New pathways for improving adhesion of DLC on steel in low temperatures

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Diamond-like carbon thin films (DLC) are state-of-art coatings that can have properties which are object of interest such as ultra-low friction coefficient, chemical inertness and low wear rates. Despite of its strident properties, the use of DLC is not yet fully widespread due to the poor adhesion of the film in some substrates, for example, plain and low-alloy steels. In order to improve DLC adhesion on steel, different interlayers have been proposed. On one hand, hybrid technologies containing a step of PVD deposition of a metal/metal nitride interlayer are industrially used, although its costs are high for several applications. On the other hand, PECVD technologies can produce silicon-containing interlayers, although the deposition temperatures that prompt adhesion as high as 300^{o}C. Previous works have pointed out that oxygen atoms act as terminator species in silicon-containing interlayers that diminish DLC adhesion on steel.
The aim of this work is to investigate new pathways of reaching high DLC adhesion by using silicon-containing interlayers in low deposition temperatures. In order to explore alternatives, a hydrogen plasma etching effect was analyzed in two different set of samples. [3] The first set look at analyzing the physicochemical processes due to hydrogen plasma interaction in the silicon-containing interlayer and, consequently, the interlayers were deposited with HMDSO at a constant temperature and time of 300°C and 10 min, respectively, varying the hydrogen etching time (0 to 10 min) at 85°C on AISI 4140 low-alloy steel. The second set look at analyzing the adhesion in low deposition temperatures and, consequently, the interlayers were obtained at different deposition temperatures (80 to 180°C) and the hydrogen plasma etching was performed at a constant temperature and time of 85°C and 6 min, respectively.
The samples were characterized by SEM, GDOES, adhesion tests, and profilometry. One can see that the interlayer thickness decreases with the increasing of the hydrogen plasma etching processing time. The etching mechanism suddenly changes at a processing time of 4 minutes. Whereas shorter etching times than 4 min remove roughly constant contents of carbon, silicon and oxygen, longer etching times than 4 min remove more silicon and oxygen than carbon. Moreover, the hydrogen etching process prompts to good adhesion of the DLC on low-alloy steel as low temperature as 85^{o}C. We propose a mechanism where the outermost interface (DLC/interlayer) is constituted by more carbon than silicon and oxygen atoms after the hydrogen etching process enabling more carbon-carbon chemical bonds than before, which increase the adhesion.