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FOR A SUSTAINABLE DEFENSE

ASETSDEFENSE WORKSHOP 2018
SUSTAINABLE SURFACE ENGINEERING FOR AEROSPACE AND DEFENSE

POSTER SESSION & NETWORKING RECEPTION

6:00 – 8:00 PM
AUGUST 21, 2018

COLORADO FOYER, 2ND FLOOR
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POSTER #1

Corrosion Monitoring System to Reduce Environmental Burden and Corrosion Maintenance Costs

Casey Jones, AFLCMC/EZP-CPCO

Corrosion and maintenance costs associated with corrosion cost the United States tax payer approximately $20 billion annually across the Department of Defense (DoD). Not only are corrosion maintenance actions expensive; theyâ€™re also detrimental to the environment through the use of hexavalent chromium cadmium and other corrosion inhibitors. Furthermore use of these inhibitors pose a serious health risk to maintainers working on these DoD assets. The intent of this effort is to successfully train a corrosion algorithm that accurately assesses cumulative exposure state as an input to a condition based maintenance plus (CBM+) algorithm to more efficiently define maintenance (Mx) requirements. The approach is to use only readily accessible data as inputs to the algorithms potentially eliminating the long-term need for on-board sensors. The technical objective of this proposed project is to develop and validate matrices of environmental indicators and a cumulative exposure state to predict the likelihood of corrosion in the form of a corrosion algorithm where the resulting data ultimately feed condition data into CBM+ algorithms offering corrosion predictive prognostics as well as greater expanded asset health monitoring (by tail/asset number). The elimination of unscheduled Mx activities will reduce hazardous material usage and waste disposal thereby lowering wastewater treatment issues. It will curb operator exposure to corrosion inhibitors and save related costs. This concept will affect every GSE and aircraft asset in the USAF and potentially DoD inventory. The proposed novel approach removes the need to install sensor(s) on every aircraft while still providing the capability to individually track assets for potential corrosion. By employing an integrated and predictive approach that integrates corrosion and CBM+ principles the DoD will realize great environmental benefits through the reduction of unnecessary Mx operations. The approach to integrate monitoring systems output with environmental conditions to develop a cumulative exposure state into CBM+ algorithms will provide reliable information to improve corrosion prediction capabilities and simultaneously address environmental impacts and Mx costs.

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POSTER #2

Predicting Aluminum Alloy Corrosion Performance for Incorporation into Design Analysis

Kenneth Smith, United Technologies Research Center

Corrosion costs the U.S. over $1 trillion annually yet is typically not analyzed at a detailed level during the product design phase. This program demonstrates an ICME approach that relates microstructure with corrosion performance using legacy aluminum alloy AA-7075 and a newer Al-Li alloy AA-2070. A linking of electrochemical and microstructural characterization of the surface to the microscale corrosion processes is demonstrated using a combination of experimental techniques (optical microscopy SEM TEM XRD EBSD Scanning Kelvin Probe Force Microscopy microcell electrochemistry zero resistance ammeter measurements and high throughput corrosion screening) and models (including microstructure evolution models; a multi-physics microgalvanic corrosion model; a phase field model; and Bayesian models of pit growth). Coupons were exposed to both salt fog cabinet and outdoor corrosion conditions to validate the predictive models. Quantification of corrosion damage is demonstrated to allow for comparison with environmental and microstructural variation. A corrosion database is developed to capture quantified description of microstructure electrochemistry and corrosion to support deployment to similar alloy systems. The ability to combine the microstructural and electrochemical characteristics into a Bayesian model for corrosion susceptibility provides a means to incorporate corrosion into design analysis through an ICME toolset combined with current mechanical analysis methods.

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POSTER #3

Computer Aided Analysis for Corrosion Risk Assessment: From Find-it/Fix-it towards Predict & Manage

Agnieszka Franczak, Elsyca NV

It is hard to believe that in XXI century when an access to the most advanced technological solutions is easily available the program management guide for corrosion prevention and control still relies on a use of the galvanic tables in order to assess corrosion risks. The corrosion problem is much more complicated since already galvanic corrosion rate is determined by corrosion current which in turn is a complex function of materials electrochemical properties corroding electrolyte chemistry and the geometry of an entire assembly that includes anodic and cathodic materials. As in the past such complex problem could not be addressed nowadays a combination of advanced electrochemical simulation technology and 3D CAE/CAD design tools enable engineers to quickly assess the impact of design strategies and material choices on corrosion resistance. This poster will introduce a new technological trend in corrosion risk assessment which solves the electrochemical currents in an assembly by incorporating its materials coatings and exact design leading to lifetime prediction and informed decisions on design material performance cost operational integrity and maintenance requirements. The technology is based on a high-level computer modelling approach enabling to predict galvanic and uniform corrosion rates even on the most complex mechanical assemblies of mixed materials.

