FABRICATION OF BIPERIODIC DAW CAVITY

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Abstract

Fabrication techniques for the biperiodic DAW cavity have been investigated for these years. The basic dimensions are optimized by computer simulations and cold model tests. According to results of material tests, all of the parts facing to the inside are made of OFC. In order to improve the properties of a bridge coupler, which is installed between two 1.2-m long accelerating tube, choke structure is implemented.

1 INTRODUCTION

The biperiodic DAW cavity for electron acceleration is under fabrication and test. The operating frequency is designed at 2857MHz so that it can replace one of the existing disc-loaded waveguide accelerating tubes. The injection energy for the acceleration test is intended to be about 60MeV. It consists of two of 1.2-m long accelerating tube and a coaxial bridge coupler that connects the two tubes. The bridge coupler has an RF coupler, a vacuum port, and three frequency tuners.[1] Recent progresses in fabricating a power model for a real acceleration of electrons are described in this paper.

2 MATERIAL TEST

At first, chromium copper (Cr-Cu) was considered as the material for mechanically severe portions, because of the mechanical complexity of the DAW.[2] Cr-Cu, however, was found to have some undesired properties for the DAW cavities as following:
1) the outgas from the Cr-Cu surface is three to four times larger than that from the OFC surface,
2) the composition of Cr-Cu changes after the parts are furnace brazed (900°C), which decreases the strength and
3) the oxidization of the surface on Cr-Cu is caused.

2.1 Outgas

The outgas characteristic was measured for Cr-Cu. The shape and the size of the specimen are shown in Fig. 1.

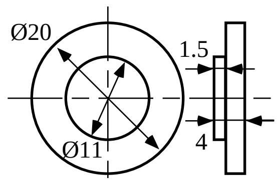

Figure 1: The dimensions of the specimen for outgas test.

	H	O
Cr-Cu	1.3 ppm	2 ppm
OFC (Class 1)	0.6 ppm	1 ppm

Table 1: Impurities in the material for outgas test.

Hydrogen and oxygen impurities are listed in Table 1. The pressure of H_2 gas was measured at 500°C for more than 30 minutes. The pressure reached its maximum value at 14 minutes after the heating started. The result showed that the outgas rate of Cr-Cu is three to four times that of OFC. The value was 2.7×10^{-6} Torr•l/cm^2/s at 30 minutes after heating, which was 47% of the maximum value. The time dependencies for both the Cr-Cu and OFC specimen were similar except for the absolute value.

2.2 Heat test

Test pieces made of Cr-Cu (Cu-0.94%Cr) and OFC were provided for a heat test. The shapes of the specimens are half cylinders as shown in Fig.2. Hydrogen and oxygen impurities are listed in Table 2. Figure 3 shows the temperature change that simulates the furnace brazing procedure.

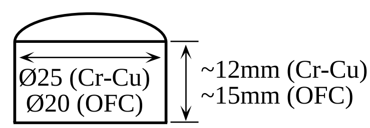

Figure 2: The dimensions of the specimen for heat test.

	H	O
Cr-Cu	1.3 ppm	2 ppm
OFC (Class 1)	0.5 ppm	1 ppm

Table 2: Impurities in the material for heat test.

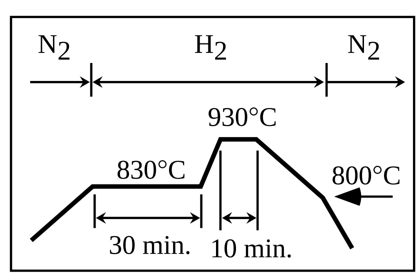

Figure 3: Temperature change for heat test.

Although the OFC specimen did not show any change in its surface color, the surface of the Cr-Cu specimen changed its color dark. A microscopic inspection showed the existence of two layers on the surface of the Cr-Cu specimen. The medium layer had a thickness of 10 μm and seemed to be pure copper. The very surface layer was so thin that it could be barely recognized. The composition of the inner portion of Cr-Cu specimen changed after the parts were heated up, which may cause decrease of the mechanical strength of the material.

In order to identify the chemical composition of these layers, we carried out a measurement with an X-ray diffraction method for chemical elements of Cu, Cr, O, H, N and C. Then only Cu and Cr_2O_3 were found for above elements. The result showed that the very surface thin layer and the 10 μm layer were made of Cr_2O_3 and pure copper, respectively. The origin of the oxygen was not clear: whether it comes from the atmosphere or the inside of the material. Because both the possible oxygen sources cannot be controlled in the current facility, the oxidization of the surface is difficult to be avoided.

Thus, OFC is considered as a material for the whole structure of DAW except for the outer water jacket.

