DEVELOPMENT OF S-BAND ACCELERATING STRUCTURE

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Abstract

In Pohang Accelerator Laboratory (PAL) in Korea construction of XFEL (X-ray Free electron Lazar) institution is under construction aiming at the completion in 2014[1]. Energy 10GeV of the linac part of this institution and main frequency are planned in S-band (2856 MHz), and about 178 S-band 3m accelerating structures are due to be used for this linac.

The oscillation of an X-ray laser requires very low emittance electron beam. On the other hand, since the accelerating structure which accelerates an electron beam has a feed port of microwave (iris), the electromagnetic field asymmetry of the microwave feeding device called coupler worsens the emittance of an electron beam.

MHI manufactured two kinds of S-band accelerating structures with which the electromagnetic field asymmetry of coupler cavity was compensated for PALXFEL linac. We report these accelerating structures.

INTRODUCTION

MHI manufactured two kinds of every two S-band accelerating structures as prototype machine for PALXFEL linac, and supplied them to PAL in June and August 2012 respectively. 1st kind of accelerating structures which MHI manufactured are S-band 3m structure which equipped J-type double feed coupler, and one more kind equips quasi-symmetrical type single feed coupler. Both accelerating structures, J-type and Quasi-symmetrical type, are the structures with which the electromagnetic field asymmetry of coupler cavity was compensated.

TWO TYPE PROTOTYPE S-BAND ACCELERATING STRUCTURE FOR PALXFEL

Fig.1 shows J-type S-band accelerating structure which equipped J-type double feed coupler. Fig.2 shows Quasi-symmetrical type S-band accelerating structure which equipped quasi-symmetrical type single feed coupler.

These are 3m long, constant gradient, S-band 2856MHz accelerating structures. Cell number is 84 regular cells and 2 coupler cells. Material of these structures is oxygen free high conductivity copper. All cell are machined by super-precision lathe, and surface roughness of these cells are suppressed to 0.1 μ m or less. And all cells are assembled by vacuum brazing. Table 1 shows the specifications of these S-band accelerating structures.

Table 1: Specifications of S-band Accelerating Structures

Resonance Frequency	2,856 MHz
Phase Shift	2π/3
Accelerator Type	C.G.
Number of Cells	84+2 coupler cell
Quality Factor	13000
Group Velocity	0.012c (average)
Shunt Impedance	49.3～60.0 MΩ/m
Attenuation Constant	0.56
Filling Time	0.84 μs
Coupler type	J-type
	Quasi-summetry

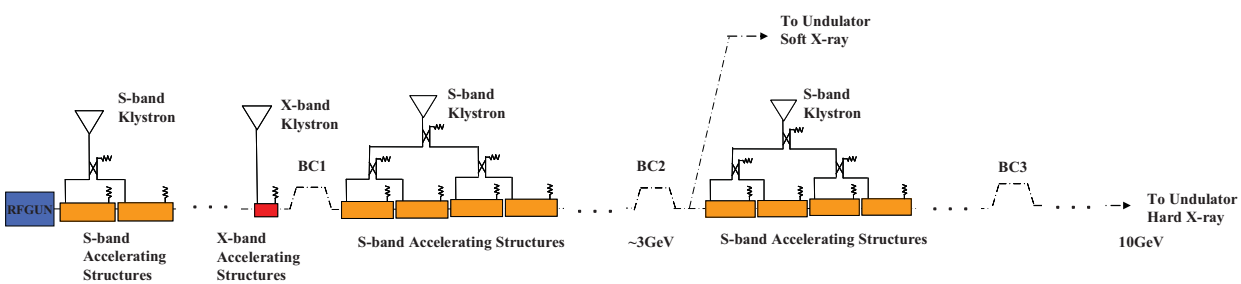

Figure 1: Linac layout of PAL XFEL project.

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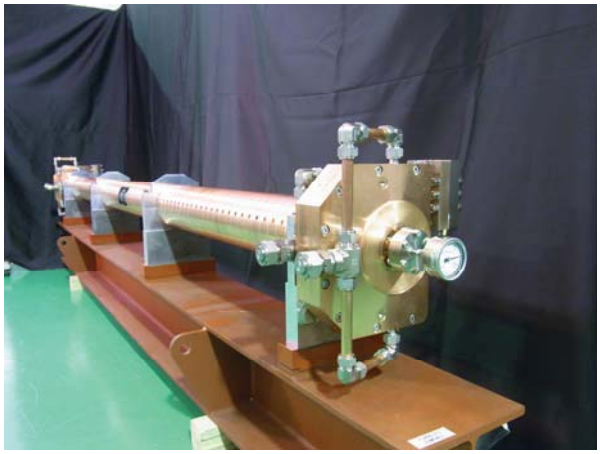

Figure 2: J-type S-band accelerating structure.

