Electron Transport Coefficients in C_2F_6-Ar Mixtures and Inelastic Cross Sections for the C_2F_6 Molecule

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1 Introduction

Hexafluoroethane(C_2F_6) is used as a working gas for diffuse discharge switches and etching plasmas for materials processing and also as a gaseous insulator in high voltage equipment. But the present state of cross section data for the molecule is not reliable enough for numerical simulations. We have been studying electron collision cross sections of molecules by the measurement of electron swarm parameters in dilute molecular gas-rare gas mixtures and in the pure molecular gas. Electron swarm parameters in the mixtures are very sensitive to the vibrational cross sections of the molecule and the elastic cross section of the rare gas atom and are nearly insensitive to the elastic cross section of the molecule. We, therefore, were able to derive detailed information on the vibrational cross sections of the molecule from the electron swarm parameters, measured in the dilute molecular gas-rare gas mixtures exclusively. The swarm parameters in the pure molecular gas, on the other hand, depend on the elastic and inelastic cross sections of the molecule, and, once the inelastic cross sections were known, we were able to derive the elastic cross section for the molecule from the measured swarm parameters measured in the pure molecular gas.

Presented in this report are the experimental results for the drift velocity and longitudinal diffusion coefficient of electrons in dilute C_2F_6-Ar mixtures and the derived vibrational excitation cross sections which are consistent with the measured swarm parameters.

We are now measuring the swarm parameters in the pure C_2F_6 gas and we are going to derive the elastic cross section for C_2F_6 using the present vibrational cross sections after completion of the measurements.

2 Measurements

We used the double shutter drift tube [1] with variable drift distances (1 - 10 cm) for the measurements of the electron drift velocity, **W**, and the product of the gas number density and the longitudinal diffusion coefficient, $\mathbf{ND}_L$, in 0.524% and 5.47% C_2F_6-Ar mixtures. The ranges of the measurements are shown in Table 1.

The measured electron drift velocities in the mixtures show the Negative Differential Conductivity (**NDC**) indicating a strong contribution from the vibrational inelastic processes of the C_2F_6 molecule over the E/N range 2 - 25 Td in the 5.47% mixture, and 0.35 - 20 Td in the 0.524% mixture.

The measured products $\mathbf{ND}_L$ in mixtures also show clearly the contributions of the molecular additive in argon. The peaks of the measured $\mathbf{ND}_L$ over the E/N range 5 - 20 Td in the 5.47%

Table 1: The ranges of the measurements

Mix Ratio (%)	E/N Range (Td)	Gas Pressure Range (Torr)
5.47	0.04 - 100	1 - 560
0.524	0.04 - 70	1 - 700

mixture and 1.4 - 7 Td in the 0.524% mixture show the characteristic of perfluoroalkanes, C_nF_{2n+2} (n=1,2,3).

Fig. 1 compares the results of the present measurements of **W** and $\mathbf{ND}_L$in the 5% and 0.5% C_2F_6-Ar mixtures [2], and of the electron drift velocity **W** in pure Ar [3].

3 Analysis

The cross sections are shown in Fig. 2. The initial set of cross sections for the C_2F_6 molecule by Hayashi [4] was modified by using a multi-term Boltzmann analysis [5].

We modified the vibrational excitation cross sections for the C_2F_6 molecule until consistent values for **W** and $\mathbf{ND}_L$ were obtained from the measurements. The thresholds of the vibrational excitation cross sections for the C_2F_6 molecule by Hayashi are shown in Table 2.

Table 2: Thresholds of the vibrational excitation cross sections for the C_2F_6 molecule

vibrational cross sections	thresholds (eV)
qv6	0.089
qv5	0.138
qv7	0.155

The results are shown in Fig. 3 and Fig. 4. The measured drift velocities in the two mixtures agree with the calculated ones over the E/N range 0.04 - 10 Td in the 5.47% mixture, and 0.04 - 4 Td in the 0.524% mixture.

4 Conclusion

We measured two electron swarm parameters, drift velocities and longitudinal diffusion coefficients in 0.524% and 5.47% C_2F_6-Ar mixtures over the E/N range from 0.04 to 100 Td. The measured swarm parameters were compared with those measured in CF_4-Ar and C_3F_8-Ar mixtures with similar mixing ratios. The E/N dependence of the measured swarm parameters clearly indicates possible direction for refinement of the vibrational cross sections.

5 Future work

We will determine the best consistent vibrational cross sections for C_2F_6 from the present measurement in the mixtures. And after that, we will determine the momentum transfer cross section for C_2F_6 from our new measurement of swarm parameters in pure C_2F_6, which has just been started.

References

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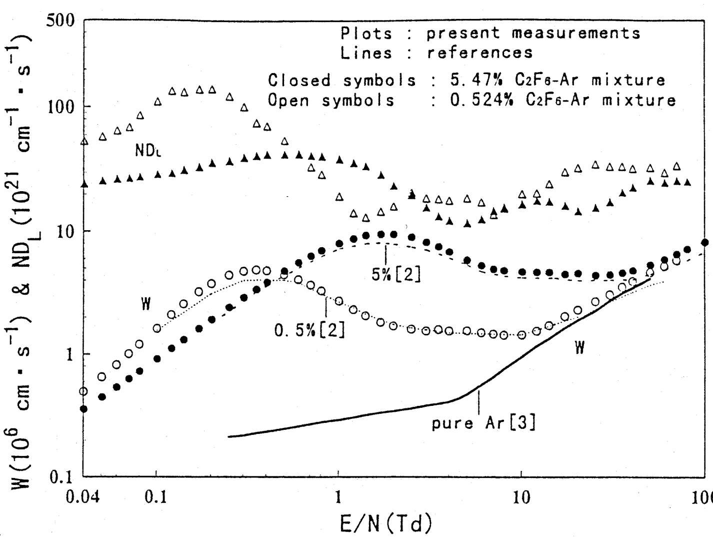

