Transactions of the Korean Nuclear Society Autumn Meeting
Changwon, Korea, October 21-22, 2021

Preliminary Test for Improving Plasma Chamber Cooling of Microwave Ion Source at KOMAC

Dae-Il Kim [a) b) *], Mun-Ho Jo [a)], Kyung-Hyun Kim [a)], Seong-Gu Kim [a)], Hae-Seong Jeong [a)], Jae-Ha Kim [a)]

Yu-Seok Kim [b)]

[a)] Korea Atomic Energy Research Institute, KOrea Multi-purpose Accelerator Complex,
181 Mirae-ro, Geoncheon-eup, Gyeongju-si, Gyeongsangbuk-do 38180

[b)] Department of Nuclear & Energy System Engineering, Dongguk University,
123 Dongdae-ro, Gyeongju-si, Gyeongsangbuk-do 38066

1. Introduction

The ion source of the 100-MeV proton accelerator at KOMAC is a 2.45 GHz microwave ion source [1]. A test bench has recently been built for conditioning microwave ion sources. It is built for plasma conditioning only [2]. The microwave ion source can be operated for a long time without maintenance. However, various emergency stop occurred in the ion source during operation. In the last four years, the most frequent occurrence occurred in high voltage insulators among the microwave ion source parts. This is caused by insulation degradation due to thermal deformation of the insulator as the microwave power, the operating parameter of the microwave ion source, increases. In this paper, the process and results of checking the temperature change of the plasma chamber and surrounding components according to microwave power to improve the cooling performance of the plasma chamber are presented.

2. Methods and Results

2.1 Breakdown statistics

The replacement cycle for microwave ion source consumables is 6 months or more. Breakdown of microwave ion source occurs in several places, including replacing some consumables. Fig. 1 shows statistics for the breakdown that have occurred in microwave ion sources over the past four years.

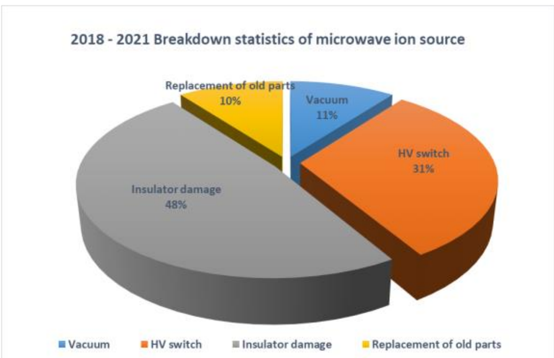

Fig. 1. Breakdown statistics of microwave ion source

In order of the most frequent occurrence, high-voltage insulators are 48%, high-voltage switches 31%, vacuum-related 11%, and other consumables are more than 10%. Fig. 2 shows the breakdown occurring in a high voltage insulator. The plasma chamber and high voltage insulator are assembled without tolerances. So, the change in the temperature of the plasma chamber affects the change in the physical properties of the high voltage insulator made of MC nylon. Among the physical properties of MC nylon, the thermal deformation temperature is from 95℃ according to ASTM (American Society for Testing and Materials) measurement method D-648.

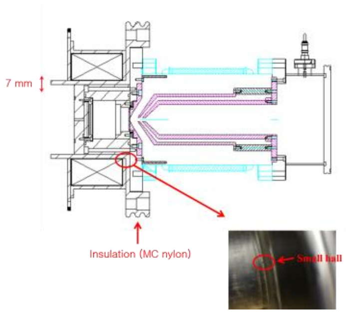

Fig. 2. High voltage insulator breakage location

2.2 Test-stand

The temperature change of the plasma chamber by microwave power was carried out on the ion source test bench as shown in Fig. 3.

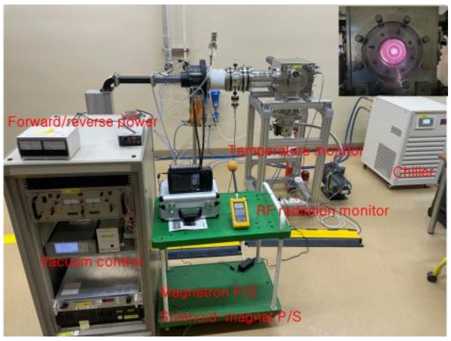

Fig. 3. Test-stand for microwave ion source

*Corresponding author: dikim@kaeri.re.kr

Temperature was measured using a thermocouple and data were collected using a GL840 (GRAPHTEC). The measurement locations are the plasma chamber outer wall, high voltage flange, microwave window, and ridge waveguide. Fig. 4 shows the temperature for each location at 700W, the microwave power when the microwave ion source is in normal operation. The temperature of the plasma chamber outer wall increased to about 93℃. (The room temperature is 23℃.)

