STATUS OF SOR-RING VACUUM SYSTEM AND PRELIMINARY STUDY OF ARGON GLOW DISCHARGE CLEANING FOR IMPROVEMENT

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Abstract

The desorption coefficient, number of molecules desorbed per incident photoelectron emitted by synchrotron radiation hit was measured in the vacuum system of SOR-RING, the respective desorption coefficients being $\eta_{H_2} \simeq 1.8 \times 10^{-4}$ mol/e, $\eta_{CO} \simeq 1.6 \times 10^{-4}$ mol/e, $\eta_{CO_2} \simeq 3.6 \times 10^{-5}$ mol/e, and $\eta_{CH_4} \simeq 2.8 \times 10^{-5}$ mol/e. In situ test of Ar glow discharge cleaning was carried out using a test chamber made of type 304 stainless steel so as to lower the desorption coefficients mentioned above. The respective η values were reduced by Ar discharge cleaning to $\eta_{H_2} \simeq 4.1 \times 10^{-6}$ mol/e and η_{CO}, η_{CO_2}, $\eta_{CH_4} < 1 \times 10^{-7}$ mol/e.

SOR-RING is a 400-MeV electron storage ring dedicated to spectroscopy,[1] and the stability of the intensity of the synchrotron radiation (SR) is required for the optical experiments. Therefore, a long beam lifetime associated with scattering by residual gases is desirable. In an electron storage ring, photoelectrons from the surfaces of a vacuum chamber by SR cause desorption of adsorbed molecules.[2] Although this electron bombardment induces pressure increases, it cleans the surfaces of the vacuum chamber, so that the desorption coefficient η (molecules/electron) is lowered during the running of the ring. When SOR-RING was operated at 300 MeV, the total desorption coefficient, which had been $\eta_T \simeq 1 \times 10^{-3}$ mol/e just after the evacuation of the ring vacuum system, decreased to 4×10^{-4} mol/e after the storage of the time-integrated beam current of 10 A·hr. Figure 1 shows the rises of the total and partial pressures at each stored current after the storage of 10 A·hr. As shown in Fig. 1, the total pressure rise was 1.5×10^{-8} Torr at 200 mA being much higher than the base pressure of 7×10^{-10} Torr. The respective partial pressure rises per stored current of 1 mA were $\Delta P_{H_2} \simeq 4.4 \times 10^{-11}$ Torr, $\Delta P_{CO} \simeq 3.9 \times 10^{-11}$, $\Delta P_{CO_2} \simeq 9 \times 10^{-12}$ Torr and $\Delta P_{CH_4} \simeq 7 \times 10^{-12}$ Torr. Because the stored current of 1 mA produces 1.1×10^{16} photoelectrons at 300 MeV and the total pumping speed is about 3000 l/s, the respective desorption coefficients were estimated as $\eta_{H_2} \simeq 1.8 \times 10^{-4}$ mol/e, $\eta_{CO} \simeq 1.6 \times 10^{-4}$ mol/e, $\eta_{CO_2} \simeq 3.6 \times 10^{-5}$ mol/e and $\eta_{CH_4} \simeq 2.8 \times 10^{-5}$ mol/e. The desorption coefficients of the above three carbon based species were found to remain relatively high.

The beam lifetime was measured as 1.1 hrs at 100 mA being as approximately same as the estimated Touschek lifetime.[1] From this, it seems to be impossible that the lifetime is made longer. However, this Touschek lifetime was found to be an underestimated value from the result mentioned below. The pressure of the vacuum system increased by 60 % when the distributed pumps were stopped, and the lifetime decreased by 40 % at each stored current showing much effect by the pressure, so that the lifetime may be longer by lowering the pressure, i.e., lowering the desorption coefficients.

A running-time of SOR-RING required for lowering the desorption coefficients to 10^{-6} range with self-cleaning by photoelectrons was estimated as about 3 years, while the ring vacuum system must expose to air once a year because of several improvements of the ring or the experimental equipments. Therefore, another fast-cleaning method should be adopted.

