PRODUCTION OF C-BAND DISK-LOADED TYPE CG ACCELERATING STRUCTURE

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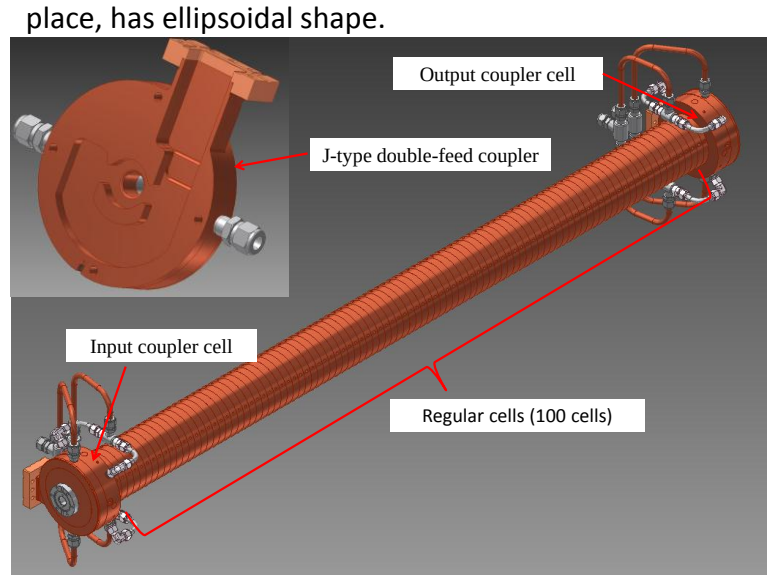
Introduction

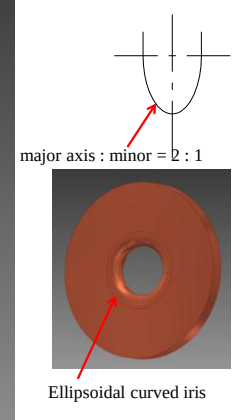
In April 2013, MHI contracted with RIKEN to manufacture six C-band disk-loaded type and quasi-constant gradient (CG) accelerating structures. The first structure was delivered in August 2013 to RIKEN and the other five were delivered in March 2014.
We will report the production and low-power RF properties of these accelerating structures.
Devices of the accelerator system operable at a high repetition rate are being developed in RIKEN as one of the possibilities to grow in performance of the SACLA. The C-band disk-loaded type structures were designed to enable the operation. We paid attention to reduction in manufacturing cost and compatibility with the C-band choke-mode type accelerating structures in use as the main accelerators of the SACLA.

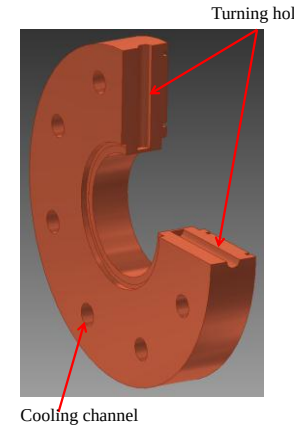
Design and Specifications

Items	Requirements specifications
Resonance frequency	5172 MHz +/- 0.2 MHz
	30 deg. C in vacuum
Coupler type	J-type double-feed coupler
Number of cells	100 + 2 coupler cell
Total cavity length	1.8 m
Structure type	Quasi-constant gradient
Phase shift	2π/3
Integrated phase error	≤ +/- 3deg.
VSWR	≤ 1.1
Q factor	8000 ≤
Shunt impedance	55 MΩ ≤
Attenuation constant τ	0.56
Filling time t_F	270 ns
Material of cells	OFC-CLASS1 HIP
Brazing process	Vacuum brazing

- Regular accelerating cells consist of disks and cylinders to simplify the geometry of parts and improve workability.
- Each cylinder has four holes arranged axisymmetrically for tuning dimpling.
- The accelerating mode was changed from $3\pi/4$ to $2\pi/3$.
- The shunt impedance and the axial electric field can increase compared with choke-mode type structure.
- To reduce the risk of breakdown, the beam-hole edge, where the maximal surface electric field takes place, has ellipsoidal shape.



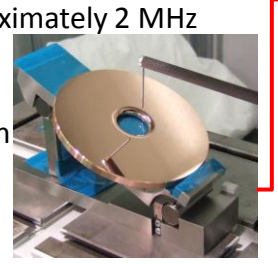


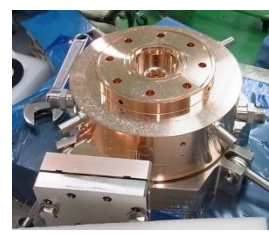


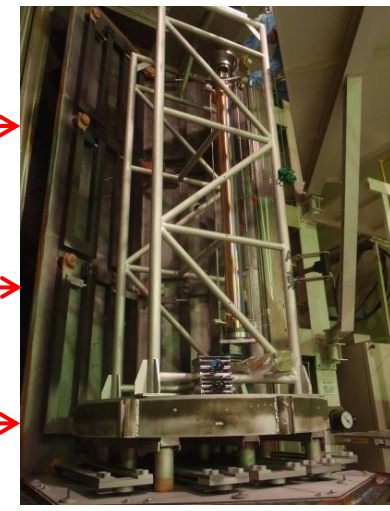
Production

- The inner surfaces of the cells were mirror finished by using ultraprecision lathe and the cells were brazed in a vacuum furnace.
- The inner diameter of the cylinder was oversized so that the frequency of the regular cells was by approximately 2 MHz lower than the operation frequency since the frequency was shifted high after the final brazing.


Cylinder


Disk


Coupler cell


Vacuum brazing layout


Completed product

Result of the low-power RF test

- The measured RF properties of the accelerating mode of the structures are shown in below table.
- During the brazing, the cells on the downstream side of the structure were subjected to the higher load than that on the upstream side and their phase shift was greatly beyond expectations. Tuning the cells by the bead-pulling method was conducted so that the degraded phase shifts were improved and reflections from the cells were reduced.
- #001 : integrated phase error of 3.2 deg. slightly did not meet the requirement specification.
- #002 : requirement specifications were satisfied.
- #003-#006 : the further oversized diameter was given to the cells on the downstream side against their large phase shift by the brazing, and tuning accuracy was improved so the integrated phase error was below 2.8 deg. and the VSWR was below 1.05.

	#001	#002	#003	#004	#005	#006
Resonance frequency [MHz]	5712	5712.02	5712	5712	5712	5712
Integrated phase error [deg]	3.2	2.8	2.7	2.8	2.8	2.8
Input VSWR	1.02	1.09	1.01	1.04	1.03	1.05
Attenuation constant τ	0.54	0.54	0.54	0.54	0.54	0.55
Filling time t_F [ns]	273	271	273	269	272	272
Q factor	8981	8969	9023	8944	8979	8950

Result of the high-power RF test

- High-power RF test of the #001 has already been conducted by RIKEN in the test bench of the SACLA. An acceleration gradient of 50.1 MeV/m was achieved for 0.5 μs in RF pulse width and at 60 pps in repetition rate.
- The operation of 42 MeV/m at 120pps was possible for 24 hours or more without stopping due to the electric discharge etc.
- It was also verified that no thermal side effect was observed during operation at 120 pps. The detailed discussions on the results of the high-power RF test are described in the reference [1] shown below.

[1] T. Sakurai et al., "High power RF conditioning of C-band disk-loaded type accelerating structure", Proceedings of the 11tha Annual Meeting of Particle Accelerating Society of Japan, 2014 (to be submitted)