Analysis of Physical Damage of Hydrogen Plasma Discharge on Microwave Window for Microwave Ion Source

Dae-Il Kim [a)] *, Han-Sung Kim [a)], Sang-Hun Lee [a)]

[a)] Korea Atomic Energy Research Institute, KOrea Multi-purpose Accelerator Complex,
181 Mirae-ro, Geoncheon-eup, Gyeongju-si, Gyeongsangbuk-do 38180
Corresponding author: dikim@kaeri.re.kr

***Keywords :** microwave ion source, Hydrogen plasma

1. Introduction

The microwave ion source is used as an ion source for a 100 MeV proton accelerator at KOMAC [1]. The replacement cycle of the microwave ion source is 6 months. The operating time of the microwave ion source is the same as the discharge time of the hydrogen plasma, which is about 1800 hours. The microwave ion source is operated stably through a periodic replacement cycle. A microwave ion source test stand has been built, and a spare part for the microwave ion source has been prepared and is being tested [2].

The microwave window of the microwave ion source transmits the 2.45 GHz microwaves generated by the magnetron to the vacuum plasma chamber and separates them from the space where hydrogen plasma discharge occurs within the plasma chamber. Here, the microwave window is subjected to various physical effects through interaction with the hydrogen plasma discharge. This is a major factor in reducing the lifespan and performance of microwave windows. In this paper, the analysis of damage to the microwave window used in microwave ion source are reported. And, a YAO (Yttrium Aluminum Oxide)-coated microwave window on a microwave ion source test bench are installed, the analysis of physical damage during the hydrogen plasma discharge process are presented.

2. Methods and Results

Hydrogen plasma discharge is generated in a plasma chamber filled with hydrogen gas by transmitting microwaves generated from a 2.45GHz microwave generator (Magnetron, 1.2 kW) to the plasma chamber through a waveguide. The end of the double-ridge waveguide is made of AlN (Aluminum Nitride) for vacuum and BN (Boron Nitride) for hydrogen plasma discharge protection. Microwave energy generates hydrogen plasma by interacting with hydrogen in a plasma chamber filled with hydrogen through a microwave window. Fig. 1 is a cross-sectional view of the ion source from which hydrogen plasma is discharged.

Here, Value Engineering Co., Ltd. helped with the analysis of the BN used, the coating of YAO on Alumina, and the analysis of etching after hydrogen plasma discharge.

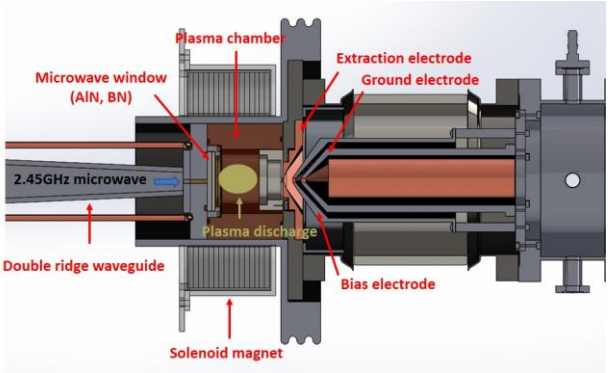

Fig. 1. Cross-sectional view of microwave ion source

2.1 Test-stand

The test stand for microwave ion source is a place to prepare microwave ion source spare parts to be used as the ion source for the 100MeV proton accelerator [3]. Fig. 2 shows the test stand microwave ion source.

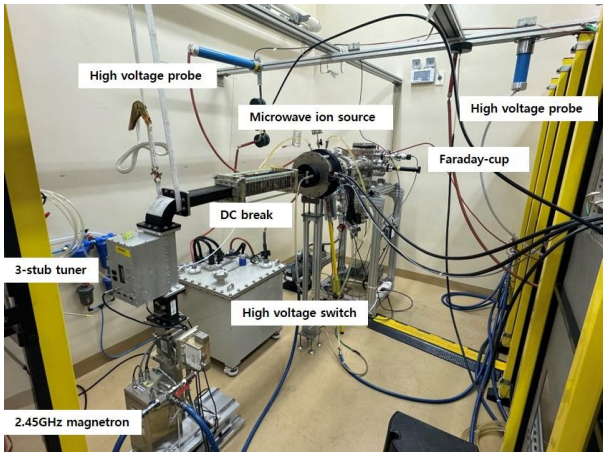

Fig. 2. Test stand for microwave ion source

Hydrogen plasma discharge testing of YAO-coated Alumina for vacuum AlN protection was performed on this test stand.

2.2 BN after use in microwave ion source

Fig. 3 is BN that has been used as an ion source in a 100 MeV proton accelerator for more than 6 months, and the cumulative time of hydrogen plasma discharge is about 3000 hours. The damaged appearance of the BN was formed following the shape of the end of the double ridge waveguide. The results of EDS (Energy Dispersive Spectroscopy) analysis of the blackened portion show that copper is about 53%. Copper is coated by sputtering in a plasma chamber made of copper. And, the amount etched on the BN surface was measured to be up to 1.5mm.

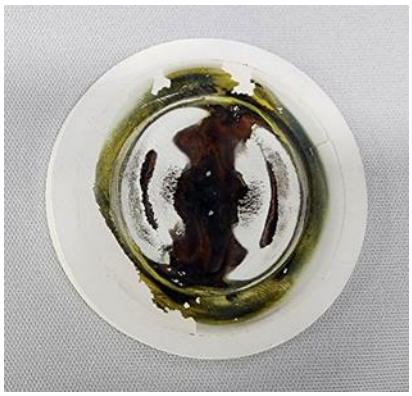

Fig. 3. BN from a microwave window used as an ion source in a 100MeV proton accelerator

2.3 Alumina coated with YAO

To protect microwave windows, we created circular disk-shaped Alumina coated with YAO to reduce damage caused by hydrogen plasma discharge. Fig. 4 shows YAO coated on Alumina and hydrogen plasma discharge for 255 hours.

Fig. 4 Alumina coated with YAO after 255 hours of hydrogen plasma discharge

In Fig. 4, the 10 mm horizontal portion of the circular alumina is the portion that is not YAO coated. When examining the depth of the etched part, the etching amount of the coated part was less than 1um, and the etching amount of the uncoated part was up to 9um.

3. Conclusions

The replacement cycle of the microwave ion source used in the 100MeV proton accelerator is 6 months. Among the consumables of the ion source, the part that protects the vacuum AlN of the microwave window is BN. The etching amount of BN used for approximately 3000 hours was analyzed. Additionally, YAO-coated Alumina was used for hydrogen plasma discharge to analyze the degree of etching. This confirmed the advantage of increasing the physical strength against hydrogen plasma discharge. In the future, analysis of the effect of the ion source on the operating characteristics will also be necessary.

Acknowledgement

This work has been supported through KOMAC (Korea of Multi-purpose Accelerator Complex) operation fund of KAERI by MSIP (Ministry of Science, ICT and Future Planning.

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