BEAM TEST OF AN RF DAMPED CAVITY AT THE PHOTON FACTORY STORAGE RING

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Abstract

We have developed a new 500 MHz damped cavity[1~6], the feature of which is that the beam ducts with large diameter are attached to the cavity and that a part of the beam ducts is made of SiC[7,8]. The higher-order-modes (HOM's), which propagate out from the cavity through the beam duct, are damped by the SiC parts. The low power measurement using a cold model and the high power test[9] using a prototype model had been already done. In the autumn of 1996, two damped cavities were installed in the PF ring and operated in the scheduled user run for about two months. The operation of these new cavities was quite successful. On the last day of the scheduled user run before long shut down, we tried very high current beam and succeeded to store the current of 773 mA, the new record in the PF ring.

1 INTRODUCTION

The Photon Factory storage ring is a 2.5 GeV electron / positron ring dedicated for synchrotron radiation experiments. The ring is now being remodeled to provide a lower emittance beam. The reconstruction started in the beginning of this year (1997). The new damped cavity was designed for this new high brilliant configuration ring. Ahead of remodeling of the ring, two of four cavities working in the PF ring were replaced by new damped cavities. These new damped cavities together with two old ones were operated in the last scheduled user run.

The high current storage was also tried on the last day of the scheduled user run before the start of reconstruction of the ring.

Figure 1 shows a schematic view of the damped cavity. The cavity has a beam ducts with somewhat large diameter. HOM's whose frequencies are above the cutoff frequency of the duct propagate out to the beam duct and are absorbed by SiC. HOM's below the cutoff frequency of the beam duct still remain in the cavity, however, these can be detuned not to introduce the coupled-bunch instability by the frequency shift method using two fixed tuner[10].

Unloaded Q of the accelerating mode was 39500 with two fixed tuners, a movable tuner and an input coupler attached. The shunt impedance of the accelerating mode is estimated to be 6.9 MΩ. The SiC is a kind of sintered SiC and has the dimension of the inner diameter of 140 mm, the outer diameter of 160 mm and of the length of 150 mm. The resistivity of the SiC was about 50 Ωcm in the frequency range of 1~5 GHz. The SiC is fixed inside of the copper duct by shrink fit. The copper duct has a water-cooling channel on the outer surface. The SiC has good thermal conductivity, therefore, the rise of temperature of the SiC duct is negligible in the usual operation of the PF ring.

The conditioning of the cavity was carried out in both CW and pulse mode. The power of up to 90 kW(CW) and 120 kW(pulse) was input to the cavity during the conditioning.

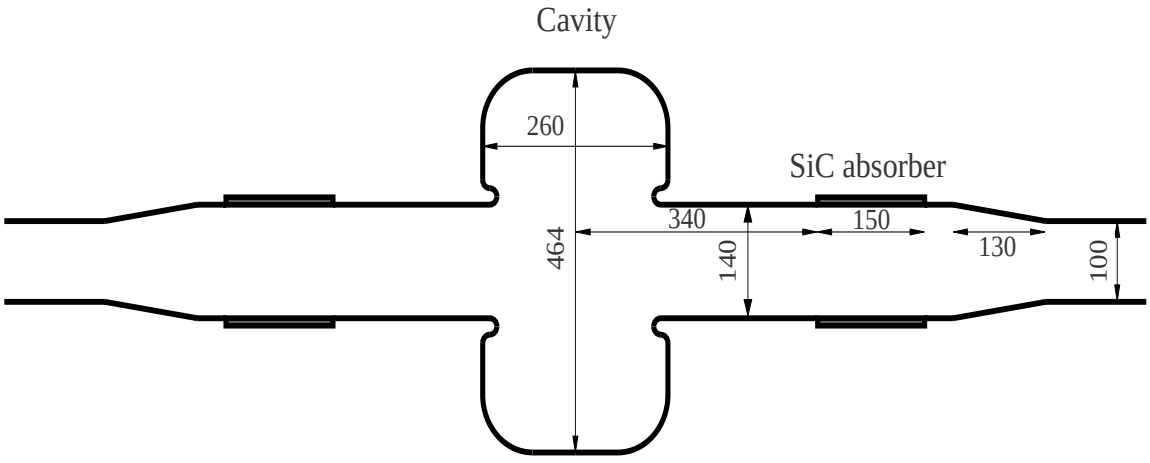

Figure: 1 Schematic view of the damped cavity

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2 INSTALLATION

Figure 2 shows two damped cavities installed in the ring. The input coupler is attached to the upper part of the cavity. The movable tuner is set in the side port of the cavity. Two fixed tuners are set in the bottom and the other side port. In the figure, a part of wave guide is removed. Between two cavities, an evacuation chamber is placed which has two 400 l/s ion sputter pumps, two Titanium sublimension pumps, a vacuum gauge and a quadruple residual gas analyzer. The base pressure was in the range of 10^{-10} Torr after baking.

