SURFACE TREATMENT TEST ON TMR ALUMINUM CHAMBERS BY MICROWAVE DISCHARGE IN VACUUM

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INTRODUCTION

In a large electron positron storage ring, TRISTAN, the pressure in the aluminum vacuum chamber must be lower than the pressure of 10^{-8}torr with beam to obtain a beam life time of several hours. In the electron positron storage rings, the main gas source is the gas desorbed from the chamber walls by photo-electrons liberated by synchrotron orbital radiations. To achieve such a low pressure below 10^{-8} torr in the operating electron positron storage rings, this gas desorption rate must be decreased at least by the factor of one thousand or even more, compared to the desorption rate of virgin vacuum chambar walls. To shorten the running time of the storage ring, necessary to clean the surface walls and lower the gas evolution rate to an acceptable level, several surface treatment methods, for examples, in situ glow discharge cleaning or discharge cleaning using electrons or ions bombardment priorto the setting of the vacuum chambers, have been developed and studied in many laboratories. As a result of these studies, to obtain an acceptable low pressure in an electron positron storage ring, it is necessary to remove tightly bound gas from the inner surface of vacuum chambers, by means of electron or ion bombardment, or a running of the storage ring itself.

As a new surface treatment method for vacuum chambers, microwave discharge in vacuum was applied to the sample of TRISTAN main ring Q-chamber, and the gas desorption rate caused by the SOR light was measured in TRISTAN accumulation ring.

EXPERIMENTAL

The experimental arrangement for the microwave discharge in vacuum is shown in Fig-1. This measurement system is composed of three parts, 1) a sample chamber with an iris for microwave coupling and with a teflon vacuum seal for pumping down, 2) a microwave power source and wave guides, and 3) a total and partial pressure measurement system with vacuum pumps. Each part is constructed as follows.

1) The sample chamber

The sample chamber is 1.3 m in total length and divided into three parts. From the left to the right in Fig-1, 1) a 500 mm long vacuum chamber with ICF-70 flange viewing port on the end, 2) a 300 mm long sample chamber with SOR light window of ICF-70 flange, set on the center axis of the chamber and on the position close to the maximum electric field position, 3) a 500 mm long vacuum chamber with an ICF-70 pumping port and with two bellows for the frequency adjustment. These three chambers are connected each other by using ICF-203 flanges.

At the end of this 1.3 m long sample chamber, an iris of 25 mm width and a teflon vacuum seal in the waveguide are set for rf coupling and vacuum sealing respectively. Whole vacuum chamber is cooled by water through the cooling pipe attached to the chamber.

The material of the sample chamber is the 6063-EX extruded aluminum pipe which is the same material of TRISTAN main ring vacuum chambers.For further details of this material, see the reference (1).

Prior to the microwave discharge tests, this sample chamber was measured and adjusted to the resonant frequency of 2452 MHz of the resonant mode TE-10n, and a coupling constant $\beta=1$, The loaded Q-value of this sample chamber including the iris was 6600.

2) Pumping and pressure measurement system

The sample chamber is pumped by a 50 1/sec turbo-molecular pump and a 250 1/min oil rotary pump,and the pumping speed at the gauge port is estimated as 25 1/sec for nitrogen gas at the room temperature. For the total and partial pressure measurement, a BA type ionization gauge and a quadrupole mass filter are set between the sample chamber and the 50 1/sec turbomolecular pump.

3) Rf power source

The microwave power source is 5-kW (CW) magnetron power supply of the frequency 2452 MHz. For monitoring the output and reflected rf power, two directional couplers and power meters are set on the waveguide.

Upstream of the teflon seal stub tuner is set to adjust the coupling constant $\beta=1$.

RESULTS OF THE MICROWAVE DISCHARGE TEST

Prior to the microwave discharge, the sample chamber was pumped down for 24-hours at the room temperature down to the pressure 5×10^{-7} torr. Microwave discharge and resulting gas desorption were observed at the rf power level from 100 Watts up to 800Watts, and continued for 3.5 hours. During this discharge period the total pressure in the test chamber had been kept at the pressure level of 10^{-6} range,by adjusting the microwave power level and, if necessary, by changing the total length of the sample chamber to achieve the minimum microwave power reflection from the sample chamber.

