HOM ABSORBER FOR THE ARES CAVITY

Y. Takeuchi, K. Akai, N. Akasaka, E. Ezura, T. Kageyama, H. Mizuno,
F. Naito, H. Nakanishi, H. Sakai, Y. Yamazaki
KEK, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba, 305 Japan
T. Kobayashi
Institute of Applied Physics, Tsukuba Univ., 1-1 Ten-nodai, Tsukuba, 305 Japan

Abstract

Two types of sintered SiC (silicon carbide) ceramics has been developed and applied as the HOM absorbers for the second prototype ARES cavity (ARES96). One is bullet-shape SiC ceramics and the other is a tile one. The prototype cavity equipped with these absorbers was successfully tested with an electron beam in the TRISTAN accumulation ring. High power tests of these absorbers were carried out using an L-band RF power source. The HOM absorber designs and the results of the tests are discussed.

1 INTRODUCTION

A second prototype of ARES cavity (ARES96) for KEKB was built[1]. Figure 1 shows a schematic drawing of the accelerator cavity of ARES96. The accelerator cavity has four rectangular waveguides, in each of which two bullet-shape SiC ceramics are inserted at the end as the HOM absorbers. Two grooved beam pipes with 32 SiC tiles are connected to the accelerator cavity to absorb dipole modes of the HOMs.

The HOM power (at frequencies above 0.7 GHz) to be handled will be on the order of ~10 kW per cavity, corresponding to ~1.25 kW per bullet-shape absorber.

On the other hand, the design value of the maximum RF power (at frequencies above 0.7 GHz) absorbed by the SiC tiles in the grooved beam pipes is about 400 W per cavity, corresponding to ~100 W per eight tiles in the groove.

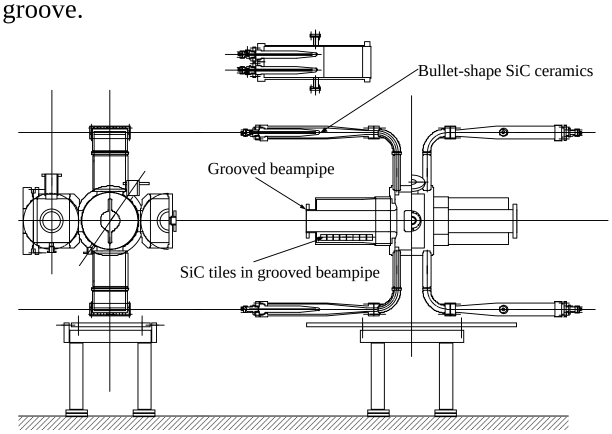

Figure 1: A schematic drawing of the accelerator cavity of ARES96.

ARES96 which equipped with these absorbers was successfully tested with an electron beam (~500 mA) in the TRISTAN accumulation ring. The maximum HOM powers absorbed by the waveguide HOM loads and the SiC tiles in the grooved beam pipe were 0.8 kW and 120 W. These values were not enough as high power tests for KEKB. Therefore high power tests were carried out using an L-band RF power source to verify the performance as the HOM loads.

2 BULLET-SHAPE SiC ABSORBER

2.1 Design

The first prototype of the ARES cavity (ARES95) adoped sixteen bullet-shape SiC absorbers (diamiter 40 mm, effective length 400 mm)[2]. Using the results[3][4], a new bullet-shape SiC absorber was designed for ARES96. The absober dimensions are 55 mm in diameter, and 400mm in total effective length including a 150mm nosecone section. The SiC absorber has a cooling water channel which is bored inside and led near the nosecone tip. The distance between the nosecone tip and the water channel is 30 mm.

Figure 2 shows the dielectlic constant ε'_r and loss tangent of the SiC ceramics, measured using a dielectric probe kit (HP85070B). Figure 3 shows the frequency response of the reflection (S_{11}) from the HOM waveguide including the E-bend and taper waveguide, which was simulated with hfss[5]. The TE_{10} mode in the waveguide was assumed in this simulation. The absorption under

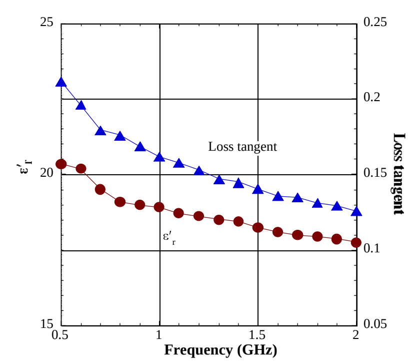

Figure 2: The dielectric constant and loss tangent of the SiC ceramics are plotted as a function of frequency.

