Chlorine, Iron, and Gold Ion Beam Extraction with 1.7 MV Tandem Accelerator at KOMAC

Nam Woo Kang*, Kye-Ryung Kim, Kyumin Choe, Hyeok-Jung Kwon
Korea Multi-purpose Accelerator Complex, Korea Atomic Energy Research Institute, Gyeongju 38180, Korea
**Corresponding author: kangnamw@kaeri.re.kr*

1. Introduction

The 1.7 MV pelletron-type tandem accelerator (NEC 5SDH-2) has been operating at KOMAC (Korea Multi-purpose Accelerator Complex), Gyeongju. The low energy beam implantation service is currently operating for user and ion beam analysis service, PIXE and RBS will be start. Also, we are preparing to provide beam services with various ion beams by utilizing the characteristics of the SNICS (Source of Negative Ions by Cesium Sputtering). This is because there are many users who want to use various ion beams. Therefore, we will introduce how we extracted, accelerated, and implanted the three elements (chlorine, iron, gold) that are highly useful.

2. System Description and Methods

2.1 System Description

The 1.7 MV tandem accelerator can accelerate a variety of ion species for use in PIXE, Implantation, RBS and nuclear physics experiments. Negative ion beams produced in a negative ion source are a little accelerated to 30 keV before being injected into the tank (5SDH-2). The negative ions are taken to the positively charged high voltage terminal and they are stripped of two or more electrons and converted into positive ions in stripping system. Positive ions are repelled by the voltage terminal and ions are accelerated once again [1]. The method of applying high voltage up to 1.7 MV in KOMAC uses the principle of van de Graaff accelerator. However, KOMAC tandem accelerator is pelletron-type. It is more efficient than the original type because it can charge in double. By using a bending magnet, you can select the isotopes from the ion source. In the same way, you can select the required multiply charged ions after acceleration.

Fig.1 Overall view of 1.7 MV Tandem Accelerator

2.2 Methods

You can extract the ion beam using the Eq. (1). Since cathodes are made of various materials, a process is required to extract the elements that you want.

$$F = \frac{\gamma m v^2}{\rho} = qvB \quad \longrightarrow \quad B\rho = \frac{mv}{q} \quad \longrightarrow \quad B\rho = \frac{\sqrt{2Em}}{q} \qquad (1)$$

By changing the value of the current applied to the bending magnet and using the Eq. (1), the elements can be separated by mass as shown in the Fig. 2.

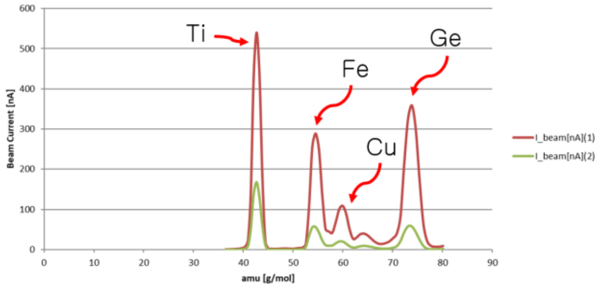

Fig.2 Iron cathode mass spectrum scanning by changing the value of the current applied to the bending magnet

Also, multiply charged ions generated after acceleration can be selected is the same method. In addition, if you have the bending magnet operating value according to the proton energy, it is possible to improve the accuracy of extracting various ion beams.

3. Results and Discussion

3.1 Chlorine Ion Beam

For ion beam analysis technology, the sample must be implanted with an element heavier than a proton. Among the elements, chlorine is an element suitable for ion beam analysis technology. So, to do the experiment, the proton operating value and Eq. (1) are used to determine the chlorine ion beam operating value. The most common energy, 1 MeV, was selected and the magnet values were calculated to complete beam extraction at 12.2 A (source magnet) and 80.4 A (bending magnet). The Fig.3 is a picture of a silicon plate implanted with a chlorine beam. And, the Fig.4 is the result of analyzing the chlorine implantation on the silicon plate by D-SIMS (Dynamic-Secondary Ion Mass Spectrometry).

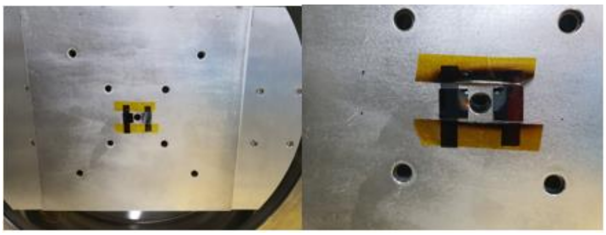

Fig.3 Photos before and after chlorine ion beam implantation on silicon plates.

