6 - 7 Progress of the China Material Irradiation Facility RFQ

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The design and low power RF measurement of the radio frequency quadruple (RFQ) for the front end of China Material Irradiation Facility (CMIF), which is an accelerator based neutron irradiation facility for fusion reactor material qualification, have been completed. The RFQ, which operated under CW mode, is specified to accelerate 10 mA deuteron beam from the energy of 20 keV/u to 1.5 MeV/u. To reduce the possibility of beam loss in supper conducting section, the output longitudinal emittance need be optimized. The idea of "Kick-drift" is adopted in beam dynamic design. The challenge for CW RFQ is not only the beam dynamic design but also in the design of cavity structure and cooling of structure. With the experience obtained in the design of the RFQ for CIADS injector II, the structure design and cooling design have been finished. The results of low power RF measurement show the flatness and asymmetry are below 4% for each module. The CMIF is a new compact neutron source with less cost and low-level risk than the project IFMIF. The schematic diagram of CMIF is illustrated in Fig. 1.

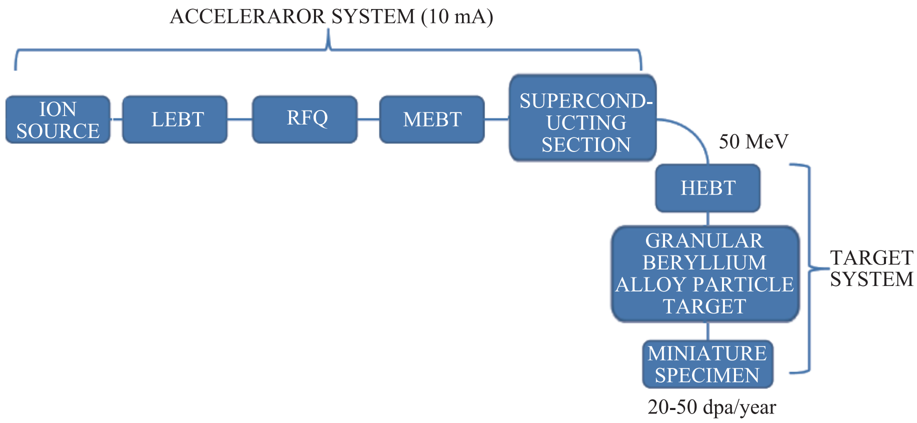

Fig. 1 (color online) The schematic diagram of CMIF.

Beam dynamic design

These goals of RFQ beam dynamic studies usually are to minimize the vane length, beam loss and emittance growth. For CMIF RFQ, two special goals are optimized Kilpatrick factor and output longitudinal emittance. PARMTEQM code, which was developed at Los Alamos National Laboratory, is used to generate RFQ parameters. The Kilpatrick factor was optimized to 1.4 computed by PARMTEQM code, which is small enough for avoiding any possible breakdown and reducing time of conditioning of the resonator. The output longitudinal emittance need be optimized to 3.5 π·mm·mrad to reduce the possibility of beam loss in supper conducting section. The beam simulation is in Fig. 2. The initial beam is water bag. The beam transmission efficient is 98.2%. In Fig. 3, the longitudinal 99.9% emittance at the RFQ exit is optimized to 3.5 π·mm·mrad. The longitudinal acceptance of downstream supper conducting accelerator is 27π·mm·mrad. The ration is 1 to 7.7. The main RFQ parameters are shown in Table 1.

Table 1 CMIF RFQ Design Parameters.

Particle	Value
Beam current/mA	10
I/O energy/(MeV/u)	0.02~1.5
Vane voltage/kV	65
Vane length/cm	526.43
Max.surface filed/(MV/m)	19.01
Transmission rate/%	98.2
Tr.n.r.emittace/(π·mm·mrad)	0.203
99.9% long.emittace/(π·mm·mrad)	3.5

RF design

The RF design and study have included the RF design of 2D cross section, 3D RF simulation of period structure and RF simulation of the whole length. Though the study of the 2D cross section, the mesh study is completed and the optimized cross section parameter to get low power consumption is got. The 3D RF simulation of period structure have included π-mode stabilizing loops (PISLs) and tuner period structure. The parameters of PISLs are optimized to separate the frequency of the quadruple and dipole. The tuner will be used to compensate the construction errors after the cavity was brazed. After the period simulation, the precise RF simulation of whole length model with modulation is performed. Some dimensions are adjusted to reach the design targets including frequency and field flatness. The distance between vane tips and the surface of end-plate is adjusted to get optimized filed flatness. Finally, the filed flatness is in range of 2%. The CST MWS model is shown in Fig. 4 and the RF simulation results are in Table 2.

