EXPERIMENTS ON HIGH CURRENT, LOW VOLTAGE, HOLLOW CATHODE DISCHARGES FOR PLASMA IMMERSION ION IMPLANTATION (AND DEPOSITION) INSIDE TI6AL4V 1.1 CMØ TUBE

Mario Ueda [1]*, Carla da Silva[1,2], Gelson B. Souza[3], Rogério M. Oliveira[1]
[1]*Associated Laboratory of Plasma, National Institute for Space Research, São José dos Campos, SP, Brazil*
[2]*Associated Laboratory of Sensors and Materials, National Institute for Space research, S.J.Campos, SP*
[3]*State University of Ponta Grossa, Ponta Grossa, PR, Brazil*

1. Introduction

Hollow cathode discharges are receiving much attention recently because they are quite versatile and powerful plasma sources for diverse applications as in Plasma Immersion Ion Implantation and Deposition (PIII&D) inside metallic tubes, powerful light sources for spectroscopy and lasers, plasma propulsion, Atomic Layer Deposition (ALD), rocket nozzle, gun barrel, and so on. Titanium alloy tubes are important components for fuel transporting/feeding and also as refrigeration components in aerospace systems. In particular, ½ an inch tubes (1.3 cm OD tubes) are most suitable ones for those purposes given their convenient size, weight and ductility. The objective of this work was to improve the surface properties of the Titanium alloy tube internal wall for different space applications.

2. Experimental

Newly acquired high power high voltage pulser RUP-6 (maximum of 17 kV, 100 A and 13 kW) was utilized to drive a small diameter Ti6Al4V (TAV) tube of 1.5 cmØ OD and 15 cm length, with a thickness of 2mm. High density nitrogen plasma was produced (high light emission, large nitrogen uptake, reached temperature of the tube as high as 900ºC) and used as a source for the PIII and PIII&D treatments of the internal walls of the TAV tube and of the samples placed there as monitors. Used samples were SS304, Ti6Al4V and Si, all prepared and cleaned adequately for ion implantation, sputtering and deposition studies.

3. Results and Discussions

In one experiment, the PIII&D system was operated for 1 hour at 5.6 kV, 20 A, at a frequency of 500Hz, 30 µs pulse length and working nitrogen pressure of $7x10^{-2}$ mbar. A total of 1600W of power was distributed to the ballast resistors (250Ω) and the plasma (100Ω) as 1000W and 600W, respectively, with about 600V peak voltage applied to the tube. The tube temperature during the nitrogen PIII&D was limited to 900 ºC to avoid excessive heating of the viewing window. An entire Si wafer (4 inch diameter) was placed in front of the tube mouth to map the film deposition profile due to the plasma flowing out the tube. This measurement could assist us to confirm a simple model for PIII&D inside metallic tubes using hollow cathode plasmas. Large nitrogen implantation, followed by thermal diffusion, resulted in a thick TiN layer on the TAV sample, as seen by XRD pattern shown below (Fig.1). Other results of surface analysis of the samples used for post-mortem diagnostics (FEG, cof, nanoindentation, roughness) will be shown and a general discussion of the results on the obtained hollow cathode discharges will be given at the conference. When the nitrogen PIII&D treatment was finished, and the pulser was turned-off after 1 h of treatment, the TAV tube with 900ºC glowed intensely, as shown in Fig.2. Results of other treatments but different PIII&D conditions will also be presented for comparison purposes.

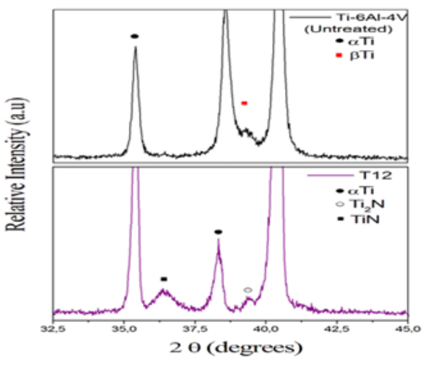

Fig. 1. *XRD patterns for untreated and PIII treated TAV samples inside the tube.*

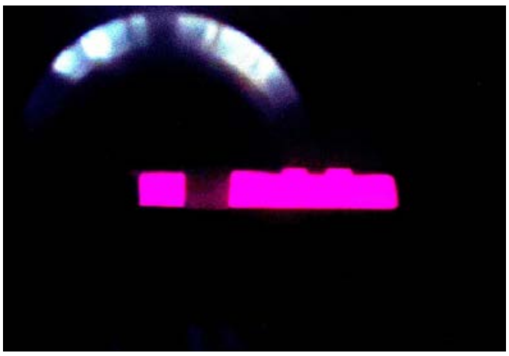

Fig. 2. *Picture of the glowing hollow cathode tube side view after plasma turn-off. Half circle behind is a reflection from a flange inside the chamber.*

Acknowledgments: Work supported by MCTIC, CNPq and CAPES

*Corresponding author: mario.ueda@inpe.br