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Tribological properties of a-C:H:F coatings with different chemical compositions

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Hydrogenated amorphous carbon (a-C:H) belongs to the diamond-like carbon (DLC) coatings well known for their high hardness, wear resistance, chemical inertness, and very low friction coefficient. Therefore, in recent years, DLC films were applied successfully for various industrial applications and in particular for automotive engine parts. The properties of DLC may be modified by the incorporation of doping elements. Among all the possibilities, great interest has been focused on the fluorine containing a-C:H film because fluorine induces surface energy reduction. The aim of this work is to compare standard a-C:H films to a-C:H:F films in order to find a compromise between low surface energy and good wear resistance.

Steel Samples (M2) were coated in an industrial PVD/PECVD reactor. Nitride PVD layers were necessary to obtain a very good DLC layer adhesion. Several films were produced by radio-frequency PECVD with different combinations of precursors in order to explore various F/C and F/H ratio. ERDA-RBS measurements were performed in order to determine the chemical composition of the films. XPS measurements gave information on the chemical bonding and elemental composition of the coatings with the decomposition of C1s and F1s peaks. Films microstructure was observed by Raman spectroscopy to estimate the sp² to sp³ bonding ratios. Then, Young modulus and hardness were measured by nanoindentation, surface energy (polar and dispersive components) and contact angle were obtained with a goniometer.

After these general characterizations, tribological tests were performed. A ball on disc tribometer was used to measure wear resistance and friction coefficient in dry conditions. In order to approach roughly engine conditions, a second test was implemented in lubricated conditions using a pin on disc tribometer. Commercial motor oil was chosen as lubricant and a 363K temperature is maintained during the test. Results obtained with a-C:H:F films are compared with standard a-C:H films. The dependency of the tribological properties on the F and H contents is discussed.

Keywords

DLC

a-C:H:F

Raman

Wear

Surface energy