POSTER #4

A Computational Modeling Framework to Support Prediction of Cumulative Galvanic Corrosion Damage in Aircraft Structures

Robert Adey, BEASY

A computational modeling framework is being developed to support prediction of cumulative corrosion damage in aircraft components. The effects of galvanic crevice and pitting corrosion are being incorporated in a corrosion service life model. The challenges in connecting environmental exposure history and electrochemical data in a computational model are discussed. A conceptual scheme for implementation of the current methodology is presented using actual corrosion sensor data.

POSTER #5

Corrosion Analysis from Design through Sustainment

Alan Rose, Corrdesa LLC

Aircraft and other complex weapons systems use many dissimilar materials in close proximity. The result is that we frequently see severe galvanic corrosion sometimes resulting in structural failure. The problem is often exacerbated by the choice of incompatible materials in sustainment usually driven by standards such as MIL-STD-889. The ONR Sea-Based Aviation team has clearly demonstrated that these galvanic standards often provide incorrect guidance because they are based on galvanic potential not galvanic current. Team members have been developing approaches that are correctly based on galvanic current prediction and NAVAIR is now updating MIL-STD-889 to take this into account. This poster will demonstrate two of these approaches and show how they can be used in combination to design and sustain more durable weapons systems: Corrosion Djinn a tool for rapid analysis and scoping to help Design and M&P engineers quickly assess options and optimize protection systems and full 3-D computer-aided engineering analysis for complex assemblies.

POSTER #6

New Accelerated Corrosion Test Methods for Atmospheric Corrosion on Aluminum Aircraft

Ekaterina Badaeva, Boeing

Paints and coatings play an important role in protecting aircraft from atmospheric corrosion. There are standard accelerated laboratory test methods that allow assessment of the coating corrosion protection performance before it is qualified and applied to aircraft. It is however hard to draw a direct correlation between these standard test methods and in-service material performance. Several new test methods have been developed to represent types of in-service atmospheric corrosion on aluminum aircraft. These tests complement standard corrosion test methods such as neutral salt spray and filiform corrosion and will possibly become a new standard for paint qualification in the future.

POSTER #7

Qualification Testing of Electroformed Nanostructured Cobalt-Alloy Bushings

Alan Grieve, NAVAIR

The objective of this program is to demonstrate the cost effective manufacturing and performance of an electroformed nanostructured Cobalt-alloy for use as a replacement for toxic Copper-Beryllium (CuBe) alloys in the manufacture of high-strength aircraft bushings. The new nanocrystalline alloy is fabricated using a process that favors nucleation of new grains over growth of existing grains resulting in an ultra-fine grain structure throughout the entire thickness of the material deposit. The resulting nanostructured materials are of higher hardness and have higher yield strength than most conventional materials- the increase in strength of metals with decreasing grain size is described in the Hall-Petch equation. In effect the grain boundaries act as pinning points impeding further dislocation propagation. The successful execution of this project will lead to a significant reduction in the use of toxic Beryllium-containing bushing alloys in low-frequency rotational wear defense-applications. Specific benefits will include; superior mechanical and tribological properties compared to alternative bushing materials resulting in longer life and the ability to handle higher loads; better galvanic match with aluminum structures resulting in less corrosion; a near net shape manufacturing method resulting in very little material waste during manufacturing (high â€œbuy-to-flyâ€ ratio); and the ability to produce bushings on-demand to alleviate delays due to material supply issues in critical repair and overhaul situations.

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POSTER #8

Advanced Nanocrystalline Cobalt Alloys and Composites as Alternatives for Chromium and Nickel Plating in Repair Operations

Jonathan McCrea, Integran Technologies Inc.