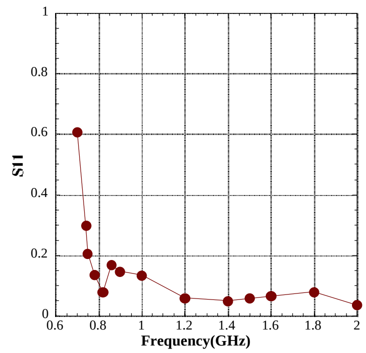

Figure 3: The frequency response of the reflection (S_{11}) from the HOM waveguide including the E-bend and taper waveguide.

1GHz was improved by adopting thicker SiC than that of ARES95. The RF characteristics of this type absober were precisely analized [4].

2.1 High power test

Figure 4 shows a layout of the high power test. The SiC absorber was inserted from the end of an L-band rectangular waveguide (WR650). The standing-wave ratio VSWR was measured ~1.14. The high power test was carried out using a CW klystron (f = 1296 MHz) up to a power of ~3.3 kW. Temperature at the position *P* of the SiC absorber was monitored using a infrared thermometer. The SiC absorber functioned normally without any vacuum, thermal, or discharge trouble up to 3.3 kW of RF power. Figure 5 shows the temperature rise at the position *P* and the vacuum pressure corresponding to the RF power loss in SiC. After this test, we also measured temperatures at the position *A~G* in figure 4 using thermosensitive labels, which indicate the maximum temperature by changing their colors. The maximum temperature rise is about 33~38 deg. at the position *C* when the RF power loss was 1.25 kW.

This SiC absorber satisfies our specification enough and would handle much higher power than 3.3 kW.

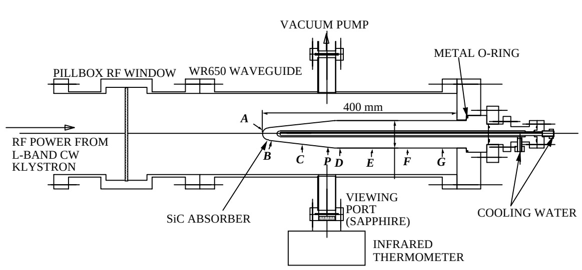

Figure 4: A layout of the high power test.

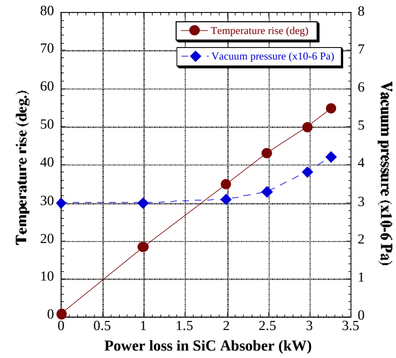

Figure 5: The temperature rise at the position P and the vacuum pressuer corresponding to the RF power loss in SiC.

3 SIC ABSOBERS IN THE GROOVED BEAM PIPES

3.1 Design

Two grooved beam pipes with 32 (8x4) SiC tiles were connected to the accelerator cavity of ARES96 to absorb dipole modes of the HOMs. Two tiles (48 x 48 x 10 mm^3) and 6 tiles (48 x 48 x 20 mm^3) were fastened with stainless steel bolts (M6, tightening torque 150 kgf·cm) on the stainless steel plate in the groove. And the plate was cooled by water. Gold foil (0.05 mm thickness) was sandwiched between the SiC tiles and the stainless steel plate to make a better thermal contact.

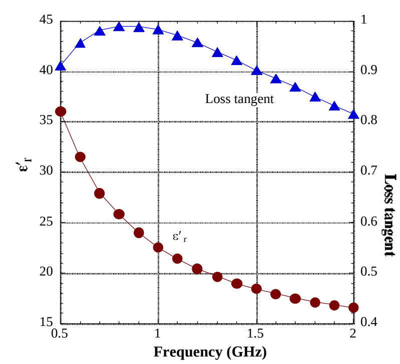

Figure 6: The frequency response of the dielectlic constant ε'_r and loss tangent of the SiC ceramic tile.

Figure 6 shows the frequency response of the dielectlic constant ε'_r and loss tangent of the SiC ceramics. We adopted a SiC ceramics which has relatively large dielectric constant and loss tangent at the frequencies under 1 GHz in order to design a compact load. Figure 7 shows the frequency response of the reflection (S_{11}) from the grooved beam pipe with the SiC tiles, which was simulated with hfss. The TE_{11} mode in the beampipe was assumed in this simulation.

