§4. An Ion Decelerating System for Studies of Low Energy Ion Impact on Solid Surfaces

Hosaka, K. †, Tawara, H.

Recently we have investigated the interaction between ions and solid surfaces. We are interested in the secondary electron emissions under low energy (< 500 eV) ion impact on solid surfaces. In general, as low energy ion beam has a tendency to diverge through their space charge, it is difficult to obtain the sufficient intensity of low energy ion beam to experiments. So we need a decelerating system in order to suppress such divergence of ions. This report describes an ion decelerating system which we have designed and constructed for studies of low energy ion impact on solid surfaces.

A duo-plasmatron ion source has been used [1] in order to produce ions. After the charge and mass selection with a Wien filter, the ions are bent 90 degrees by an electrostatic quadrupole-deflector [2], which is also able to select the energy, and directed into a collision chamber after collimated to 3 mm in diameter. Because the ion source is floated at + 2.5 kV, we need to apply the positive potential to the target and put the decelerating system in front of the target in order to suppress the divergence of the low energy ion beam. As shown in Fig.1, the present decelerating system can be divided into two parts: the beam deflectors and the decelerating lenses. For the beam deflectors, we use the two sets of parallel plates for controlling the ion beam up and down, and also right and left in order to fix the ion beam at the central axis of the lenses. The decelerating lenses consist of 7 cylindrical electrodes using the combination of three triple-cylinder-lenses, all made of stainless steel. We employed two kinds of the triple-cylinder-lenses (Lens A and Lens B) and calculated the ion trajectory for these two lenses. These Lens A and Lens B have a constant focal length which is independent of the decelerating ratio. In other words, these are so-called zoom lenses. We based upon the geometries, the diameters and the gaps of the lenses which were calculated by Harting et al. [3]. In the present system, the inner diameter is 20 mm and the gap between electrodes is 4 mm. In order to the determine the combination of Lens A and Lens B, we had to take into account some conditions: 1) the shape of the beam at the entrance of lenses, 2) the divergence of the beam in the lenses, 3) the distance between the last electrode and the target and 4) the restriction of the space in the vacuum chamber. In our system, the lenses are arranged in order of Lens B, A and B. The aperture plates with a hole of 8 mm in diameter are located at the middle of the electrodes L3 and L5, in order to remove the strayed and scattered particles. We made a rough estimate of the ion trajectory using the data given by Harting et al. [3] and, finally, used the SIMION code for simulation of the ion trajectory.

By applying proper potentials to the electrodes (L1-L7) which were estimated through the simulation, the energy of the ion beam can be varied from 2.5 q·keV (q is the incident ion charge) down to 70 q·eV without losing the beam. In Fig.2, typical incident energy dependences of Ar^+ and Ar^{2+} beam intensities at the target are shown.

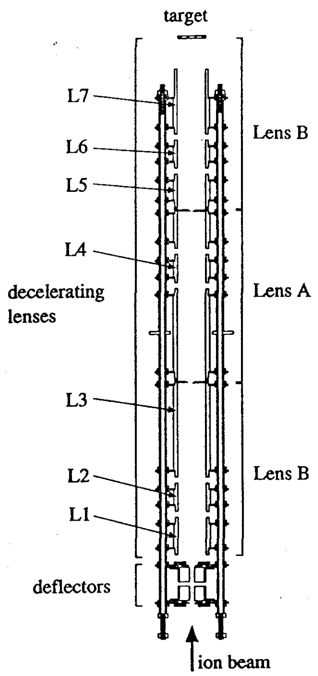

Fig. 1. A diagram of the decelerating system. This system consists of the beam deflectors and the decelerating lenses.

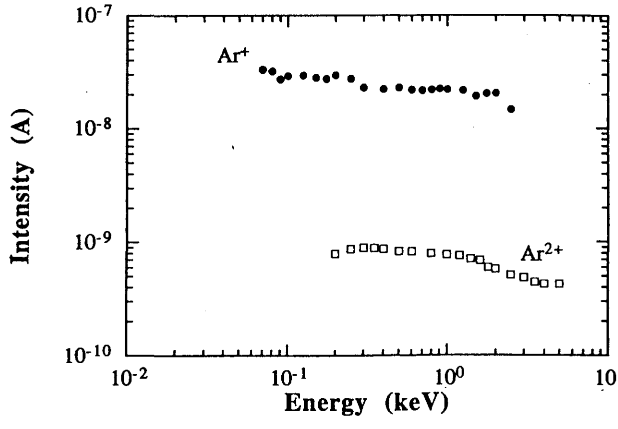

Fig. 2. Typical incident energy dependences of ion beam (Ar^+, Ar^{2+}) intensities at the target.

References

1) Tawara, H. et al. : Nucl. Instr. Meth. **31** (1964) 353
2) Zeman, H. D. : Rev. Sci. Instr. **48** (1977) 1079
3) Harting, E. et al. : *Electrostatic Lenses*, Amsterdam, Elsevier (1976)

† JSPS Research Fellow