

# OPTICAL SPECTROSCOPY OF PULSED PLASMA USED ON TITANIUM NITRADE COATINGS PRODUCTION

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## Abstract

We use a RLC circuit to produce a discharge of 5 KJ in about 30 ms with a peak current of 300 A. The capacitance  $C=54$  mf is a bank of electrolytic capacitors, the inductance  $L=2.3$  mH is a coil made in number 8 bare copper wire and  $R=0.46 \Omega$  is the resistance of the coil. The RLC circuit is connected to a D.C. voltage source of 340 V. With this system we have done a pulsed discharge between two opposite electrodes placed inside of the vacuum chamber. The pressure range of the chamber is 0.5 mbar to 5 mbar. The distance between electrodes varies from 3 mm to 10 mm. We have deposited TiN on stainless steel samples reference 304. The coating was characterized by electron microscopy (TEM, SEM, Auger) and X-ray diffraction. During discharge optical spectroscopy was done with a diffraction grating spectrograph. It uses a CCD (Charge Coupled Device). Which has a 2-dimensional array of photo-sensors (1024 x 256 elements). In this paper we related the coatings characteristics with optical spectroscopy of plasma produced by pulsed discharge.

## 1. Introduction

There are many methods to produce thin films on materials to improve their characteristics. One of these methods is a pulsed discharge between two opposite electrodes. This technique use a cathodic arc evaporation to deposit metal and compound films. Producing hardness and wear-resistant coating on forming and cutting tools. [1]

So much people have studied plasma characteristics and deposited films properties, and there are many ways, like using electrostatic probes, emission spectroscopy, XPS analysis, etc.[2]

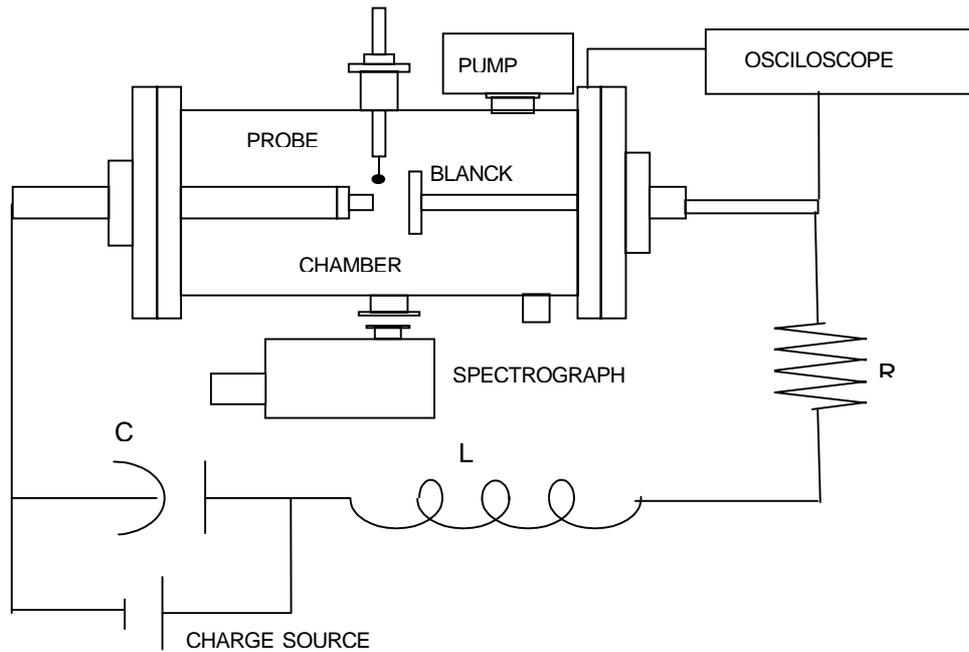
We are discussed about ionization and excitation mechanisms of  $N_2$  in a nitrogen atmosphere (0.5 to 2,5 mbar), in a pulsed discharge with a titanium cathode using spectroscopic measurements. [1]

Excitation and ionization processes of plasma particles and relationship between plasma and deposited films properties had not been enough studied. But in this paper we analyze ionization process of  $N_2$ , and how getting titanium ions ( $Ti$ ,  $Ti^+$ ,  $Ti^{++}$ ) and their combination to produce TiN.