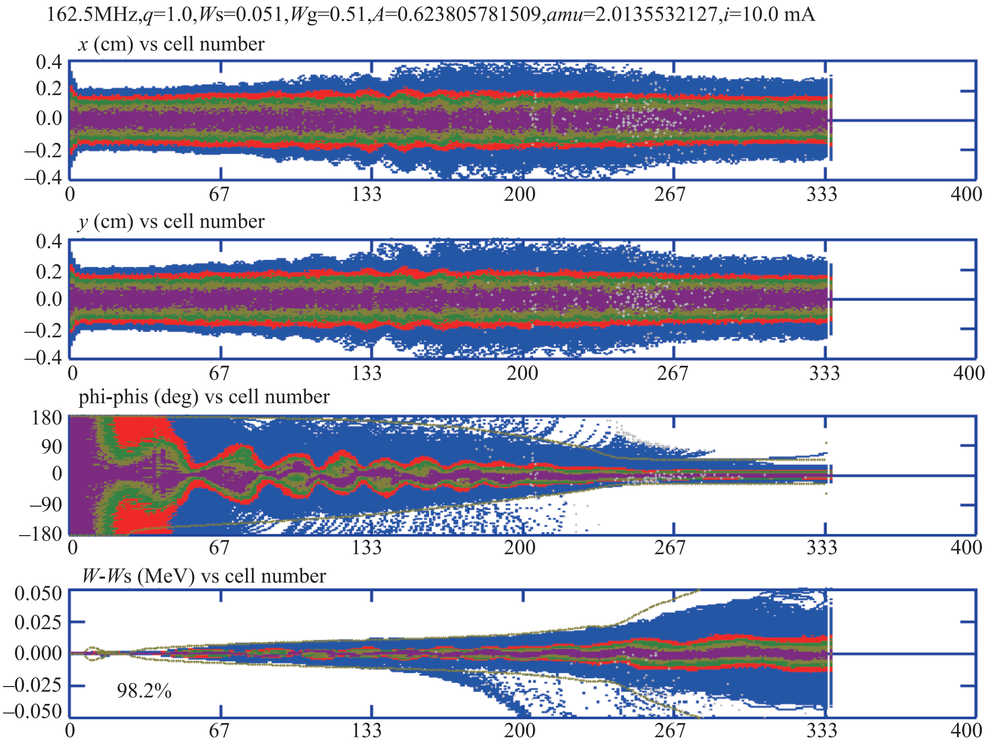

Fig. 2 (color online) The beam simulation used PARMTEQM.

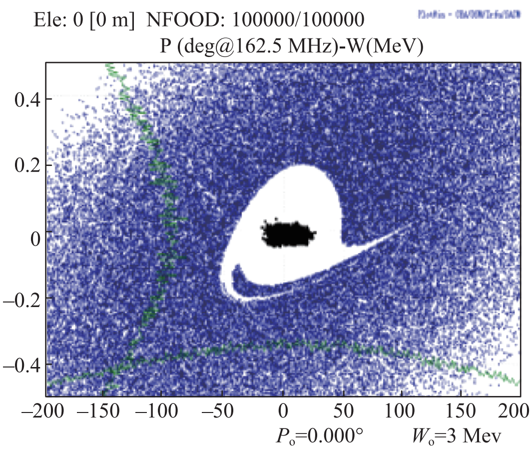

Fig. 3 (color online) The 99.9% longitudinal emittance and longitudinal acceptance of supper conducting section.

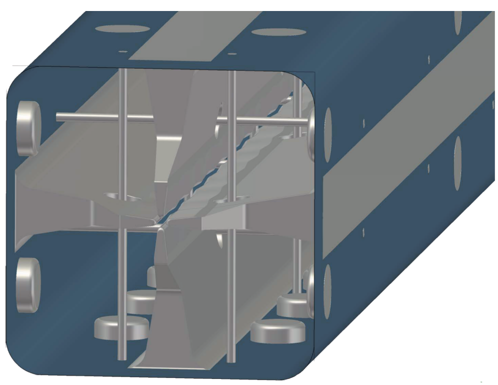

Fig. 4 (color online) The CST MWS model of CMIF RFQ.

