DLC coatings deposited by novel doping strategies with HiPIMS

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Abstract

Diamond-like Carbon (DLC) coatings have been recognized as one of the most valuable engineering materials for various industrial applications including manufacturing, transportation, biomedical and microelectronics. Among its many properties, DLC stands out for a good frictional behaviour combined with high surface hardness, offering an elevated protection against abrasive wear. Nevertheless, a factor limiting the widespread application of DLC coatings is their thermal stability. DLC is very temperature-sensitive since its sp^3-sp^2 structure undergoes a graphitization process at high temperatures that deteriorates both hardness and coefficient of friction. In order to overcome this limitation, new ways to modify DLC coatings for acceptable high temperature performance have been explored. In this work, we investigated a novel deposition technique of hard DLC coatings doped with various elements (e.g. W, Cr, Ti, Si) using HiPIMS by incorporation of positive pulses. Highly ionized plasma discharges were obtained during HiPIMS deposition. The high ion energy bombardment resulted in a higher sp^3 to sp^2 bond ratio. EELS and Raman spectroscopy were used to characterize the sp^3 and sp^2 structures in the deposited films. Nanoindentation tests revealed improved mechanical properties (hardness up to 35 GPa) for doped DLC coatings. Additional high temperature nanoindentation tests performed in the range of 27 ºC to 450 ºC showed that the mechanical properties at high temperature are dependent on the sp^3 content. Pin-on-disk tests were carried out in order to assess the tribological performance of the coatings both at room and high temperature. The increased toughness and reduced compressive stress that doping provides to the carbon matrix together with a high sp^3 bonding structure obtained with HiPIMS deposition improves the stability of DLC coatings for high temperature tribological applications. Finally, micromilling trials were carried out to assess the performance of these doped DLC coatings in micromachining of Ti6Al4V samples and compared to an uncoated tool, an increased tool performance was obtained.