3 BRIDGE COUPLER

Two 1.2m-long accelerating tubes are coupled by a coaxial bridge coupler, which has an RF coupling slot, an evacuation port and frequency tuners (Fig. 4). The RF power is fed through the coupling slot on the coaxial bridge coupler. The spool in the bridge coupler is supported by four straight pipes connected to the body of the bridge coupler, so that the cooling water can go through the spool. The electric field distributions in the bridge coupler for the accelerating mode and the coupling mode are shown in Fig. 5.

The spool in the bridge coupler is upheld by four supports that are located at the center of the bridge coupler so that disturbance of the electric field for the accelerating mode becomes small. On the other hand, they disturb the electric field distribution of the coupling mode, which raises the coupling mode frequency about 200 MHz. This frequency shift is too large to be compensated by modifying only the spool shape and dimensions, even with an inter-rim at the center of the spool. In order to cure this situation, we adopted the choke structure in the spool supports (see Fig. 6). Because

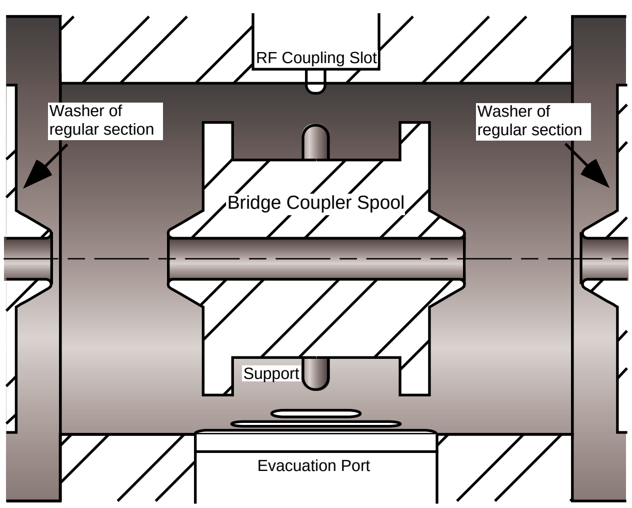

Figure 4: Coaxial bridge coupler.

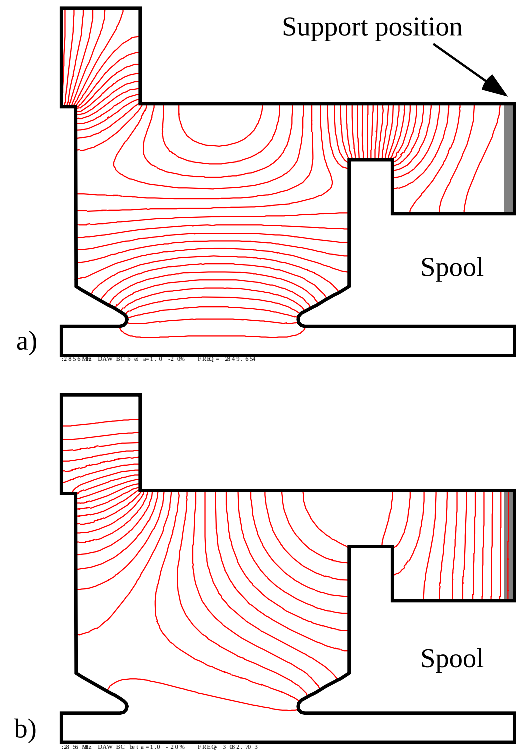

Figure 5: The field distribution in the coaxial bridge coupler; a) the accelerating mode, b) the coupling mode.

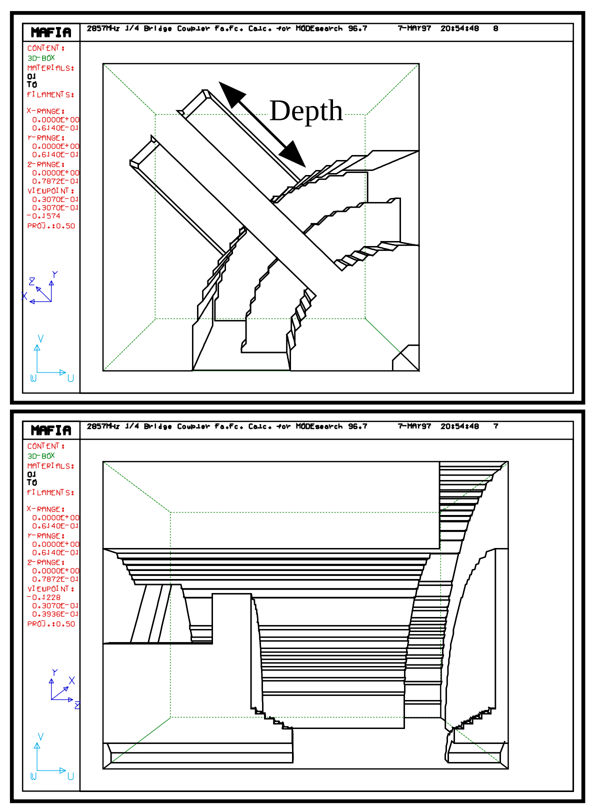

Figure 6: Choke structure implemented for the supports.

a support is connected to a λ/4 coaxial line, it is practically insulated from the outer wall. The coupling mode frequency can be adjusted by the depth of the choke. On the other hand, the accelerating mode frequency is not affected by the choke.

