Development of Evacuation System for Electron Storage Ring, KSR

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Abstract

The increase of the beam life is very important in order to utilize KSR as the light source. Now the beam life is limited by the vacuum pressure. The vacuum pressure better than 10^{-7}Pa is attained in KSR without the beam. However it becomes about 8×10^{-7}Pa with the beam storage of the beam energy of 300MeV and the current of 5mA.

The conditioning of KSR to decrease the desorption gas has been continued. So the 1/e beam life of about 20minutes has been attained by the storage mode with its beam current of 2mA.

1 INTRODUCTION

KSR is a compact ring with the racetrack lattice, whose circumference and length of the long straight section are about 25.6m and 5.6m, respectively.

It is an electron storage ring, with the maximum energy of 300 MeV. Electrons with the energy of 100 MeV is injected into KSR and then accelerated to 300 MeV (storage mode) or slowly extracted with the repetition rate of 1Hz with use of third order resonance and RFKO without acceleration (stretcher mode).The stretcher mode is possible to improve the duty factor from 2×10^{-5} to ~90%[1]. And the storage mode is utilized as the light source whose synchrotron radiation from the bending magnets has the critical wave length of 17nm for the case of beam energy of 300MeV [2].

The vacuum pressure of about 1×10^{-5}Pa is needed for the 1/e beam life of 1sec with the stretcher mode. However the beam life of the several hours is needed in order to utilized the synchrotron radiation with the storage mode. So the storage mode is needed lower pressure .

In the present paper, the present status of the vacuum system are described.

2 VACUUM SYSTEM

2.1 Layout

In order to realize the order of 10^{-8}Pa (ultrahigh vacuum) with the synchrotron light source, as shown in Fig.1 the evacuation system consists of KSR of 10

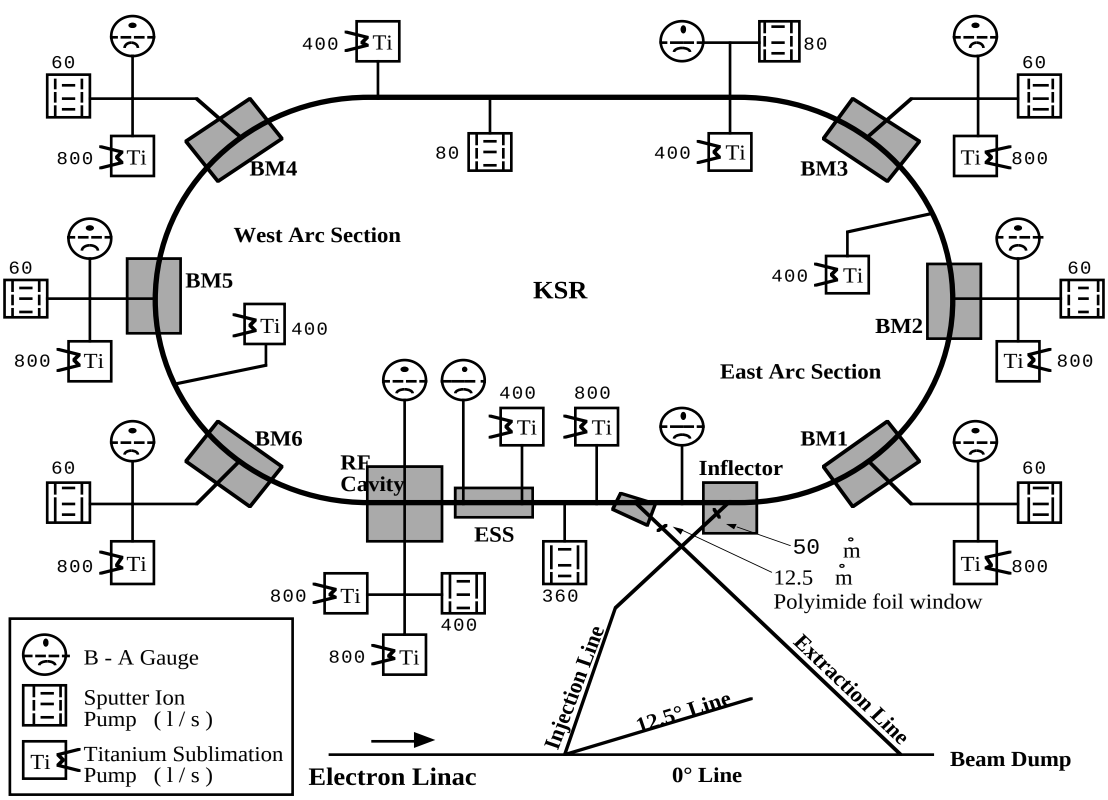

Fig. 1 Layout of the evacuation system in KSR.

