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Room and high-temperature tribological performance of Diamond Carbon coatings produced by HiPIMS in Ar-Ne discharges

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Diamond like carbon (DLC) films are one of current most promising solution for the automotive industry to reduce friction in piston´s rings of internal combustion engines. In a previous work, the authors have shown that adding Ne to the discharge gas in Deep Oscillation Magnetron Sputtering (DOMS), a variant of HiPIMS, allowed for a significant improvement of the tribological and mechanical properties of DLC films. DLC films with a significantly lower specific wear rate than standard state of the art CrN films (4x10-17 against » 1.1x10-16 m3/Nm for CrN) and much lower friction coefficient (0.15 against 0.75 for CrN). However, the thermal stability under operation at elevated temperatures is a fundamental requirement for piston´s ring thin films. In this work, the tribological properties of DLC films deposited by DOMS with and without Ne in the plasma were investigated as a function of temperature.
The DLC films were tested using a pin-on-disk tribometers with increasing temperature up to 300 ºC. All the tests were carried out in ambient atmosphere using AISI52100 counterparts. At each temperature, the wear tracks, ball-wear scars and wear debris were characterized by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM–EDS) and micro-Raman spectroscopy. The specific wear rate was calculated using interferometric optical microscope. The specific wear rate of the DLC films increases with increasing temperature for both the films deposited width and without Ne in the discharge gas. The DLC film deposited without Ne is completely worn at 300 ºC, while those deposited with Ne still show relatively low specific wear rates (between 4.5 x10-15 and 4x10-15 m3/Nm). The increase in the specific wear rate by more than one order of magnitude from room temperature to 300 º C was attributed to the transformation of sp3 sites to sp2 sites and subsequent loss of hardness. Although adding Ne to discharge gas significantly improves the DLC films performance, additional development of the deposition process has to be carried out in order to increase their temperature stability.

Keywords
DLC
HIPIMS
Tribology