The gas desorption characteristics during the discharge period is shown in Fig-2. Fig-2(a) and (b) show the total pressure variation with rf power, and the partial pressure change, respectively.

At the beginning of the discharge period,from t=0 to 25 minutes, the pressure was very quick and unstable, therefor only the average pressure of this period is shown in Fig-2(a). At first the total pressure decreased gradually while the microwave discharge was going on, and

Fig-1 Schematic diagram of microwave discharge test system

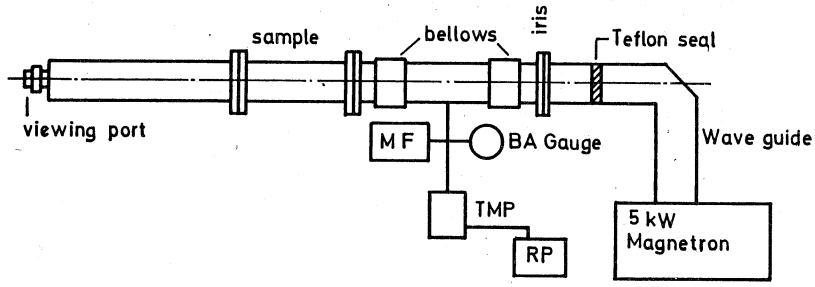
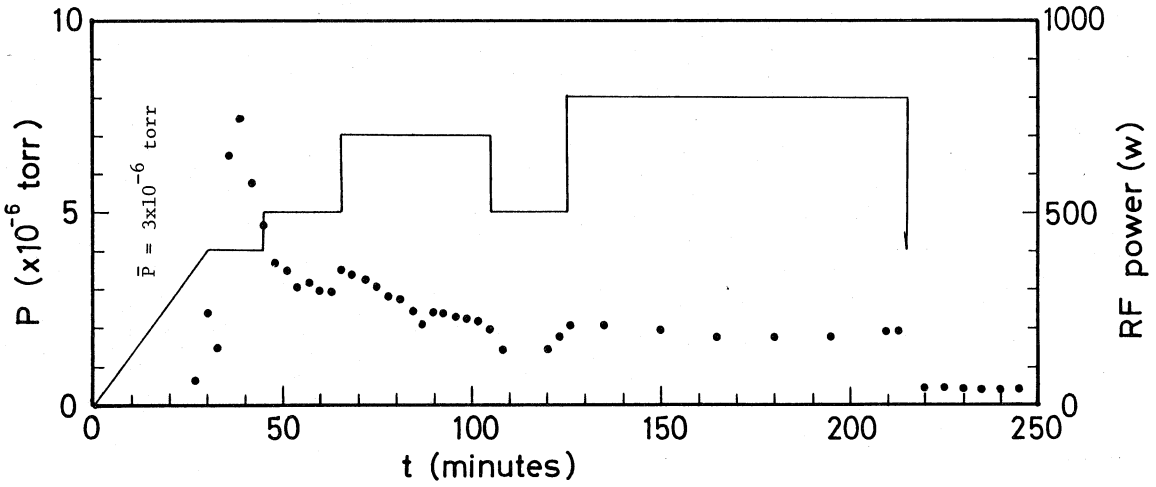
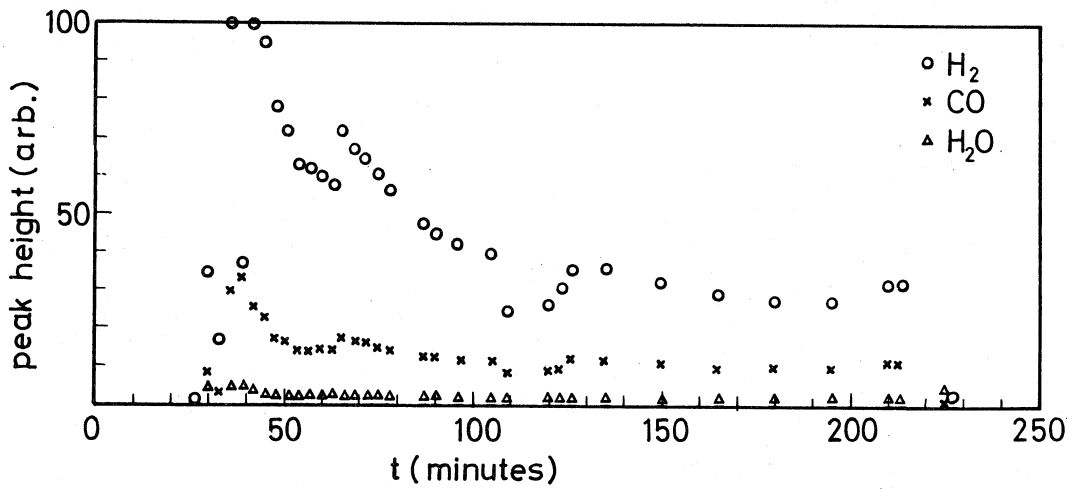


