Design of 5.8 MHz RF Electrode for AMS Cyclotron

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Abstract

Accelerator Mass Spectrometry (AMS) is a powerful method for separating isotopes, and electrostatic tandem accelerators are widely used for AMS. Sungkyunkwan University is developing AMS that can be used in a smaller space based on cyclotron. Unlike conventional cyclotrons used in PET or proton therapy, cyclotron-based AMS provides high turn number and high resolution. In this study, we proposed a cavity with a frequency of 5.8 MHz and an accelerating voltage of 300 V to accelerate the particles in the cyclotron. The proposed cavity was designed as an electrode and verified by CST Microwave studio.

RF cavity Feature

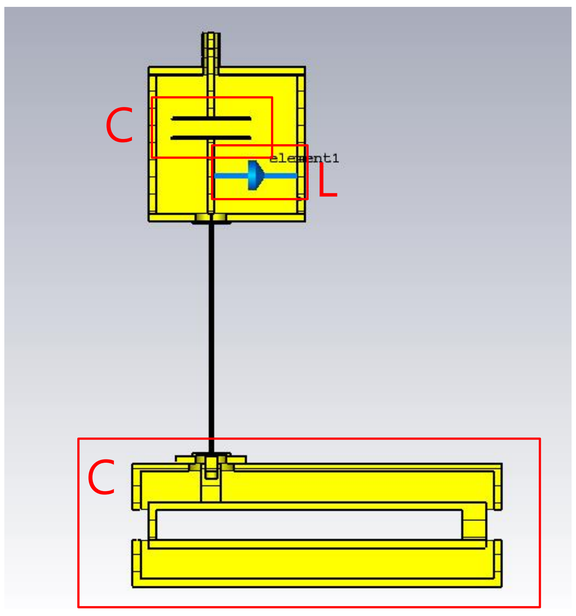


Figure 1 RF cavity

- Fig 1(A) shows fabricated X-band linac cavities.
- Fig 1(B) how small the x-band cavity is.
- In order to get a sufficient **surface roughness** as shown fig 1(C) of the copper device, use single crystal diamond tool to fabricate copper bulk.
- Table 1 shows specification of X-band linac cavity.

Table 1: specification of AMS cyclotron

Specification	Value
E [keV]	200
R_{in} / R_{ext} [mm]	138 / 453.6
Mass Resolution	5000
Turn number	159
Dee voltage[V]	300
Frequency[MHz]	5.8
E_{in} [keV]	25
Dee angle [°]	20
Number of Dee	2

Simulation

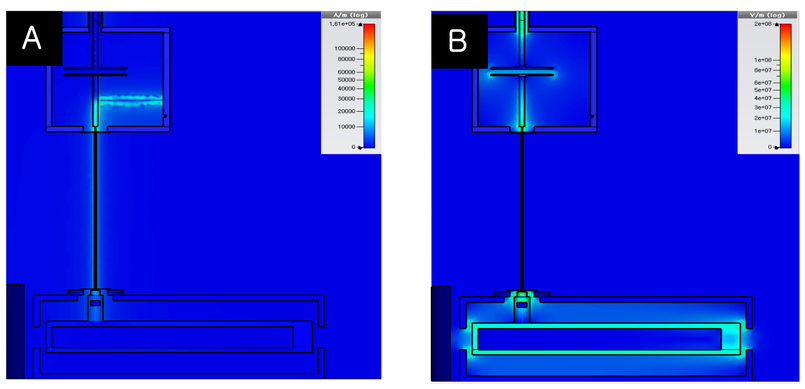
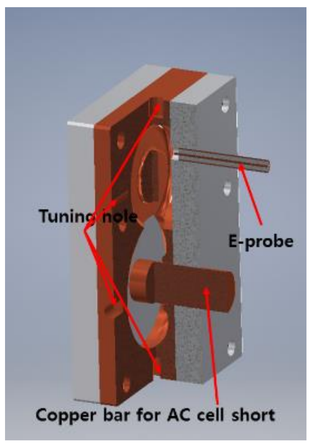


Figure 2: (A)H-field, (B)E-field

- Fig 2 shows design step for removing stop-band.
- The boundary conditions were selected so that the electromagnetic fields of pi / 2 mode were generated in AC and SC.



- E-probe consists of inner-conductor and outer-conductor and material is annealed copper.
- The material between Inner and Outer is generally used as Teflon (Epsilon = 2.1)
- The probe was inserted 0.5 mm away from the aluminum jig surface

Figure 3: Device for measurement of each cell

- Fig 3 shows each cell measurement system in Sungkyunkwan university.
- Tuning was carried out by putting a bead in the tuning hole and pushing a bead into cavity wall.
- The resonant frequency can be changed from 0 to 10 MHz in one hole. There are 6 tuning hole of each cell(AC: 3, SC: 3) except coupler cell(AC:2,SC:3) because of coupling hole

