EVALUATION OF TEMPERATURE BEHAVIOR IN DIFERENT CONFIGURATIONS OF HOLLOW CATHODES TO BE USED IN PLASMA IMMERSION ION IMPLANTATION

Carla da Silva[1]*, Mario Ueda[1] and Carina Barros Mello[1]
[1] *National Institute for Space Research*

1. Introduction

Hollow cathode discharge is one possible configuration of high current discharges that has been used in surface treatment of materials and thin film deposition process. One of the effects that came out by choosing this configuration is a better plasma confinement resulting in its high density. This effect has been pointed out by the plasma immersion ion implantation (PIII) community, as an essential step for advancing the PIII technique for further improvement of its science and technology applications [1].

Recently, surface treatments have been carried out using nitrogen PIII inside metal tubes. In our system, the temperature during PIII treatment could be an important factor, because some materials, as titanium and its alloys, require high temperatures for significant surface modification. They require temperatures of treatments higher than 700ºC, because the diffusion of nitrogen in these alloys is only effective at such temperatures [2, 3].

In this work, optimization of nitrogen PIII process in tubes of SS304 was carried out, aiming to increase the treatment temperature of substrates loaded inside those tubes.

2. Experimental

Two hollow cathode discharge configurations were adopted by using two different diameter tubes of SS304: 4 cm and 16 cm. Both had thickness of 2 mm.

In the first configuration, a double tube system, with the internal tube of 4 cm diameter (not concentrically arranged in relation to the larger tube) had one closed end, and the external tube (grounded) had four times larger diameter than the internal tube.

In the second configuration, only the smaller tube with one closed end was tested.

For the optimization of the PIII process, the substrate surface was firstly cleaned with argon ion bombardment during 10 minutes, then, the nitrogen implantation was carried out for 120 minutes. The pressure during the experiment was $4x10^{-2}$ mbar. Nitrogen was implanted with the following H.V. pulser conditions: 3 kV, 1.8 A, 3 kHz, 30 μs negative high voltage pulses applied to the metal tubes.

3. Results and Discussions

Considering the first configuration, no significant temperature increase occurred. However, the distribution of the electric field lines was improved. They connected the external tube to the smaller one, making it much more defined than the case without the use of the external grounded tube. Since using this arrangement neither affected the discharge nor the temperature reached, we abolished the use of external tube in the subsequent experiments.

In the second configuration, a much better plasma confinement was attained, consequently a higher intensity ion bombardment resulted in the internal walls of the tube, increasing the tube temperature to 720ºC. In this configuration, the temperature exceeded significantly the value of 580ºC, obtained previously in tubes of 4 cm diameter with two open ends.

After this optimization, it was possible to perform high temperature PIII treatments in materials that were distinct from the materials used in the tube, as titanium and its alloys.

Results obtained in these treatments, at both, low and high temperatures during the nitrogen implantation in samples of titanium and Ti-6Al-4V, will be presented at the conference with results of XRD, FEG, EDS, among others.

4. References

[1]- M. Ueda, A. R. Silva, E. J. D. M. Pillaca, S. F. M. Mariano, R. M. Oliveira, et al., Rev. Sci. Instrum., **87**, 013902 – 013902-8, (2016).
[2]- C.B. Mello, M. Ueda, M. M. Silva, H. Reuther, L. Pichon and C. M Lepienski, Wear, **267**, 867-873, (2009).
[3]- V. Fouquet, L. Pichon, A. Straboni and M. Drouet, Surf. & Coat. Tech., **186**, 34-39, (2004).

Acknowledgments

This project is supported by CAPES and MCTI.

*Corresponding author: carla.silva@inpe.br