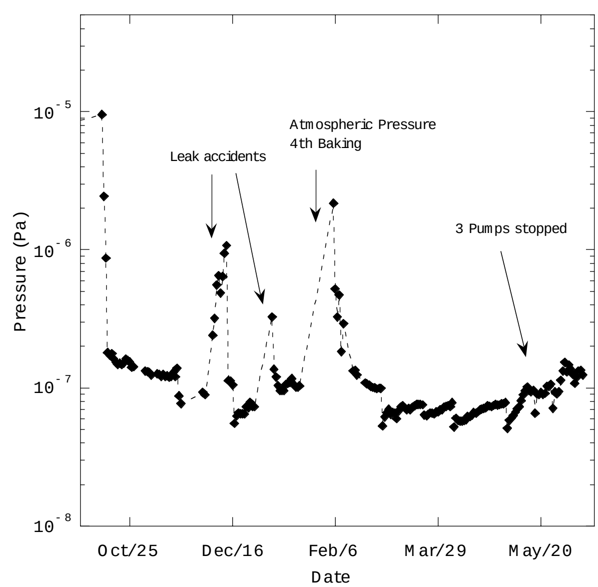

Fig. 2 The average vacuum pressure measured from Oct. 1, 1999.

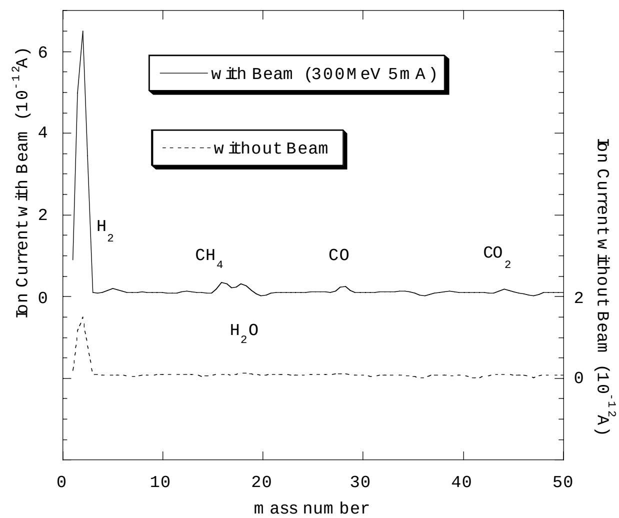

Fig. 3 Mass spectra of the residual gas.

Sputter ion pumps (SIP), 14 Titanium Sublimation Pumps (TSP) as the main pumps and 1 roughing pump unit. But the vacuum pressure of the transport lines is the order of 10^{-6}Pa (very high vacuum). So vacuum system of KSR and the transport line is divided with the windows of the polyimide foils at the Inflector and the septum magnet for the beam extraction as indicated in Fig.1.

2.2 Status

As shown in Fig.2, the vacuum pressure of $7x10^{-8}$ Pa in average is realized throughout the whole circumference with several application of TSP after the baking process up to 120~170˚C.

The mass spectra of the residual gas with and without the beam are shown in Fig.3. It is considered that most of the residual gas and the adsorption gas are H_2 and the rates of H_2O is little without the beam. So its baking temperature is considered enough to decrease the desorption gas. The vacuum pressure is worse at the south straight section where a lot of components such as an electrostatic septum (ESS), DC-CT, RF-knockout and so on are installed into the vacuum system. The evacuation system is not enough to realize the good vacuum pressure.

3 BEAM LIFE

3.1 Status

The relation between the 1/e beam lifes with the electron beam and the beam dose values are shown in Fig.4. The relation between the vacuum pressure and beam dose is shown in Fig.5. The data of the beam dose is taken from the end of last month when the machine conditioning for the storage mode with the beam energy of 300MeV was started.

This conditioning is the machine operation in order to decrease of the desorption gas by the photon stimulation and the electron stimulation for the synchrotron radiation. The stimulation by the baking temperature of 170˚C is less than the case hit by the synchrotron radiation. So the partial pressure of H_2O, CH_4 and H_2 increased with the

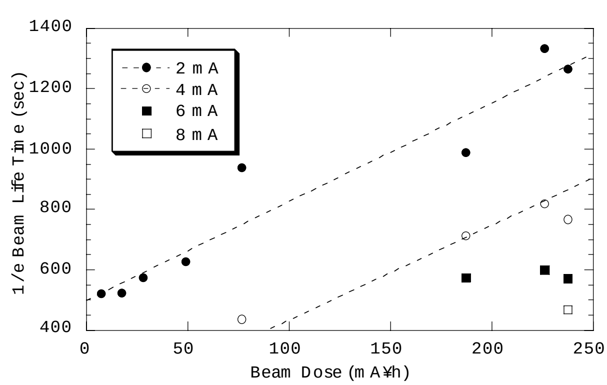

Fig. 4 The beam dose dependence of the1/e beam life with the storage mode.

