Surface Engineering - Applied Research and Industrial Applications
Room On Demand - Session G6

Application-Driven Cooperations between Industry and Research Institutions

G6-1 Hard Protective Coatings Inside Narrow Tubes and Cavities in Aircraft Engine Components, *J. Crespo Villegas, A. Kilicaslan, O. Zabeida, E. Bousser,* Polytechnique Montreal, Canada; ***Jolanta-Ewa Klemberg-Sapieha (jsapieha@polymtl.ca)***, Polytechnique Montrtreal, Canada; *L. Martinu,* Polytechnique Montreal, Canada

There is an ever-growing interest in the use of functional coatings to protect surfaces of materials and workpieces against harsh environments such as corrosion, abrasion or solid particle erosion (SPE), making surface engineering solutions a very attractive balance between performance and cost. Numerous vapor-based fabrication techniques have been developed, namely PVD, CVD, and PECVD, that can be used to achieve the high hardness and high wear resistance while being compatible with substrate materials such as metals, and different substrate shapes. This is increasingly important in the case of inner surfaces of tubular components, such as parts of aircraft engines, oil pipelines, mining components, and numerous others.

In the present work, we study a novel Non-Line-Of-Sight (NLOS) technique to coat the inner parts of non-linear surfaces and cavities with hard, wear- and erosion-resistant coatings possessing high SPE resistance, a hardness significantly higher than the hardness of the particles impacting the surface, as well as a large thickness (more than 8 µm).

Specifically, we review, study and demonstrate the fabrication process of hard SPE-resistant TiN protective coatings on the inner surfaces of narrow tubes using an NLOS approach yielding a uniform film thickness and properties along the tube axis (better than 20%). The deposition process indicates the importance of applying pulsed-DC PECVD when uniform hard TiN films are prepared at low-frequency in the kHz range. The TiN films (about 12 µm thick), exhibit high hardness and relatively low Young's modulus (25 and 225 GPa, respectively), corresponding to the (111) preferred crystallographic orientation. We show that the SPE resistance on the inner surface decreased by a factor of more than 15 compared to the bare substrate and that the process is well suited for the protection of aerospace, manufacturing, 3D printed and other critical components with a complex shape of inner surfaces.

G6-2 Prediction of Loss of Barrier Properties in Cracked Thin Coatings on Polymer Substrates Subjected to Tensile Strain, ***Marcus Vinícius Tavares da Costa (marcus.tavares@angstrom.uu.se)***, *E. Gamstedt,* Uppsala University, Angstrom Laboratory, Sweden

The layered structure of carton containers for food and beverage packaging is one of the most widely used products in our daily life which allows the transportations while keeping the food protected. This design has been around for decades, but more sustainable solutions are needed to replace aluminium barrier layers with thinner and more environmentally friendly coatings. Recent developments in thin film deposition over large areas of polymer substrate have sparked the interest of food packaging producers in thin brittle coatings of nanometre thick of various compositions in the package structure. Such coatings can be impermeable and therefore enhance the barrier properties of the packages as a whole [1]. However, when these coatings are implemented in the manufacture process, cracking in the coating is almost inevitable since the package materials are deformed in the converting process, and hence the barrier properties are impaired. A mechanism-based model to predict the loss of barrier properties during deformation in the manufacturing process could potentially serve as a tool in developing improved packaging.

In this presentation, we will tackle this question by showing how the fracture behaviour of coatings on polymers substrates is affected by uniaxial tensile deformation, and subsequently how a key barrier property for beverage packaging, namely the oxygen transmission rate (OTR), is affected by the fractured coating. This is done quantitatively by numerical modelling. The modelling is dependent on reliable experimental characterization published previously [2, 3]. The specimens for this study case were produced by roll-to-roll atomic layer deposition of metal oxides, with thickness values between 4 and 20 nanometers on poly(ethylene terephthalate) substrate films. The advantages and disadvantages of the model will be addressed, as well as its accuracy.

References

[1]P. Fayet, C. Neagu, K. Gamstedt, Mechanics-driven material design for optimized barrier films, Proceedings of the AIMCAL Web Coating and Handling Conference, Naples, USA, 2015.

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G6-3 PALMS - Plasma Additive Layer Manufacture Smoothing, ***Tomasz Brzezinka (tomasz.brzezinka@wallworkht.com)***, *J. Housden, A. Fox,* Wallwork Cambridge Ltd, UK; *N. Laugel, A. Matthews, A. Yerokhin,* The University of Manchester, UK

Additive manufacturing (AM) offers unprecedented design freedom and the possibility to produce lightweight optimised components that are impossible to make with traditional techniques. Despite the significant progress made in AM, the surface roughness of parts produced by this method remains a significant hindrance to more wide-spread industrial use. The aerospace and medical industries, where the surface finish of components is highly critical, are particularly attentive to the issue. We have developed PALMS (Plasma Additive Layer Manufacture Smoothing), an innovative cost-effective macro-polishing solution based on electrolytic plasma technology. The use of electrolytic plasma polishing, with its fast and uniform material removal, makes for a particularly effective method of finishing components. The method is moreover largely unaffected by complex geometries, a key advantage for an AM finishing method. AM parts are treated in less than 90 minutes with highly reproducible resulting surface states, leaving a uniform, smooth micro-finish (R_a<0.1µm), and considerably improved aesthetics and mechanical performance.

This collaboration, involving multiple industrial partners within the framework of the PALMS project and coordinated by Wallwork with academic support from the University of Manchester, recently led to a published account of some of the development achieved (Yang et al. Additive Manufacturing 2020, vol. 34 p. 101204). Strategies for successful PALMS application to further case studies, such as hot stamping tools or AM demonstrators will be discussed here, and the resulting surface performance presented.

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