Electrodeposited nickel and hard chromium coatings have been extensively used throughout the DoD for the repair and overhaul of damaged components. However with growing concerns over the environmental and health risks associated with nickel and chromium (Cr6+) a demand for environmentally-compliant alternative repair technologies has arisen. Integran Technologies Inc. in collaboration with Cirrus Materials Science and Corrdesa is working on SERDP Project WP-2609 to develop an alternative technology based upon cost-effective electrodeposited nanostructured metals and metal-matrix composites. The project seeks to develop optimize and validate a nanostructured cobalt alloy matrix with nano-sized particles which as a minimum meets or exceeds the properties and performance of electrodeposited nickel/chromium-based repairs for military applications. The technical objectives of this project are to: 1) Optimize a nanocrystalline cobalt-phosphorus electrodeposition process for repair operations that is based on conventional direct current rectifiers (reduce infrastructure costs); 2) Develop novel nanocomposite coating systems consisting of a nanocrystalline cobalt-phosphorus matrix embedded with second-phase hard particles in order to improve the abrasive wear performance of nanocrystalline cobalt-phosphorus systems; composite coatings will be created by novel in-situ particle formation and deposition of nanoparticles (Cirrus technology) and co-deposition of suspended particles; and 3) Evaluate suitable equipment to enable brush plating for specialized repair using the nanocomposite material system. An update on the achievements-to-date in the project will be presented. Current efforts are targeted at the scale-up and validation of the newly developed systems. Evaluation and validation testing performed to date includes: abrasive wear resistance sliding wear resistance coefficient of friction micro-hardness hydrogen embrittlement resistance ductility and corrosion performance (galvanic compatibility LPR and salt spray).

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POSTER #9

High-Performance Corrosion Inhibitors for Aerospace and Marine Aluminum Alloys

Jeannine Elliott, TDA Research Inc

The high performance required of military assets requires the use of strong lightweight alloys such as the AA2XXX and AA5XXX series of aluminum alloys. Alloying elements are added to the bulk aluminum to produce the alloys and the final properties are further modified by either mechanical work heat treatment or both. Some materials such as AA5083 and AA5456 (marine grade aluminum alloys) use an excess of magnesium to produce the desired mechanical properties while others such as Al2024 and AA7075 (aerospace aluminum alloys) use copper as a strengthening agent. It is the presence of these alloying agents that ultimately lead to corrosion that degrades the performance of the alloys.Corrosion of AA2024 and AA7075 alloys is driven by the reduction of oxygen at the copper nano-cathodes produced by the initial anodic dissolution of the intermetallics formed by the alloying process. Stopping the cathodic reduction of oxygen at the copper cathodes is the most efficient method for inhibiting the corrosion. For the AA5083 and AA5456 marine alloys there is a thermodynamic driving force to reduce the amount of magnesium in the alloys to below the solubility limit. Magnesium migrates to the grain boundaries and forms a magnesium aluminate whose electrochemical potential is anodic to the bulk aluminum phase. As the magnesium aluminate undergoes anodic dissolution defects appear that lead to cracking under stress (stress corrosion cracking). Stopping the anodic dissolution is the most efficient method for inhibiting corrosion of the AA5083 and AA5456 alloys.TDA Research Inc. has been developing novel corrosion inhibitors since 1995 to replace dichromates (and other hazardous materials). Using both experimental and computational tools we identified high-performance synergistic corrosion inhibitors. Using this novel inhibitor package we developed a chromate-free fuel tank coating with excellent performance on AA2024 and AA7075 alloys even with a nonchrome pretreatment. Our marine grade aluminum corrosion inhibitors have also been demonstrated to stop stress corrosion cracking on AA5456 and AA5083.

POSTER #10

MetlonÂ® Pearl Black - Environmentally Friendly Surface Modification to Blacken EN Coated Components for High Temperature Applications

Ameya M, Aztron Technologies

As the demand for electroless nickel (EN) coatings increase for its excellent wear hardness and corrosion resistance properties there has been a growing demand for its black aesthetics for various applications. Black being highly absorptive meets a variety of coating requirements for aerospace firearms military and defense optics solar panel etc. To meet these industry requirements with sustainable chemistries environmentally friendly water-based MetlonÂ® Pearl Black was developed to blacken EN coated components for high temperature applications. In this research properties such as surface morphology thickness wear / abrasion corrosion resistance and gloss were studied. It was found that MetlonÂ® Pearl Black maintained deep black finish with excellent wear and corrosion properties at >800ËšC while maintaining excellent coating uniformity over complex geometries.

