BEAM TEST OF A SiC DUCT DEVELOPED FOR AN RF DAMPED CAVITY

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Abstract

Beam test of a SiC duct was carried out in the Photon Factory storage ring (PF ring). The SiC duct is the key part of an rf damped cavity [1] developed in the Photon Factory in collaboration with the Institute of Solid State Physics (ISSP), the University of Tokyo. The low and high power test of the SiC duct has already made[2] . The results were very promising. The remaining test is to install the duct in the ring and to examine its vacuum characteristics in the presence of beam and power absorption arising from higher-order-mode (hom) loss of the beam. The experiment was made in both multi and single bunch operation. The temperature of several parts of the SiC duct and the vacuum pressure near the duct were measured. The results are presented here.

1 INSTALLATION OF THE SIC DUCT

The SiC duct is composed of a water-cooled aluminum (Al) duct with ICF253 Al flanges and a cylindrical SiC. The SiC is inserted in the inside of Al duct by shrink fit. The dimension of the duct is shown in Fig. 1. The inner diameter of the duct is somewhat larger than that in the ring. Therefore the tapered ducts are attached to the SiC duct.

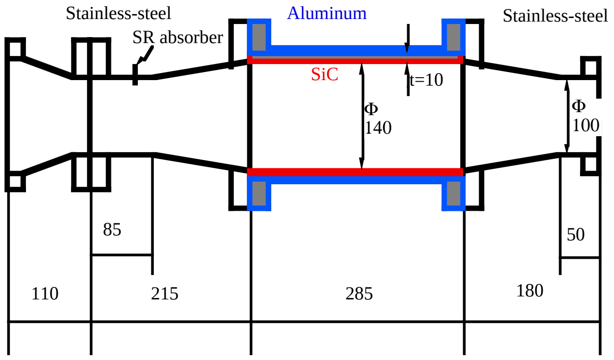

Figure : 1 Schematic view of the SiC duct with tapered ducts.

The SiC duct was pre-baked at a test bench before installation. First, the tapered ducts of stainless steel were baked without the SiC duct at the maximum temperature of 300 °C. Then the SiC duct was attached to the pre-baked tapered ducts and baked at the temperature of about 100 °C. Figure 2 shows these ducts just after baking. The amount of outgas during baking was the same level as that of metal usually used in the ring. The SiC duct with tapered ducts was installed in the downstream of the cavity section(Fig.3).

Figure : 2 The SiC duct after pre-baking.

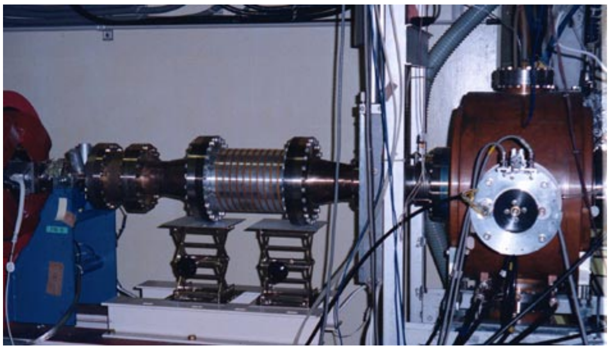

Figure : 3 The SiC duct installed in the ring.

The installation was made quickly with pure nitrogen gas flowing. The vacuum pressure recovered to 10^{-10} Torr range within several hours without baking.

2 EXPERIMENT AND RESULT

Figure 4 shows the change of vacuum vs. the stored current in multi-bunch operation. The vacuum pressure near the SiC duct increases when the stored current increases. However, the pressure is at 10^{-10} Torr range and increases in the same behavior as the average pressure around the ring. The figure shows that there is no abnormal outgasing from the SiC duct.

