Plasma immersion ion implantation inside a conducting tube using an ExB fields configuration

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Abstract

Plasma immersion ion implantation (PIII) is a well established method used mainly for the surface modification of materials. Several simulation studies have shown that using PIII to implant ions into the sidewalls, the average ion impact energy obtained is significantly reduced, due to the reduction of about 30% of the external applied potential. So, in order to improve the ion impact energy it has been suggested the use of an auxiliary electrode (AE) along the cylindrical bore. We have analyzed by means of experiment and numerical simulation, the effect of PIII inside a tube in the presence of a low magnetic field, while varying the voltage and the gas pressure.

The PIII experiment was carried out in a cylindrical vacuum vessel with 0.38-meter length and 0.26-meter diameter. A tube with 3-cm diameter and 16-cm length with a central grounded AE was placed along the axis and in the center of the vacuum chamber. The PIII vacuum chamber was equipped with a magnetic coil system, where a magnetic field of about 60 G in the center of the tube was generated. The voltage and the gas pressure were varied from 0 to 6kV and from 0.6x10-3 to 2.0x10-2 mbar, respectively. The pulse parameters were kept constant in 500 Hz frequency and 20 microsecond pulse-width. The experimental results revealed that, depending on the choice of the PIII parameters, the total current becomes dominant inside or outside the tube. These results are explained by numerical simulation, performed via KARAT code. The numerical results show that the use of an AE enables to straighten the electric field making it perpendicular to the inner surface hence improving the crossed **E**x**B** fields configuration. Here, the PIII inside the tube is performed with significant raise of the implantation energy and plasma density.

Stainless steel samples with 0.3 cm thick and 1.5 cm diameter were placed on the inner wall of the tube and treated for 60 min using the best condition, i.e., with higher pressure. They were characterized by different techniques: Atomic force microscopy, X-ray diffraction, Scanning electron microscopy and Micro-hardness test. The obtained results show that PIII in this configuration leads to a change in the internal structure of the sample due to the presence of high nitrogen content. They also have caused an alteration on the surface morphology, resulting in higher roughness. As a result, its tribological and mechanical properties were improved greatly.

Keywords: Plasma immersion ion implantation with magnetic field, EXB fields configuration, stainless steel tube inside implantation

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