Tribological and Wettability evaluation of magnetron sputtered WS-C/F coatings

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Abstract

The automotive industry produces a huge amount of mechanical components daily. Namely, the ignition systems need lubrication on their assemblage step, which their excessive use is nowadays a concern because of environmental/human risks. The lubrication tools in use are often stopped for maintenance due to either deficient distribution of the lubricant or high friction phenomena. The solution for these issues is the development of functionalized surfaces addressing both low friction/longer lifetime, due to an improvement of the wear resistance, and further special water/oil wettability properties to improve the lubricant application homogeneity. Two possible surface modification approaches can be used, separately or in synergy, as solutions for those problems: (i) surface structuring by anodization processes and/or (ii) deposition of self-lubricating coatings. In this work, the latter was explored by the optimization of the deposition of self-lubricant coatings based on TMDs, alloyed with carbon and fluorine (W-S-C/F).

WS-C/F coatings were deposited by magnetron sputtering in a reactive Ar/CF_4 gas mixture, from a WS_2 target. Different F contents up to 20 at.% were achieved by varying the CF_4 flow rate. The top-view/cross-section morphologies, the chemical composition/bonding, structure and wettability of the coatings were characterized by SEM, XPS, XRD techniques and water/oil contact angle measurements, respectively. The mechanical properties such as hardness, elastic modulus were as well performed through nanoindentation procedure and the adhesion by scratch testing. The tribological performance was evaluated at room temperature (RT) and at 200 ºC at 20N load against a 100Cr6 steel ball.

The F incorporation led to higher surface hydrophilicity of the coatings, with no effect on the oil wettability, behaviour which could be related to the decrease on the surface roughness. RT tribological tests showed that averagely all tested coatings have similar friction coefficient (COF mean value=0.06), however, both pure WS_2 and the highest F-containing coatings showed a very irregular friction curve at the first 5000 running cycles. Sudden increases of COF, followed by its progressive decrease down to very low values, were observed (0.04 for pure WS_2 and 0.02 for WS-C/F coating). Tribological testing at 200 ºC (dry conditions) showed the same trend, i.e. high F-doped coating reached a COF mean value of 0.016 compared to 0.030 for WS_2 coating. This was interpreted as a beneficial effect of F on increasing the interplanar basal distance of the hexagonal WS_2 tribolayer formed in the contact, decreasing the van der Waals bonding, with the consequent decrease of the COF.