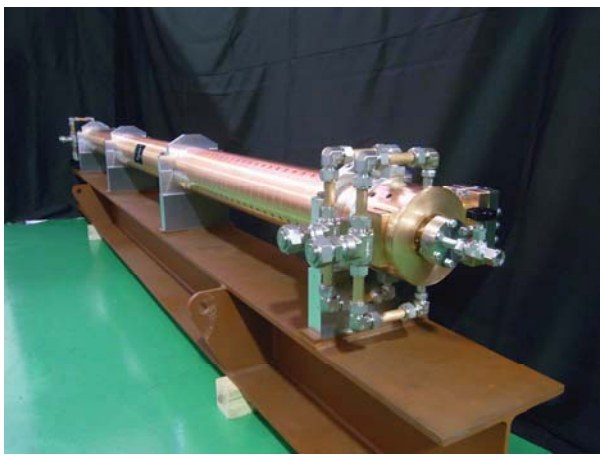

Figure 3: Quasi-symmetrical type S-band accelerating structure.

J-TYPE COUPLER AND QUASI-SYMMETRICAL COUPLER

J-type double feed coupler that Professor Matsumoto in KEK devised[2] has two irises although that has only one connection with wave-guide. Therefore, the surface field intensity at the iris is low, and low beam emittance is maintainable since electromagnetic field in the coupler cavity is symmetrical.

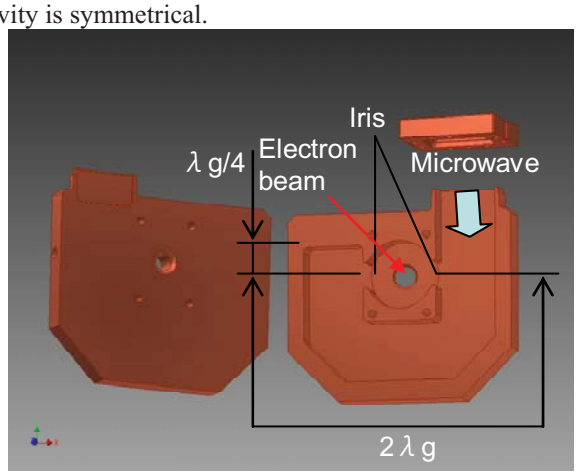

Figure 4: J-type coupler.

Quasi- symmetrical type coupler have wave guide of 1/4-wave length in iris opposite side in order to compensate asymmetry of electromagnetic field in the coupler cavity.

The single feed type S-band accelerating structures which MHI manufactured is operated by a high axial gradient up to 30 MV/m in ATF/KEK and PLS II /PAL. The axial gradient of PALXFEL linac is 20 ～ 25 MV/m. Thus an accelerating structure with this type of coupler is applicable for PALXFEL linac.

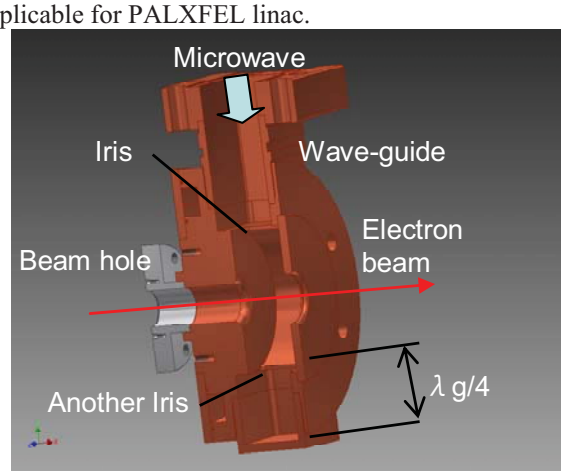

Figure 6: Quasi- symmetrical type coupler.

ANALYSIS AND MEASUREMENT

A decision of the coupler optimal shape was made by the analysis by a computer and RF measurement of a test model. The computer code used the three-dimensional electromagnetic field analysis code HFSS. The test model was manufactured based on calculated data. The coupler optimal shape was determined by correction processing of the test model while performing RF measurement. RF measurement was performed by the nodal shifting method using the network analyzer.

