Fabrication of an X-band 30cm Accelerating Structure by Diffusion Brazing

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Abstract

Precise fabrication method for X-band disk loaded accelerating structure has been studying at National Laboratory for High Energy physics (KEK) and Ishikawajima-Harima Heavy Industries Co.Ltd (IHI). An X-band (11.4GHz) accelerating structure (30cm in length) was bonded by gold/copper diffusion brazing, aiming at the negligible deformation. Characteristics of this bonding are measured. The variation of frequency change in every cell was found to be well less than 1MHz. Alignment of cells came out to be 4.5μm. These results show that the diffusion brazing is very promising for fabrication of an accelerating structure with less deformation.

1 INTRODUCTION

For the main linac of Japan Linear Collider (JLC)[1], an accelerating structure must satisfy the following requirement. The wake field must be negligibly small at following bunches to suppress the emittance growth. To this aim, an X-band detuned accelerating structure has been studying at KEK [1]. Relative frequency tolerance for dipole modes in all cells is 1×10^{-4} [2]. Therefore, the tuning after bonding cells should be avoided in addition to make the cells precise. A precise fabrication method has been developed using precisely machined cells[3]. Tests for 2-cell, 5-cell and the short structure model (6 regular cells, 2 coupler cells and 2 wave guides) were performed and reported before [4]. Following these tests, a 30cm accelerating structure was fabricated to verify the feasibility of the present method and various characteristics are described in the present paper.

2 SPECIFICATION

1. Out look (see fig.1)
   32 regular cells and 2 coupler cells
   2 wave guides
   4 cooling tunnels

2. RF characteristics
   Resonant frequency 11.424 GHz (2π/3mode)
   Frequency tolerance $\leq$ 1 MHz (objective)

3. Mechanical
   Coaxiality among all the cells $\leq 1\mu$m (objective)

3 DIFFUSION BRAZING

In usual fabrication methods, deformation of cavity is mostly caused by bonding. To reduce it, gold/copper eutectic mixture was applied to join flat surfaces in the bonding of the present accelerating structure. This method, diffusion brazing, has following advantages. A groove for usual bazing is not necessary. An eutectic point of a gold/copper alloy is lower than the temperature of a Cu/Au brazing, but higher than that of a Cu/Ag brazing. This gives a less deformation than Cu/Au brazing but still a Cu/Ag brazing is possible in the following steps.

To keep surface flatness of the precisely machined cells and purity of the materials (copper and gold), the gold films were created by the RF sputtering on the copper surfaces. Cavity area was masked against gold film by using photo-resist technique [4]. Then, the main parts (32 regular cells and 2 coupler cells) were bonded by diffusion brazing. Vacuum ports and wave guides were brazed by Cu/Ag afterwards. It should be noted that the present diffusion brazing method is very reliable on vacuum leak tightness, judging from the bonding tests (13 times with 29 junctions) where we experienced no vacuum leak.

4 ALIGNMENT OF CELLS

The outer diameter of cells were precisely machined as a reference of axis of the structure. Cells were assembled on the precise V-block (straightness of 2μm). Measurements of the concentricity were performed 3 times, 1)after assembling cells, 2)after bonding by diffusion brazing and 3)after bonding by Cu/Ag brazing. The axial concentricity was observed by outside positions of four points around each cell, while sustaining whole structure at two particular cells. Fig.2 shows the result of the measurements. Errors of the first assembling were less than 0.5μm. After diffusion brazing, it increased to 4 μm. After Cu/Ag brazing, the amount of concentricity was kept within the

measurement error. The alignment became 4.5μm in total. This diffusion brazing was found very promising in a precise fabrication of accelerating structure.

5 RF CHARACTERISTICS

In order to keep a total phase shift of the accelerating mode within 1°, tolerable relative frequency of each cell is $\pm 3 \times 10^{-5}$. If this condition is satisfied, the required tolerance for dipole modes in a detuned structure will be automatically fulfilled. This is because the frequency sensitivity of the TM_{110} mode, the most severe dipole mode, is similar to that of the accelerating mode. In this sense, RF characteristics of the accelerating mode were measured to study the influence of a diffusion brazing. Fig 3 shows the shift of resonant frequencies (pseudo $\pi/2$ mode of TM_{010}) in every cavity caused by the bonding. The frequencies of this $\pi/2$ mode were measured by detuning the adjacent cells using precisely positioned plunger. The variation is ± 0.2 MHz and the frequency shift is -0.68MHz in average. Fig 4 shows input VSWR, showing little change. These results show the usefulness of the present diffusion brazing technique for fabricating an accelerating structure without tuning.

