Upgrade of the Vacuum System in KSR

H. Tongu, T. Shirai, T. Sugimura, Y. Iwashita A. Morita and A. Noda
Nuclear Science Research Facility, Institute for Chemical Research, Kyoto University
Gokanosho, Uji-city, Kyoto 611-0011, Japan

Abstract

The maximum storage beam current in KSR reached about 10mA after the acceleration up to 300MeV. When the storage current is 5mA, the vacuum pressure and the beam lifetime are about 8×10^{-7} Pa and about 10 minutes, respectively. The beam lifetime is enhanced efficiently by the upgrade of the evacuation system at arc sections. And further aging will enhance the beam lifetime to the design goal of about one hour.

A separation of the insertion device section from the remaining section by two gate valves is planned in order to keep the effect of aging during the study of the insertion devices.

1 INTRODUCTION

The electron accelerator at ICR (Institute for Chemical Research) consists of an electron storage ring, KSR (Kyoto Storage Ring) and an electron linac. As shown in Fig.1, KSR is a compact ring with a racetrack lattice, whose circumference, length of the long straight section and bending magnet radius are about 25.6m, 5.6m and 0.835m, respectively.

KSR has been utilized as a storage ring with the maximum energy of 300 MeV (storage mode) for the light source [1][2] and a pulse stretcher for the linac (stretcher mode) [1][3]. The insertion devices are to be installed in a long straight section. The storage mode at the beam current of 100mA however has not yet been realized because the vacuum pressure gets worse by the synchrotron radiation.

The status of the vacuum system in KSR, and its upgrade for the storage mode are described together with the installation design of the insertion devices in the present paper.

2 STATUS OF VACUUM SYSTEM

2.1 Layout

In order to manage both the storage and the stretcher modes, the injection and the extraction sections have been realized to coexist at the same long straight section. In addition, an RF-cavity, an electrostatic septum (ESS) and the beam current monitors were installed at the same long straight section as shown in Fig.1, so as to leave another long straight section for the insertion devices .

In order to realize enough low pressure for beam life in the storage mode, the evacuation system in KSR has ten Sputter Ion Pumps (SIP), fourteen Titanium Sublimation Pumps (TSP) as the main pumps and one roughing pump unit as shown in Fig.2.

2.2 Vacuum Pressure

Because vacuum pressure of the beam injection and extraction lines is on the order of 10^{-6} Pa, the vacuum