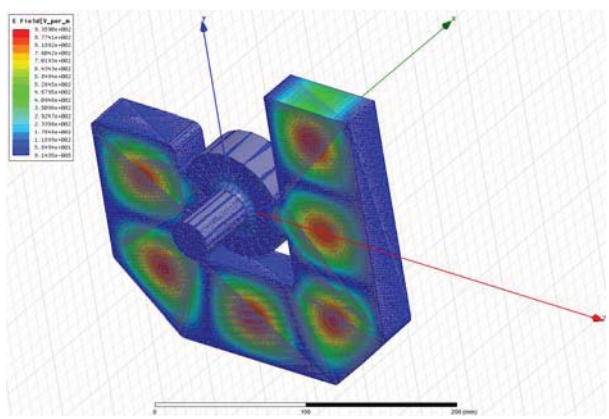

Figure 7: Analysis model (J-type).

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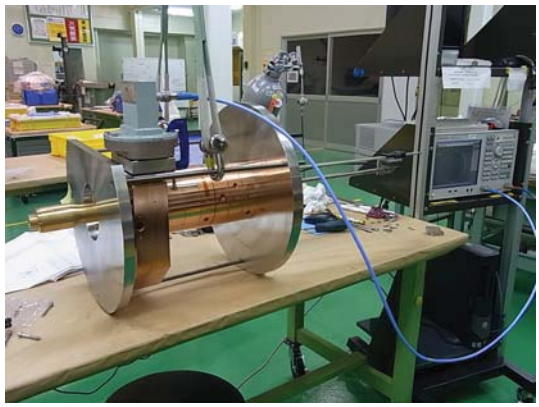

Figure 8: RF measurement (J-type).

LOW LEVEL RF RESULTS

MHI manufactured two J-type S-band accelerating structures and two quasi-symmetrical type S-band accelerating structures. Table2 shows Final RF result. Input and output VSWR are less than 1.05 (tolerance) at operation frequency. Phase error is lass than 2.5 degree (tolerance).

Table 2: Low Level RF Results of S-band Accelerating Structures

Item	Accelerating structure type			
	J-type 01	J-type 02	Q-type 01	Q-type 02
Input VSWR	1.032	1.021	1.014	1.007
Output	1.023	1.037	1.044	1.04
Phase error	±0.17deg	±0.18deg	±0.14deg	±0.11deg
Quality Factor	13668	13265	13621	13667
Group	0.012	0.012	0.012	0.012
Attenuation Constant (τ)	0.551	0.567	0.551	0.551
Filling Time	0.84μs	0.84μs	0.84μs	0.84μs

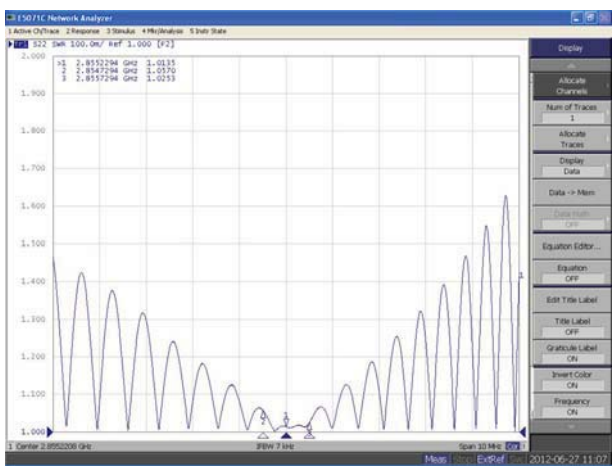

Figure 9: Example of input VSWR (PQ01).

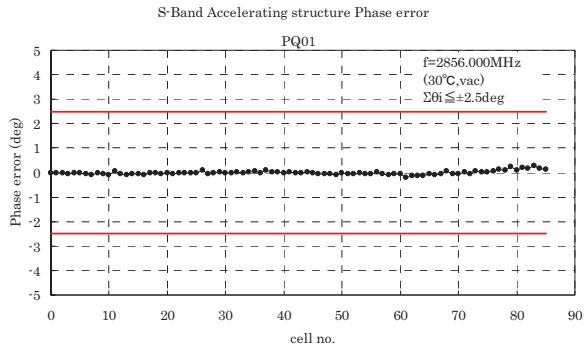

Figure 10: Example of phase error (PQ01).

SUMMARY

- MHI manufactured two prototype J-type S-band accelerating structures and two prototype quasi-symmetrical type S-band accelerating structures for PALXFEL.
- These accelerating structures are due to have high power test carried out in PAL.
- MHI receive the order of 40 accelerating structures from PAL, and are already preparing mass production.

REFERENCES

[1] J.-H. Han et al., "STATUS OF THE PAL-XFEL PROJECT", Proceedings of IPAC2012, New Orleans, Louisiana, USA.

[2] H. Matsumoto et al. "Fabrication of the C-band (5712MHz) Choke-Mode Type Damping Accelerating Structure", Proceedings of the 24th Linear Accelerator Meeting in Japan.

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