§45. Cross Sections of Charge Transfer by Slow Tungsten Ions in Collisions with Hydrocarbon Molecules

Kusakabe, T. (Dept. Phys. Kinki Univ.),
Pichl, L. (ICU),
Kato, D.,
Sakaue, H.A.

Construction of the ITER (International Thermo-nuclear Experimental Reactor) which is a next day large nuclear fusion device is advancing 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 hydrocarbon molecules are required. However, these cross section data are still scarce in the low collision energy.[1-3] In this research, the producing method of W ions is established first, and we measure the charge-transfer cross sections of W ions in collisions with hydrocarbon molecules in the energy region below 4 keV/q (q : the number of ionic charge).

In the present experiment, as a first step of this study, tungsten ions were extracted from an electron impact ion source (EIIS) with ion source test equipment as shown in Fig. 1. Tungsten hex carbonyl $W(CO)_6$ is widely used in electron beam-induced deposition technique. Because its vapor pressure is relatively high, it is easily vaporized under a high vacuum. In this experiment, the tungsten hex carbonyl powder in a reservoir evaporates 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 homogeneous magnetic field in a 60° sector magnet, in which magnetic density can set to be up to about 6 k Gauss and its radius is 0.15 m, and were detected with a channel electron multiplier (CEM) or a micro-channel plate detector (MCP). The front and main chambers were evacuated down to the back pressure of less than about 1×10^{-4} Pa by 50 l/s and 150 l/s turbo-molecular pumps (TMP).

Figure 2 shows a typical mass spectrum of tungsten and their fragment ions generated from the tungsten hex carbonyl extracted from the EIIS. The electric potential for acceleration of ions is 700 V. The net $W(CO)_6$ gas pressure was about 1×10^{-3} Pa at outer region of the EIIS. It can be thought that some ions such as H^+, H_2^+, H_2O^+, O_2^+, and so forth among the detected ions were produced from H_2O, and O_2 molecules of residual gas. Singly and doubly charged tungsten ions, W^+ and W^{2+}, were clearly detected and separated from many fragment $W(CO)_n^+$ and $W(CO)_n^{2+}$ ions ($n = 1 \sim 6$). A large number of the ions corresponding to CO^+, its dimmer $(CO)^{2+}$, C^+, O^+, O^{2+}, and so forth considered to originate in the carbonyl radical (-CO-) of tungsten hex carbonyl, were also identified.

As mentioned above, singly and doubly charged tungsten ions were separated and detected from many fragment ions with the mass spectrometer by a uniform magnetic field. However, a Wien filter is used to analyze the mass and charge of extracted ions from the ion source in our current experimental apparatus for cross section measurement. At present, the mass resolution of this Wien filter is low, and these fragment ions cannot be separated. In order to be able to perform cross section measurement, some improvements in the mass resolution of this Wien filter are under preparation.

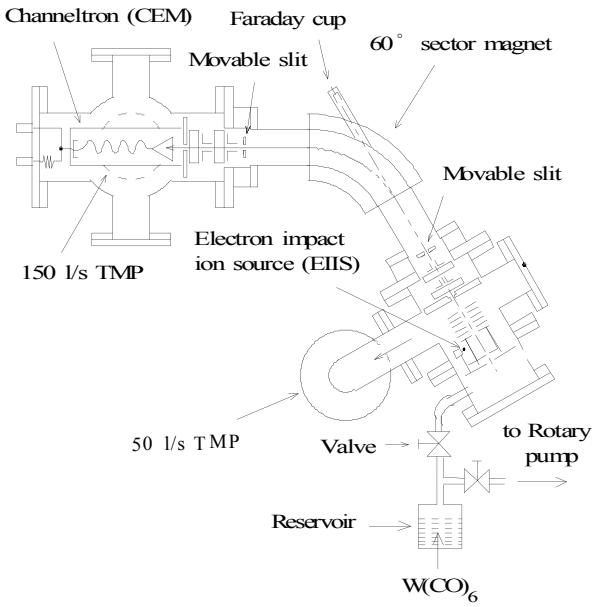

Fig. 1. Experimental apparatus for testing the ion source.

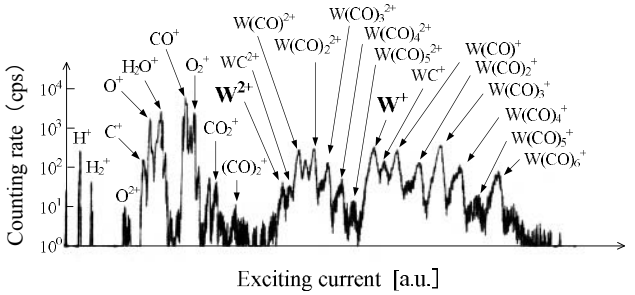

Fig. 2. Mass spectrum of tungsten and their fragment ions generated from tungsten hex carbonyl extracted from the EIIS. The electric potential for acceleration of ions is 700 V.

1) Janev, R. K., Belić, D. S., Bransden, B. H.: Phys. Rev. A **28** (1983) 1293.
2) Meyer, F. W. *et al.*: Phys. Rev. A **19** (1979) 515.
3) Kheyrandish, H., Armour, D. G., and Jones, E. J.: Vacuum **34** (1984) 269.