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POSTER #11

Recycling and Reuse of Metal Alloys by a Single Solid-State Additive Manufacturing and Repair Process

Paul Allison, University of Alabama

A transformative hybrid solid-state high-shear additive manufacturing process MELD (AFS-Deposition) is proposed to recycle metal waste/scrap at a forward operating base (FOB) to either fabricate new or repair existing components. In this proposed work two specific metal waste streams from the deployed Military Occupational Specialty (MOS) units are identified (1) scrap metal from machine chips generated by maintenance-MOS activities and (2) expeditionary airfield (EAF) aluminum landing mats from EAF-MOS activities. These two waste streams generate chips and metal strips respectively that will be processed by MELD. Wherein the novel solid-state MELD process metals are deposited additively layer-by-layer through a hollow rotating tool. The proposed low-power approach incorporates the advantages of additive manufacturing and grain refining into a single process allowing fabrication of small and large parts can use a variety of metals in different forms does not require secondary processing or atmospheric controls has superior build rates yielding enhanced mechanical properties can be operated by a machine shop technician and is ISO container transportable. The process has been demonstrated with both powder and solid feedstock material. Very importantly for FOB use the MELD process does not require metal powders which can be difficult energy intensive or impractical to produce in theater. Aluminum alloys fabricated by the proposed MELD process to-date have produced full densities and refined grain structures.

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POSTER #12

Additive Repair by Cold Spray Deposition of Fastener Holes in High Strength Aluminum Alloys

Luke Brewer, University of Alabama

This presentation will discuss the use of cold spray deposition for additive repair of fastener holes in high strength aluminum alloys AA7075 and AA2024. Mechanical fasteners such as bolts and rivets can experience both crevice and galvanic corrosion of the aluminum plate material around the fastener. Cold spray deposition is being developed as a means for replacing this corroded material thus prolonging the life of the component. A fatigue lap shear test component was designed and fabricated to measure the fatigue behavior of pairs of plates fastened by a bolt. Material was systematically removed from one side of this component to simulate corrosion damage. Cold spray deposition was used to refill this material up to 60% of the plate thickness. These deposits were produced using the VRC Metal Systems generation III cold spray system and as-atomized AA7075 and AA2024 powders. Fatigue testing of repaired AA7075 and AA2024 plates showed excellent performance in low cycle fatigue. Repaired AA2024 also showed excellent performance under high cycle fatigue while repairs in AA7075 showed a slight reduction in high cycle fatigue life compared with non-repaired samples. The adhesion of the deposited repair material was consistently sound and none of the tested samples exhibited spallation of the repair deposits during fatigue and fracture. This data will be compared with free-standing cold spray fatigue data and with center-hole plate fatigue data.

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POSTER #13

Standardized Test Methodologies for Coating Durability

Karen Schultz, Boeing Research & Technology

Repair and replacement of exterior coating systems that no longer meet aesthetic or protective requirements generates a significant volume of environmentally hazardous waste. There are strong economic and environmental drivers to extend the service life of aerospace coatings. However development and use of the most durable coatings systems have often been limited by the ability to predict service performance in accelerated tests. Existing accelerated test techniques do not adequately employ the chemical thermal or mechanical stressors that produce relevant damage mechanisms such as cracking at structural discontinuities in coated airframes. Additionally single coating layers may be qualified individually rather than as part of a representative multilayer stack-up. As a result current test methods cannot be used for accurate quantification of coating performance and service life. In this work test methodologies that employ combined environmental and mechanical stressors are utilized to induce relevant failure modes of multilayer systems such as coating cracking at sealant-filled lap joints. The mechanisms and kinetics of damage progression are quantified throughout static and dynamic atmospheric tests using in situ measurements of coating system properties. It is observed that the coating barrier properties and resistance to cracking at a lap joint are dependent upon both the individual effects of strain temperature and humidity as well as the combined interactions of these stressors. For example coating cracking occurs more readily in dry conditions (25 Â°C / 30% RH) whereas crack propagation is slower in warm humid conditions (35 Â°C / 95% RH). Combined temperature humidity and mechanical cycling showed that visible cracks in the topcoat occur within 2000-3000 strain cycles while subsurface cracking was detected in underlying layers after only 1000-2000 cycles. Based on these observations test cycles are being refined to accelerate coating degradation processes that are relevant to service environments i.e. extreme temperatures at altitude dynamic flexing and acoustic vibrations in flight.

