PERFORMANCE STUDY OF THE PEFP MICROWAVE ION SOURCE WITH MODIFIED MICROWAVE SYSTEM*

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Abstract

A microwave ion source has been developed as a proton injector for the Proton Engineering Frontier Project (PEFP) 100-MeV proton linac. The microwave ion source consists of the 2.45-GHz microwave components, a solenoid magnet, a vacuum system, power supplies for beam extraction and bias electrode, a cooling system. It was operating for 1 year to supply beam to the 20-MeV proton accelerator. Recently, a multi-layer insulation DC break was installed between proton source and 2.45-GHz microwave components. The tests of the microwave system have been done to study the effect of the DC break. In this paper, the performance studies of the PEFP microwave ion source with DC break are discussed.

INTRODUCTION

A microwave ion source operated for the proton injector of PEFP (Proton Engineering Frontier Project) linac since 2010 at Korea Atomic Energy Research Institute (KAERI). The microwave ion source was developed and validated to continuously operate without any trouble and maintenance more than 100 hours, which is the requirement for the weekly operation schedules of the 100-MeV proton linac [1].

The microwave components of a microwave ion source are electrically connected with high voltage for beam extraction. It is not easy to control and maintain the microwave system on the high voltage platform. To put it on ground voltage, a multi-layer DC break was developed [2-3].

FABRICATION

The DC break consists with insulator parts and conductor parts. To select the insulator material, we made 2mm thickness insulator with alumina, Teflon and G-10. The conductor parts of 20mm thickness are made with aluminum as shown in Figure 1.

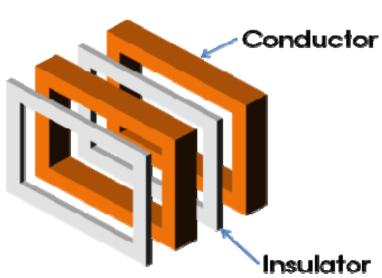

Figure 1: Multi-layer insulation.

The inner size was determined just like the WR340, the width is 86.4 mm and the height is 43.2 mm, due to the 2.45GHz of the microwave source. To fix the shape of layers, 4 rods were adopted which were made with G-10. The 19 insulators and the conductors assembled with a voltage divider of 160MΩ resister x 19ea on a granite surface plate to avoid the change in the microwave property due to the misalignment [2].

MICROWAVE LEAKAGE MEASUREMENTS

To check the propriety of insulators, the microwave leakage depending on material was calculated and the results were shown in Table 1. The alumina has the lower level of microwave leakage but it is so brittle that there were cracks when was laminated [4].

Table 1: Leakage depending on the material

	BN	Alumina	Teflon	G-10	Air
Microwave Leakage [%]	5.3	2.0	47.1	4.3	71.7

Two kinds of insulators were fabricated with Teflon and G-10. And two multi-layer DC break were installed on microwave ion source and we measured the microwave leakage.

Figure 2: Installation of multi-layer DC break on the microwave ion source.

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The Figure 2 shows the microwave ion source installed with the multi-layer DC break. The microwave leakage was checked during the ion source operation. The microwave leakage depending on the magnetron power was measured at 1.5m away from the multi-layer DC break. The measured values are shown in the Table 2. The results show that the leakage level of Teflon is 10 times higher than that of G-10, which is similar with a calculation.

Table 2: Microwave leakage measurements [mW/cm^2]

Magnetron Power	350 W	400W	450W	500W	1000W
Teflon	1~3	4~6	13~15	20	-
G-10	0.2	0.8	0.7	0.7	1.1

HIGH VOLTAGE TEST

After a multi-layer DC break with G-10 insulators was assembled, it was tested on high voltage as shown in Figure 3. During the high voltage test, we observed the corona discharges on the insulator rods near to the waveguide adaptor flange above 40-kV. It is required to modify its structure for the normal operation without discharges, so its structure has been optimized.

Figure 3: High voltage test of a multi-layer DC break.

Optimization

The multi-layer structure was optimized with POISSON code. Figure 4 shows the structure before optimization. It was simplified into the structure with a insulator rod and two waveguide adapter flanges. The electric field strength was calculated by changing the a hole structure at a ground side of the waveguide adapter flanges. Figure 5 shows the structure after optimization. The Figure 6 shows results of the electric field strengths on the border where the corona discharge broke out. The electric field strength was minimized at the structure of the radius 5 mm.