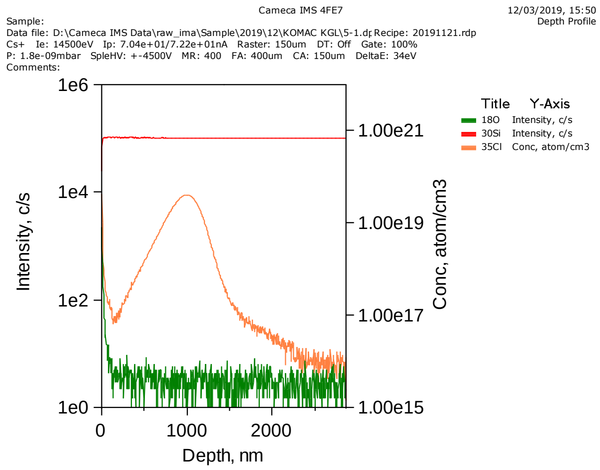

Fig.4 Result of D-SIMS analysis (Chlorine)

3.2 Iron Ion Beam

Destructive Physical Analysis (DPA) is performed to ascertain the high quality of parts used in the designs of space and semiconductor products. Recently, increasing number of users want to know how the quality of products is damaged by implanting an ion beam with a heavy mass. So, we chose to extract iron ions beam to prepare for DPA service. However, due to the heavy mass, a high magnetic field value was required, and a high load has been applied to the bending magnet. So, among the polyvalent ions generated after acceleration, Fe^{2+} was selected to reduce the load on the bending magnet. We chose 3 MeV, which is an energy that is in high demand, and succeeded in extracting the ion beam by setting the magnet values to 16.2 A (source magnet) and 86.9 A (bending magnet). And, the Fig.6 is the result of analyzing the iron implantation on the silicon plate by D-SIMS.

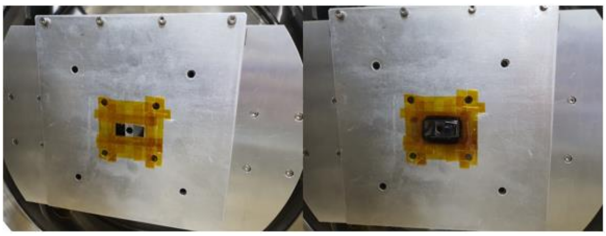

Fig.5 Photos before and after iron ion beam implantation on silicon plates.

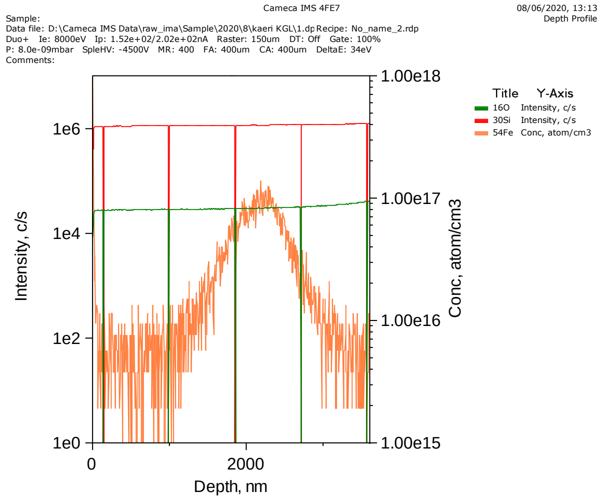

Fig.6 Result of D-SIMS analysis (Iron)

3.3 Gold Ion Beam

Since the purpose of this experiment was to extract various ion beams, we tried to extract gold, which has the heaviest mass among the elements that we have. The beam energy was set to 0.8 MeV due to the high mass value. Nevertheless, because of the magnet's load, we gave up Au^{+} and chose Au^{2+}. The magnet values were calculated to complete beam extraction at 30.2 A (source magnet) and 84.8 A (bending magnet). The Fig.7 is a picture of a silicon plate implanted with a gold beam. And, the Fig.8 is the result of analyzing the gold implantation on the silicon plate by D-SIMS.

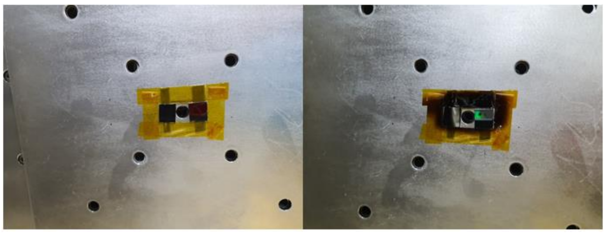

Fig.7 Photos before and after gold ion beam implantation on silicon plates

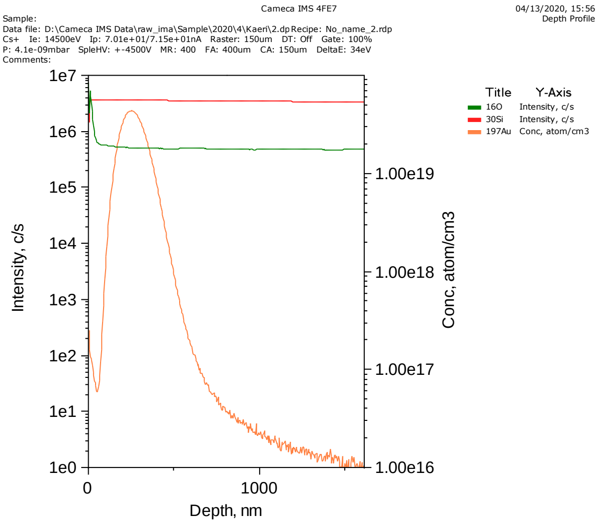

Fig.8 Result of D-SIMS analysis (Gold)

4. Conclusions

This experiment was conducted because of the demands of users who want to use various ion beams. Although it succeeded in extracting various ion beams, there were many things to improve. For example, a bending magnet should be upgraded to extract higher mass ion beam with higher energy, or another ion beam extraction should be attempted based on this experiment. In the future, we will improve this device more useful and reliable.

REFERENCES

[1] NEC (National Electrostatics Corporation), Instruction Manual for Operation and Service of 5SDH-2 Pelletron Accelerator, 1986.