Table 2 RF simulation results.

Frequency/MHz	Frequency of dipole/MHz	Q factor	Max power loss density/(w/cm^2)	Total power loss/kW	H/mm
162.459	180.119	14 148	22	109	169.3

Low power RF measurement

Before braze and after braze, the cold model tests were performed for each module. The results of low power RF measurement show in Fig. 5, it shows that the flatness and asymmetry are below 4%, which is within the tuning range. The discrepancy between simulated frequency and measured frequency is below 500 kHz, which is also within the range of tuning.

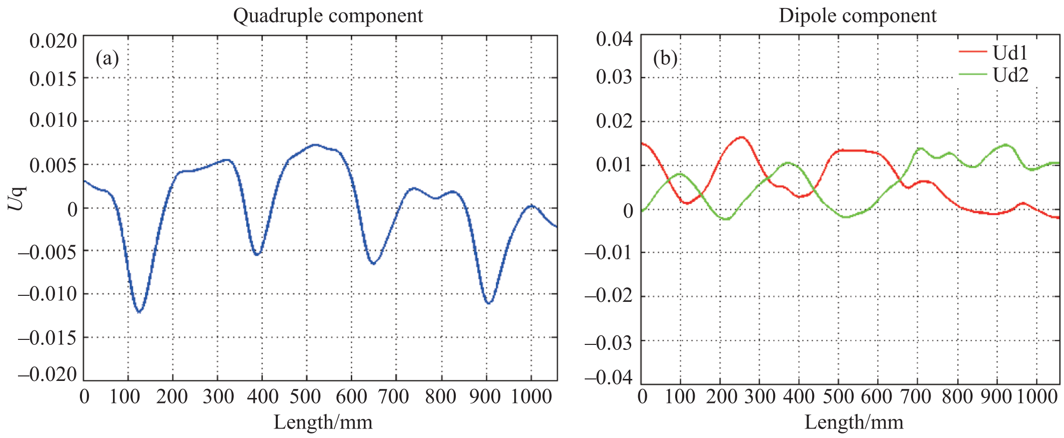

Fig. 5 (color online) The flatness and asymmetry.

6 - 8 Electropolishing of Niobium from Choline Chloride Based Ionic Liquid

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The BCP solutions use mixed acids based on HF acid, which carry significant potential safety hazard during operation. Developing a safe and green polishing solution without HF is an important research subject for cavity's surface treatment[1]. We adopt green ionic liquids for polishing solution of electropolish niobium samples.

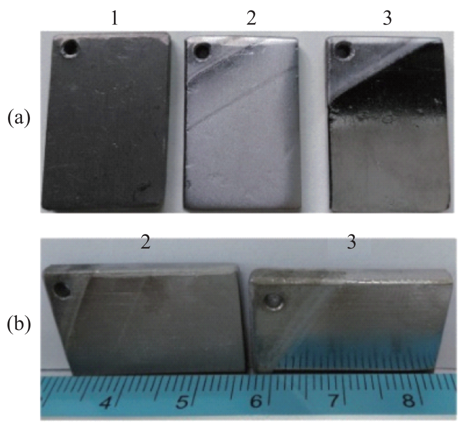

Fig. 1 (color online) Pictures of Nb samples: (1#) without any treatment; (2#) electropolished at 50 ℃, 20 min, −5 V; (3#) 80 ℃, 20 min, −5 V.

In the experiment, niobium samples were electropolished from a 1:2:1 Choline chloride–urea-ammonium fluoride ionic liquid under different conditions (Fig. 1). The surface of Nb sample without any treatment is dark and uneven (1# of Fig. 1). After electropolished at 50 ℃, the surface of Nb sample become smooth, but the glossiness is not good (2# of Fig. 1). Improving the electropolishing temperature to 80 ℃, the glossiness of Nb becomes good and the surface becomes even (3# of Fig. 1). In order to compare the electropolishing effect intuitively, put a ruler before the treated samples. Sample 3# has a certain mirror effect, but sample 2# does not. A smoother and better glossiness Nb can be achieved from choline chloride based under properly controlled conditions.

Reference

[1] A. I. Wixtrom, J. Buhler, C. E. Reece, et al, ECS Trans., 50(2012)199.