Fabrication of the Prototype Target Stack and Test Mock-up for the PEFP Radioisotope Production Facility

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1. Introduction

The Proton Engineering Frontier Project have a plan to construct 100-MeV Proton Linear accelerator and also, will construct radioisotope production facility using 100MeV proton beam for medical application. Sr-82, Cu-67 and Ge-68 were selected as the objective radioisotope in this facility. They are promising radioisotope for the PET imaging and cancer therapy.

To produce Sr-82, Cu-67 and Ge-68, RbCl, Zn metal and Ga metal were chosen as a target materials which they have claddings of stainless steel or Inconel. and also to produce these radioisotopes at the same time, we have introduced target stack in tandem [1].

Table 1 indicated the general characteristics of the designated radio-isotopes.

Table 1. Characteristics of the designated radio-isotope

Isotope	material	Nuclear reaction	Half-life	Emitting radiation
Sr-82	RbCl	natRb(n,xn)82Sr	25.5d	Positron
Cu-67	Zn	68Zn(p,2p)67Cu	2.6d	Electron
Ge-68	Ga	natGa(n,xn)68Ge	270d	Positron

2. Methods and Results

2.1 Design of RI production Target Stack

To design RI target, we have derived the optimum thickness of target materials considering the beam energy loss by the beam window, cooling water and target claddings through SRIM calculation [2].

First we fixed the thickness of the inconel beam window, each cooling channel and target cladding as 0.5 mm, 5 mm and 0.3 mm. and then, we optimized the thickness of target materials such as RbCl, ZnO and Ga metal by using iterative SRIM calculation.

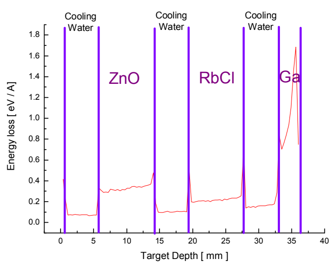


Fig. 1. The energy loss of proton beam at target stacks

Figure 1 and Table 2 shows configuration of prototype target stacks. As a result of SRIM calculation, we optimized the thickness of RbCl, ZnO metal and Ga metal as 8 mm, 8 mm and 4 mm.

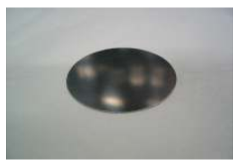
Table 2. Material, thickness of designed target stack

Layer	Thickness [mm]	Energy
Beam window	0.5	103~100.88
cooling water	5	100.88~97.17
Inconel cladding	0.3	97.17~95.85
ZnO	8	95.84~69.67
Inconel cladding	0.3	69.67~68.01
cooling water	5	68.01~62.9
RbCl	8	62.9~41.93
cooling water	5	41.93~34.92
Nb cladding	0.3	34.92~30.99
Ga metal	4	30.99~2.96
Nb cladding	0.3	0
cooling water	5	0

2.2 Fabrication of Prototype Target Stack

Prototype target stack consist of thin window, metal ring and simulated target. the material of simulated target was made of aluminum on behalf of RbCl, ZnO and Ga. the window was manufactured with 0.3 mm thickness and 56 diameter. The metal ring was manufactured with 5 mm thickness and 60 mm diameter. Target cladding was made of stainless steel. Fig. 3 shows the manufactured simulated target and cladding.

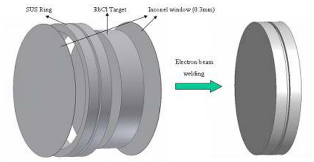

(a) Simulated target


(b) Window

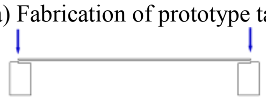

(c) Ring

Fig 3. The manufactured simulated target and cladding

The prototype target stack was fabricated through the electron welding. The Fig. 2 shows schematics of target fabrication.



(a) Fabrication of prototype target



(b) EB-welding method

Fig. 2. Schematics of target fabrication

Figure 3 shows EB-welded prototype RI target. The target cladding is required no leak to restrict leakage of radioactive species. To examine flaw or micro-crack on prototype target cladding, the penetration test was conducted. (Figure 4)

Fig.3 The fabricated prototype RI target (EB-welded)

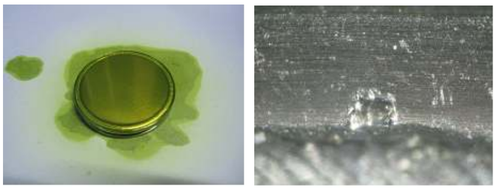


Fig. 4. Penetration test for prototype RI target

2.3 Fabrication of RbCl pellet

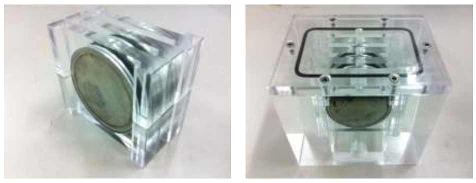
RbCl, which can produce Sr-82, are formed with powder naturally. To produce Sr-82 efficiently, the RbCl must be pressed to achieve its theoretical density.

First, Rbcl powder was dried in the vacuum drying oven for at least 24h to minimize water contents. And then, the dried powder was pressed with 350 MPa [3].Figure 4 shows the pressed RbCl pellet.

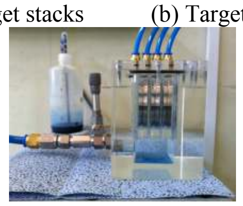
Fig. 4 Pressing of RbCl pellet

2.4 Test mock-up for cooling water flow

During the irradiation for radioisotope production, 100-MeV proton beam loss their kinetic energy in the target stack. Thus massive heat generate in the target stack proportional to beam current. The deposited heat has to be removed by forced convection of the flowing cooling water. To verify the flow rate at each cooling channel and the stream behavior in the target chamber by ink injection, the visible acrylic target holder and chamber was fabricated. Figure 5 shows the fabricated test mock-up and the experimental set-up for coolant flow.



(a) Target stacks (b) Target chamber



(c) Experimental set-up

3. Conclusions

In this paper, we have optimized the thickness of target and fabricated the prototype RI production target by electron beam welding. After EB-welding, the fabricated prototype RI target was examined by penetration test method.

The RbCl pellet for Sr-82 production was prepared by 350 MPa cold-pressing. And then, the test mock-up for coolant flow was prepared to verify flow rate and stream behavior at each cooling channel using the visible acrylic chamber and the ink injection.

Acknowledgement

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