VACUUM SYSTEM OF UVSOR

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ABSTRACT

UVSOR is a 600 MeV storage ring at IMS dedicated to synchrotron radiation research. Main part of its vacuum doughnut is made of stainless steel. The doughnut is evacuated with sputter ion pumps, built-in pumps and titanium sublimation pumps. Total pumping speed is 2.4×10^{4} l/s. The doughnut has been evacuated without baking and the present base pressure is 7×10^{-10} Torr. The pressure is degraded to 1.3×10^{-8} Torr with stored current of 160 mA. The lifetime in which the current of 100 mA decays to 1/e, is 20 minutes. Baking and argon discharge cleaning will be made in near future. To one bending section, two outlets of synchrotron radiation are attached. A front end of beam lines connected to the outlet composed of a beam shutter and two valves, protects the doughnut against accidental leakage from optical instruments.

INTRODUCTION

A 600 MeV storage ring (max. 750 MeV) dedicated to ultraviolet sychrotron orbital radiation research was commissioned on November 1983. Fig. 1 shows the plane view of the vacuum doughnut of UVSOR.[1] It is composed of eight bending sections, and four long and four short straight sections. Its circumference is 53.2 m. Vacuum vessels constituting the doughnut are almost made of stainless steel. The inner material of an RF cavity is copper. DCCT and perturbator chambers are made of ceramics. Inner surface of the perturbator chambers is coated with 1000 A gold. Copper gaskets are used for jointing flanges. The power of synchrotron radiation from 600 MeV electrons with a current of 500 mA is 2.6 kW. The bending sections can be cooled by water. The whole doughnut is evacuated with 14 sputter ion pumps, 8 built-in pumps and 17 titanium sublimation pumps.

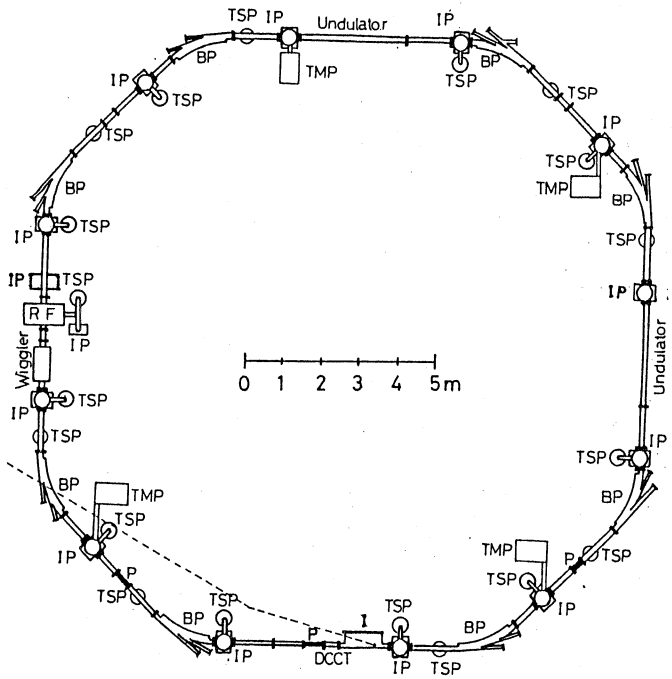

Fig. 1. Plane view of vacuum doughnut of the UVSOR storage ring. IP : sputter ion pump, TSP : titanium sublimation pump, BP : built-in pump, TMP : turbo-molecular pump, RF : RF cavity, P : perturbator chamber, DCCT : DCCT chamber and I : exit of inflector.

Roughing pumps are four turbo-molecular pumps. The vacuum of the storage ring is separated from the beam transport line with a small polyimid window at point I in Fig. 1 . For each bending section, two outlets of synchrotron radiation are available. The outlet is connected to a front end of one or two beam lines composed of a beam shutter, a tightly closing valve and a fast closing valve, which protects the vacuum of the ring against accidental leakage from optical instruments. In this paper design principle and the status of the vacuum doughnut, and the configuration of front ends of beam lines are described.