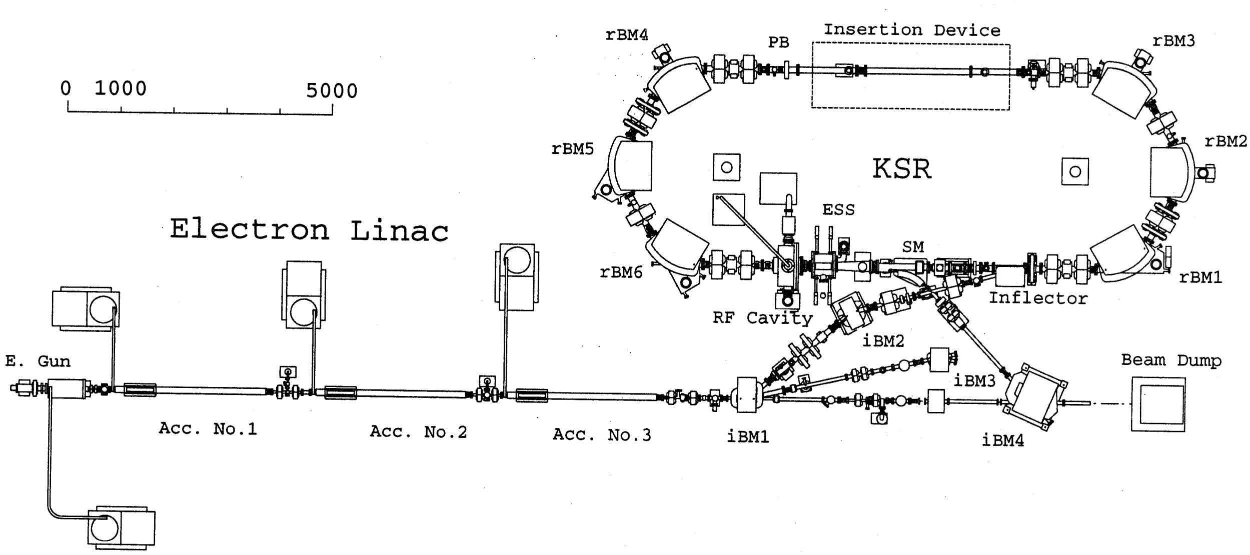

Fig.1 Layout of electron accelerator in ICR

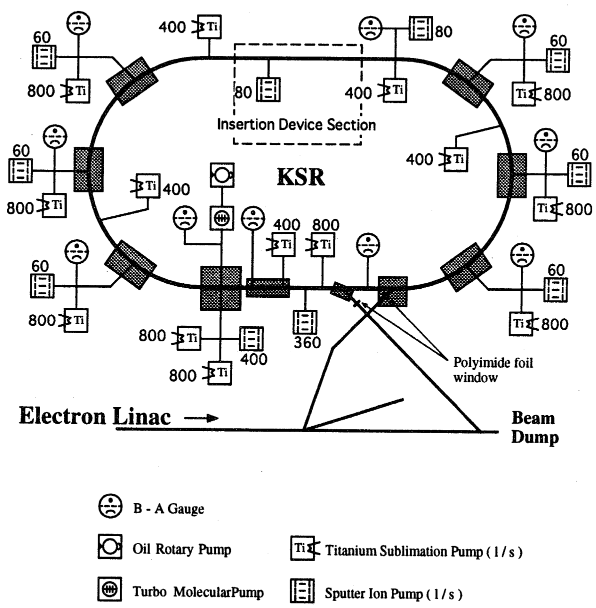

Fig.2 The evacuation system in KSR

system of KSR has been separated from that of the beam transport line by polyimide foils [4]. The vacuum system of KSR has attained the average vacuum pressure of about $2x10^{-8}$ Pa without any beam injection as shown in Fig.3. It however becomes about $8x10^{-7}$ Pa at the storage beam current of 5mA after the beam acceleration up to 300MeV because the synchrotron radiation generates the photodesorption gas.

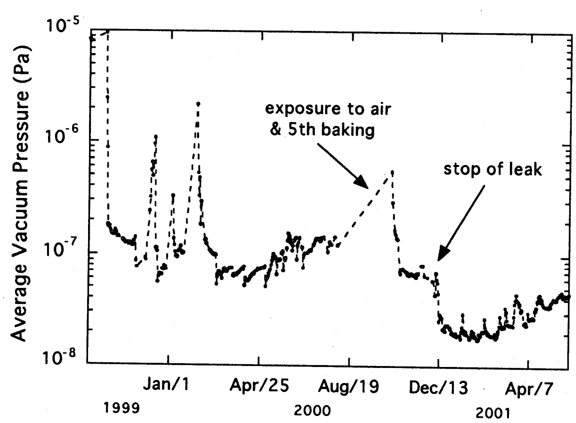

Fig.3 The average vacuum pressure

2.3 Beam Life

The beam lifetime is about 10 minutes at the storage beam current of 5mA, while the maximum current up to now with the storage mode is only 10mA. It is required to realize the beam lifetime of a few hours for the light source application. Therefore the outgas rate has to be decreased for the beam storage current of 100mA. The aging by the synchrotron radiation is under way.

3 FUTURE PLANS

3.1 Insertion Device

An installation of a superconducting wiggler for a light source of ultraviolet wavelength region is being prepared [2]. Studies of X-ray production with laser-Thomson scattering have also been started [5].

The exposition of vacuum components to the air gives serious influence on the aging process, especially at the arc sections whose photodesorption gas is much more. During the machine conditioning and operation for the R&D of the insertion devices, the vacuum vessel connected to the insertion device will be exposed to the air several times. Thus the insertion device section is to be separated from other sections by two gate valves as shown in Fig.4.

The vacuum systems of the insertion device and other sections can be disconnected by this modification. Therefore the aging of the arc sections will receive little influence during the study at the insertion deice section.

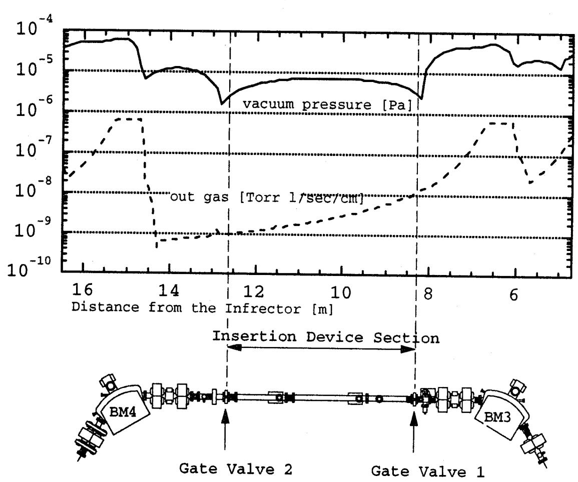

Fig.4 The vacuum pressure and the outgas rate at the insertion device. The residual gas is sum of the thermal desorption gas and the photodesorption gas. The values are estimated for the storage mode of the beam current of 10mA and the photodesorption yield of 0.005 (molecules/photon).