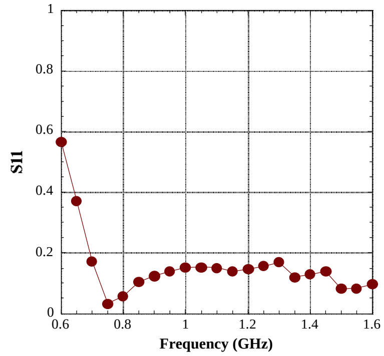

Figure 7: The frequency response of the reflection (S_{11}) from the grooved beam pipe with the SiC tiles.

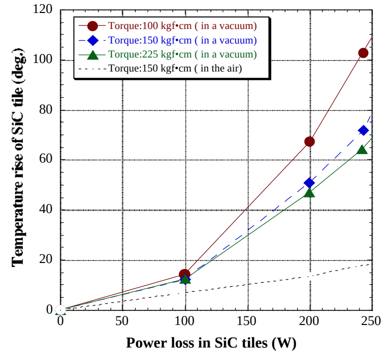

Figure 9: The temerature rise of the #4 SiC tile with different tightening torques in a vaccum. The open circles shows the teperature rise of the #4 SiC tile in the air.

3.2 High power test

Eight SiC tiles with gold foil fastened on the cooling plate with bolts (M8) were tested using the same test waveguide set shown in figure 4. Figure 8 shows a schematic drawing of the test sample. The SiC tiles on the cooling plate was put in the waveguide from the end plate. The temperature of the #4 SiC tile was monitored by the infrared themometer. And the temperature of each SiC tile was measured by using termosensitive labels.

Figure 9 shows the temerature rise of the #4 SiC tile with different tightening torques. The open circles in figure 9 show the teperature rise of the SiC tile in the air. The temperature rise of the tile in the air increase linearly with the power loss. On the other hand, the temperature rise in a vacuum does not. It was considered that the thermal coductivitiy under vacuum between the SiC tile and the cooling plate depend on the temperature rise. The tensile stress in the bolt decreases as the temperatures of the SiC tile and bolt increase, because the coefficient of thermal expansion of the SiC ceramics (4.5×10^{-6} /K) is smaller than that of the stainless steel (17×10^{-6} /K). The tension in a stainless steel bolt (M8, degreased) is about 500 kgf at a tightening truque of 150 kgf·cm. If we assume that the temperatures of the SiC tile and the bolt tightened with the toruqe of 150 kgf·cm are equarl, then the tension in the bolt becomes 0 when temperature rise is about 55 deg.. Therefore we have to pay attention to the temperature rise of the SiC tiles and the tension in the bolts. We are planning to test using coned disk springs to keep the tension in the bolt. Titanium bolts, which has the smaller coefficient of thermal expansion than stainless steel, will be tested.

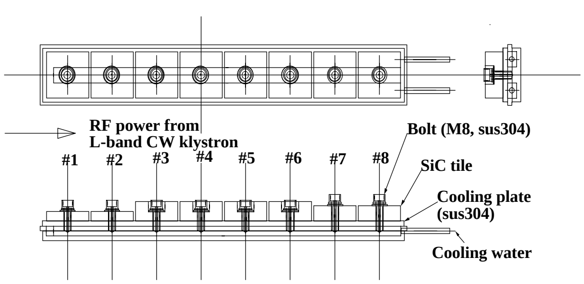

Figure 8: The schematic drawing of the test sample.

The maximum temperature rise in the SiC tiles (tightening torque 225 kgf·cm) was measured about 20~25 deg. on the #3 SiC tile when the RF power loss was 100 W. Since the temperature rise is small enough at 100 W of RF power, we will apply this simple cooling scheme of fastening SiC tiles with bolts to the ARES cavity for KEKB.

4 CONCLUSION

Two types of sintered SiC ceramics has been developed and applied as the HOM absorbers for the second prototype ARES cavity (ARES96). One is bullet-shape SiC ceramics and the other is a tile one. ARES96 was successfully tested with an electron beam (~500 mA) in the TRISTAN accumulation ring. Furthermore, high power tests of these absorbers were carried out using an L-band RF power source. These HOM absorbers were demonstrated to be capable of the RF power specifications. Based on these studies, designing the HOM absorbers for the production cavity is in progress.

REFERENCES

[1] T. Kageyama et al., "Dvelopment of high-power ARES Cavities", in this conference.

[2] T. Kageyama et al., "The ARES Cavity for the KEK B-Factory", Proc. of EPAC96, p2008.

[3] Y. Takeuchi et al., "HOM Absorber for the KEKB Normal Conducting Cavity", 1995 Particle Acc. Conf., KEK Preprint 95-69 (1995).

[4] Y. Takeuchi et al., "The SiC Absorber for the KEKB ARES Cavity", Proc. of EPAC96, p2020.

[5] HP Part No. 85180A, Hewlet Packard Corp.