STRUCTURAL AND MORPHOLOGICAL CHARACTERIZATION OF DLC FILMS DEPOSITED BY PLASMA IMMERSION ION IMPLANTATION AND DEPOSITION (PIII&D) WITH MAGNETIC FIELD INSIDE TUBES

Samantha de Fátima Magalhães Mariano[1, 2]*, Mario Ueda[2], Rogério de Moraes Oliveira[2]
[1]*National Institute for Space Research (INPE), Associated Laboratory of Sensors and Materials (LAS)*
[2]*National Institute for Space Research (INPE), Associated Laboratory of Plasma (LAP)*

1. Introduction

For the purpose of coating the inner side of metallic tubes, a magnetic field enhanced PIII&D process was used. A set of silicon-p type (100) samples were put inside a substrate steel (AISI 304) tube (150 mm length and 110 mm diameter), prior to the investigation of the PIII&D process affected by *ExB* drift. The structural analysis of the DLC as-coated samples were performed in order to observe the effects of the magnetic field on the properties of the obtained DLC film. In our previous work, hollow cathode discharges with argon, nitrogen, methane and acetylene plasmas were studied as regard to their I *versus* V characteristic curves, in the presence of the magnetic field [1]. As a continuation to that, the main objective of this work is to provide useful information about the molecular structure of the carbon bonds of DLC films, as well as, on their morphology along the inside of the tube, which are changed as the magnetic field is applied.

2. Experimental

Silicon wafers (15 mm x 15 mm) were fixed in the bottom of the tube, at its inner wall. Their positions were numbered from #1 to #4, from the left (back of the chamber) to the right (front of the chamber). For the two experiments, the substrate tubes were biased to 4 kV, with 20 μs of pulse width and 500 Hz of repetition rate, and at a working pressure of 4.5 Pa which was kept constant. The DLC growing steps were as follows: 15 min Ar PIII + 60 min N_2 PIII + 30 min CH_4 PIII + 30 min C_2H_2 deposition. Two experimental procedures were taken to compare the effectiveness of the magnetic field for the deposition. First, a standard discharge mode without magnetic field (0 G) was used with the four DLC growing steps. Later, a magnetic field of 22.5 G was applied during the whole PIII&D treatment. Then, Raman spectroscopy was used to analyze the structural arrangement of carbon bonds. The morphologies of the surfaces of DLC films were analyzed by SEM and optical profilometry.

3. Results and Discussions

In general, when the magnetic field is applied, the intensity of D band is greatly reduced and the G peak position is shifted to lower wavenumbers in comparison with the DLC films deposited at 0 G. Also, a significant decrease in I_D/I_G ratio was observed for the second experiment. The I_D/I_G ratio decreased from 0.875 to 0.475 as we moved from the back samples towards the front ones of the tube. This result is ascribed to a disordering of carbon bonding structure and can be an indicative of hardness improvement in such films [2]. As regard to their hydrogenation, the same trend was observed for both experiments: the DLC as-coated samples placed on the edges of the tube showed higher at.% H, about 28 at.% H for deposition at 0 G and about 20 at.% H for DLC deposited with 22 G. For both experimental cases, the samples from the middle of the tube showed DLC films with the lowest values of hydrogen content. DLC films deposited using magnetically confined plasmas showed defect-free morphology on the surface. For the same sample position, the roughness was clearly reduced in the DLC films deposited in PIII&D with magnetic field.

4. References

[1] S. F. M. Mariano, M. Ueda, R. M. Oliveira, E. J. D. M. Pillaca and N. M. Santos, Surf. & Coat. Tech., 312, 47-54, (2017).
[2] C. Casiraghi, A. Ferrari and J. Robertson, Phys. Rev. B, 72, 85401, (2005).

Acknowledgments

This work was supported by CNPQ and CAPES.

*Corresponding author: samanthafmm@outlook.com