Topical Symposia
Room Sunrise - Session TS3
Coating of Synthetic Materials – Engineering for the Future
Moderators: Klaus Böbel, Bosch GmbH, Fred Fietzke, Fraunhofer FEP

8:00am **TS3-1 Development of PVD Coatings by R2R on Basis of TI/AG, TI/ZN and TI/AG/ZN on Textile Fabrics**, ***Martin Fenker,*** *H Kappl,* FEM Forschungsinstitut Edelmetalle & Metallchemie, Germany

Silver and zinc coatings are interesting materials in the biomedical field as they possess antimicrobial properties. Therefore, PVD coatings on the basis of Ti/Ag, Ti/Zn and Ti/Ag/Zn have been deposited by non-reactive DC magnetron sputtering on textile fabrics like polypropylene (PP), polyvinylidene fluoride (PVDF) et cetera. These polymers are used for example as implant material or for wound bandage. A roll-to-roll (R2R) unit was constructed and installed in our semi-industrial PVD machine and tests have been performed with elemental targets as well as with compound targets. Coating thickness was measured on coated glass samples. Ageing test were performed by ultrasonic agitation of the coated fabrics. Light optical microscopy and scanning electron microscopy were used for visual inspection of the as-deposited as well as the sonicated samples. Delamination of the coating occurred for some samples and will be discussed.

8:20am **TS3-2 Coating of Plastic Components by Electron-beam Evaporation**, ***Fred Fietzke,*** *H Klostermann, J Heinß,* Fraunhofer FEP, Germany

Vacuum coating of plastic components as an alternative to electroplating already has a long tradition in industrial practice. The applications range from metallization of headlamp reflectors over decorative controls and instruments up to EMC shielding of electronic devices. Predominantly used methods are magnetron sputtering and thermal evaporation.

A particular challenge is the low thermal stability of many engineering plastics in conjunction with the high energy input of PVD processes and the limited possibilities of substrate cooling in vacuum. Furthermore, for most plastics a sufficient adhesion of PVD coatings directly on the substrate material still cannot be achieved, so that primers or lacquers have to be used as sublayers.

A new approach for PVD direct metallization is taken by Fraunhofer FEP. Here, a short-cycle system for the coating of components by high-rate electron beam evaporation is used to coat components made of polycarbonate (PC) and PC/ABS (acrylonitrile butadiene styrene copolymer) blend. After a short treatment in oxygen plasma the parts are coated with an aluminum layer of some microns thickness in less than one minute, without showing thermal deformations or film delamination.

The key to meet these challenges lies in a high evaporation rate already at low power input in combination with a substrate movement adapted to the component geometry. Possibilities and limitations of the method are explained, properties of coated parts are analyzed in comparison with the current state of the art, and further possible applications are discussed.

8:40am **TS3-3 Aspects of Coatings on Plastic products for Decorative and automotive parts.**, ***Roel Tietema,*** IHI Hauzer Techno Coating BV, Netherlands; *D Doerwald, C Trivedi, I Kolev, J Landsbergen,* IHI Hauzer Techno Coating B.V., Netherlands **INVITED**

Plastic products are playing an ever bigger role in our daily life and they draw more and more attention of the market. Reasons for this trend are low cost, ease of producibility, large freedom of design and low weight.

Coatings on plastic products have mainly been produced by electroplating and lacquers.

Since the 1980's PVD coatings have been used for decorative applications in the watch industry. Nowadays decorative coatings are applied on watches, faucets, door handles, spectacles (both frames and glasses) and mobile phones.

In recent years a new market has emerged for PVD-coatings on plastics driven by the requirement to reduce weight. This occurs because on one side the expectations of a growing market share for electrical cars exists as well as on the other side CO_2 emissions and fuel consumption can be reduced by weight reduction. The consequence is that the use of plastics in the automotive industry as light weight base material for both interior and exterior parts will have an increasing share. Until now electroplating is the major applied technology, but PVD will get an increasing share in this market due to the requirement for replacement of electroplated chromium. Electroplating is a technology requiring the use of carcinogenic hexavalent chromium (in form of trichromate) during several steps of the plating process. This material is on the list of SVHC's (Substances of Very High Concern) and imposes severe health dangers on personnel working with the plating lines. Besides this plating technology requires intensive efforts to dispose waste materials.

As replacement for electroplating in-line processes where plastic parts are coated with UV-cured lacquer and a subsequent chromium PVD layer have been developed and are available on the market. Mass production for automotive plastic products is already applied.