VACUUM DOUGHNUT

Pressure

The lifetime of the beam depends upon following effects, such as scattering by residual gas, quantum fluctuation and electron-electron scattering (Touschek effect). The Touschek lifetime in UVSOR with the current of 500 mA is estimated at 1 hour, so that the lifetime due to residual gas should be much longer than 1 hour, as the lifetime due to the quantum fluctuation is. Thus, the lifetime due to the vacuum is aimed at being longer than 24 hours. The calculated total cross section of scattering loss of electrons by residual gas is 7.9×10^{-24} cm^2. The pressure must be lower than 1×10^{-9} Torr under stored beam condition to satisfy the above condition.

Pumps

Followingly, the doughnut is regarded as it is only compsoed of stainless steel vessels and a copper RF cavity. Firstly the required pumping speed is calculated for the stainless steel vessels. The rate of photo-desorption due to the 600 MeV electrons with 500 mA is 1.33×10^{-5} Torr l/s, assuming the efficiency of photo-desorption from stainless steel surface is 2.5×10^{-6} molecules/photon.[2] As total surface area is 1.6×10^{5} cm^2, thermal outgassing rate is 8×10^{-7} Torr l/s. Thus, total outgassing rate is 1.41×10^{-5} Torr l/s. In order to realize the pressure of 1×10^{-9} Torr, pumps are installed as follows. Two sputter ion pumps with pumping speed of 400 l/s and two titanium sublimation pumps with 1000 l/s are located in long straight section. In short straight section, a sputter ion pump with 400 l/s and two titanium sublimation pumps with 1000 l/s are located. The bending sections are evacuated by built-in pumps, which utilize fringing field of bending magnets. Pumping speed of the built-in ion pump is estimated at 170 l/s/m, from the results previously obtained at SPEAR[3] and SOR-RING.[4] The arc length of a bending section is 1.5 m. Therefore the pumping speed of a built-in pump is estimated at 250 l/s. Total pumping speed for stainless steel vessels is 2.3×10^{4} l/s.

The RF cavity is re-entrant type which is made of copper plates and a pair of copper electrodes. As total surface area is 3.2×10^{4} cm^2 and thermal outgassing rate from unit area of copper surface is 7×10^{-11} Torr l/s/cm^2,[5] the required pumping speed is 2.2×10^{3} l/s. However at present, the RF cavity is evacuated by a sputter ion pump with pumping speed of 400 l/s and a titanium sublimation pump with 1000 l/s.

Total pumping speed for the whole doughnut is 2.4×10^{4} l/s.

Baking

The vacuum vessels can be heated by ohmic heating with a direct current flow of 1600 A (40 V) through vacuum vessels themselves, with the exception of pumps and ceramic chambers, which are heated by mantle or sheath heaters. Argon discharge cleaning can be made in the bending sections.

Status

The vacuum doughnut was first evacuated at the beginning of November without baking. On 10th November the first beam was accumulated. After that, the doughnut was exposed to the atmosphere several times for improving devices in the doughnut and evacuated without baking. Followingly, the status of the vacuum at the end of February 1984 is described.

The average pressure in stainless steel vessels without current was 6×10^{-10} Torr, while the pressure in the RF cavity during excitation was 2×10^{-8} Torr. The average pressure of whole doughnut was 7×10^{-10} Torr. Fig. 2 shows the dependence of the pressure in the doughnut on the amount of stored current at the injection. The pressure was degraded with the increase of the current, with the rate of 8×10^{-10} Torr/mA and at 160 mA, the pressure became 1.3×10^{-8} Torr. Maximum current so far is 170 mA.

Fig. 3 shows the decay of the stored current. The lifetime in which the current of 100 mA decays to 1/e was 20 minutes. The vacuum was not good enough to store electrons for long time.

The feature at present (in the middle of August) is similar to that at the end of February 1984. Baking and Argon discharge cleaning will be made at the end of September.

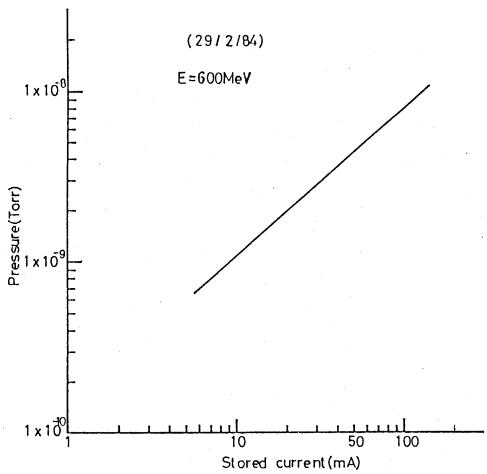

Fig. 2. The dependence of the pressure on the amount of stored current at the injection.

