§15. Measurement of Charge-Transfer Cross Sections of Slow Tungsten Ions in Collisions with Hydrocarbon Molecules

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A next day large nuclear fusion device ITER (International Thermo-nuclear Experimental Reactor) is being constructed by international cooperation. Tungsten (W) materials are planned to use together with carbon based materials at the divertor of the ITER. For the modeling of ITER plasma, the cross section data of charge-transfer processes of W ions colliding with some kinds of atoms and molecules are required. However, these cross section data are still scarce in the low collision energy.[1,2) In this research, the producing method of W ions is established first, and we measure the charge-transfer cross sections of W ions colliding with hydrocarbons at collision energies below 4 keV/q (q: the number of ionic charge).

Tungsten ions were successfully extracted at year before last from the electron impact ion source (EIIS) with the ion source test equipment. Tungsten hex carbonyl $W(CO)_6$ powder was used to produce the W ions. Because its vapor pressure is relatively high, its powder in a reservoir is easily vaporized under a high vacuum, and is introduced into the EIIS. $W(CO)_6$ molecules were ionized and decomposed by 100eV electron impact. Extracted ions were mass-separated with a 60° analyzing magnet, and were detected with a channel electron multiplier. W^+ and W^{2+} ions were detected and separated from many fragment $W(CO)_n^+$ and $W(CO)_n^{2+}$ ions ($n = 1 \sim 6$).

However, in our current experimental apparatus for cross section measurement, a Wien filter has been used to analyze the mass and charge of extracted ions from the ion source. At present, the mass resolution of this filter is low, and these fragment ions are not separable from the W ions. In order to perform cross section measurement, we carried out various improvements to the ion source test equipment.

Figure 1 shows the improved experimental apparatus. At first, a 350 l/s turbo-molecular pump (TMP) was newly installed in the collision chamber instead of a 150 l/s TMP. This 150 l/s TMP was attached in the vacuum chamber which contained the EIIS instead of a 50 l/s TMP. Then, the performance of the vacuum pumping system was enhanced. A position sensitive micro-channel plate detector (MCP-PSD) system and the collision cell with gas feed system were newly installed in order to perform the cross section measurement of charge transfer. To measure the pressure of target gas, a capacitance manometer (Baratron) was enabled to connect with the collision cell. A small TMP (30 l/s) vacuum system was newly coupled to the $W(CO)_6$ reservoir. The amount of evaporation of $W(CO)_6$ can control now under a high vacuum. By this system, $W(CO)_6$ vapor is directly introduced into the EIIS.

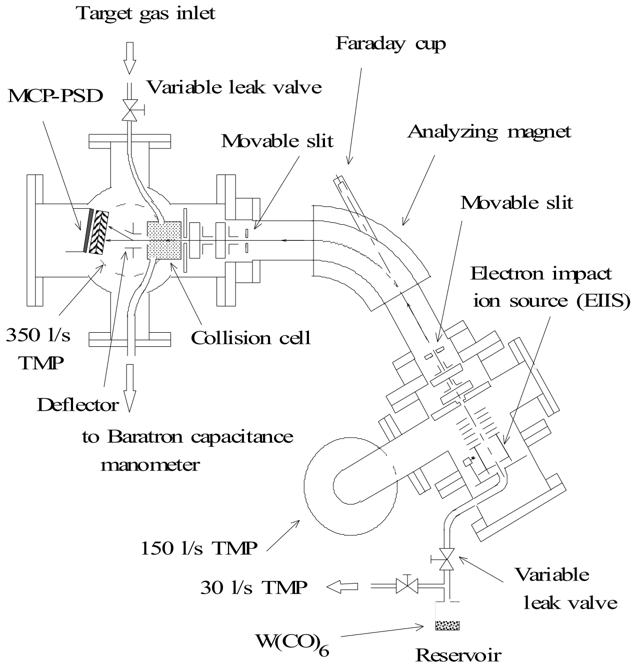

Fig. 1. Improved experimental apparatus.

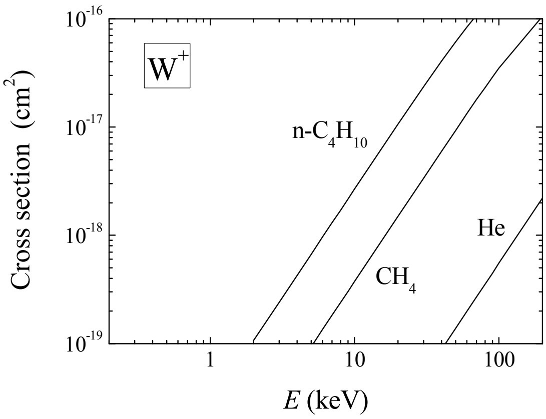

Fig. 2. Charge-transfer cross sections of W^+ ions colliding with He, CH_4, and n-C_4H_{10} estimated by using the Rapp-Francis formula.[3)]

We have also estimated the charge-transfer cross sections of W^+ ions colliding with He, CH_4, and n-C_4H_{10} using a simple theoretical formula proposed by Rapp and Francis.[3)] As shown in Fig. 2, every calculated cross section value is found to be small. This is due to the heavy mass of W ions and relatively large energy defect of the reaction in each charge transfer process.

The final adjustment of the experimental apparatus is progressing now and cross section measurement will start before long.

1) Janev, R. K., Belić, D. S., and Bransden, B. H.: Phys. Rev. A **28** (1983) 1293.
2) Meyer, F. W. *et al.*: Phys. Rev. A **19** (1979) 515.
3) Rapp, D., and Francis, W. E.: J. Chem. Phys. **37** (1962) 2631.