6 SUMMARY

Summary of a diffusion brazing in manufacturing an accelerating structure are as follows.

1. Frequency change due to this bonding $\leq 1 \times 10^{-4}$.
2. Alignment of cell can be less than several μm.
3. High reliability against vacuum leakage.
4. Cu/Au and Cu/Ag brazing can be performed in addition to the diffusion brazing.

7 REFERENCES

[1] JLC group, JLC-1, KEK report 92-16, KEK, pp166-173 Dec. 1992.

[2] T.Higo,*"Precise Fabrication of X-band Accelerating Structure"*,proc. 9th symp. on Accelerator Science and Technology, Tshukuba, Japan, Aug. 1993.

[3] H.Sakai and Y.Higashi et al,*"Precise Fabrication of X-band Accelerator Cell for JLC (3)"*,proc. 18th Linear Accelerator Meeting Japan, Tsukuba, Japan, July 1993, pp264-266.

[4] A.Yamamoto et.al.,*"Fabrication of an X-band Structure by Diffusion Brazing with inserting Sputtered Gold Films"*, proc.18th Linear Accelerator Meeting Japan, Tsukuba, Japan, Tsukuba, Japan, July 1993, pp261-263.

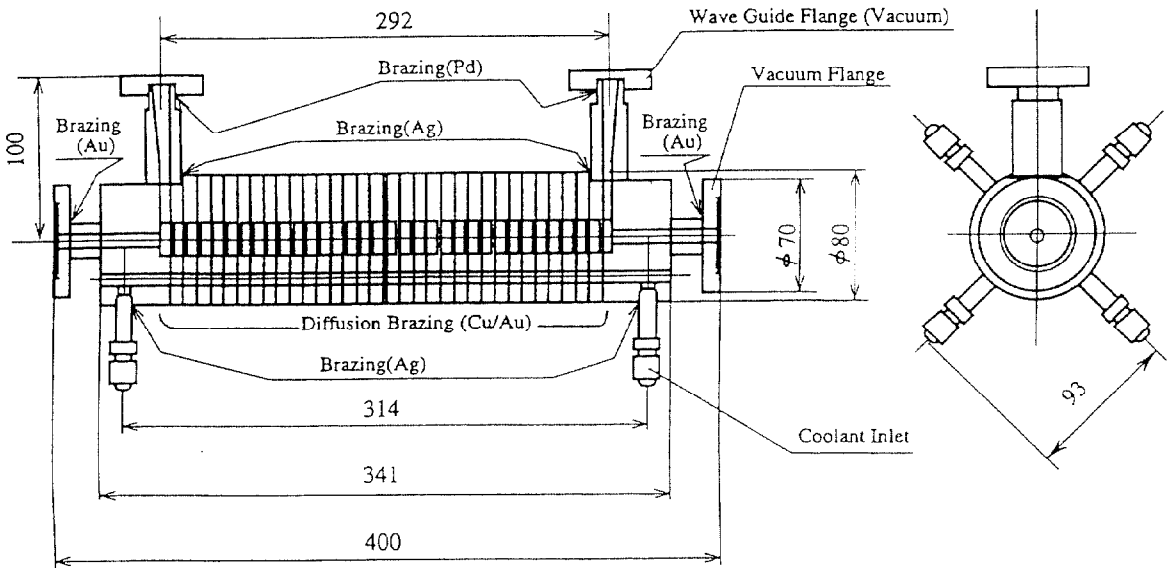

Figure 1. Schematic view of a 30cm accelerating Strucrute

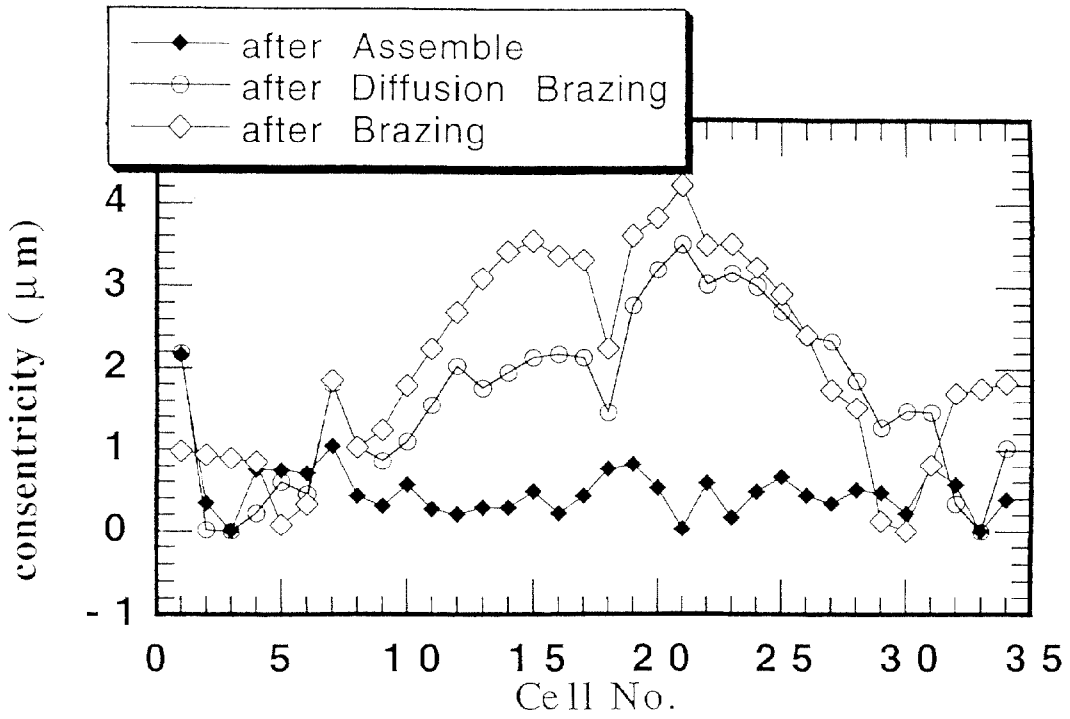

Figure 2. Result of Cell Alignment at each step

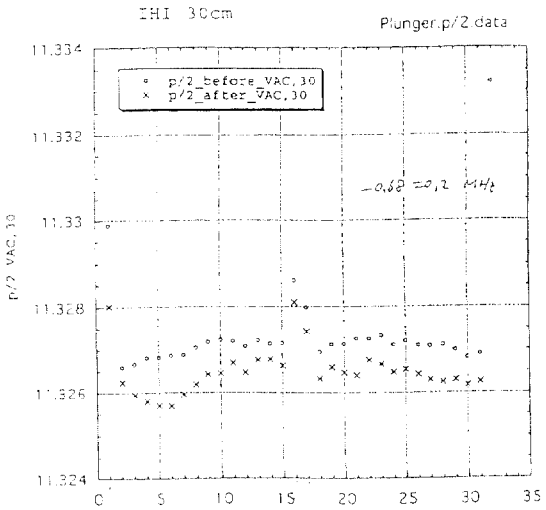

Figure 3. Frequency Shift

Circles show values of before bonding
Crosses show values of after bondig

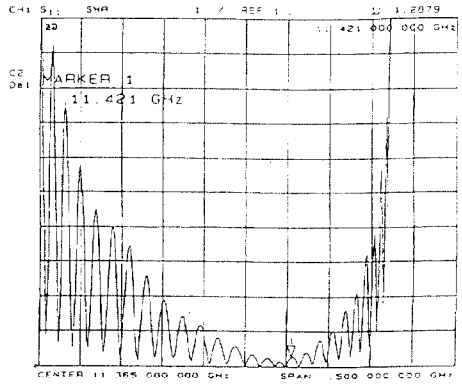

Fig 4 -1 VSWR before bonding

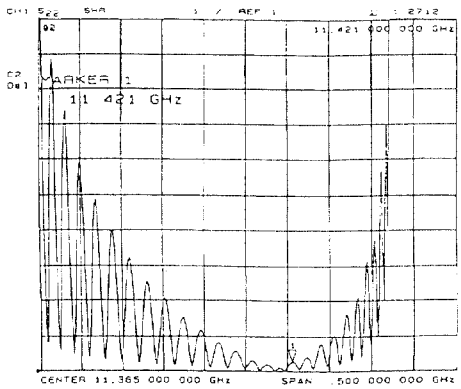

Fig 4 -2 VSWR after bondig