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POSTER #14

The Effect of Corrosion Inhibitors on Corrosion Fatigue under Complex Environmental Conditions

Sarah Galyon Dorman, SAFE Inc

Research shows that chromate can offer a large 10 fold reduction in corrosion fatigue crack growth rates when added to a bulk NaCl solution in high concentrations and can inhibit corrosion fatigue when added to a bulk NaCl solution in concentrations based on inhibitor leaching studies. However it remains unclear if chromate epoxy based and other polymeric inhibitor coatings can inhibit corrosion fatigue under atmospheric corrosion conditions. The protection provided by corrosion inhibitors under fatigue conditions can be affected by loading conditions (âˆ†K frequency) but it is also likely affected by the environment due to changes in inhibitor leaching. An improved understanding of how environment and loading parameters influence a coatingâ€™s ability to offer protection against corrosion fatigue damage would greatly help the coating community to design more robust coatings and better evaluate new coating protection systems. In work funded by the Office of Naval Research a corrosion fatigue test method to better replicate real world corrosion conditions is being developed. The method uses a relative humidity controlled salt film environment with ozone and UV-light in combination with fatigue loading. This method is being used to evaluate how epoxy chromate primers and chromate replacement coatings (solvent and water-borne rare earth primers and an aluminum rich primer) applied to a legacy aluminum alloy (7075-T651) perform under these simulated atmospheric corrosion conditions. The understanding of how these coatings protect against fatigue damage under these complex corrosion conditions can then be used to better inform the selection and design of chromate free corrosion prevention systems. As expected current findings show that each primer provides protection by different methods. The chromate primer is able to slow fatigue crack growth rates over long approximately 15 mm crack lengths. The rare earth primers are able to arrest crack growth in low stress intensity ranges (Î”K=4MPaâˆšm). The aluminum rich primer protects the fatigue fracture surface from environmental attack.

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POSTER #15

Characterization of Corrosion at the Aluminum and Paint Interface Using ToF-SIMS and SEM

Xiao-Ying Yu, Pacific Northwest National Laboratory

Corrosion on equipment and infrastructure adds a multibillion cost to many industries each year. For example it comprises approximately 25% of all maintenance costs and nearly $20 billion annually in the Department of Defense. Paint coating is the most common means for corrosion prevention. Illustration of the corrosion process at the interface between metal and paint coating helps visualization of the process. However it is challenging to map the trace amount inhibitor metal (i.e. Cr) distribution as well as interesting organic molecules mixed in aluminum at the metal-paint coating interface. Time-of-flight secondary ion mass spectrometry (ToF-SIMS) is a powerful surface tool with submicron spatial resolution and high mass accuracy. It was used to demonstrate characterization of the metal-paint coating interface in corrosion in this work. A thin aluminum (Al 7075) metal coated with a commercial protective paint was used to make the corrosion interface. The Al sample was fixed in resin and the cross-sections were polished prior to any treatment. The surface of the painted Al pieces was scratched to expose the unprotected metal to perturbing conditions including acidic alkaline and high salt conditions simulating sea water in the latter case. Samples treated for approximately three weeks were analyzed to show corrosion effects. The cross section of the Al-paint surface was cut and secured in resin prior to optical ToF-SIMS and SEM analysis. Optical microscope was used to survey the morphological and shape changes at corrosion sites. ToF-SIMS was used to chemically (i.e. elemental isotopic and molecular) image the cross-sections and visualize trace metal and organic distribution around the Al-paint interface. Furthermore scanning electron microscope (SEM) was used to acquire highly magnified images of elemental distribution resulting from corrosion complementing SIMS imaging. These new results demonstrate the potential to study corrosion surface sites and the corrosion development process using sensitive imaging mass spectrometry coupled with SEM. It is anticipated that such observations would provide valuable physical measurements at the submicrometer scale to facilitate mechanistic model development in the future.

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POSTER #16

The Assessment of Low Hazard Chemicals to Replace Hexavalent Chromate Conversion Coatings for Passivating Aluminium Alloys