Fig-2 Total and partial pressure measurements of microwave discharge

(a) Total pressure and rf power level



(b) Partial pressure



then, at the end of the discharge the pressure stayed roughly constant at 2×10^{-6} torr. During the discharge localized discharge was observed at the one ICF-203 flange connection through the viewing port, at this flange the temperature was raised up to 110°C at the end, but in partial pressure readings, any noticeable difference was not observed. The most part of the sample chamber remained cold by cooling water.

Using the pumping speed at the gauge port the total amount of desorbed gas was calculated as 6×10^{15} molecules/cm^2. It should be noted that this value is so called nitrogen equivalent value.

In Fig-2(b) the results of the mass analysis during the microwave discharge are shown. Hydrogen and carbon monoxide are the main components during the discharge, these two peaks show the same tendency as the total pressure change throughout the measurement. The water vapour decreased slightly while the microwave discharge was going on. Because of the same reason mentioned above at the beginning of the discharge period, mass spectrum data are omitted for about 20 minutes in this figure.

These results show the typical aspect of the gas desorption phenomena caused by the discharge or electron bombardment exceptonly the decrease of water vapour during the discharge.

The decrease of water vapour pressure during the microwave discharge is reported by Y.Saito et al on the case of Cu waveguide system of 2.5 Gev electron linac in KEK.(2) This result can be considered as a general characteristics of the gas desorption induced by microwave discharge in vacuum.

PHOTON INDUCED DESORPTION MEASUREMENT IN TRISTAN ACCUMULATION RING

After the completion of the microwave discharge test, the sample chamber was kept under vacuum at the pressure of 10^{-7} torr range for several days.

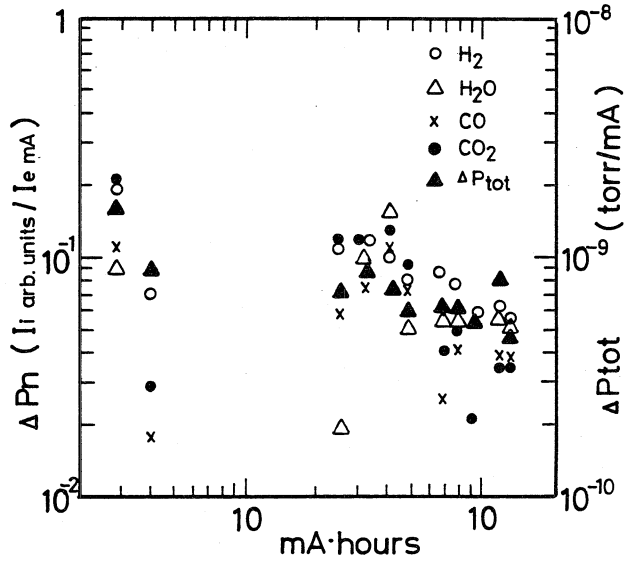
Prior to the measurement in accumulation ring, the sample chamber was exposed to the ambient atmosphere for about two hours, while transportation and assembling to the measurement system in accumulation ring.