In this presentation the developments will be discussed beginning from initial applications on watches and faucets by sputter and arc technology in the 1990's. In the early 2000's coatings have been introduced on mobile phones, whereas finally in the last decade the application of coatings on plastic parts by hybrid lacquer/PVD-PECVD processes have been developed.

Different aspects of the requirements for coated products and the related processes will be discussed from the point of view of technologies, productivity, performance and sustainability.

9:20am **TS3-5 Combined Impact and Sliding Testing for Evaluation of Surfaces on Different Materials**, ***Claus Rebholz,*** University of Cyprus, Cyprus **INVITED**

Light-weight materials such as polymers and magnesium alloys exhibit tremendous challenges for surface engineering, not only in terms of selecting appropriate coating architectures and processes, and therefore reducing or avoiding issues that can result in premature coating failure at relatively low stress levels compared to more rigid substrates, but also for the development of sophisticated testing methods for quality evaluation and inspection.

Several well established testing methods (e.g. impact, pin-on-disk, scratch) have been widely used to evaluate the properties of coatings on various substrates. However, many of these existing techniques have limitations, since they mainly focus on a single mode of loading and wear (e.g. only impact or sliding). Here, a combined impact and sliding test for the tribo-mechanical evaluation of surfaces under complex loading conditions is presented, where materials are simultaneously subjected to sliding and impact loading. Such modes exist in many critical applications, from biomedical (e.g. hip/knee implants) to automotive applications (e.g. diesel injectors, engine valves, cam shafts), in cutting tools, general machine parts and systems, etc. The proposed testing set-up offers a feasible way for fast, economical and reliable evaluation of complex coating/tribo systems. Benefits include the time and cost effective evaluation of various surfaces (testing time usually less than a minute) and the better understanding of their properties such multi-mode loading conditions. Some of the unique characteristics of this new instrument (e.g. combined impact and sliding, wear area in a single small "point", etc.) are discussed and examples of evaluated metallic bulk materials/coatings are presented.

10:00am **TS3-7 Interfacial Stability of the Aluminium-Polyimide Interface Against Thermal Treatments**, ***Barbara Putz,*** Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, Austria; *G Milassin, Y Butenko,* European Space Research and Technology Centre, Netherlands; *B Völker, C Gammer,* Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, Austria; *C Semprimoschnig,* European Space Research and Technology Centre, Netherlands; *M Cordill,* Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, Monanuniversität Leoben, Austria

Metal-polymer systems are usable for innovative high-tech applications, including flexible and rigid microelectronics or spacecraft and satellite insulation. The metal-polymer interfaces, which have to bridge the distinct physical and chemical properties of the adjacent materials, are critical elements determining the overall reliability of the composite. A thorough understanding of the thermal stability of these interfaces is essential for reliable devices, considering the inevitable thermal treatments such as annealing or cycling which typically occur during manufacturing or operation. Considering the low homologous temperature of polymers combined with the difference in thermal expansion coefficients (factor 2-3) between the two components thermal treatments are likely to cause interfacial degradation and need to be critically investigated. In this study the interfacial stability of Aluminum-Polyimide (Al-PI), used as multilayer insulation blankets on satellites, is investigated as a function of thermal cycling (±150°C) and thermal annealing treatments (150-300°C). Mechanical adhesion measurements are combined with X-ray photoelectron spectroscopy (XPS) and transmission electron microscopy

(TEM) in order to relate the interface strength to the interface chemistry and structure. The interfacial adhesion energy was measured using tensile induced delamination. In order to assess the chemistry of the interface, a 180° peel test was used to provide access to the metal side and the polymer side of the interface without additional etching or sputtering steps that would alter the interface chemistry. XPS survey and high resolution core level scans were recorded on both sides of the peeled interfaces to identify and understand relevant interfacial bonding and distinguish between adhesive failure of the interface and cohesive failure in the substrate during peeling. TEM cross-sections were used to examine the interface microstructure and morphology. It was determined that the Al-PI interface, which initially shows very good adhesion, is resistant to thermal cycling of +/-150°C up to 200 thermal cycles. After thermal annealing, however, small mutations in the interface chemistry and structure were detected and identified starting at 225°C. Mutations were invisible to mechanical adhesion measurements and include the thickness increase of an amorphous interlayer between Al and PI of about 2nm and a change in the failure mechanism during the peeling. Being able to trace and identify subcritical mutations with the presented experimental approach before they become fatal is essential to predict the reliability and improve the design of metal-polymer composites.

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