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Development of 6-inch wafer loading system 1-MV electrostatic accelerator at KOMAC

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1. Introduction

1-MV electrostatic accelerator is being developed at KOMAC. This device consists of a 200 MHz RF ion source, a high voltage power source for ELV-type acceleration, triplet, beam line equipped with raster scanner, and target chamber for beam irradiation.

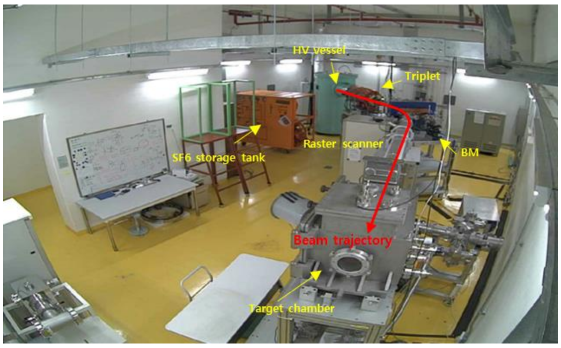

Figure.1. Layout of the accelerator

One of the features of this device is that a small sized ion source is installed at the limited space in a SF_6 pressurization vessel up to 6 atm with the high voltage system [1]. For this, an RF ion source with low power consumption is used. The ELV-type high voltage power source and compact RF ion source are suitable for long-term operation without maintenance, and are easy for actual maintenance [2]. Table.1 is the specification of 1MV electrostatic accelerator.

Table.1.Specifications of 1MV electrostatic accelerator

Beam current max	>1 mA
Accelerating voltage	0.2-1.0 MV
Ions	Gas (H2, O, N etc.)
Power for ion source	<1 kV
Life times of ion source	> 2000 hours

The beam type of 1-MV electrostatic accelerator is DC beam and has stability of ion source and high voltage performance maintenance. This is suitable for semiconductor wafer irradiation.

However, for industrial use, a device capable of automatically loading a semiconductor wafer is required. In addition, the role of a scanner is required so that the beam can have a uniform distribution, and devices for measuring the distribution of the scanning beam must be provided. In this paper, we will describe the development of a 6-inch wafer loading system and a beam irradiation test.

2. Installation

2.1 Wafer loading system

The wafer loading system consists of the loading chamber and a linear motion enables the movement of wafer holder in the loading chamber. The loading chamber is located above the target chamber. In addition, there is the gate valve between target chamber and loading chamber. Therefore, it is possible to move the wafer holder in the vertical direction. When loading a wafer, the gate valve is closed Because of the vacuum boundary between the loading chamber and the target chamber. After the wafer loading is completed, the roughing pump vacuums the loading chamber. At this time, the target chamber maintains a high vacuum environment, and the wafer holder is transferred in a linear motion with the gate valve open between the loading chamber and the target chamber.

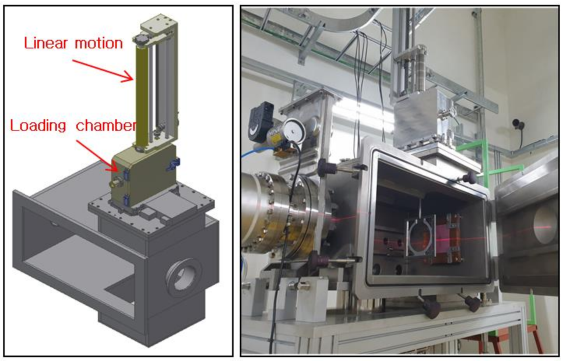

Figure.2. Loading chamber and linear motion installed on the target chamber

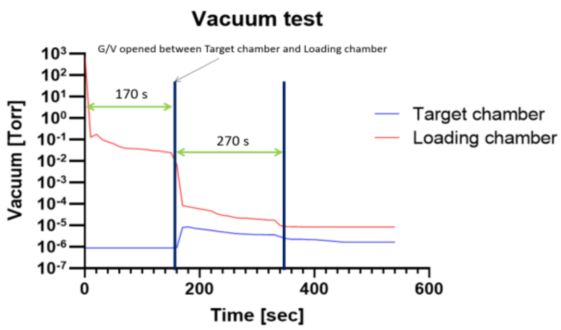

Figure.3. Chamber vacuum test

After loading the wafer, we examined how long it takes for the wafer beam to be irradiated. According to the graph below, after loading the wafer, it took about 270 seconds to stabilize the high vacuum with the gate valve open between the loading chamber and the target chamber. In the meantime, the wafer can be placed in the center of the beam.

2.2 Beam current measurement system

The beam current measurement system consists of four Faraday cups, a Faraday cup holder and a current integrator. The Faraday cup holder part is located inside the target chamber. The Faraday Cups are located in four areas around the center of the beam, measure the cumulative and instantaneous current of the scanning beam, and can be monitored with a current integrator. When a 6-inch wafer is placed in the center of beam in the target chamber after the loading, it enables beam irradiation according to the target dose.