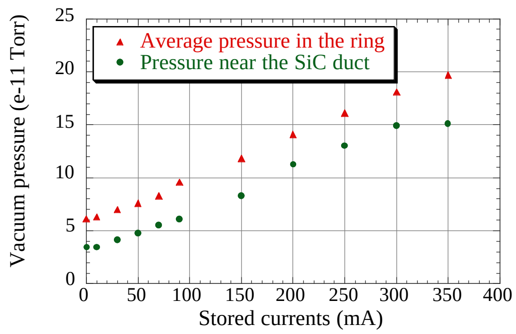

Figure : 4 Change of vacuum pressure near the SiC duct.

As seen in Fig. 1, the SiC duct with tapered ducts is a simple cavity. It may have many resonances, however, the SiC having the resistivity of about 20 Ωcm damps considerably these resonances. A typical quality factor is 20~30 according to MAFIA[3] calculation. The stored beam does not excite these resonances continuously below a certain stored current, that is, the threshold current of the coupled-bunch instability in multi bunch operation. The stored current of about 360 mA in multi-bunch operation, which is nominal in the PF ring, is lower enough not to introduce the coupled-bunch instability due to the resonances of the SiC duct. Actually the difference between the temperature of in and out cooling water was very small.

On the other hand, it is not the case in single bunch beam. Figure 5 shows the calculated loss parameter of the SiC duct with tapered ducts. The calculation was made by using MAFIA(T2). The current dependence of the loss parameter in Fig. 5 is arising from the bunch lengthening. The bunch length in the single bunch mode in the PF ring is reported in ref.[4] and was used in calculation.

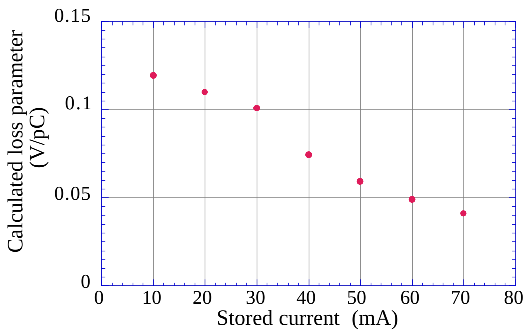

Figure : 5 Calculated loss parameters of the SiC duct with tapered ducts.

The transmission coefficient of the SiC duct was measured in the low power measurement and the value was only 10 % at 2.45 GHz[2]. Therefore most of lost energy in the SiC duct section is absorbed in the SiC. The energy loss P is expressed as $P=k*I^2*f^{-1}$, where k is the loss parameter, I the average current and f the revolution frequency.

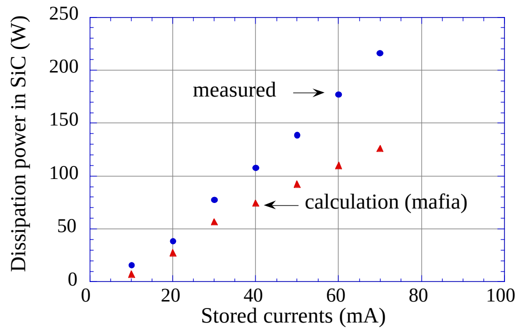

Figure : 6 Measured and calculated power dissipated in the SiC duct

The absorbed power can be estimated by measuring the rise of temperature of the cooling water. The rise of the temperature was 1.6 °C at maximum with a cooling water flow of 2.2 **l/m**. Figure 6 shows the comparison of the measured absorbed power and the calculated power in the single bunch operation. The discrepancy between the measured and calculated power in Fig. 6 is considered that 1) there is a power flow due to hom loss of the rf cavity and bellows which locate just at upstream of the SiC duct, and that 2) the effect of synchrotron radiation (SR) absorber (see Fig. 1) is neglected in calculation. The temperature of Al duct, tapered ducts, and flanges was monitored during experiment. The highest temperature was that of tapered duct to which the SR absorber is attached. The value was 25 °C that was only 3 °C rise. The vacuum pressure was less than 2×10^{-10} Torr at 70 mA. Therefore there is no vacuum nor thermal problem in the SiC duct. We will install the new damped cavity with SiC duct in the PF ring in this summer.

REFERENCES

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