## 2. Experiments and results

### A. Experimental Apparatus

Equipment used in this experiment is composed by a cylindrical steel vacuum chamber of 20 cm. of length and 30 cm. of diameter with two opposite electrodes using a gap of 5 mm. A bank of capacitors



**Fig. 1.** Experimental apparatus

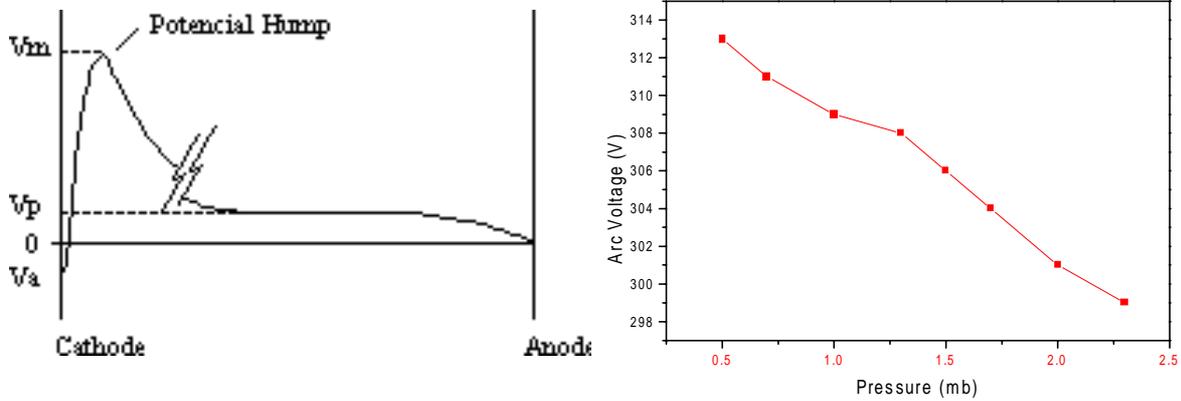
is charged to 340 V. With a D.C. source. When the bank is charged the source is disconnected and an RLC circuit is connected to the chamber and a trigger pulse begins the discharge that occurs in 35 ms. approximately. The spectral graphics are taken with a spectrograph Oriol model 77480. It has a diffraction grating of 2400 l/mm. and a resolution of 2 Å. And a CCD of 1024 x 256 array of elements. The experimental apparatus is shown in Fig. 1. The arc current is 100 A. and pressure was measured with a pirani and cold cathode gauges that are driven by a TPG 300 controller Balzers mark.