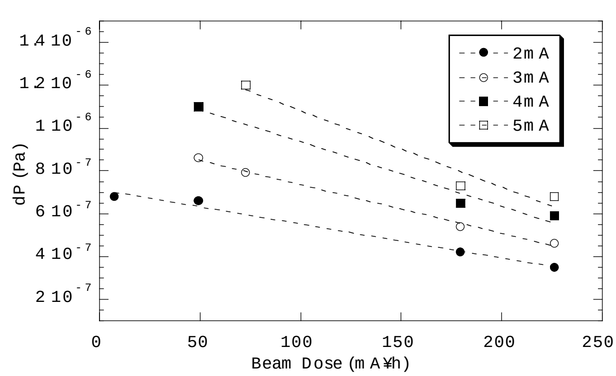

Fig. 5 The storage current dependence of the vacuum pressure with the storage mode.

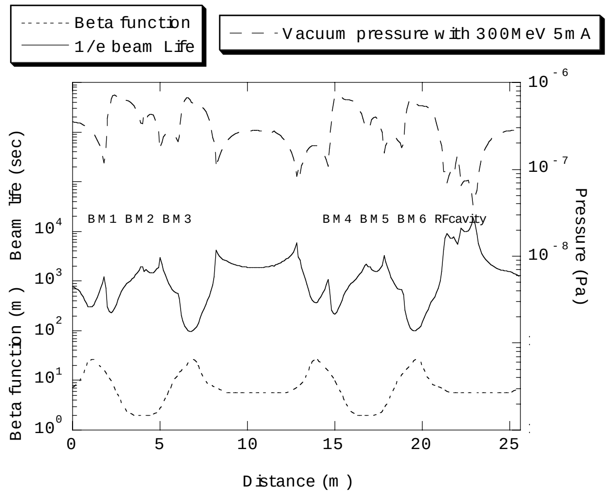

Fig. 6 The influence on the beam life at distance from the Inflector.

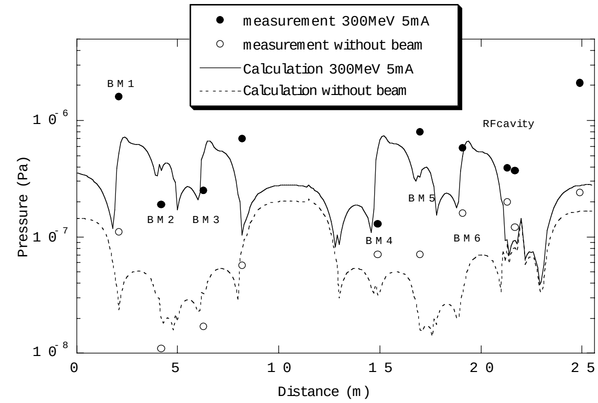

Fig. 7 Estimated the vacuum pressure at distance from the Inflector.

storage mode as shown in Fig.3. Also the partial pressure of H_2 did not change through the baking processes [3]. So the desorption gas of H_2 could not be decreased by the baking process.

Now the maximum current with the storage mode is about 10mA. As shown in Fig4, the increase of the beam life is depending on the beam dose. The dP in Fig.5 is the difference of the vacuum pressure between the cases with and without the beam. The dP becomes lower as the increase of the beam dose because of decrease of the desorption gas. The decrease of dP corresponds to the increase of the beam life.

3.2 Discussion

The beam life is limited by several factors such as the ion trapping, the Touschek life and so on in addition to the vacuum pressure. Now the 1/e beam life time with the storage current of 2mA is about 20 minutes as shown Fig.4. If it is limited by only the vacuum pressure, the beam life will be increased as the conditioning is continued and it is expected that the long time for the conditioning is needed in order to storage up to 100mA. So the improvement of the evacuation system is scheduled in coming summer in order to shorten the conditioning time.

The 1/e beam life with the beam current 100mA is estimated about 1.5 hours, taking the Touschek life into an account. And the vacuum pressure is about $2x10^{-7}$Pa for the 1/e beam life of 1.5 hours with the estimation. However the average vacuum pressure with the beam current of 5mA is measured about $8x10^{-7}$Pa. It means that the machine conditioning time is not enough.

It is assumed that the beam life is limited by the scattering between the beam and the residual gas. Its mejor part is the Rutherford scattering. And the Rutherford scattering depends on the beta function. In all elements of KSR, the aperture of 35(ver.) x 110(hor.) mm^2 with the racetrack shape is kept for the beam circulation. the vertical beta function is shown in Fig.6.

In order to estimated Fig.6 and Fig.7, the beam line is divided 256sections and the length of a section is 0.1m. As shown in Fig.6, the 1/e beam lifes are estimated with the value of the vacuum pressure and the beta function at each sections. The each values of the beam life are short at BM1, BM3, BM4 and BM6. Because at these sections, the beta function is large and the vacuum pressure is not good as shown in Fig.6. So the vacuum pressure at those places are important for increase of the beam life.

The vacuum pressure with the calculation and the measurement are shown in Fig.7. At the moment, 1SIP at BM5 and 2TSP at BM1 and BM2-3 in Fig.1 had stopped because of the break of the filament. So the measured pressure at BM1 is most high. The stopped pumps are to be restored in this summer. So improvement of the beam life can be realized at BM1. And it is expected that the original beam life will be increase d.

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