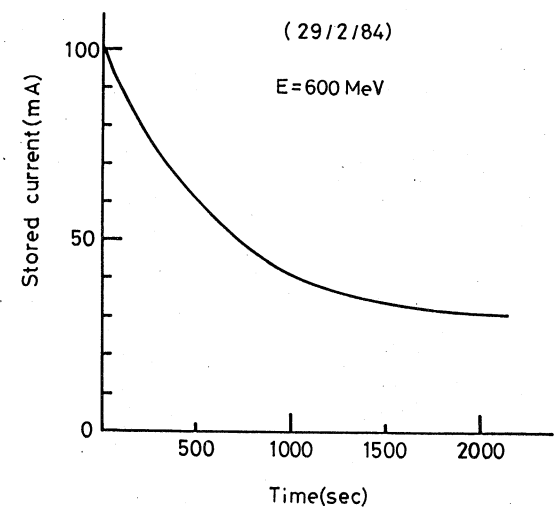

Fig. 3. The decay curve of the stored current of 100 mA.

BEAM LINE

From one bending section, two outlets of synchrotron radiation are available. Through an outlet, synchrotron radiation with a horizontal angle of 80 mrad can pass. The outlet is connected to a front end of beam lines. The side view of the beam line of BL7B is shown in Fig. 4, as an example. Its front end is composed of a beam shutter (BS1), an all metal tightly closing valve (VS) and a fast closing valve (VF) with finite conductance. When optical instruments are accidentally leaked, the fast closing valve shuts with a closing time of 10 ms. Its leak rate is 0.5 Torr l/s and closing time of VF is 6 s. Only the air of 3 Torr l will enter in the ring. At present, nine front ends are attached to the outlets.

As shown in Fig. 4, a mirror chamber, an acoustic delay line and a tightly closing valve with a viton gasket(VP) are connected to the front end. The sensor for VF and that for VP are located at the up-stream and the down-stream of VP, respectively. The pressure in mirror chambers should be lower than 3×10^{-9} Torr. Acoustic delay lines[6] which can delay the speed of leakage of air are inserted just before entrance slits of monochromators, in the case that the distance between the front end and the entrance slit is not longer than 10 m. The connection of monochromators to the beam lines are now under way.

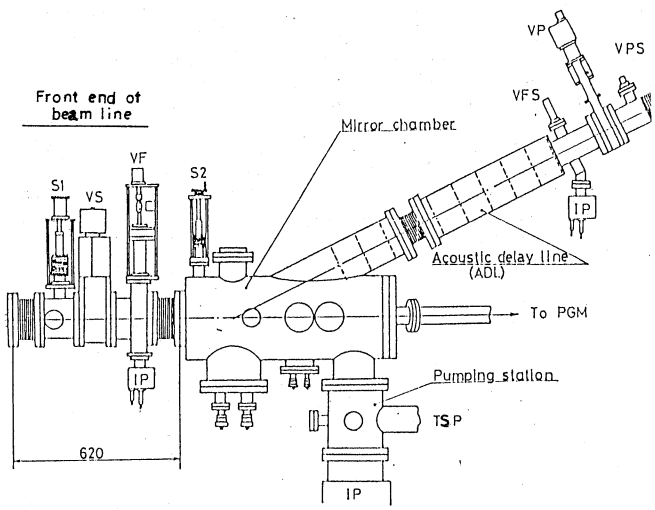

Fig. 4. Side view of BL7B beam line. S_1 and S_2 : water-cooled beam shutter, VS : all metal tightly closing valve, VF : fast closing valve, VP : tightly closing valve with a viton gasket. VFS : sensor for fast closing valve, VPS : sensor for tightly closing valve with a viton gasket, IP : sputter ion pump and TSP : titanium sublimation pump.

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