Deposition of functional thin films for corrosion resistance applications and adhesion promotion using Atmospheric plasma processes.

Hisanori Miyoshi[1] , Dhia Bensalem[2] and Magnus Buske[2]

[1] *Nihon Plasmatreat Inc., Tokyo, Japan*
[2] *Plasmatreat GmbH, Steinhagen, Germany*

Abstract: The influence of deposition parameters on the anticorrosion properties of plasma polymerized SiOx thin films on Aluminium surfaces is reported in this study. Influence of the thin film thickness characterized by ellipsometry and film composition characterized by attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR) will be discussed. Using ellipsometry characterization and with a silicon dioxide model approximation, the film thickness on Si wafer was estimated at 400 nm and coated aluminium samples were able to withstand up to 720 hours in salt spray chamber environment. Moreover, an overview of actual challenges and a presentation of different application of plasma deposited coatings for anticorrosion and adhesion promotion as alternative environmental friendly process for the industry will also be presented.

Keywords: Atmospheric pressure plasma, thin film deposition, industrial applications, adhesion promotion coatings, anticorrosion coatings.

1. General

To reduce Volatile Organic Compounds (VOC) emission coming from solvent cleaning and chemical primer application prior bonding, atmospheric plasma processes have been more and more considered in the industry and identified as environmental friendly processes able to remove organic contaminations and at the same time increase the surface energy of the treated surface.

Moreover, atmospheric plasma processes can also be considered to deposit functional coatings such as barrier coatings, adhesion promoter and anticorrosion layers [1,2]. To improve the coating performance and consider them for industrial application it is necessary to understand the influence of deposition parameters on the coating composition and at the same time the thickness of the films deposited.

In this work, both plasma processes e.g. atmospheric pressure plasma treatment and atmospheric plasma thin film deposition will be presented in order to define and optimize the treatment conditions.

First part of the work will be focused on plasma treatment of the aluminium surface prior coating. Using contact angle measurements characterization and also fluorescence measurement, it is possible to evaluate the surface energy before and after plasmatreatment and also ensure that the contaminations are removed from the metal surface.

Second part of the work will present the deposition of plasma thin films using different silicon based precursors in combination with organic precursors [3]. Influence of plasma parameters such as ionization gas, ionization gas flow, plasma power and and more especially precursor flow and deposition parameters will be highlighted to define the optimized parameters.

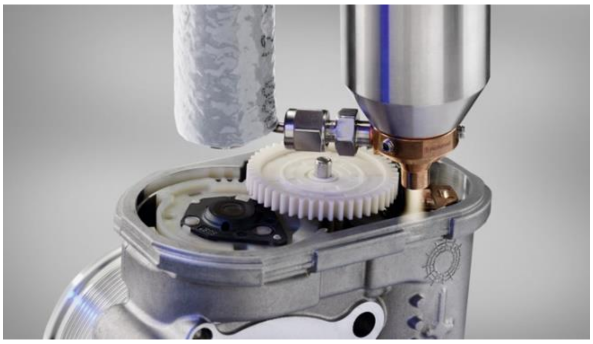

Figure 1: Atmospheric pressure plasma deposition of SiOx coatings on Aluminium samples for corrosion protection

The thickness of plasma deposited film will be characterized by ellipsometry and SEM as presented in the Figure 2. Homogeneity of the layer will characterized and associated to the deposition parameters.

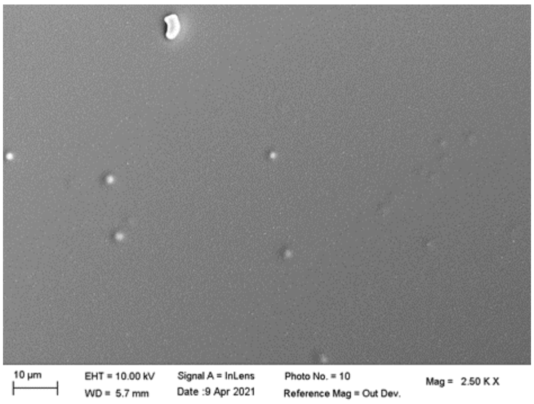

Figure 2 : SEM characterization of plasma deposited coatings with 25 g/h (Top View)

Moreover, the film composition characterized by attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR) as presented in Figure 3 will be also be studied in order to understand the influence of the deposition parameters on the anticorrosion properties.

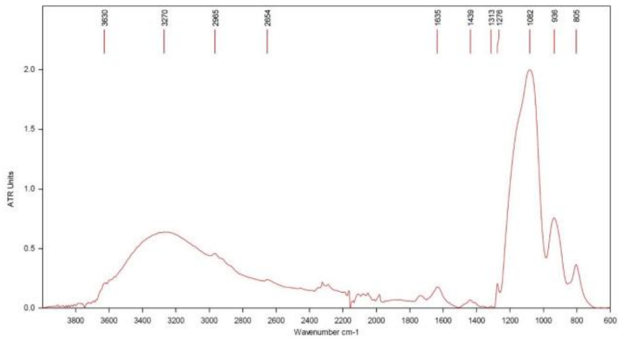

Figure 3 ATR-FTIR Spectrum of plasma deposided film at atmospheric pressure

Adhesion promotion and sealing properties of plasma deposited coatings will also be presented in order to promote plasma deposition as alternative environmentally friendly process.

As highlighted by Wulf et al [3], the introduction of limonene in addition to the Hexamethyldisiloxane precursor during plasma deposition has lead to clear modification of the plasma deposited layer with a modification of the SiOSi bands and the introduction.

In this work, an investigation of different type of precursors will be presented and compared with the SiOx layers for anticorrosion and bonding properties. According to the results obtained, the precursor fragmentation, the environment surrounding the plasma discharge and the deposition parameters play a significant role in the atmospheric pressure plasma deposition.

Previous study published by Hegemann et al [4] dedicated to the dielectric barrier discharge and the plasma polymerization and deposition of HMDSO has defined basic principles relating energy from the plasma, collisions, energy transfer and the conversion from monomer to dense plasma polymerized thin film.

The understanding of the mechanisms involved during precursor fragmentation and the control of the functional groups as well as the film composition deposited on the surface will contribute to the development of the atmospheric pressure plasma enhanced chemical vapor deposition using plasma jets as a reliable cost-effective and environmentally friendly solution for the industry.

2. References

[1] J.Pulpytel, V. Kumar, P.Peng, V. Micheli, N. Laidani, F. Arefi-Khonsari, Plasma Process. Polym. **2011**, 8, 664–675.

[2]A. Fahmy, M. El Sabbagh, M. Bedair, A. Gangan, M. El-Sabbah, S. M. El-Bahy & J. F. Friedrich , Journal of Adhesion Science and Technology, 35:16, 1734-1751, **2021.**

[3] G. Wulf, B. Mayer, U. Lommatzsch**,** Plasma **2022**, 5, 44–59.

[4] D. Hegemann, E. Bülbül, B. Hanselmann, U. Schütz, M. Amberg, S. Gaiser, Plasma Process and Polymer, Volume 18, Issue2, **2021**