PRELIMINARY EXPERIMENT ON DISCHARGE CLEANING OF A SECTOR MAGNET VACUUM CHAMBER FOR THE RIKEN SSC (2)

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1. Introduction In an accelerator which has narrow magnetic gap, it is generally difficult to bake the vacuum chamber surfaces inserted into the gap. At the same time, the vacuum chamber has low conductance compared with pumping speed. High speed evacuation owing to degassing by discharge cleaning becomes attractive. Fortunately we can easily utilize magnetic field in the chamber. This gives us the possibility of application of ECR (electron cyclotron resonance) discharge cleaning method.

In the SSC to be constructed at RIKEN, a vacuum chamber between the magnet poles has the conductance of 2000 ℓ/sec, and the total surface area of 1.6×10^5 cm^2 for the pumping speed of 2.5×10^4 ℓ/sec. We investigate the ECR discharge cleaning by the use of a model which has the conductance of 200 ℓ/sec, the surface area of 1×10^4 cm^2 and the pumping speed of 500 ℓ/sec. This model provides the scaling condition on pumping speed/total surface area as follows, real machine : 1.6×10^{-1} ℓ.sec^{-1}/cm^2

model : 5×10^{-2} ℓ.sec^{-1}/cm^2.

2. Experimental apparatus The experimental apparatus is schematically shown in Fig. 1. A vacuum chamber with 5 cm hight and 75 cm diameter is inserted between magnet poles the diameter of which is 72 cm, which are shown in fig.2. Microwave whose frequency and power are respectively 2.45 GHz and 800 W CW max is supplied via helix launcher. A double prove is used to measure the electron temperature and the ion density of plasma produced for cleaning. A quadrupole mass analyser(QMA) is set near the pump head of a turbomolecular pump(500ℓ/sec) to observe the residual gases, and another QMA is set after an orifice(conductance=1ℓ/sec) to allow observation of produced gases during discharge cleaning.

3. Experimental Results The cleaning plasma was produced with a hydrogen pressure of 4.7×10^{-2} Pa. The vacuum wall temperature increased from 25° to 80°C during about 6.5 hours. The microwave power was typically 600 WCW. The plasma was not uniform in the chamber and the spatial distribution depended upon the pressure and the magnetic field. Nevertheless we can say the plasma has the electron temperature $10<T_e<20$ eV and the ion density $3\times10^{10}<N_i<1\times 10^{11}$ cm^{-3}.

Produced gases during cleaning were H_2O, CO, CH_4 and CO_2 for virgin surface. The temporal change is shown in fig. 3.

4. Discussion The ECR discharge cleaning is accomplished by wall surface impact and chemical reaction between the wall surface impurities (oxygen and carbon) and hydrogen ions and Franck-Condon neutrals from the plasma.[1] We give here very rough estimation of the fluxes by assuming i) ions hit the wall surfaces along the magnetic line of force (top and bottom surfaces), ii) the neutrals hit uniformly all surfaces, iii) the plasma exists uniformly in the domain $r \leq 68$ cm/2 = 34 cm with the density and the electron temperature 3×10^{10} cm^{-3} and 10 eV respectively, iv) ions have the thermal speed (300°K). After calculation, we have

ion flux $\phi_i \simeq 8.2 \times 10^{15}$ cm^2/sec

and neutral flux $\phi_o \simeq 6 \times 10^{15}$/cm^2/sec

On the other hand the pressure increases as a mean by $\Delta P = 6.7 \times 10^{-3}$ Pa due to the production of H_2O and so on. The produced gas amounts $Q = \int_0^T \Delta P S_p dt$ where S_p is the pumping speed (500 ℓ/sec) and T is the total cleaning time (6.5 hrs). Q becomes 7.8×10^4 Pa. ℓ ∿ 7.2×10^{22} molecules. This means we transformed the surface impurities 7.2×10^{18}

molecules/cm^2, into gases, that is to say, about 10^3 monolayers are treated.

5. Conclusion Model study on ECR discharge cleaning of the vacuum chamber inserted in the sector magnet was carried out by using H_2 gas pressure of 4.7×10^{-2} Pa and the 2.45 GHz 600 W microwave. A hydrogen plasma whose density and electron temperature were respectively $3 \times 10^{10} < N_i < 1 \times 10^{11}$ cm^{-3} and 10 $T_e \lesssim 20$<eV transformed the impurities (C and O) into H_2O, CO, CH_4 and CO_2. About 10^3 monolayers near the surface were cleaned down.

Reference

1) Y. Sakamoto et al: J. Nucl. Mater. 93 & 94 (1980) 333

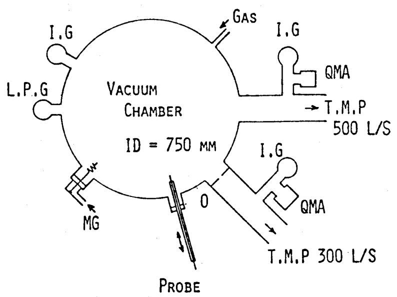

Fig.1 Schematic diagram of experimental arrangement

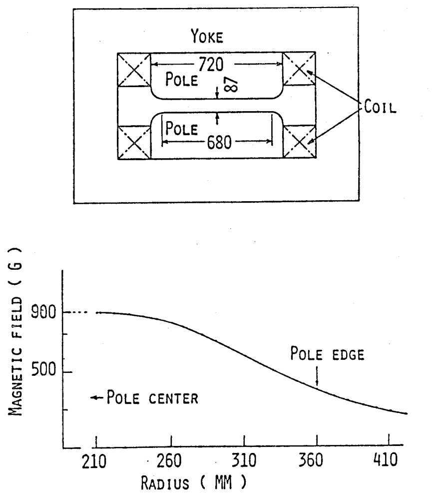

Fig.2 Used electromagnet and the radial distribution of axial magnetic field

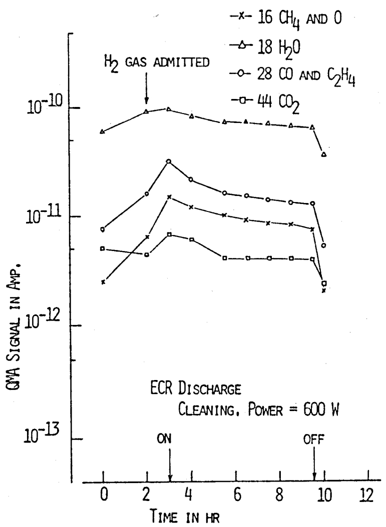

Fig.3 Temporal variation of partial pressures of produced gases during ECR discharge cleaning