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Tribological properties of diamond-like carbon coatings deposited by deep oscillation magnetron sputtering in Ar-Ne discharges

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Diamond-like carbon (DLC) films have been the paramount solution to reduce friction during operation of internal combustion engines for the automotive industry because they offer excellent surface properties, including very low coefficient of friction (<0.2) and wear rate ($<10^{-16}$ m^3/Nm), even under high load/pressure. The authors have shown that a recently developed variant of high power impulse magnetron sputtering (HiPIMS), called deep oscillation magnetron sputtering (DOMS), was suitable for the deposition of hydrogen-free DLC coatings comparable to those of the DLC films deposited by other state of the art deposition processes. Adding Ne to the discharge gas has been shown to be an effective method to increase the ionization fraction of the sputtered carbon species in an HiPIMS discharge. In this work, the properties of the DLC films deposited by DOMS are characterized in order to investigate the effect of adding Ne to the discharge gas on the film growth processes and on the tribological performance of the films.
On the overall, the substitution of Ar by Ne in the discharge gas up to 50 % results in changes of the DLC films properties similar to those observed when the substrate bias is increased from – 80 to – 100 V. However, the addition of Ne to the discharge gas results in much lower specific wear rates, reaching a minimum value of 4 $x10^{-17}$ m^3/Nm, without any significant increase of the films residual stresses. Moreover, the higher wear resistance of the Ne films is achieved with only a small increase of the coefficient of friction, which remains close to 0.15, i.e., within the range of typical values for DLC films tested in relatively humid conditions. Thus the tribological properties of the DLC films deposited in this work are very interesting for many applications in the automotive industry, such as for the replacement of the CrN coatings nowadays standardly deposited onto the piston rings of internal combustion engines.

Keywords
DLC
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Ne
Hardness
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