3 BEAM TEST

Figure 3 shows the vacuum pressure together with the output power of the klystron. Data were taken when the beam was at first stored. Each cavity has one klystron as a power source. Therefore the output power in the figure shows the generator power for each cavity. The stored current is also printed in the figure. The range of vacuum pressure is 10^{-8} Torr before the elapsed time of about 5 hours and 10^{-7} Torr after that time. As seen in the figure, the vacuum pressure became higher and higher with the increase of the stored current, however, gradually lowered. Apart from such slow change of the vacuum pressure, there exist burst outgassing. The worst one among such burst outgassing took place at the elapsed time of about 3.5 hours, however, the peak pressure did not exceeded the range of 10^{-7} Torr. About 10 hours after the first beam injection, the stored current of more than 400 mA was attained without any serious rf and vacuum problem.

The conditioning using beam continued for 4 days with the maximum stored current of 500 mA. After the conditioning, the base pressure decreased to the range of 10^{-9} ~10^{-10} Torr at the stored current of 350 mA. No burst

Figure: 2 The damped cavities installed in the ring

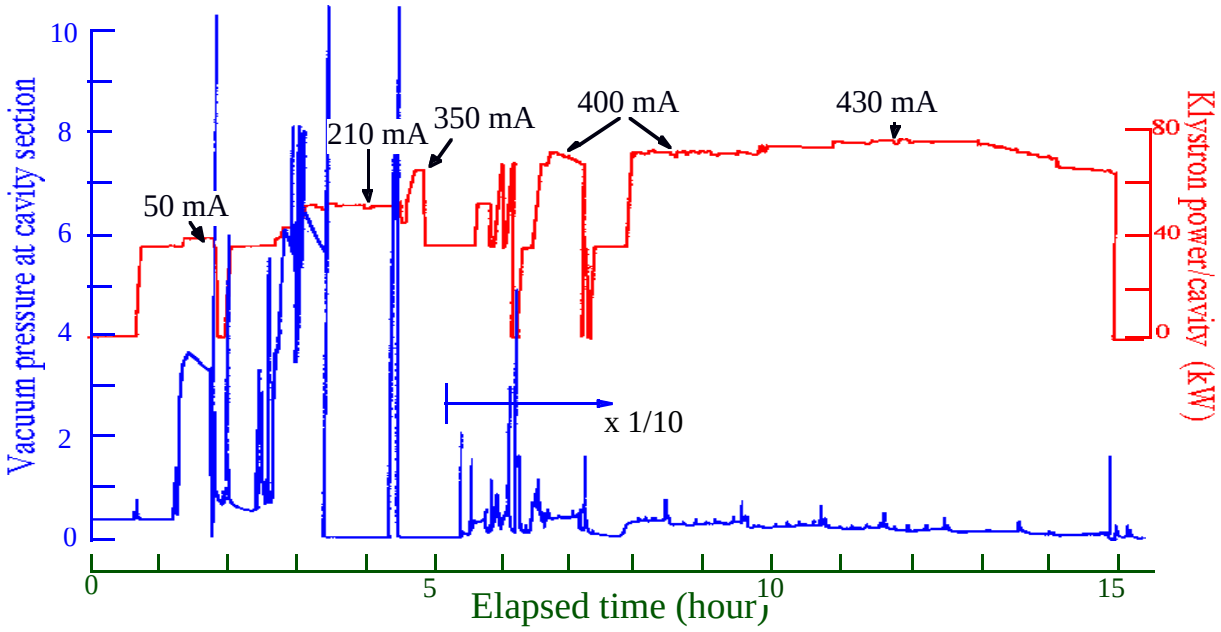

Figure: 3 Change of the vacuum pressure at first storage

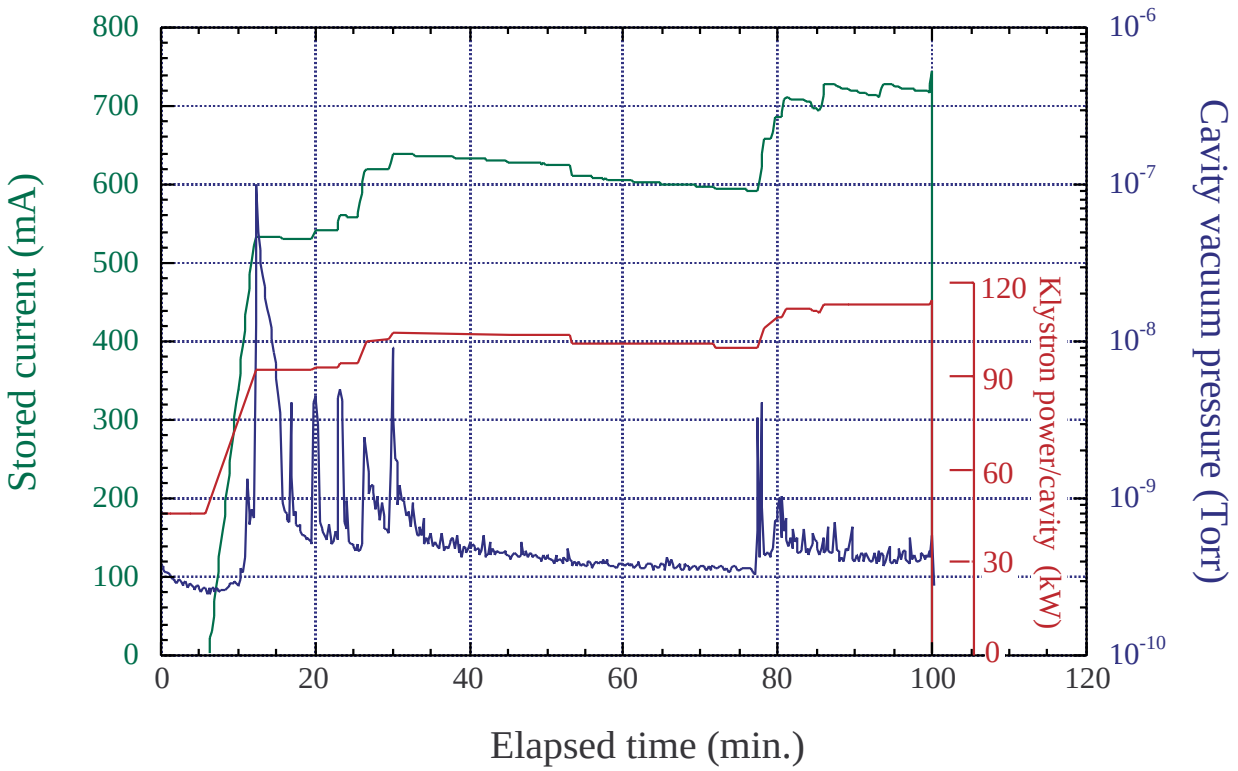

Figure:4 Change of vacuum pressure at high store current.

outgassing was observed in the usual operation after the conditioning.

The detuning of HOM's was quite successful. We could not find out any transverse coupled bunch instability. The longitudinal coupled bunch instability was still observed. However, it is considered to be due to old type cavities since the frequency of the beam spectrum was different from the resonance frequency of HOM's in the new cavities.

4 HIGH CURRENT BEAM TEST

In the end of the scheduled user run in 1996, we tried to store the electron beam as much as possible. The record of the stored current in the PF ring was around 500 mA. Figure 4 shows the new record was achieved. As mentioned in section 1, CW conditioning was made below the power of 90 kW. The vacuum pressure began to rise when the cavity input power exceeded 90 kW. Although the rise of the pressure was not so large, the data in figure 4 suggest the outgassing come from the input coupler. Though the beam was down at 743 mA in the figure, the maximum stored current was 773 mA, the new record in the PF ring. The transverse coupled bunch instability was not observed up to the maximum current. The longitudinal instability was clearly seen on the spectrum analyzer, however, it was not so harmful since the injection rate did not decreased drastically. We could not find out any difficulties to operate the ring at such high current except for the lifetime of the beam, which would be overcome by conditioning using beam to get the low vacuum pressure around the ring.

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