OPERATION OF NEW RF DAMPED CAVITIES AT THE PHOTON FACTORY STORAGE RING

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Abstract

Two of four cavities working in the Photon Factory (PF) storage ring were replaced with the new damped cavities during the summer shut down in 1996 and were successfully operated during the user run in the autumn. The remaining two cavities were installed during the long shut down scheduled for the reconstruction for the low emittance configuration of the PF ring in 1997. The results of the operation of these new damped cavities are presented.

1. INTRODUCTION

The damped structure rf cavity has been developed for two low emittance electron/positron storage rings. One is a high brilliance configuration of the PF storage ring [1]. The other is a third generation VUV-SX synchrotron radiation source which is a future project of the University of Tokyo [2,3]. For these storage rings, the coupled-bunch instability due to higher-order-modes (HOM's) in rf cavity is a serious problem when a stable beam with high current is required.

The damped cavity which we developed has large beam duct, a part of which is made of a SiC microwave absorber. The HOM's propagating out from the cavity through the beam duct are expected to be damped by the SiC part. The low power measurement using a cold model of the cavity showed the SiC beam ducts strongly reduce the Q-values of HOM's in the cavity [4,5,6].

The nominal operating voltage of the cavity system is 1.5 to 1.7 *MV* for both the PF ring and the VSX ring. In case of the PF ring, four cavities are used. Therefore the nominal gap voltage per cavity is about 0.4 to 0.45 *MV*. Taking into account the reduction of Q-value of 10 % for the actual cavity, the gap voltage requires the power of about 30 *kW* to be dissipated in the cavity. The value of the wall loss of 150 *kW* which is the maximum input power that we achieved has large safety margin and operational flexibility.

2 DAMPED CAVITY

The high power model cavity was manufactured at Keihin Product Operations of Toshiba Corporation [7]. Figure 1 shows the cross-sectional view of the high power model. The main part of the cavity was made of class1-OFHC copper which had been treated with Hot Isostatic Press (HIP) before. The cooling-water flow of 200 *l/min* is available with a pressure drop of 0.4 *MPa*. The cavity has tow beam ports and four side ports for an input coupler, a movable tuner and tow fixed tuners. U-tight seal gaskets are adopted as rf contacts between each port and the attached equipment. The input coupler was newly designed [8] being based on that for the 508 *MHz* APS cavity of TRISTAN ring, KEK. We changed the shape of the top of coaxial line where a coupling loop is placed and optimized the positions of the short plates of the rectangular waveguide and the coaxial line in order to obtain low reflection for 500 *MHz* . The movable tuner is the similar type to that has been used in the PF cavity. The fixed tuner is a cylindrical copper block with a ICF-flange to pad the port of the cavity. Two fixed tuners are attached to the bottom port and the side port of the cavity.

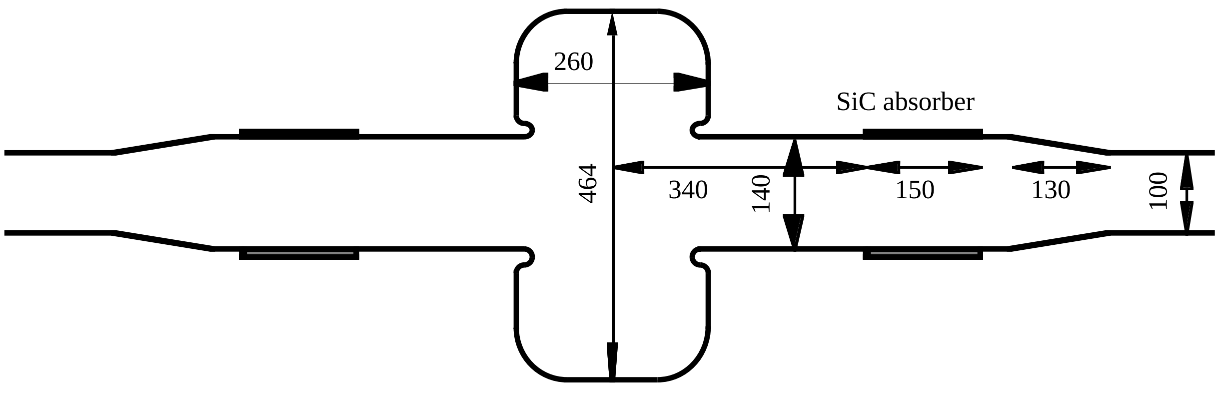

Fig. 1 Schematic view of the damped cavity. The unit is in mm.

