Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Irradiation Uniformity Measurement at the New Beam Line of 1.7-MV Tandem Accelerator

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1. Introduction

A new beam line was designed and installed at the 1.7 MV pelletron-type tandem accelerator (NEC 5SDH-2) of KOMAC (Korea Multi-purpose Accelerator Complex). This beam line can be utilized for power semiconductor fabrication [1], nuclear material radiation hardness test [2], ion beam analysis [3-4], neutron production [5], etc. Especially, for the power semiconductor applications, a large-area irradiation, more than 5 inch in diameter, is required. Reflecting these users' requirements, we developed a new beam line by which we can irradiate 6-inch wafer. At the target chamber, we installed sample holder for 6-inch wafer positioning and Faraday cups for in-situ dose and uniformity monitoring. The uniform irradiation is performed by using electrostatic ion beam raster scan system of NEC. The results of uniformity measurements using Gafchromic film, Chromox plates, and Faraday cup are presented.

2. Methods and Results

2.1 Beam Line

For the fabrications of power semiconductor devices, proton beam irradiation can be used for the property improvement by controlling the minority carrier lifetime and creating a field-stop layer.

The users' requirements are summarized as follows;

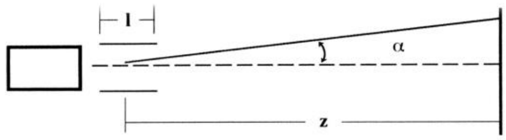
- Ions: Proton
- Irradiation area: 6" or 8" wafer size
- Energy: 1~2 MeV
- Uniformity: >90%
- Dose: 1E13~1E14 /cm^2

The beam line is composed of a steerer, a beam profile monitor, a faraday cup, a slit, a X-Y scanner, gate-valve, beam transport pipe and target chamber. The design parameters of the tandem accelerator and beam line are summarized in Table 1.

Table I: Parameters of Tandem Accelerator and Beam Line.

Accel. Voltage	0.1~1.7 MV
Max. Energy	3.4 MeV for proton
Ions	Proton, D, He, Cl, Fe, Al, etc.
Voltage Stability	< 1 kV
Beam Current	10 μA max for proton.
	5 μA max for iron
Irrad. Area	16 cm X 16 cm max. for 3 MeV proton
Irrad. Uniformity	± 10 %
Fluence Accuracy	± 10 %

To increase the uniform beam irradiation area, the diameter is increased to 16 cm and above, we changed the length of the beam line, the distance between the center of the 2nd plate of the scanner and the surface of the sample. The distance is changed from 1.74 m to 3.27 m. The deflection angle of a charged particle by one pair of plates is given in following equation. As a calculated result, the one-axis length of the irradiation area is changed from 9.4 cm to 17.7 cm and deflection angle is 1.53 degree for 3-MeV proton beam.



$$\tan\alpha = \frac{V \times l \times q}{2 \times d \times E} \qquad [1]$$

Where, V: voltage between plates [kV]
l: plate length [cm]
q: ion charge state [e]
d: spacing between plates [cm]
E: ion beam energy [keV]

For the raster scanning, we used electrostatic raster scan system, ERS-7 of NEC as shown in Fig. 2. The plate length and separation are 30.5 cm (12") and 3.8 cm (1.5"). The maximum voltage between plates is 20 kV. The scanning frequencies for X- and Y-directions are 517 and 65 Hz. The scanner is originally designed for use with an NEC silicon wafer ion implantation system. The scanner can deposit up to 3 MV doubly charged ions across 6 inch diameter silicon wafers. [6]

Fig. 1. Electrostatic raster scan system of NEC.

2.2 Target Chamber

The target chamber is installed at the end of the beam line. For the sample loading and dose measurement, a new sample holder was designed to be able to load a 6 inch wafer with 4~5 Faraday cups at the same surface of the sample. Faraday cups are FC-1 model of Beam Imaging Solutions. The aperture is 6 mm in diameter and permanent magnet is installed at the entrance of the cup for the electron suppression.

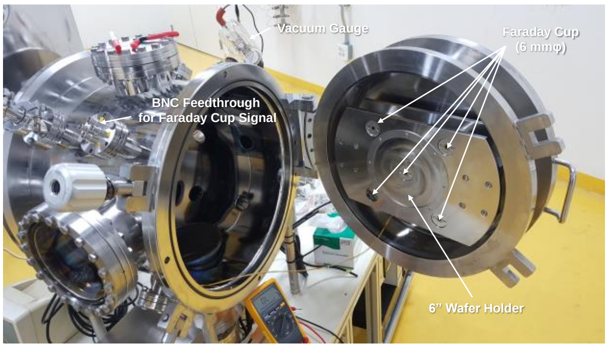
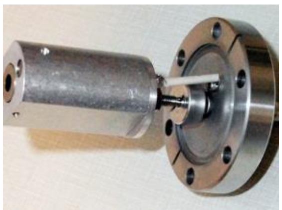


Fig. 2. Photographs of the target chamber.



Aperture: 0.25″ (6.35mm)
Input: Max. 2W continuous
Feedthrough:50 Ohm, BNC

Fig. 3. FC-1 Faraday cup.

2.3 Irradiation Uniformity Measurement

For the irradiation uniformity measurement, Gafchromic film (HD-V2), Faraday cups, and Chromox plate were used. As shown in Fig. 4, 10 cm x 10 cm size four Chromox plates were installed to cover 20 cm x 20 cm at maximum. As a result, it was identified that the maximum irradiation area is more than 20 cm x 20 cm using raster scan system.

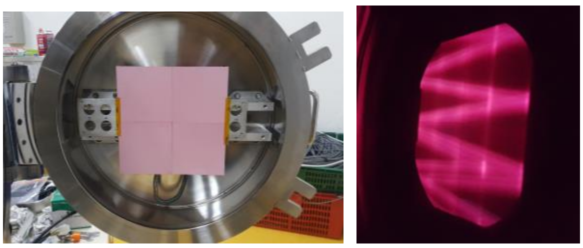


Fig. 4. Photographs of the Chromox plates and beam scanning results

The result using Gafchromic film is shown in Fig. 5. As shown in the right graph of Fig. 5, the irradiation uniformity is within ± 5 %.

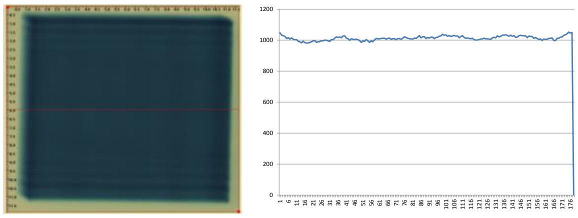


Fig. 5. Irradiation Uniformity (HD-V2).

3. Conclusions

A new beam line was installed at the 1.7 MV tandem accelerator. The maximum irradiation area is larger than 20 cm x 20 cm and the uniformity is within ± 5 %. So, it is identified that this new irradiation beam line can meet users' requirement in the power semiconductor fabrication and activate the utilization of the 1.7 MV tandem accelerator.

ACKNOWLEDGEMENT

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

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