III. 4.  Upgrade of Ion Irradiation Apparatus for Semiconductor Devises

Makino T., Hagiwara M., Itoga T., Hirabayashi N*, and Baba M.

Cyclotron and Radioisotope Center, Tohoku University
*Tokyo Electric Power Company

As reported in 2002 Annual report, we installed an ion irradiation apparatus to test radiation resistivity of semiconductors for use in the space exploration with protons and heavy ions, at the 33 course in Tohoku University k=110 AVF cyclotron (Fig. 1). The apparatus was designed to meet the required 1) beam fluxes of $\sim 10^7$ #/cm$^2\cdot$s (~ pA) for protons and $\sim 10^4$#/cm$^2\cdot$s for heavy ions, and 2) the flat beam profile over the devices (~ a few cm), for simulating the space environment. In addition, 3) a beam with various energies is required for study of the energy dependence of the resistivity. The system performed fairly satisfactory, but has a room for improvement: 1) beam uniformity, and 2) energy dependence of the SEM sensitivity.

To improve the performance we modified the arrangement, we moved the diffuser to 1.5m upstream along the beam line. A beam from the cyclotron is diffused and made flat with a gold diffuser. After that, the beam is led into SEM (secondary emission monitor) for the measurement of beam intensity in real time. Then, the beam energy is changed with copper degraders for the case of protons, and a cocktail beam (mixture of ions with the same M/Z where M is mass of the accelerated ion, and Z is charge of the ion) for heavy ions. Finally, the beam is extracted to the air through a Kapton foil which separates the beam line from air. Further, an external Faraday cup was prepared at the device position, and we can measure the absolute value of beam current at the device position by means of the Faraday cup. Newly installed beam attenuator in the incident line is also very helpful for control of beam intensity.

The beam profile and beam flux are important on the irradiation test. Therefore, we developed the measurement method of the beam profile at device position by using IP (imaging plate: high sensitive two-dimensional imaging sheet). We can measure the
beam profile with good spatial resolution from directly irradiated IP by applying special readout technique with filter sheets (Fig. 2)\(^5\). The beam flux can be measured reliably using SEM. The apparatus is stably running on proton irradiation test.

We are implementing S-SEM (Segmented-SEM) for all ions and a position-sensitive gas counter to measure the beam flux and profile concurrently.

References


Figure 1. Ion irradiation apparatus.

Figure 2. Intensity distribution by using IP, Ne 131 MeV.