PRODUCTION AND CONTROL OF HOLLOW CATHODE AND HIGH VOLTAGE GLOW DISCHARGE PLASMAS FOR ION IMPLANTATION AND DEPOSITION INSIDE METALLIC TUBES

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1. Introduction

Ion implantation inside metallic tubes became an important issue nowadays because of the advent of new applications of such a technique in science and industry, for improving the mechanical and tribological properties of materials by their surface modification. Plasma immersion ion implantation (PIII) is the only method available to achieve such a goal so far. Previous works of the group in the field of PIII in tubes include: nitrogen implantation in tubes of SS304 with different diameters and lengths; magnetic field enhanced PIII in tubes; tests of different configurations and achievement of ion implantation into workpieces placed inside such tubes; DLC deposition (PIII&D) inside the tubes with and without magnetic field; etc.

2. Experimental

Case A) Nitrogen implantation tests have been performed in very large diameter (16 cm) and 20 cm length, metallic stainless steel tube of 2 mm thickness, to achieve optimized conditions of surface treatment in the interior wall of such large tube. This experiment was possible to be carried out mainly by the large size of the vacuum chamber (80 cm diameter by 1.2 m length, 600 liters) and by the moderate pulse power (up to 10 kW) available. Only temperatures below 250^{o}C were reached here.

Case B) On the other hand, a small stainless steel tube of 4 cm diameter and 20 cm length was also tested. In this case, temperature of more than 700^{o}C was attained in 15min, after which it saturated.

3. Results and Discussions

Case A) Hollow cathode and high voltage glow discharges were produced inside the large tube solely driven by 30 µs, 1 kHz, and 2-3 kV negative pulses applied to the tube. These discharges alternated in on/off regime because the applied negative voltage pulse train resulted in an envelope profile of the voltage pulses due to the specific current controlled mode of the available pulser (LIITS 250). This determined the plasma on/off and the alternated discharge modes (hollow cathode or glow discharge) behavior which depended on the variations of the voltage and current waveforms. Pressures used were in the range of 4 to $6x10^{-2}$ mbar, and currents obtained reached 4 A, with temperatures below 250ºC, for this case of very large tube.

Case B) The pulser conditions used were: 4 kV, 30 µs and 1 kHz. Nitrogen gas pressure was around $4x10^{-2}$ mbar, and currents were on the order of 3 A. Temperatures higher than 700ºC was reached here. It was possible to treat different materials samples: Si, SS304, pure Ti, Ti alloy, taking advantage of such high temperatures during PIII which cause strong diffusion of nitrogen into these materials.

Sputtered material from the tube walls were deposited on the samples surface in the smaller tube case. This hot metal tube PIII method can simplify drastically the configuration of auxiliary heated PIII processing previously used. High temperature PIII is very useful for surface treatment of components made of high temperature standing materials. Characteristics of the PIII processing in those tubes and the results on the surface properties measured on the SS304, Si, Ti and Ti alloy samples which were placed inside those stainless steel tubes, will be discussed in the conference.

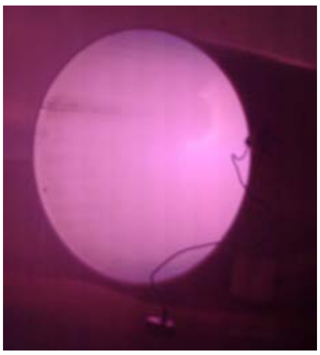

Fig. 1 *Hollow cathode plasma in 16cmØ tube*

Fig. 2. *Plasma heated 4cmØ tube*

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