Martyn Staff, AWE

The assessment of low hazard chemicals to replace hexavalent chromate conversion coatings for passivating aluminium alloys;Chromate conversion coatings are commonly used for passivation and corrosion protection of aluminium alloys. However this processes requires the use of hexavalent chromium (Cr(VI)) containing substances which are being phased out by European Unionâ€™s REACH (Registration Evaluation Authorisation and restriction of Chemicals) regulations as they are carcinogenic and mutagenic. To comply with the REACH Authorisation AWE is assessing alternative REACH compliant chemicals and technologies for eventual implementation. A total of six aluminium alloys (i.e. Al 2024 Alâ€¯5082 Al 5251 Al 6062 Alâ€¯6081 and Al 7075) were treated with five REACH compliant conversion coatings (i.e.â€¯Iriditeâ€¯NCP SurTec650 Chemeon TCP-HF Gardobond C4749 Oxsilan MGâ€¯0611). The samples were subsequently salt spray tested in accordance with BSâ€¯ENâ€¯60068-2-11-1999; samples failed the salt spray test if there were more than 5â€¯corroding points with a diameter greater than 0.8â€¯mm not including areas up to 6â€¯mm from the edge of the sample. All uncoated aluminium alloys failed a salt spray test following a 168â€¯hour exposure thus confirming the requirement for coating. SurTec650 was the conversion coating that showed the most promise as five aluminium alloys (Alâ€¯2024 Alâ€¯5082 Al 5251 Alâ€¯6062 Al 6081) passed the salt spray test; SurTec650 and Alocromâ€¯1200 a popular hexavalent chromium conversion coating produced a similar quality coating based on the minimal levels of corrosion following the salt spray tests. SurTec650 additionally benefits from having no associated hazard statements. Further work will focus on optimising the application of SurTec650 onto aluminium alloys to form consistent coatings. Â©British Crown Owned Copyright 2018/AWE

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POSTER #17

Nanofiber Based Energy Efficient Paint Over Spray Air Filtration

Jayesh Doshi, eSpin Technologies, Inc.

Many of the Department of Defense high value assets are protected using corrosion resistant coatings. Surface treatment such as sanding, grinding, plasma cutting of the surfaces prior to coating generates fine dust that contains chromates, cadmium, and other chemicals that are environmentally hazardous. Additional hazards arises during coating and painting processes when large quantity of fine aerosolized primer (i.e., overspray) particles containing these hazardous compounds are not collected from the air stream. This poster presents approach to mitigating these hazardous particulate matter using energy efficient reactive air filtration.

POSTER #18

Launching over the Valley of Death into Space Applications - Enbio's CoBlast SolarBlack Coating

Dayna Lamb, Enbio

The poster will introduce Enbioâ€™s novel green ambient temperature ambient pressure blast coating technology CoBlast. This innovative process uses conventional grit/micro-blasting equipment to remove a metalâ€™s natural oxide layer and replace it with a desired functional coating. The unique simultaneous removal of the oxide layer roughening of the metalâ€™s surface and application of the coating in one step ensures a robust environmentally friendly coating. CoBlast can be used for various applications including corrosion inhibition adhesion priming thermal control and mould release. We will highlight a case study for the thermal control application for European Space Agency where CoBlast's SolarBlack coating went from concept to flight hardware production in less than 3 years perhaps record time for implementation of a new green technology.

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POSTER #19

Environmentally-Preferred and Improved (Rapid) Laser Coating Removal Process for the Safe Removal of Coatings from Composite Substrates

Jesse Holdaway, USAF

Laser coating removal of coatings is an environmentally-friendly process that utilizes no hazardous solvent chemicals nor blast media. This process eliminates the exposure of workers to hazardous work environments hazardous chemicals and gets the workers to out of heavy and bulky personal protective equipment. The Air Force Life Cycle Management Center Product Support Division (AFLCMC/EZP) is dedicated to advance and implement laser technology for depaint operations across entire Air Force fleet. The objective of this project is to validate/qualify a new commercially available nano-pulsed 1 kW fiber laser system on metallic skins and advanced composites coated with traditional and non-traditional military paint systems. The outcome of the qualification will be to implement the new qualified nano-pulsed laser system in a full production robotic laser coating removal system. Current efforts performed to-date were focused on optimization tests for coatings removal on aluminum substrates to specify optimized process parameters for a 1 kW NPF laser for later use in qualification testing. Process parameters optimization for 1 kW pulsed Ytterbium Fiber laser system with polygon scanner was completed on coupons coated with standard MIL-PRF-23377 primer and MIL-PRF-85285 top coat. Testing results demonstrated that maximum substrate temperatures were well below the allowable substrate temperature (250F) for all test configurations. Process parameters were established for the highest coating removal efficiencies. However lab setup and optimization testing performed revealed issues with the size of the polygon scanner and the closed loop efforts were insufficient and not production representative. Advances in galvo-scanner technology have enabled use of a smaller galvo-scanner to achieve the desired results. The future efforts will focus on a galvanometer-based scanner that has already been proven in the field. Testing will be based on the lessons learned from the optimization performed with the polygon scanner. The full-scale automation approach will be utilized to deliver the process to the full outer mold line depaint of the aircraft with extreme precision.