The sample chamber was pumped by the turbomolecular pump system, down to the background pressure of 10^{-8} torr range, and exposed to the SOR light emitted by the 2.5Gev electron beam in the accumulation ring, for 8 hours. Further details of the measurement are reported by K.Kanazawa et al in this proceedings.(3)

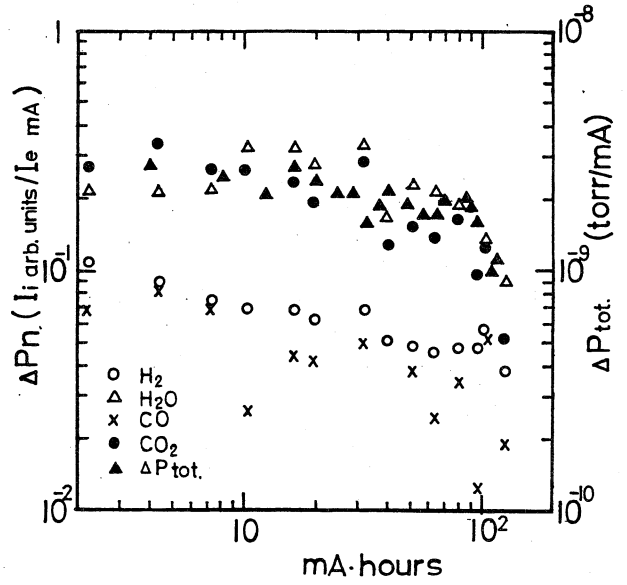
In Fig-3, the results of this photon induced desorption are shown for various samples. Fig-3(a) is the results of total partial pressure measurements on the sample which was cleaned by microwave discharge method. In spite of the exposure to ambient atmosphere after the pretreatment, two samples, cleaned by microwave discharge

Fig-3 Results of the photon induced gas desorption

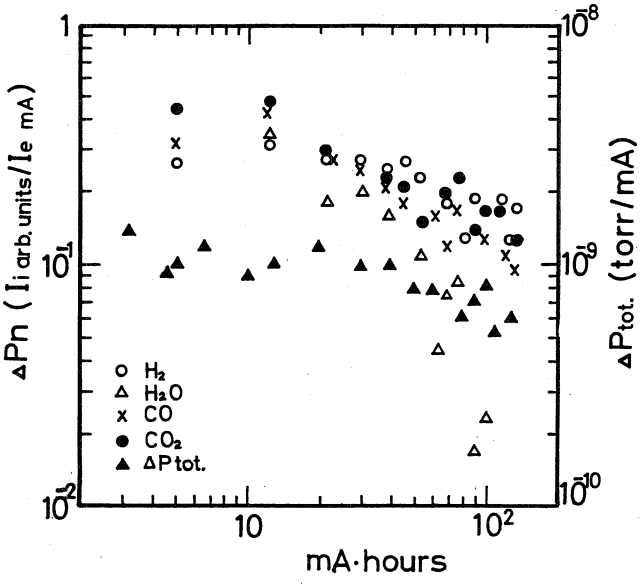
(a) microwave discharge treatment



(b) virgin sample



(c) electron bombardment



and electron bombardment respectively, show the much smaller total pressure rises compared to that of the virgin sample. Except water vapour in the case of the virgin sample, the main component of the desorbed gas species is carbon dioxide, and larger than the other two components hydrogen and carbon monoxide,by the factor 2 or 3. On the other hand, these three components are almost the same,for other two samples cleaned by pretreatments. (4)

Apparently, these results mean the fact that at some extent these pretreatments are effective to remove tightly bound gas molecules from the sample surface.

SUMMARY AND DISCUSSIONS

As a new pretreatment method, microwave discharge cleaning was tested on the samlpe chamber made of TRISTAN main ring Q-magnet beam pipe. As the present results of gas desorption measurement in accumulation ring, this method is as effective as the electron bombardment method. The total amount of the desorbed gas by microwave discharge is about 6×10^{15} molecules/cm^2. In the electron bombardment experiment this figure reached 1.2×10^{17} molecules/cm^2. (4) This result suggests that, on the sample surface cleaned by microwave discharge, adsorbed gas still remains more compared to the surface cleaned by electron bombardment.

These rather contradictory results can be interpreted as follows, 1) in the sample chamber, the intensity of microwave discharge was not uniform due to the standing wave effect, or 2) exposure to ambient atmosphere maybe cleared the difference between two samples, 3)much longer measurement of gas desorption in accumulation ring may reveal the difference.

REFERENCES

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4) K.Narushima, et al. ; "SURFACE PRETREATMENT TEST ON TMR ALUMINUM CHAMBERS BY ELECTRON BOMBARDMENT" this proceedings