STUDY OF PIII TREATMENT IN BATCH PROCESSING MODE APPLIED TO AISI 304 USING A LARGE VACUUM CHAMBER

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Plasma ion immersion implantation (PIII) in batch mode processing was used to getting reproducibility of treatments in the work-pieces. Samples of stainless steel AISI 304 were used to test PIII in various plain sample holders. Several sample holders (rectangular cross section towers) with various samples were distributed inside a vacuum chamber of 600 liters. The sample holders were positioned in cross shaped geometry, with spacing greater than 20 cm between each one of them. From x-ray diffraction analysis of the samples, we found that there was a non-uniformity ion implantation. The samples in the towers located close to the filament electron source were more influenced by higher temperature from electron heating than others. It is believed that the supply of electrons in the region around the hot filament generates a region of higher density plasma, according to the principle of charge balancing, which may have contributed to a more efficient ion implantation. The temperatures of the sample holders were monitored by an optical pyrometer with lowest limit of measurement set at 250° C. Best temperature measurement achieved in this experiment was approximately 300°C.

Keywords: Batch processing, plasma, stainless steel, plasma ion immersion implantation

Introduction

Plasma immersion ion implantation (PIII) or plasma source ion implantation (PSII) is a well-known technique to change the surface properties of materials [1]. Stainless steel AISI 304 treated by PIII has shown great improvements in surface properties, especially with respect to hardness and friction coefficient [2]. Nowadays, several studies are being conducted to obtain significant modification in stainless steel using PIII technique [3-5]. However, for applications in areas requiring high qualification and reproducibility of the final product, this process is encountering difficulties. In industrial line of production, it is common to use a batch process mode to solve the problem of reproducibility and treatment of large quantities of work-pieces. This work deals with a study of effectiveness of using PIII in batch processing mode.

Experimental part

PIII of nitrogen was applied to the samples of AISI 304 by using glow discharge plasma at a work pressure of 0.8 Pa. Pulses of 10 kV, 30 µs and 1 kHz were applied. The treatment time was 120 minutes. The sample holders (x5) were positioned in cross shaped geometry, with spacing greater than 20 cm between each one of them inside a vacuum chamber of 600 liters. Samples were made of AISI 304 stainless steel with 3 mm of width and 15 mm of diameter. They were ground and polished using diamond paste of 3µ and 1µ. The temperatures of the sample holders were monitored by an optical pyrometer with lowest limit of measurement set at 250°C. X-ray analyses were performed to compare the treated samples in different regions of the vacuum chamber.

Results and discussion

The measured temperatures were different for each sample holder. From x-ray diffraction analysis of the samples shown in Figure 1, there was a lack of uniformity in implantation. The samples in the towers located close to the electron source filament (case A and B) were more influenced by higher temperature (300ºC) due to electron heating than others (case C and D). The cross section distribution of sample holders with respect to the hot filament position can be analyzed better in Figure 2. It is believed that the supply of electrons in the region around the hot filament generates a region of higher density of the plasma, according to the fundamental principle of energy balance [2], which may have contributed to a more efficient ion implantation.

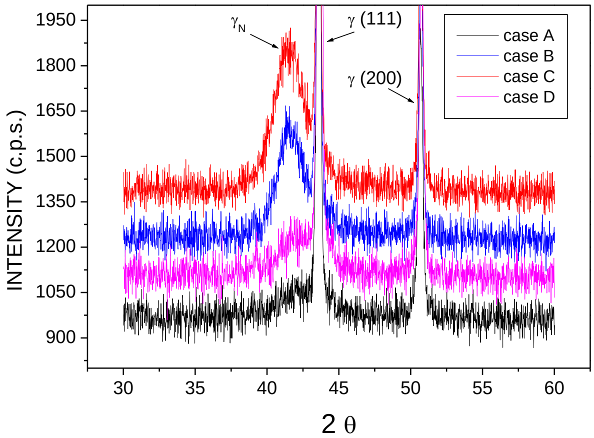

Fig. 1 – *X-ray analyses for treated samples by nitrogen PIII.*

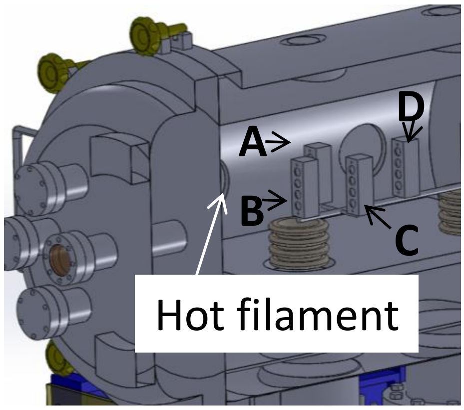

Fig. 2 – *Schematic distribution shows the sample holder within the vacuum chamber relative to the hot filament.*

Conclusions

Nitrogen implantation using a batch processing mode was obtained with success. A small non-uniformity was observed probably due to the influence of the hot filament presence. The solution of this problem could be setting a more regular distribution of hot filaments, using more than one filament. RF plasma source instead of the glow discharge can be another good option also, because then there is no necessity of hot filament in the plasma generation.

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