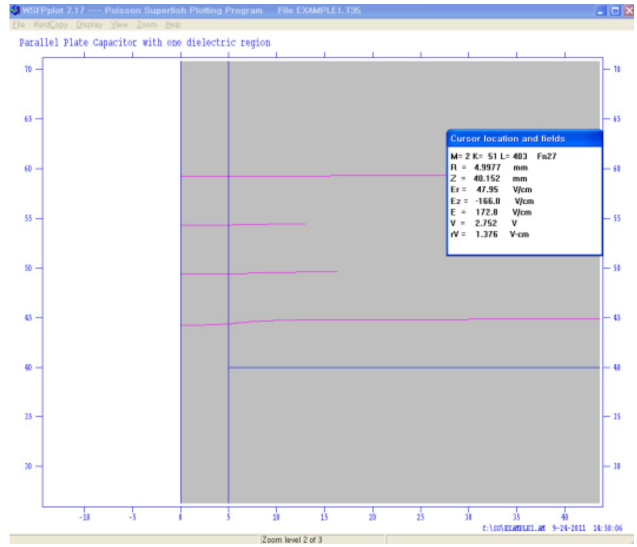

Figure 4: Structure before optimization.

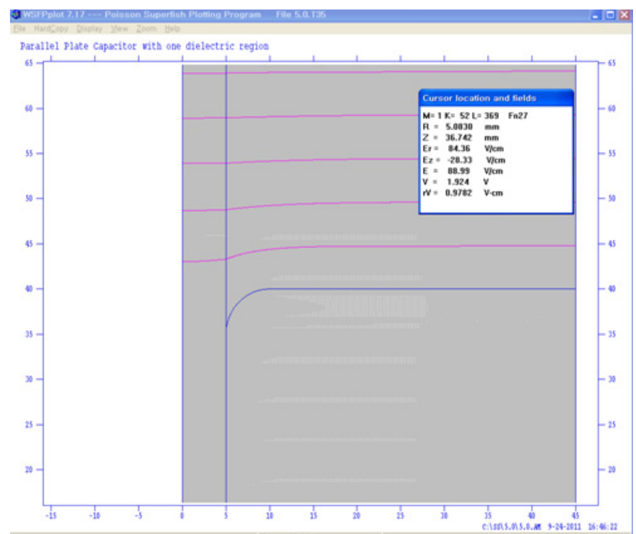

Figure 5: Structure after optimization.

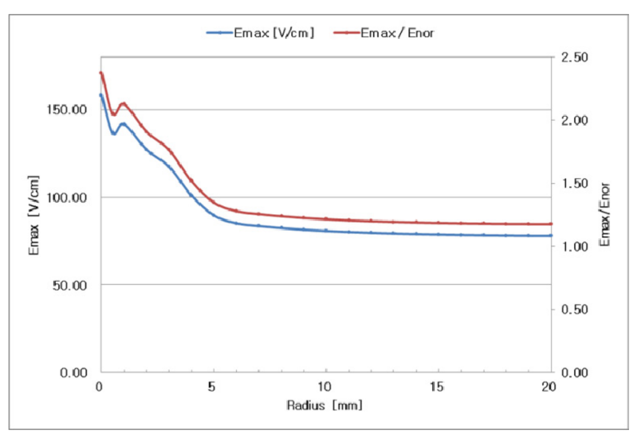

Figure 6: Electric field strength.

High Voltage Test

After the multi-layer structure was modified as shown in Figure 7, the multi-layer DC break was tested up to 60 kV without any problem.

Figure 7: Modified multi-layer DC break.

BEAM EXTRACTION

The modified multi-layer DC break was installed on the microwave ion source. All components of the microwave ion source were put on ground voltage except for a solenoid magnet and its power supply. During a pulse beam operation, the microwave ion source with multi-layer DC break was run continuously without any problem. After the multi-layer DC break was installed on the microwave ion source, it has been operated for two months. The Figure 8 shows the extracted beam at the ion source. The operating condition should be also optimized for an stable operation of the microwave ion source.

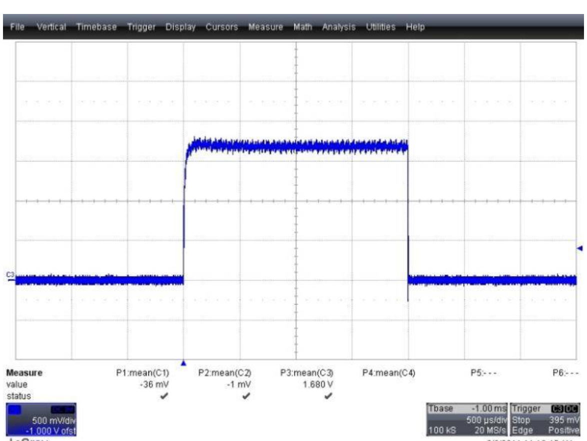

Figure 8: Beam current (13mA, 2ms).

CONCLUSION

The multi-layer DC break for isolation from high voltage at the microwave ion source has been fabricated. There was a microwave leakage during the operation, and the leakage of the insulator fabricated with G-10 was measured less than Teflon in accordance with the calculated value. The multi-layer DC break was modified and it has been tested up to 60-kV at high voltage without any problem. After the modified multi-layer DC break was installed on the ion source, the operating condition on the microwave ion source was adjusted for the stable and typical beam current.

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