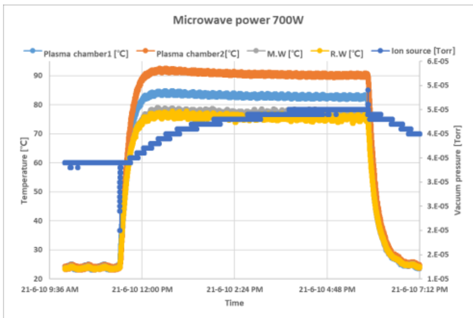

Fig. 4. Temperature variation at each location at 700 W of microwave power without cooling

2.3 Cooling jacket for plasma chamber

In order to insert a cooling jacket for water cooling in the existing plasma chamber, the structure of the plasma chamber was changed and manufactured as shown in Fig. 5. In the experiment using the cooling jacket, the microwave power was increased from 700W to 900W. Here, the temperatures of the plasma chamber outer wall converge at about 63℃, about 74℃, and about 81℃, respectively as shown in the Fig. 6. (The room temperature is 23℃.)

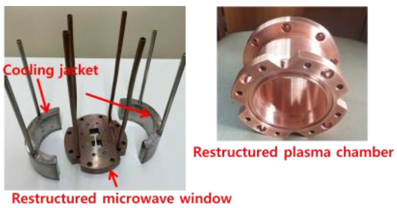

Fig. 5. Cooling jacket

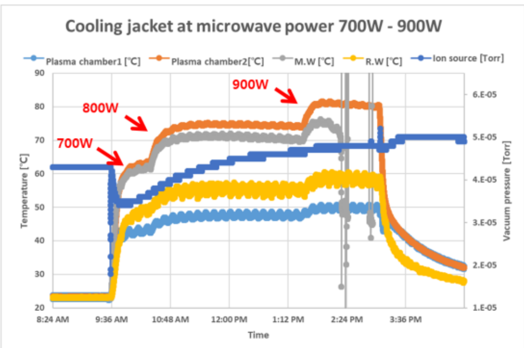

Fig. 6. Temperature variation by each location at 700 W - 900W of microwave power with cooling jackets

2.4 Air cooling for plasma chamber

Air cooling of the plasma chamber was made possible by increasing the inner diameter of the solenoid electromagnet. A space of 5 mm was created between the outer wall of the plasma chamber and the high voltage insulator, and air cooling was performed there. Fig. 7 shows an experiment for air cooling. The microwave power 700W operation was started without air cooling, and air cooling was started at an equilibrium temperature of about 108℃ and converged to about 87℃. (The room temperature is 26.5℃.)

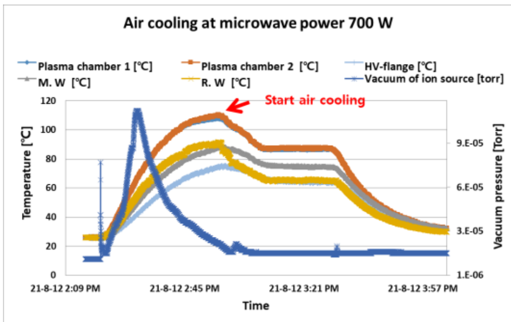

Fig. 7. Temperature variation by each location at 700 W of microwave power with restructured solenoid magnet

3. Conclusions

For dielectric breakdown of high voltage insulators, two tests were performed to improve the cooling of the plasma chamber against dielectric breakdown of high voltage insulators. Using the cooling jacket, it was possible to operate at a temperature of about 63℃ at a microwave power of 700W. Through this, it was possible to confirm the temperature compensation of about 30℃. In the case of air cooling, temperature compensation of about 20℃ was confirmed. In the future, based on the experimental results, it is necessary to optimize the structure for cooling the ion source in the direction of minimizing the change in the existing structure.

REFERENCES

[1] Hyeok-Jung Kwon, et al., "Study on the Microwave Ion Source of 100-MeV Linac" ICABU2015, Gyeongju, 2015.
[2] Dae-Il Kim, et al., "Installation of Test-stand for Conditioning of the Microwave Ion Source at KOMAC" Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, 2021.

*Corresponding author: dikim@kaeri.re.kr