These fixed tuners are used for the frequency shift of HOM's by properly choosing the length of the copper block. As mentioned above, HOM's whose frequencies are above the cutoff frequency of the beam duct propagate out to the beam duct and absorbed by SiC. HOM's below the cutoff frequency of the beam duct still remain in the cavity with high Q-values. However, these can be detuned so as not to introduce any coupled-bunch instability. This frequency shift method [9,10,11], using two fixed tuners to detune the HOM's, was first developed at the Photon Factory. The unloaded Q of the accelerating mode was 39500 with all equipment described above attached. The shunt impedance of the accelerating mode estimated to be 6.9 $M\Omega$. The SiC is made by Toshiba Ceramics Co. Ltd. and the trade name is CERASIC-B which is fabricated by sintering in an argon atmosphere under normal pressure. The dimension of the SiC is an inner diameter of 140 *mm*, an outer diameter of 160 *mm* and a 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 process [12,13]. The copper duct has a water cooling channel on the outer surface. Since the SiC has good thermal conductivity of 100 *W/mK*. , the rise of temperature of the SiC duct is negligible under the usual operation of the PF ring.

3 OPERATION OF NEW CAVITIES

During the summer shutdown in 1996 and 1997, all of the four cavities were replaced by new ones. Figure 2 shows these cavities installed in the ring. Between two cavities, an evacuation chamber is placed which has two 400 *l/s* ion sputter pumps, two Titanium sublimation

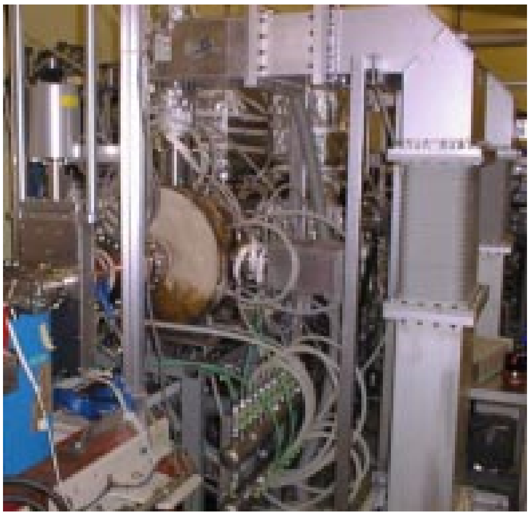

Fig. 2 New damped cavities installed in the ring.

pumps, three vacuum gages and a quadruple residual gas analyzer. The base pressure was 10^{-10} *Torr* after baking. Conditioning of these cavities was carried out in both CW and pulse modes. An rf power of up to 90 *kW* (CW) and 120 *kW* (pulse) was put into the cavities during the conditioning. The operation of the new cavities during the first beam storage after the installation is reported in ref.[12]. The operation of the ring started on Oct. 3 in 1997 after the reconstruction of the ring for the new low emittance optics. The scheduled user run started on Nov. 4. Figure 3 shows the change of vacuum at the cavity section where two new cavities were installed during the summer shutdown in 1997. The elapsed time in the figure does not include the scheduled shut down period. The vacuum pressure ranged around 10^{-8} *Torr* at first,

