§16. Cross Section Measurements for Electron-Impact Dissociation of CHF_3 into Neutral and Ionic Radicals

Toyoda, H., Goto, M., Nakano, T., Nakamura, K., Sugai, H. (Faculty of Eng., Nagoya Univ.)
Tawara, H.

CHF_3 discharge plasmas can be used for in-situ removal of boron or silicon film deposited on the first wall of fusion devices. In order to clarify elementary processes in the plasma removal of deposited films by the CHF_3 discharge, measurements of the electron-impact dissociation cross section of CHF_3 into CF_x radicals are very important, because these dissociation processes produce chemically-active species that drive gas phase and surface reactions. We measured the absolute cross sections for electron-impact dissociation of CHF_3 molecule into CF_3, CF_2, CF, CHF_2 and CHF, using appearance mass spectrometry.[1]

Experimental measurements were made in a dual-electron-beam device combined with a quadrupole mass spectrometer (QMS). This system consists of three compartments which are differentially pumped with two turbo molecular pumps. The first compartment is a dissociation cell where a primary electron beam incident and dissociates into ionic and neutral radical species. The second compartment is a detection cell where a probing electron beam emitted from a rhenium filament ionizes neutral radicals effusing from the dissociation cell. The third compartment is an electron source cell, where the primary electron beam is produced from a hot negatively-biased filament. Figure 1 shows examples of the semi-logalithmic plot of the QMS output for m/e $=69(CF_3^+)$ as a function of the energy E_Q of the probing electron beam. The output signal of CF_3^+ with the beam turned on (full circles) is larger than the signal with the beam off (open circle) in a region of energies lower than 14 eV. The difference between them is attributed to electron impact ionization of CF_3 radicals effusing from the dissociation cell.

The absolute value of cross sections was determined considering the ionization cross section, surface loss probability, and vacuum conductance for radicals. The mass dependence of QMS sensitivity is also considered. The absolute values of partial cross sections for dissociation of CHF_3 into CF_3, CF_2, CF, CHF_2 and CHF radicals are shown in Fig.2. The cross sections for CF, CF_2 and CF_3 have a maximum at E=40, 70, and 110 eV respectively and gradually decreases as the electron impact energy increases. This behavior is similar to the energy dependence of partial cross sections for dissociation of CF_4 into neutral radicals.[2] The branching ratio at E=150 eV was CF_3:F_2:CF:CHF:CHF=27:5:10:2:1.

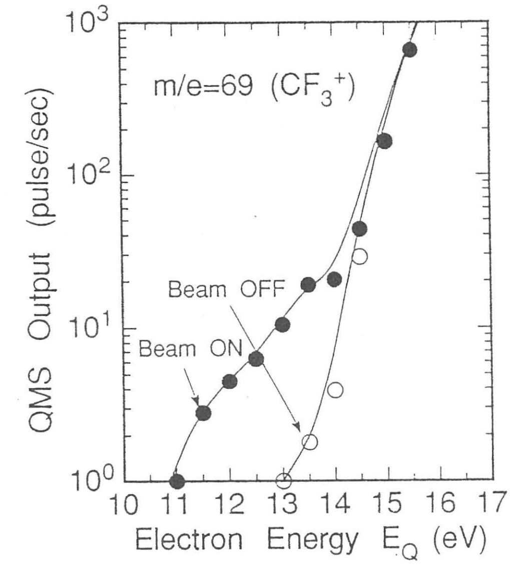

Fig. 1. Quadrupole mass spectrometer output for $m/e=69(CF_3^+)$ as a function of probing beam energy E_Q.

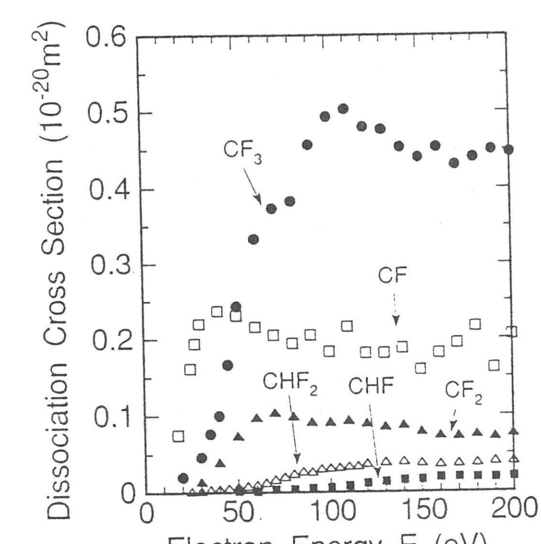

Fig. 2. Absolute cross sections for neutral dissociation of CHF_3 into CF_3 (full circles), CHF_2 (open circles), CF_2 (full triangles), CHF (full squares) and CF (open squares).

References

1) Sugai, H., Toyoda, H., J. Vac. Sci. Technol. A10(1992)1993.
2) Nakano, T., Sugai, H., J. Phys. D26(1993)1909.