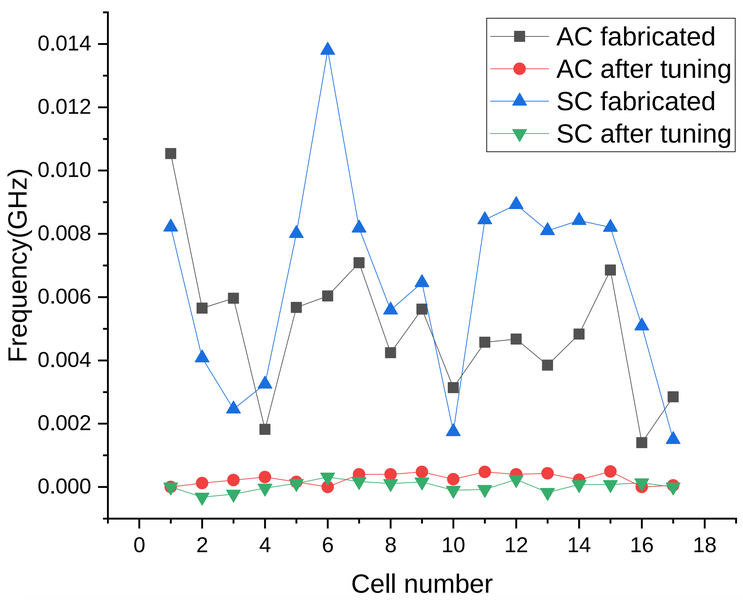


Figure 4: resonant frequency before and after tuning

- Fig 4 shows the resonant frequency before and after tuning.
- Before the tuning, it has a difference of 0 ~ 15 MHz from the reference frequency.
- After tuning, There are a difference of -0.5 ~ 0.5 MHz.
- It means that the resonance frequency of AC and SC are equal.

Bead-pull measurement

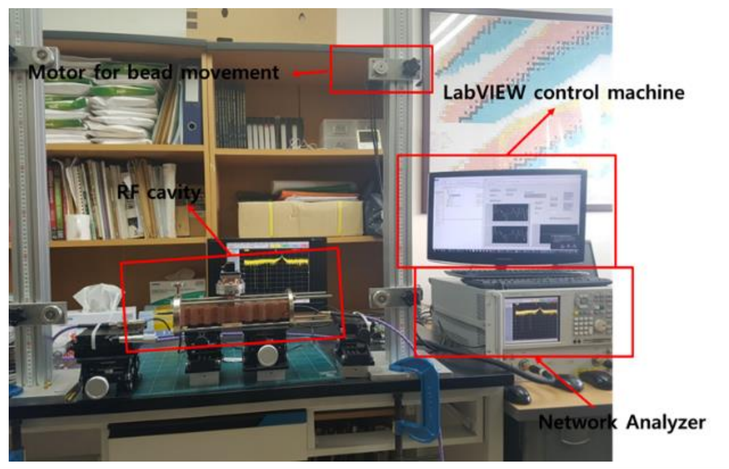


Figure 5: bead-pull system

- Fig 5 shows bead-pull system of Sungkyunkwan university.
- In the software, LABVIEW code was used.
- The developed LABVIEW code consists of reading field map data, storing data, and processing data.
- In the hardware, supporters, motors, and fishing lines were used.

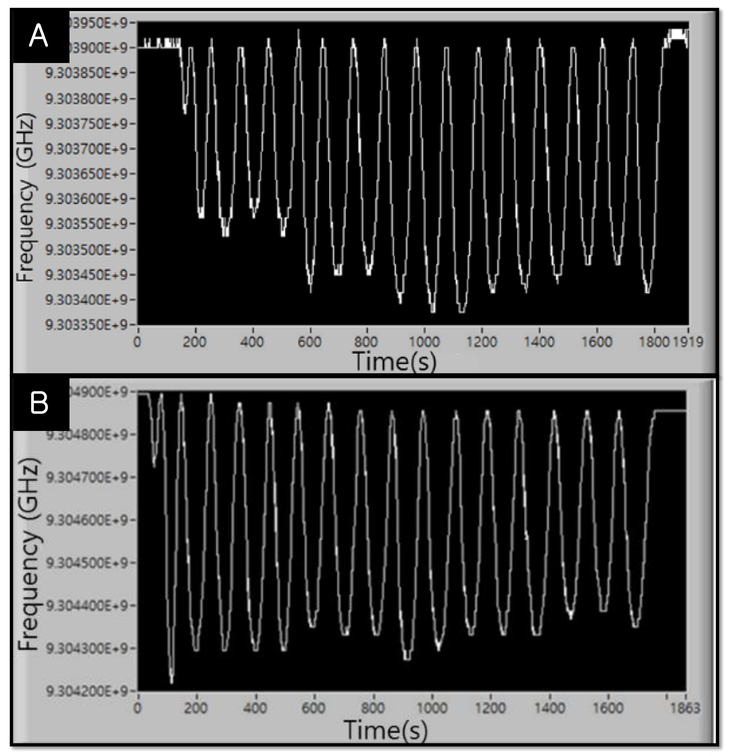


Figure 6: electric field map in cavity ((A) initial state of field map, (B) field map after tuning)

- Fig 6 shows the electric field distribution in cavity.
- In the initial state of cavity, the difference between the maximum peak and the minimum peak was more than 30%.
- After the tuning using the bead pull system, it was less than 9%.
- Through the data obtained after tuning, we verified through ASTRA simulation code and confirmed that the beam accelerates to 6 MeV

Conclusion

- In this study, electric field distribution measurement and tuning of the fabricated 6 MeV electron accelerator was verified.
- In each cell measurement and tuning process, various variables (temperature, e-probe depth, surface roughness and so on) were simulated by CST microwave studio code before application.
- To measure the electric field distribution and obtain the required field flatness, bead-pull system based on perturbation theory was used.

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