Influence of the magnetic field on DLC coatings grown by plasma immersion ion implantation and deposition

Samantha Mariano[1,2], Mario Ueda*[1], Elver Pillaca[1], and Rogerio Oliveira[1]

[1]Associated Laboratory of Plasma, National Institute for Space Research, S. J. Campos, S. Paulo, Brazil (INPE) – Brazil

[2]Associated Laboratory of Sensors and Materials, National Institute for Space Research, São José dos Campos, SP, Brazil (INPE) – Brazil

Abstract

Amongst the researches related to Diamond-like Carbon (DLC) one of the greatest challenges during deposition process is to avoid film peeling besides the growth of well adherent coatings on metallic substrates. When these challenges are overcome, good tribological properties can be ensured. In this work, we propose a plasma immersion ion implantation and deposition (PIIID) process in magnetic bottle configuration using high voltage glow discharge so that the DLC films can be deposited over 304 stainless steel alloy. For this configuration, two couples of coils were wound to produce low magnetic field for plasma confinement (~ 60 G at the center axis) outside the vacuum chamber. Numerical simulations were also carried out in previous work and showed the possibility of achieving high deposition rates with process in which an external magnetic field is applied. Raman Spectrum analysis shows that graphitic films were obtained with hidrogen content at about 18 at.%. Micrographs from Scanning Electron Microscopy (SEM) show that films produced at higher working pressures (20 mTorr) using magnetic field were the most homogeneous ones and free of porosity compared to those at lower pressures (1.6 mTorr). The film morphology and roughness were also analyzed by Atomic Force Microscopy (AFM), and they exhibited roughness lower than 4 nm. Scratching tests were performed on the sample surfaces using a Rockwell C stylus with a 200 μm diamond tip in order to verify the critical load and evaluate the adherence between the film and the substrate. High critical load values up to 13 N were obtained for the coatings produced with magnetic field. Friction coefficients were measured using a tribometer in a pin-on-disk test with 3-mm-diameter alumina ball and 1 N load and wear scars were examined by means of SEM and a Wyko NT1100 optical profiler. Deposition process based on PIIID with an external magnetic field demonstrated to be an effective system to synthesize DLC films with good adhesion since they significantly improved the stainless steel resistance against wear and exhibited lubricant surfaces. Work supported by CAPES and MCTI.

Keywords: plasma immersion ion implantation and deposition, magnetic field, Diamond like carbon, adhesion, wear.

*Speaker