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Synthesis of nitride titanium film by RF Sputtering

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Abstract

The electrons cloud phenomena has been observed at DAΦNE machine. Since it affects the machine performance, investigations on the coating are under study. In this note the first experimental tests are focused.

Introduction

The electron clouds phenomena has been observed in many accelerators [1-3]. It affects the machine performance through pressure degradation, beam instabilities, incoherent emittance growth, tune shift, heating and so on.

Electron clouds formation is a result of electrons bouncing back and forth between surfaces, which cause emission of secondary electrons giving a multipacting dischages.

A beam pipe high wall resistivity generates beam quality degradation [4]. Some authors already discussed the coating tests carried out on accelerators [5, 6].

In order to study the coating approach a dedicated benchmark has been built for testing small aluminum objects using a RF Magnetron sputtering plasma deposition technique.

One method to mitigate electron discharges is to get a low secondary electron yield of the vacuum chamber.

With a proper beam pipe surface coating, as a example with a titanium nitride (Ti-N) or amorphous carbon (a-C) the electron clouds formation can be suppressed. An experimental and coating activity at INFN/LNF is under study. A preliminary deposition technique by coating small aluminum objects using a RF Magnetron operating at 13.56 MHz is described in this paper. A titanium metallic target in reactive N2/Ar gas mixture has been used for the films elaboration, too. The main variables investigated are the composition of the Ar/N2 gas mixture, the total pressure, the deposition time and the power of discharge. Preliminary experimental tests are reported.

Experimental Activity

The technology under investigation for Ti (target)-N coating of vacuum chambers is the RF magnetron sputtering. To this end, a sputtering benchmark has been realized [Fig. 4].

The device is equipped with a pumping system (turbo molecular and scroll pumps) to reach a base pressure up to 10^{-7} mbar in the vacuum chamber, before introducing an ionization gas (Argon), reactive gas (Nitrogen) and to start of coating process. The machine is also equipped with a 2 inch titanium disc target of high quality (grade 2, minimum 99.7 % Ti).

The DC glow discharge of the substrate can be adopted as a pre-treatment step, in order to remove a possible contamination and to allow an enhancement of Ti-N adhesion by increasing substrate surface roughness.

To obtain a film of Ti-N, reactive sputtering process, the optimization of gas and electrical parameters are required. Thus, the benchmark also includes a mass flow controllers for gas process (Argon) and reactive gas (Nitrogen).

In addition, the process strongly depends on the position of the samples inside the plasma so a sample holder has been developed in order to keep them position in the chamber during different depositions run [Figs. 2-3].

The best process parameters optimization has been got by depositing film on aluminum substrates.

For a given magnetron power supply and sample holder position under the magnetron (see. Fig. 2), by keeping a constant Ar flow; then the Nitrogen flow variation leads to different color Ti-N films.

In the following table, the results obtained for several depositions in the same position with an applied power supply of 700W and Argon pressure of 8 x10^{-2} mbar are shown.

Table 1

Ar (mbar)	**N2 (mbar)**	**P (W)**	**Time (sec)**	**Plasma colour**	**Film colour**
8 x10^{-2}	**1.2 x10^{-3}**	**700**	**300**	**fuchsia**	**grey**
8 x10^{-2}	**2,4x10^{-3}**	**700**	**300**	**white**	**gold**
8 x10^{-2}	**4 x10^{-3}**	**700**	**300**	**white**	**brown**

As shown in the figure 2-3 just the samples(1,2) near the lines of force of the magnetron magnetic field present a gold colour, the sample 3 has a different colour because it has been treated in a different plasma density. All the samples are covered by titanium nitride but the sample 3 has a different stoechiometric ratio between Titanium and Nitrogen than samples 1-2.

Conclusions

The aim is to be able to coat the vacuum pipes inner surfaces with a nanometric and stoechiometric Ti-N films, in order to reduce a secondary electron emission coefficient. In the first step we optimized a dedicated Ar -Ni mixture. To measure the film stoechiometric Ti-N ratio, dedicated samples and the related tests are in progress.