3.2 Beam Storage

In order to utilize the light source, the beam lifetime has to be enhanced. The increase of the beam dose (the integration of the storage current) enhances the beam lifetime as shown in Fig.5. The beam dose has reached about 260mA·h up to now. In order to increase the beam dose efficiently, the vacuum pressure that becomes worse after the beam acceleration has to be recovered rapidly, which is more important than improving the ultimate pressure. Thus a reinforcement of the exhaust power at the arc sections whose photodesorption gas is much more is planned.

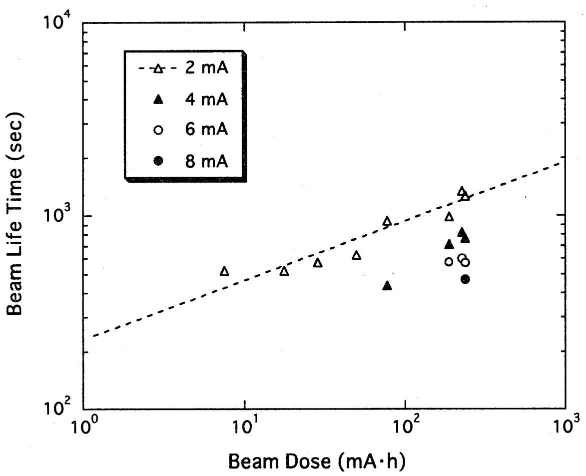

Fig.5 Measured beam lifetime for the storage current from May 2000

As stated above, the vacuum pressure becomes about 10^{-6} Pa by the photodesorption gas at the storage mode. The main part of the photodesorption gas is H_2 [4]. TSP has more exhaust speed than SIP generally. But TSP doesn't have any exhaust power for H_2. Then SIP keeps up the exhaust power in the vacuum pressure worse than 10^{-7} Pa. So six SIP which has the exhaust speed of 60 l/s at the arc sections are to be replaced with those of 200l/s.

3 DISCUSSION

The residual gas on the beam orbit causes the beam loss. In the electron storage ring whose aging by the synchrotron radiation is not sufficient, the outgas rate of the photodesorption is much more than that of the thermal desorption.

The beam loss (beam scattering) reduces the beam lifetime. Its dominant factors are the vacuum pressure (the scattering with the residual gas) and Touschek scattering (Coulomb collision with particles in a beam bunch). In the present status of KSR, the beam lifetime is affected more seriously by the vacuum pressure than the Touschek scattering [6]. The Touschek lifetime is estimated about 1.5 hours with the storage beam current of 100mA.Present photodesorption yield is estimated about 0.005 (molecules/photon) [6]. When the photodesorption yield becomes about 10^{-5} with the progress of the aging, the beam lifetime of about one hour is expected to be realized with the storage beam current of 100mA as shown in Fig.6.

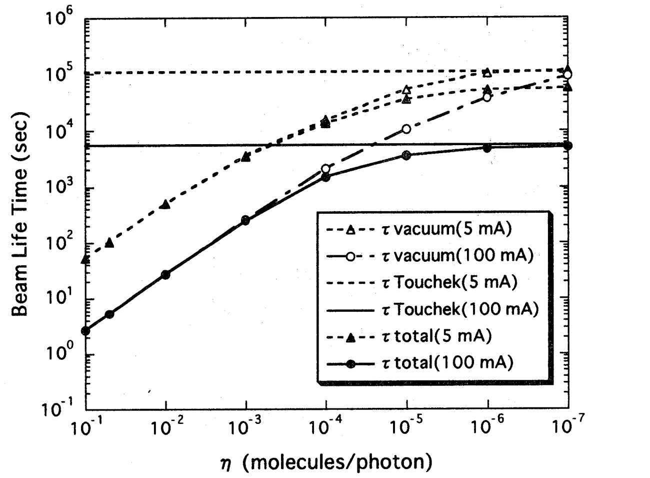

Fig.6 Estimated total lifetime that depends on the vacuum pressure and the Touschek-effect. The Touschek lifetime is estimated at the RF-voltage of 30kV. The values enclosed in the brackets show the storage currents.

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