### B. Results analysis

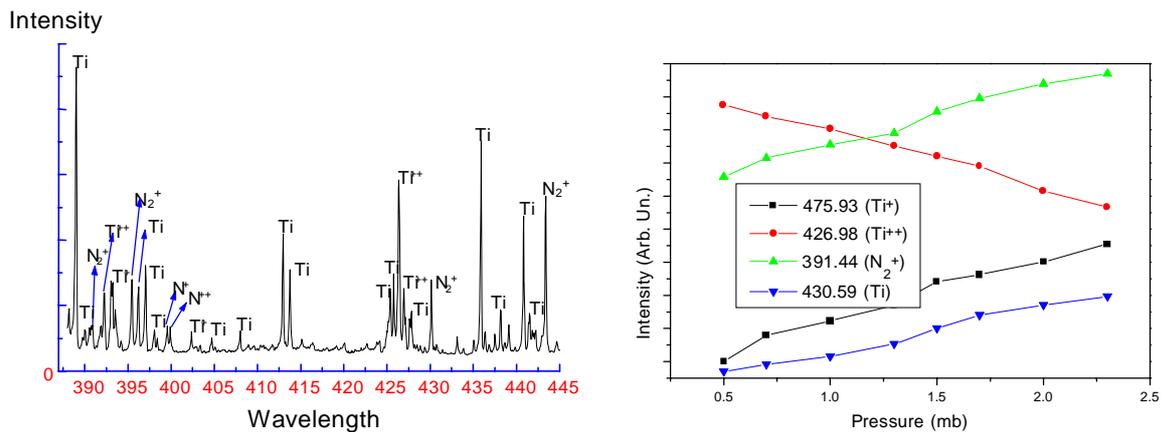
#### a. Voltage arc

In vacuum arc discharge, the potential between electrodes has a distribution like fig 2 a, where  $V_a$  is the arc voltage,  $V_p$  is plasma potential and  $V_m$  is the potential Hump formed near the cathode.

Many electrons from the cathode spot can pass through hump region and then penetrate into plasma region. The arc voltage decreases from 306 V (at 0.5 mb) to 294 (at 2.3 mb) when the pressure is decreasing. The electrons from the cathode reach the anode if they don't have collisions with any particles.



**Fig 2.** a) Potential Distribution in vacuum arc b) arc voltage dependence of the pressure (arc current 100 A)



**Fig. 3.** a) Pulsed discharge spectral b) intensity lines dependence of pressure

b. Intensities of plasma spectrum

To take the spectrums it was necessary to use a neutral filter with 10% of transmittance because the lines are really intense and it saturate the CCD. It means that exists a bigger ionization in the discharge, and produces all forms of species like ( $Ti^{++}$ ,  $Ti^+$ ,  $N_2$ ,  $N_2^+$  and  $N$ ). Fig 3 a) shows spectrum of this discharge and Fig 3 b) shows variation of spectral lines intensity of some ions when the pressure is changing  $N_2^+$ ,  $Ti^+$  and  $Ti$  spectral intensity increase when pressure increase and  $Ti^{++}$  decrease when pressure increases. It means that some  $Ti^{++}$  are combined with free electrons to produce  $Ti^+$  and  $Ti$ . [1]



We deposited TiN on a steel substrate and for X-ray photoelectric spectroscopy made in Comisión Nacional de Energía Atómica-Argentina and it show spectral components of nitrides.

### 3. Final remarks

This paper show the pressure changes influence in arc voltage and spectral intensity lines, and reaction that can occur due of this variations. Moreover, We didn't find TiN lines in spectrums, it can means that this composed is formed at subtract surface, because in XPS analyses it had been found TiN coating [2]

### References

- [1] M. Sakaki and T. Sakakibara: "Excitation, Ionization and Reaction Mechanism of a reactive cathodic arc deposition of TiN", IEEE Trans. Plasma Sci. Vol **22** No. 6, pp1049-1054, 1994.
- [2] A.Michalski: "Structure and properties of coatings composed of Tin-Ti obtained by reactive pulsed plasma method", Journal of Materials Sci. Letter **3** pp 505-508, 1984
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### APPENDIX

#### Effluence or driven or retrained by a confining magnetic field (A. Devia)

Moreover, we are working in effluence or driven or retrained by a confining magnetic field. Conducting fluid is continuously injected through a pair of parallel porous walls and escapes in both directions along the channel. The flow forms a stagnation line at center and the effluence is restricted by a magnetic field. A theoretical analysis of the steady state solutions of the MHD equations in the incompressible case in given, as a function of three parameters  $R_e$ ,  $R_m$  and  $M_a$  ( $R_e$ : Reynolds number;  $R_m$ : magnetic number and  $M_a$ : Alfvénic Mach number) for all the significant asymptotic limits. The resistive and viscous boundary layers are examined (both for dielectric and conducting walls) as well as the dependence of the pressure gradient, that drives the flow, with the non dimensional parameters. For highly conductivity plasma ( $R_m \gg 1$ ) it is found that the magnetic field restrains the outflow for  $M_a < 1$ , and drives the escape of the fluid for  $M_a > 1$ . In motions If low conductivity ( $R_m \ll 1$ ) the magnetic field contains (and can be to used control) the effluence when the Harmann's number  $H_a$ , is large. Finally we study the stability of the system for several magnetic Reynolds number.