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POSTER #20

Plasma Electrolytic Depaint Process: Environmentally Friendly Paint Removal from Military Components

Mike Froning, AFLCMC/EZP

IBC Materials & Technologies in Lebanon Indiana has developed a Plasma Electrolytic De-Painting process (PEDP) for removing polymer coatings from military components without use of hazardous chemical strippers. PEDP is conducted by immersing the part in a weak non-hazardous water-based electrolyte and applying a high energy electrical potential. During the process intense plasma is created on the surface of the painted part. Careful control of this plasma electrolytic process results in the removal of epoxy and polyurethane-based paint from the part within fifteen minutes leaving the underlying anodized layer intact. No special pre-treatment of the part is required aside from some basic cleaning. Additionally the electrolyte solution can be reused after filtration eliminating hazardous waste disposal.Microstructural analysis of samples treated by the PEDP process confirmed the epoxy primer and polyurethane-based paint were completely removed and the anodized substrate layer was still intact. Topcoat and primer fragments removed by the process were analyzed with a scanning electron microscope. Energy dispersive spectroscopy (SEM-EDS) and X-ray diffraction spectroscopy on the paint fragments also confirmed that anodized aluminum was not removed during the process.

POSTER #21

A Laser-based Surface Treatment of Aluminum Alloys for Enhanced Coating Adhesion

Adrian Sabau, Oak Ridge

The maintenance of aluminum-skinned aircraft requires periodical coating applications. Aluminum surfaces contain native oxides and lubricant oils which are residual from their forming/molding operations but are detrimental to coating application. Surface treatments prior to application of coating systems aim to modify the Al surface to attain contaminant removal wettability with primer and highly roughened surfaces. To date the aluminum-skinned aircraft surface preparation techniques include two multi-step and complex processes: chemical conversion coated or anodization. Chemical conversion coatings usually employ chromate solutions often hexavalent chrome (type I) and are highly toxic. Anodization processes are electrochemical processes very expensive to maintain and operate. Recently a high-productivity laser-interference technique was used at ORNL for structuring Al alloy surfaces with fine feature sizes: 1Î¼m dia <500 nm depth. This technique was based on harnessing the inherent constructive and destructive interference from two-or-more laser coherent beams to create a periodical structuring pattern that results in making 200 to 20000 ridges (pits wells) at once i.e. per laser spot on the surface. Results are presented on surface chemistry and wetting behavior for the laser-interference structuring of as-received Al 2024-T3. The results were obtained using electron energy dispersive spectroscopy (EDS) contact angle measurements and profilometry measurements. The data shows that the laser-interference technique has the potential to alter significantly not only the topology of the surface but also its chemical composition. In addition the laser-interference technique is shown to â€œsmooth-outâ€ all the sharp features from a rolling surface minimizing surface defects. This is in sharp contrast with micro-cracking on aluminum alloy surfaces typically seen around melt cavities produced with traditional one-beam laser surface structuring. The proposed single-step and non-chemical laser-interference processing has the potential to drastically reduce the environmental impact of chemical surface treatments used in the manufacture and maintenance of DoD weapons systems.

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POSTER #22

Isocyanate-Free High-Performance Topcoats for DoD Aircraft and Ground Support Equipment

Erick Iezzi, U.S. Naval Research Laboratory

The U.S. Naval Research Laboratory (NRL) has recently developed single- (1K) and two-component (2K) polysiloxane topcoats as replacements for the 2K polyurethanes used on the exterior of DoD aircraft and aerospace ground support equipment. The 1K polysiloxane topcoat is based on an alkoxysilane-terminated N-substituted polyurea polymer whereas the 2K polysiloxane topcoat is based on amine-functional polysiloxane polymers and epoxy-functional oligomers. These topcoats demonstrate similar mechanical properties chemical resistance and exterior weatherability compared to qualified polyurethanes yet do not containing harmful isocyanates or hazardous air polluting solvents (HAPs). The development of a 1K topcoat also provides a user-friendly system for applicators by alleviating metering and mixing of components. This poster will present results on the polysiloxane topcoats when tested to Navy and Air Force aircraft topcoat performance specifications spray applications at depots and field demonstrations on DoD assets. This program is currently sponsored by ESTCP (WP-201506).

