Ar Glow Discharge Cleaning in the Photon Factory Vacuum System

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1. Introduction

The 2.5 GeV electron storage ring in the Photon Factory is desinged for the synchrotron radiation (SR) source. The intensity of SR should be stable so that a long beam lifetime associated with the scattering by residual gases is desirable. However, photoelectrons emitted by SR cause desorption of gas molecules, and the pressure rise caused by this effect becomes very high at strong beam intensities.[1] Although the bombardment of photoelectrons induces the pressure rise, it cleans the surfaces of vacuum chambers so that the desorption rate is lowered during the running of a ring; this effect is called self-cleaning. In the case of the Photon Factory ring, the pressure rise at the beam current of 100 mA, which had been 5×10^{-7} Torr after the running of the integrated beam current of 1 A·hr, decreased to 1×10^{-7} Torr by the continuous self-cleaning of 10 A·hrs. From this result, it is concluded that the self-cleaning more than 200 A·hrs will be necessary to lower the pressure rise at the beam current of 100 mA under 1×10^{-8} Torr. This means 1-1.5 year operation of the ring will be required to obtain a long beam lifetime. Therefore, another fast cleaning method should be adopted. It is wellknown that Ar glow discharge cleaning (ArGD) is an effective method to lower the pressure rise induced by the photoelectron bombardment.[2,3] Hence, ArGD is scheduled to be carried out in the near future.

In the present paper, the result of the preliminary test of ArGD are briefly described.

2. Experiment and Results

We performed the preliminary study of ArGD using the one of the B ducts made of aluminum alloy (A-6063) having a wire for initiating the discharge. The ArGD was carried out by injecting pure Ar gas(99.99 %) of about 10^{-2} Torr through the variable leak valve and pumping out with the turbo-molecular pump.

The desorption coefficient(number of molecules desorbed per incident electron) was measured after each step of cleaning by using a hot filament mounted in the duct. Figure 1 shows the results for electrons with the energy of 300 eV. As shown in the figure, the respective desorption coefficients before bakeout were η_{H_2}=10 mol/e, η_{CO} =1.5 mol/e, η_{CH_4}=.12 mol/e and η_{CO_2} =.1 mol/e being reduced by about one order after bakeout. By ArGD with ion dose of 6.2 x 10 ions/cm^2, the surfaces of the duct were cleaned

with η_{H_2} = 3 x 10^{-4} mol/e, η_{CH_4} = 4 x 10^{-6} mol/e, η_{CO} = 9 x 10^{-7} mol/e, η_{CO_2} = 1 x 10^{-7} mol/e and η_{Ar} = 3.5 x 10^{-6} mol/e. However, η_{H_2} remained relatively high and an increase of η_{Ar} was observed. To further reduce the desorption coefficients, the surfaces of the duct were bombarded by 300 eV electrons with a dose of 2 x 10^{-2} A·hr/cm^2, which corresponds to 2 week operation of the storage ring. The respective desorption coefficients after this self-cleaning reduced to η_{H_2} = 1.6 x 10^{-5} mol/e, η_{Ar} = 1.2 x 10^{-7} mol/e and η_{CH_4}, η_{CO}, η_{CO_2} < 10^{-7} mol/e.

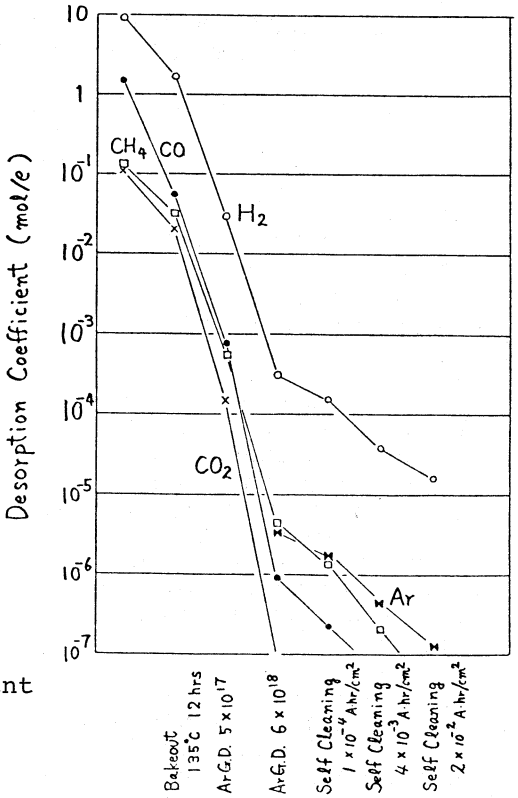

Fig. 1
The desorption coefficient as a function of the treatment of the duct

3. Conclusions

The pressure rise by the photoelectron bombardment is given as

$$\Delta P_m = \frac{2\,Ne\,I_B(mA)\,\eta_m}{3.29 \times 10^{19} S_m(\ell/s)}$$

where I_B is the beam current, Ne, the number of photoelectrons emitted per beam current of 1 mA, Sm, the pumping speed. The number of photoelectrons in the Photon Factory ring is estimated to be 1.7 x 10^{17} electrons/sec/mA and the total pumping speed is about 30,000 l/s. Therefore, if the surfaces of the ducts in the storage ring can be cleaned by ArGD with η < 1 x 10^{-5} mol/e, the pressure rise at the beam current of 100 mA is expected to be under 1 x 10^{-9} Torr.

References

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