Kouptsidis and Mathewson reported that the desorption coefficients could be lowered to $10^{-6} \sim 10^{-7}$ range by Ar glow discharge cleaning.[3] Our in situ test of Ar discharge cleaning was similar to their test except for shape and material of the vacuum chamber. The chamber in our case, made of type 304 stainless steel, was a more practical one being 1 m long, and its cross section had a rectangular shape of 15 cm x 3.6 cm. A tungsten wire 0.3 mm in diameter and 90 cm long was stretched in the chamber for carrying out both electron and Ar bombardments. Most of the photoelectrons in SOR-RING operated at 300 MeV have energies less than 50 eV, so that the desorption coefficients were measured with 50 eV electrons. Figure 2 shows the desorption coefficients measured after each step of cleaning. As shown in Fig.2, the respective desorption coefficients before bakeout were $\eta_{H_2} \simeq 2.1 \times 10^{-3}$ mol/e, $\eta_{CO} \simeq 1.5 \times 10^{-3}$ mol/e, $\eta_{CO_2} \simeq 5.7 \times 10^{-5}$ mol/e and $\eta_{CH_4} \simeq 4.2 \times 10^{-4}$ mol/e, being reduced by an order of about 1.5 after bakeout. The Ar discharge cleaning was carried out for 2 hrs, by applying 320 V to the wire, resulting ion dose being 6.3×10^{18} ions/cm^2. After the Ar discharge, the surfaces of the vacuum chamber were cleaned with $\eta_{H_2} \simeq 4.1 \times 10^{-6}$ mol/e and η_{CO}, η_{CO_2}, $\eta_{CH_4} < 1 \times 10^{-7}$ mol/e. The Ar discharge cleaning will be applied to SOR-RING vacuum system, since it is desirable that the carbon based species have very low desorption coefficients.

References

1) T. Miyahara et al., Particle Accelerators 7 163 (1976)
2) G. E. Fischer and R. A. Mack, J. Vac. Sci. Technol., 2 123 (1965)
3) J. Kouptsidis and A. G. Mathewson, DESY 76/49 September 1976

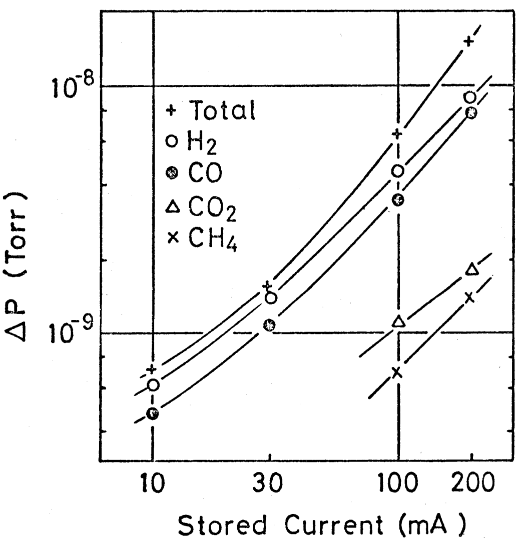

Fig.1 Rises of total and partial pressures at each stored current in the vacuum system of SOR-RING.

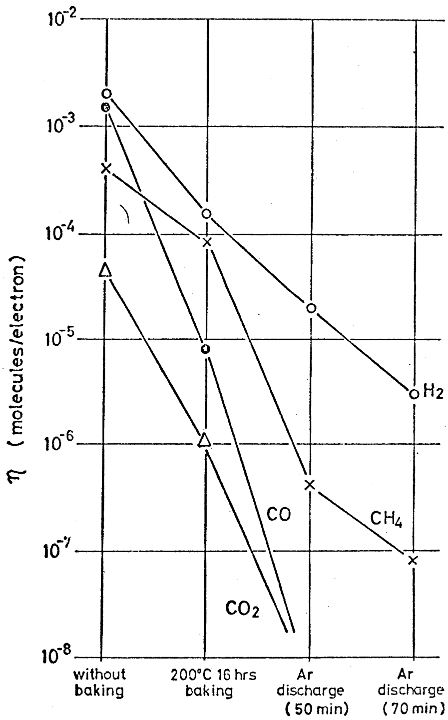

Fig.2 Desorption coefficients measured after each step of cleaning.