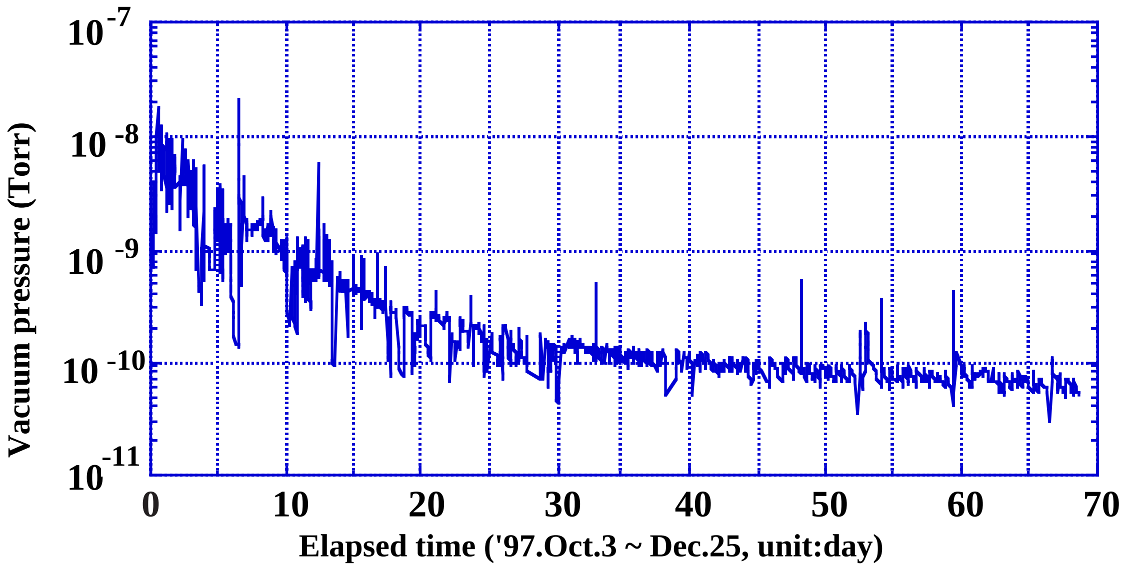

Fig. 3 Change of vacuum pressure at the cavity sectin

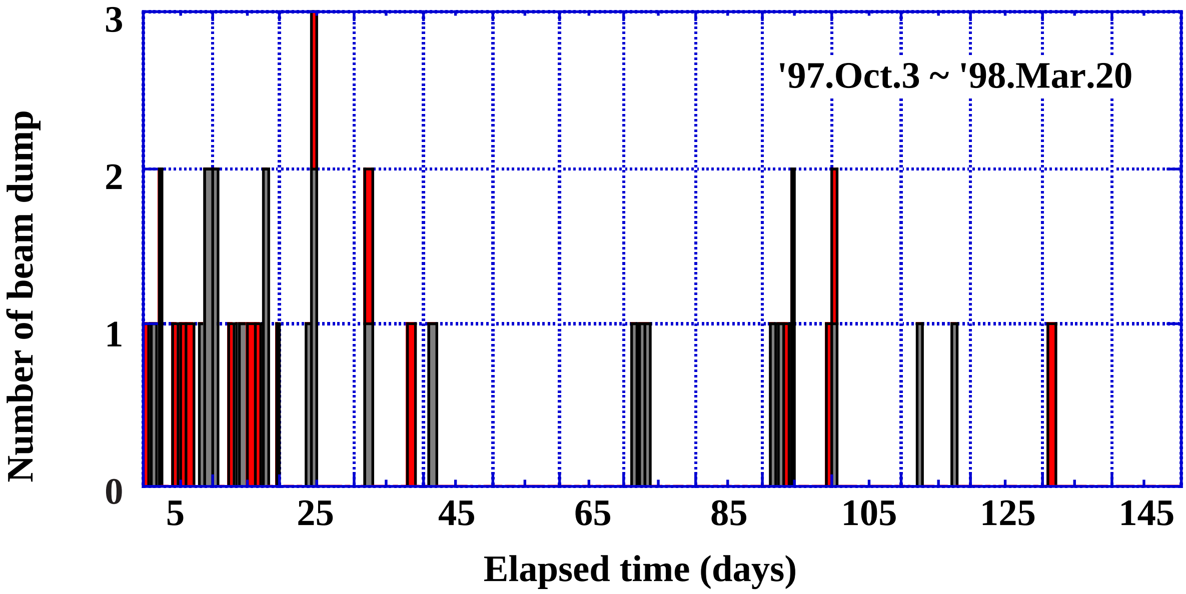

Fig. 4 Number of beam dump during beam storage.

however, decreased to 10^{-11} *Torr* range about one month after. At present, the vacuum pressure at the cavity section is below 10^{-10} *Torr* at a stored current of 400 *mA*, the nominal stored current in user run. Figure 4 shows the number of beam dump which took place during the operation from '97.Oct.3 to '98.Mar.20. Roughly speaking, the rf trip takes place only once or twice a month.

The detuning of the HOM's was quite successful. We could not detect any coupled-bunch instability due to the HOM's of cavities at the present operation point. However, the weak longitudinal coupled-bunch instabilities are still observed. They might be due to the components around the ring, since the frequencies of the beam spectrum are different from the resonance frequency of the HOM's in the new cavities. These longitudinal instabilities are not so harmful for the operation of the ring. The bunch-by-bunch feedback system seems to be the best way to cure these instabilities.

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