# COMPARATIVE STUDIES OF NITROGEN PIII AND PIII&D EXPERIMENTS USING TUBES OF SS304 AND TI6-AL4-V WITH 1.1 CM DIAMETER

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## 1. Introduction

Surface modifications of the interior of metallic tubes using depositions of DLC and other films or ion implantations of different species, have become the subjects of much interest for research and developments, in recent years [1, 2]. Plasma Immersion Ion Implantation (PIII) and Deposition (PIII&D) treatments are the best options for those purposes when compared to the techniques of ion nitriding or ion beam implantation. These facts are impacting positively some parts of modern industries using tubes, as the pre-salt petroleum extraction sector, where more than 50 km of DLC coated segmented steel tubes are already being used in the explorations in the pre-salt fields of different countries. On the other hand, nitrogen PIII (N-PIII) has been shown to improve the mechanical, chemical, as well as tribological properties of the inside walls of SS304 and Ti6-Al4-V tubes [3]. Hence, a broad range of applications of PIII and PIII&D treatments in tubes are envisaged in pharmaceutical, chemical, defense, aerospace, medical and food industries. Therefore, researches on nitrogen implantation and film deposition inside metallic tubes are under way in our laboratory for some years, looking for high performance tubes to be used in such industries as well as for space use [4].

## 2. Experimental

In this work, comparative studies of two cases of N-PIII were made: one, inside an SS304 tube, and other inside Ti6-Al4-V tube. Both tubes were closed with a lid in one side and had a small internal diameter of 1.1 cm, a thickness of 2 mm and were 15 cm long. They were driven by a high power RUP-6 pulser (maximum nominal power of 12 kW), under similar optimized conditions of operations and pressures of 4 – $6x10^{-2}$ mbar.

## 3. Results and Discussions

For SS304 tube, the N-PIII treatment produced a reasonably thick (more than 1.5 µm) nitrogen rich layer consisting of $Ti_2N$ and TiN, below FeO and CO depositions (Fig.1). On the other hand, for Ti6-Al4-V tube, a similar thickness nitrogen rich layer was obtained but a much thinner film deposition of Fe and C oxides was seen (Fig.2). Both the measurements of the elemental profiles by GDOES and the method of 2D – deposition on Si wafer targets detecting the plasma and sputtered materials expelled from the tube confirm this tendency. The resultant mechanical and tribological properties for these two cases will also be discussed in the presentation.

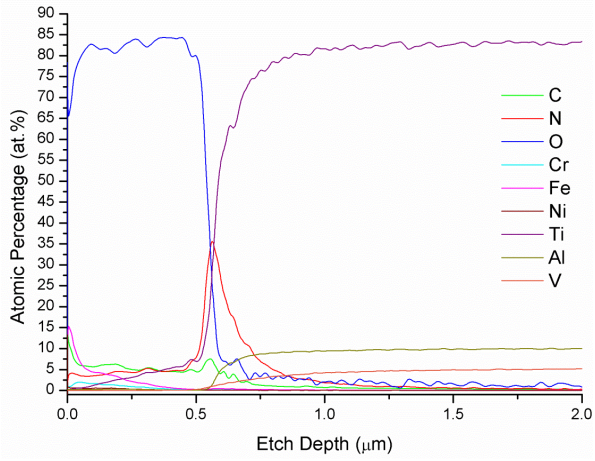


**Fig. 1.** *GDOES elemental profiles of TAV samples treated by PIII and PIII&D inside the SS304 tube of 1.1 cmØ, for 2h.*

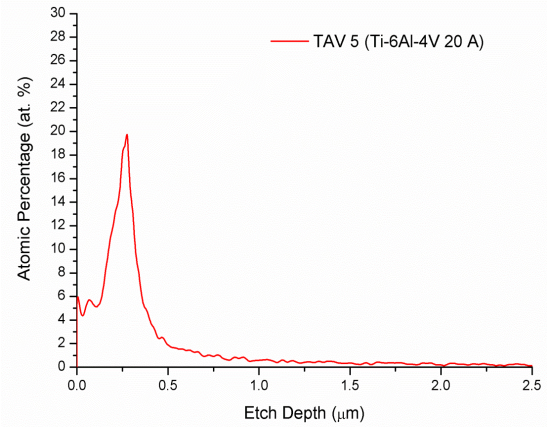


**Fig. 2.** *GDOES profiles of nitrogen implanted on the TAV sample treated by Nitrogen-PIII inside TAV tube of 1.1 cmØ, for 2h.*

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## 4. References

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