POSTER #23

Multi-functional Hybrid Low-profile Coatings for Light Metal Substrates

Glen Slater, Cirrus Materials Science Ltd

This poster explains the innovative Cirrus Hybridâ„¢ technology and updates the widening scope of application for this innovative coating. Cirrus Hybridâ„¢ is a hard wearing thin coating for light metal substrates that is time and energy efficient to apply and can be tuned for wide variety of applications and performance needs. This poster will set out the fundamental design techniques underlying application of this new coating technology; and showcase some of the many tunable and functional performance features it has to offer. These features are created by designed interactions during formation of the unique anodised / electro-plated sub-structure which can be tuned to produce coatings that are variously highly conductive or completely insulating; reflective or highly absorptive of light (IR through to vis); soft to the touch and oleophobic or hard-wearing with a low co-efficient of friction. We will also include the most recent data on Hybridâ„¢ electro-plated â€œshark-skinâ€ drag reducing coatings for light metals.

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POSTER #24

Repair and Touch Up Solutions

Keith Cox, Sherwin Williams

Corrosion continues to be a major cost to the US DOD. Minimizing corrosion in the field and performing successful repairs at maintenance facilities are two opportunities to combat corrosion and have a positive impact on the costs associated. Due to the special characteristics of CARC, it is mandatory that these coatings are repaired with US Army approved coatings including touch up products. We intend to highlight some unique, Army approved touch up solutions that will offer the applicator repair materials that are easy to use, providing a successful repair while creating minimal waste.

POSTER #25

Enhanced Trivalent Chromium Process Coatings for Light Metals

Catherine Munson, CHEMEON Surface Technology

Catherine Munson Ph.D. and Sjon Westre Ph.D. CHEMEON Surface Technology, Peter Sheridan Fleet Readiness Center South East United States Navy; Trivalent chromium process coatings (TCP) have become the default replacement for hexavalent (hex) chromium conversion coatings on aluminum alloys. A large roadblock in implementing TCP as drop-in replacement for hex chrome is the lack of easily identifiable coating on parts. Current hexavalent chrome coatings have an obvious yellow color change on aluminum parts while the TCP color change is a transparent green/blue tint and difficult to identify. New patent-pending enhanced-TCP (eTCP) conversion coatings are being developed through a cooperative research and development agreement (CRADA) between CHEMEON Surface Technology and the Fleet Readiness Center Southeast (FRCSE) in Jacksonville Florida (NESDI Project #514). The new eTCP coatings are presented and current performance test results are reviewed. Two formulations are currently available eTCP-Blue and eTCP-Violet. Both eTCP coatings provide more than 1000 hours of neutral salt spray corrosion resistance and passing paint adhesion tests (per ASTM B117 MIL-DTL-5541 and MIL-DTL-81706) while producing visually distinct and readily identified blue and purple coatings. Beach front testing at NASA with the eTCP-Violet began April 2018 with panels showing no corrosion after 3 months. These eTCP coatings will provide the easily visualized color change necessary to implement TCP as a drop-in replacement for hexavalent chrome conversion coatings on aluminum aluminum alloys and other light metals.

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POSTER #26

Wear Performance of REACH Compliant Trivalent Chromium Plating Process

EJ Taylor, Faraday Technology Inc.

Faraday will discuss recent research work on the development of a fully REACH compliant trivalent chromium plating process to replace hard hexavalent chromium plating. Hexavalent chromium plating has been used for many years to provide hard durable coatings with excellent wear and corrosion resistance properties. However hexavalent chromium baths have come under increasing scrutiny due to the toxic nature of the bath effects on the environment and workersâ€™ health. In this paper Faraday will present results from its development programs and discuss the similarities between chrome deposits from the REACH compliant and hexavalent chemistries. Specifically Faraday will discuss the effect of processing conditions on wear resistance as well as other functional properties and the potential for a hexavalent chromium free plating shop.

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POSTER #27

Aluminum Electroplating using Ionic Liquids

Weina Li, United Technologies Research Center

Aluminum (Al) electroplating from ionic liquids (ILs) has attracted both scientific and technological interest because it provides an eco-friendly and drop-in replacement of cadmium (Cd) as a corrosion protection coating. Considerable effort has been made to advance this ionic liquid-based Al plating process as a competitive commercial Al deposition technology. However industrial adoption of Al electroplating in ILs has been impeded due to the nature of water- and air-sensitivity of chloroaluminate ILs. Because of the latter new technology barriers are introduced into the critical electroplating steps including sample pretreatment electroplating and post-treatment compared to traditional aqueous electroplating. In this project the team focuses on the advancement and maturation of Al ILs electroplating technology by addressing these issues. Effects of various electroplating parameters such as IL compositions substrate pretreatment alloys and post-treatment on coating performance are carefully investigated. Techniques for maintaining and prolonging ILs bath lifetime are studied as well.