and coatings. This talk will provide an overview of tribological solutions employed in several sections of gas turbine engines. After a general review of aircraft engine tribology, the talk will focus on coatings used for

Tuesday Evening Poster Sessions, October 23, 2018

clearance control (i.e. abradable air seals) as well as tribological materials used to minimize fretting type of wear. More specifically, a study will be presented on the influence of self-lubricating hexagonal boron nitride (hBN) on the erosion and abrasability of Ni-based abradable coatings. Subsequently, a series of studies on the friction and wear behavior of Ni-based and Co-based superalloys at elevated temperatures will be presented. Emphasis will be placed on the correlation between the third body formation process (e.g. oxide layer formation, transferfilms) and the tribological behavior of the superalloys. This talk will conclude with the future strategies of tribological coating solutions in Pratt & Whitney's PurePower® PW1000G family of engines.

SE-TuP-7 Effect of Laser Processing on the Atmospheric Corrosion Behavior of Mg Alloy AZ31B and Weldments, *M Melia*, Sandia National Laboratories; *L Agnew, J Skelton, J Scully, James Fitz-Gerald*, University of Virginia

The widespread implementation of lightweight magnesium alloys to the automotive and aerospace industries is currently limited by its poor and unpredictable corrosion response. Of major concern is the localized corrosion of Mg alloys, driven by a uniform population of electrochemically noble secondary phases present in the chemically heterogeneous microstructure, resulting in a rapid loss of structural integrity. These microstructural heterogeneities are accentuated when Mg alloys are welded causing galvanic coupling between weld zones. A research investigation to mitigate localized corrosion of a Mg alloy (AZ31B), with and without weldments, via laser surface engineering has been conducted.

Lasers operating in a nanosecond pulse duration regime are capable of melting and solidification rates on the order of 10^9 K/s with the ability to extend the solid solubility limit of the alloying elements. The irradiation of AZ31B with an excimer laser (FWHM= 25ns, $\lambda= 248$ nm) observed significant changes in the near surface microstructure and secondary phase particle dissolution, characterized in this case by scanning electron microscopy equipped with a backscatter electron detector. The corrosion response of Mg alloy AZ31B (3wt% Al, 1wt% Zn, 0.6wt% Mn, and Mg balance) was investigated using the accelerated atmospheric test (GMW14872) for 30 wet-dry cycles. The atmospheric exposure test consists of a 24-hour cycle involving three 8-hour stages. During the first stage, samples are held at ambient temperature and humidity (25 °C, 45% RH) and are sprayed every 90 minutes with a salt solution (0.9% NaCl, 0.1% CaCl₂, 0.075% NaHCO₃). During the second stage the temperature is increased to 49 °C and samples are continuously sprayed with a deionized water fog (~100% RH). During the third stage temperature is increased to 60 °C and held at less than 30% relative humidity. The corrosion product was analyzed using Fourier transform infrared spectroscopy (FTIR) and grazing incident x-ray diffraction (GI-XRD). At early stages of the exposure experiments the laser processed specimens showed less corrosion product coverage than as-polished or welded specimens.

Author Index

Bold page numbers indicate presenter

— A —

Agnew, L: SE-TuP-7, **2**

— B —

Bielefeld, J: SE-TuP-3, **1**

— C —

Caruso, A: SE-TuP-3, **1**

— D —

Deluna, M: SE-TuP-2, **1**

Dianat, G: SE-TuP-2, **1**

Dorsett, L: SE-TuP-3, **1**

— F —

Fitz-Gerald, J: SE-TuP-7, **2**

— G —

Gupta, M: SE-TuP-2, **1**

— H —

Hsieh, J: SE-TuP-1, **1**

— J —

Jarvis, K: SE-TuP-5, **1**

— K —

King, S: SE-TuP-3, **1**

— L —

Lee, J: SE-TuP-4, **1**

Lin, S: SE-TuP-1, **1**

Lin, Y: SE-TuP-4, **1**

— M —

Malik, S: SE-TuP-3, **1**

McArthur, S: SE-TuP-5, **1**

Melia, M: SE-TuP-7, **2**

Merrill, D: SE-TuP-3, **1**

— P —

Paquette, M: SE-TuP-3, **1**

— S —

Scully, J: SE-TuP-7, **2**

Seidel, S: SE-TuP-2, **1**

Skelton, J: SE-TuP-7, **2**

Stoyanov, P: SE-TuP-6, **1**

— T —

Thapa, R: SE-TuP-3, **1**

— W —

Wagner, S: SE-TuP-3, **1**

Wu, G: SE-TuP-4, **1**