The first results show a very good gold deposition on aluminum samples. The coating velocity deposition has been roughly defined and it will provide in the future the parameters to define the final procedure for the nanometric films.

Probably during vacuum pipes treatment a dedicated geometry must be studied and realized.

Further studies are in progress to develop a method to be applied on the real vacuum chambers.

References

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Figure captions:

Fig 1 Aluminum samples covered by titanium nitride.

Fig 2 Schematic view of sputtering process.

Fig 3 Sample holder after film deposition.

Fig 4 Sputtering set-up.

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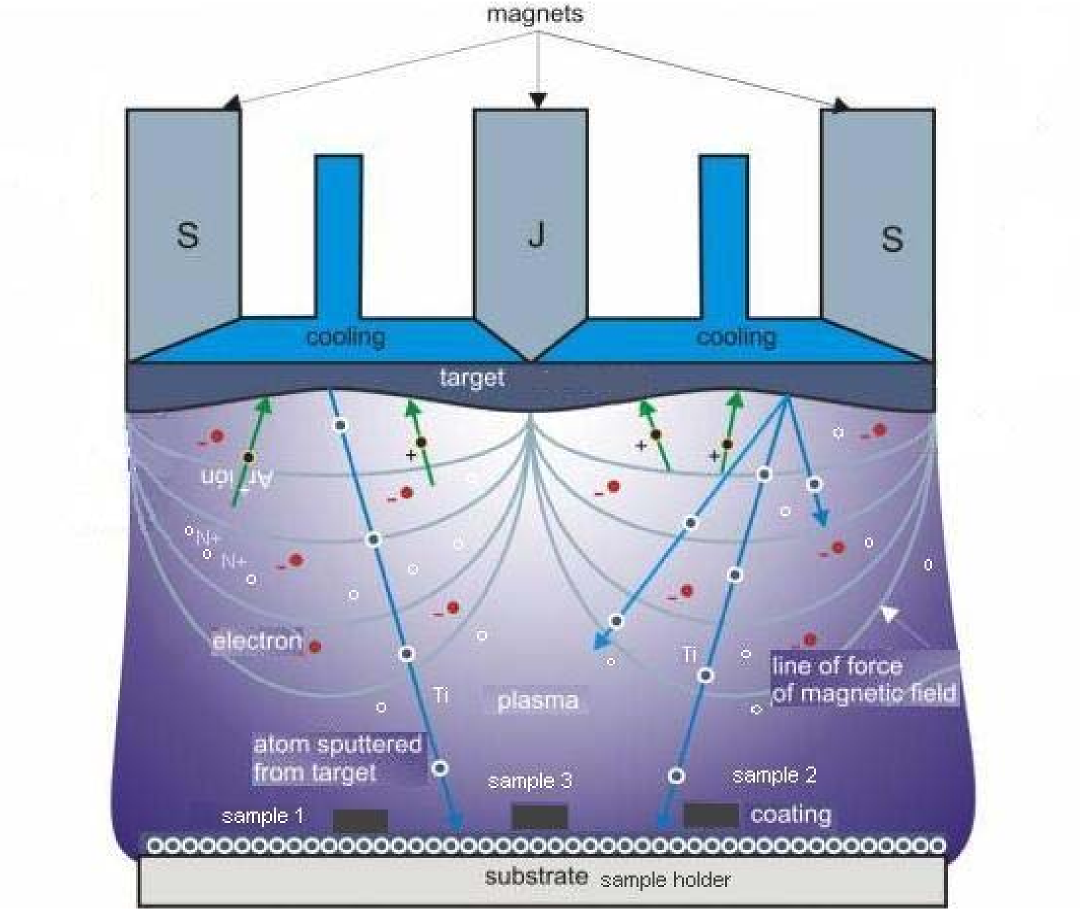

Fig 2 Schematic view of sputtering process.

Fig 3. Sample holder after film deposition.

Fig 4 Sputtering set-up.