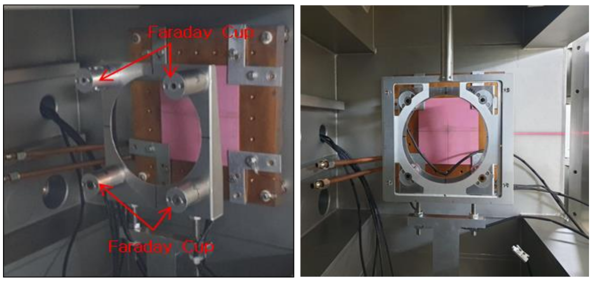

Figure.4. Faraday cup holder in the target chamber

2.3 Proton beam scanning system

After the proton beam separated by the bending magnet, it would be scanned through a raster scanner before reaching the target chamber. For raster scanners, the applied voltage is up to 20 kV and the frequency is 517 Hz horizontally and 64 Hz vertically. The test for high voltage application of the raster scanner is completed and S-to-S waveforms and amplitude values can be checked through an oscilloscope at the control room.


Figure.5 Raster scanner HV input test

According to calculations, the scanning diameter of the proton beam that can reach the wafer is up to 233 mm. The actual beam size is 190 mm in diameter due to the target chamber collimator. The actual scanned beam is in figure 5 below.

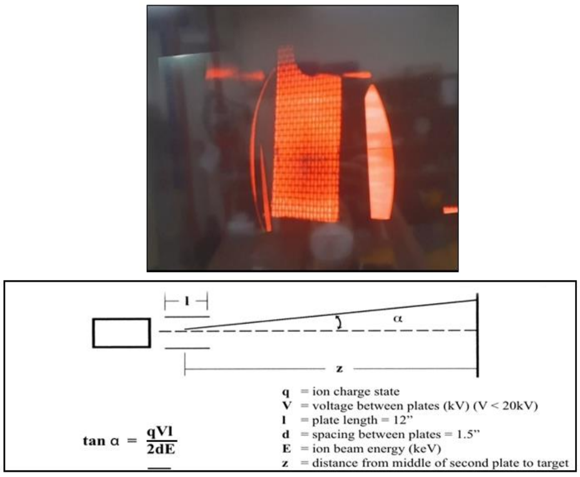

Figure.6 Beam scanned by raster scanner and Beam size calculation formula

3. Test

3.1 Scanning beam uniformity test

We conducted two experiments to measure the uniformity of the scanning beam. First, to figure out the overall distribution, the proton beam sensitized the film. In the experiment, a beam with an energy of 0.7 MeV irradiated film. As a result, the uniformity was less than 10 %.

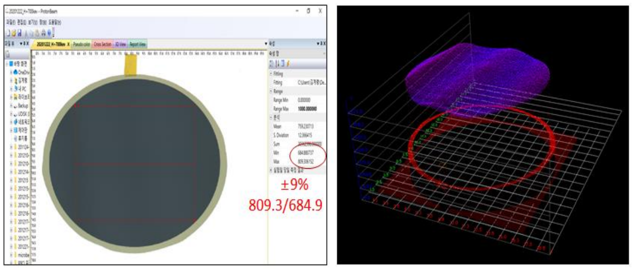

Figure.7 Uniformity measurement through film irradiation experiment

The second experiment, the Faraday cup current was converted into data using a current integrator to measure the uniformity of the four Faraday cups. Compared to the film irradiation experiment, it is similar to the conditions for irradiating an actual wafer because it irradiates a relatively long time. Currently, four sets of 6-inch wafer provided by domestic semiconductor manufacturers beam irradiation experiments have been completed. We will be able to receive Data such as density and uniformity later.

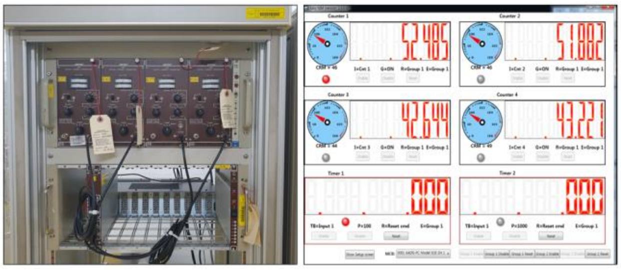

Figure.8 Integrator for measuring FC current

4. Conclusions

The 1MV electrostatic accelerator is being developed by KOMAC. Through this experiment, we could see the possibility that the 1-MV electrostatic accelerator could be used for real industrial applications. In addition, it is our goal to develop a device that can be automatically driven while loading a large amount of wafers..

REFERENCES

[1] Dae-Il Kim, et al., “Preliminary Test of 1 MV Electrostatic Accelerator at KOMAC” IPAC16, Busan, 2016.

[2] Yong-Sub Cho, Kye-Ryung Kim, Chan-Young Lee, Basic Design Study on 1-MV Electrostatic Accelerator for ion irradiation, Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 29-30, 2014.