3.1 *MAFIA calculation*

MAFIA calculations were performed to show the choke effect. Because no inter-rim is implemented on the spool for simplicity, the coupling mode frequency (fc) does not match with the accelerating mode frequency (fa). The outer cylinder is approximated by a square for ease in meshing. The calculated frequencies are listed in table 3. Because the original fc (without support) is 200 MHz higher than fa, the choke is used in over-compensation way.

	fa [MHz]	fc [MHz]
without support	2847	3078
with support	2856	3243
with choke depth=23.5	-	2917
with choke depth=24.8	2852	2855
with choke depth=25.5	-	2824

Table 3: Effect of the choke depth.

3.2 Coupling Mode Frequency of Cold Model

Cold model tests were carried out to determine the choke depth. The geometry difference from the MAFIA model was the approximated outer cylinder of the choke. The accelerating mode frequency decreased only 3 MHz with the implementation of the choke structure. Figure 7 shows the depth dependence of the coupling mode frequency in conjunction with the MAFIA results. Taking account of the practical mesh, the difference between the calculations and the measurements are reasonable. The rough parameters were obtained from these results. The precise tuning can be done with minor adjustment of the spool dimensions. The tilt sensitivity[3] with 9 gap-regular section on each side was up to 10 %/MHz in the cold model (see Fig. 8). On the other hand, that without the choke was as much as 50 %/MHz. The difference is much more drastic if only the values around the bridge coupler are compared.

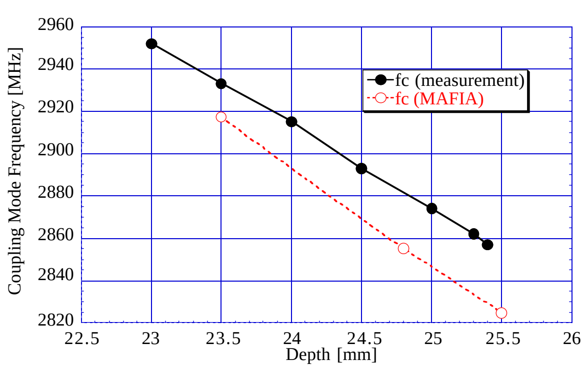

Figure 7: Coupling mode frequencies as functions of the choke depth.

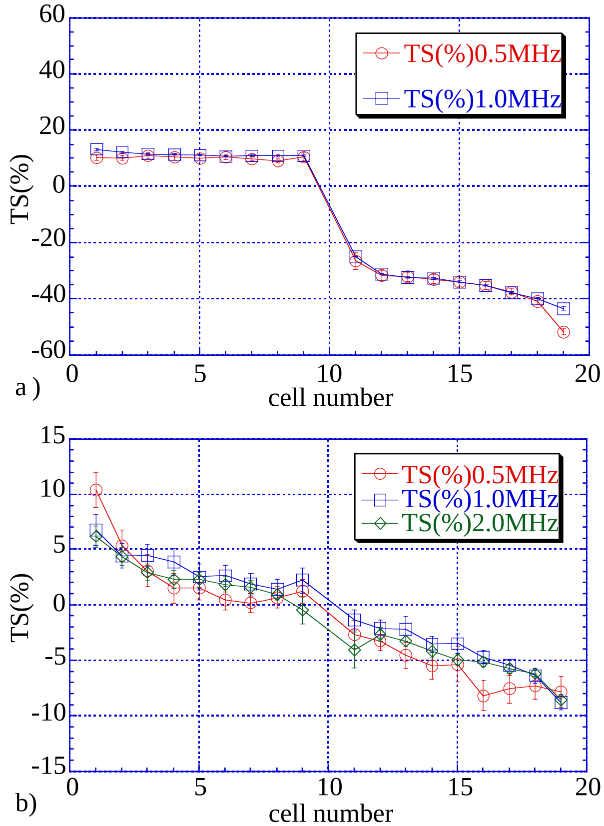

Figure 8: Tilt sensitivity a) without choke , b) with choke

4 CONCLUSION

According to the results from the material tests, OFC was chosen as the material for fabrication and the accelerating tube was designed. The choke structure was implemented on the supports for the spool in the bridge coupler. Because the washers should be water-cooled, they have cooling grooves in them. The fluid and thermal calculations were also performed for the groove design. We are preparing for a power test and a beam acceleration test including the measurement of the power model tank.

5 ACKNOWLEDGEMENTS

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