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Evaluation of Corrosion Resistance of Diamond-Like Carbon Films Deposited on AISI 4340 Steel

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Abstract – The corrosion resistance of amorphous diamond-like carbon (DLC) coatings deposited via rf-PECVD on AISI 4340 substrate is evaluated in saline atmosphere (5% NaCl). DLC coatings effectively protect the substrate until 48 hours in salt fog chamber. For up to 168 hours, the corrosion is restricted to small pits. Under the same conditions TiN coatings did not protect the substrate even for 2 hours of exposure. Microscopic analysis showed that porosity of coatings plays an important role in the corrosion protection.

Amorphous diamond-like carbon (DLC) coatings are currently under intensive research in various fields of engineering due to its versatility and the outstanding properties that can be obtained. High modulus of elasticity and hardness, wear resistance, biocompatibility and chemical stability are some examples.

In the present work the corrosion resistance of DLC films deposited by rf-PECVD (radio frequency plasma enhanced chemical vapor deposition) from pure methane onto high-strength steel AISI 4340 substrates is evaluated. Samples were polished, cleaned and submitted to argon plasma cleaning before deposition. A thin amorphous silicon layer was deposited in order to obtain good adhesion. DLC films are about 2 – 3 microns thick. The samples were subjected to the corrosive atmosphere of ASTM B117 salt fog test in comparison to uncoated substrates and samples coated with titanium nitride (TiN). Samples were removed after 2, 6, 24, 36, 48, 72, 120, and 168 hs in order to be observed. The corrosion resistance of the three types of samples was evaluated by optical microscopy, scanning electron microscopy (SEM-EDS) and contact profilometry.

The results show that DLC coatings present an improved corrosion resistance compared to TiN films for all times. For up to 48 hours of exposure to salt fog atmosphere DLC samples completely protect the substrate showing no signs of corrosion, while TiN coatings protect the substrate for less than 2 hours. Moreover, no degradation of the DLC coating was observed even after 168 hours of exposure, suggesting that the corrosion process occurs at pre-existing surface micropores. Complementary corrosion tests are under way in order to get a deeper insight into the role of the coatings microporosity.

In conclusion, the development of techniques that may reduce the presence of pores during the deposition of DLC films would provide a highly efficient corrosion protection of the substrate in saline environment.

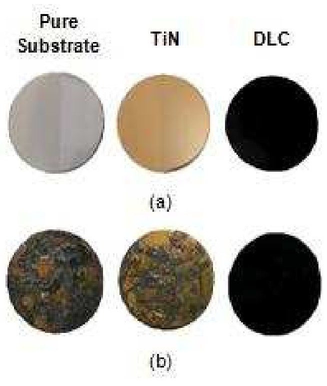

Figure 1: Samples before the salt fog chamber (a); and after 168 hours of corrosion in saline environment (b).

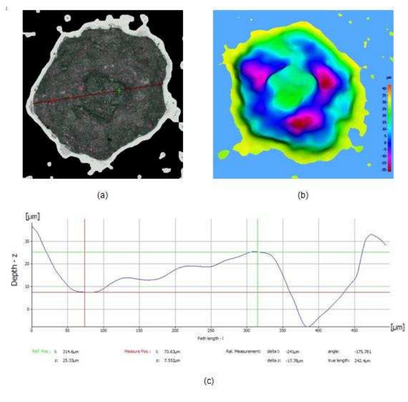

Figure 2: Corrosion pit in DLC coating after 168 hours exposure in saline atmosphere as observed by optical microscopy with digital elevation model (dimensions are 17 μm in length and about 45 μm in depth).

References

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[2] Kim, H.G., Ahn, S.H., Kim, J.G., Park, S.J., Lee, K.R., Corrosion performance of diamond-like carbon (DLC)-coated Ti alloy in the simulated body fluid environment, Diamond and Related Materials, Volume 14, Issue 1, January 2005, Pages 35-41.