Fig.1 W and ND_L as a function of E/N in C_2F_6-Ar mixtures

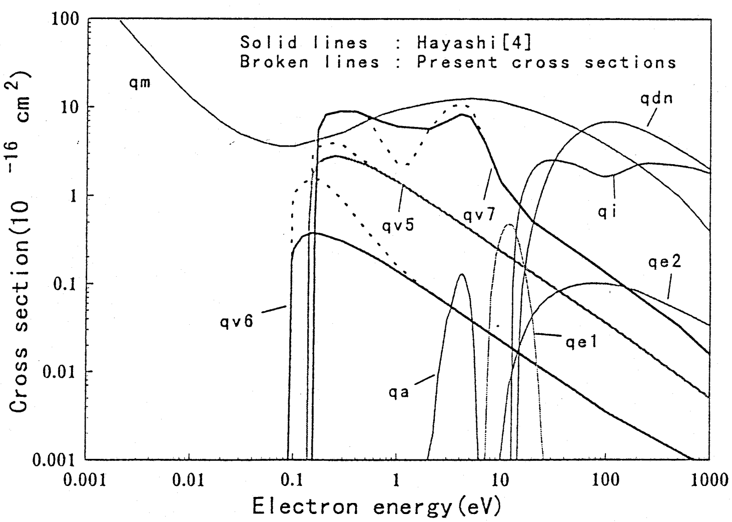

Fig.2 Electron collision cross sections for C_2F_6

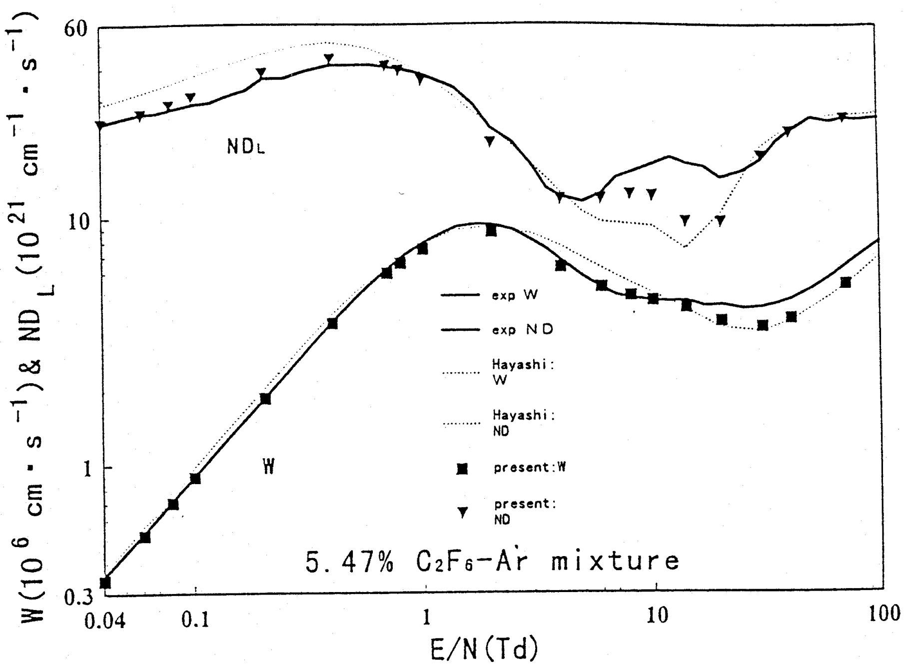

Fig. 3: W and ND_L in the 5.47% C_2F_6-Ar Mixture

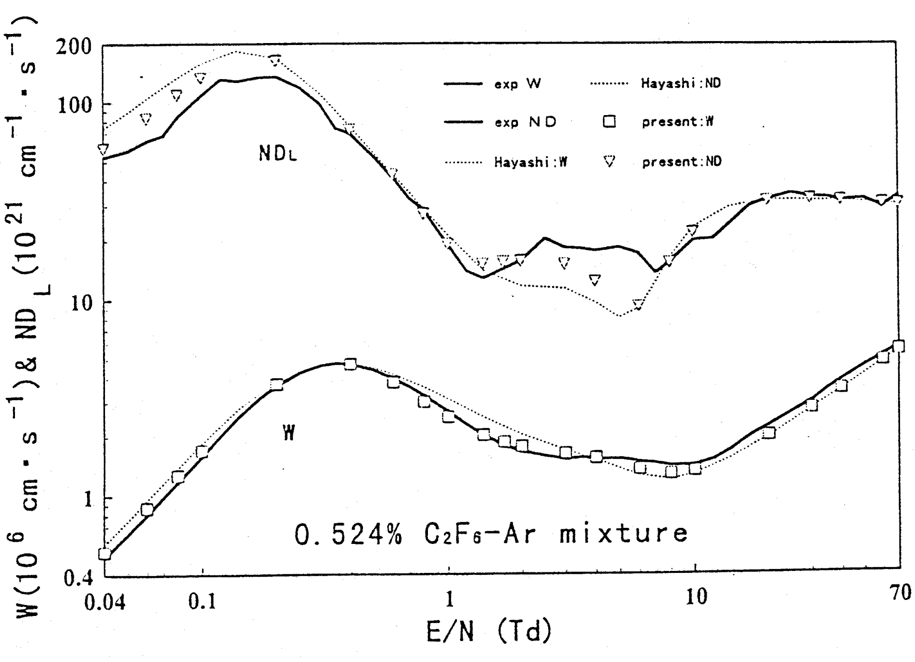

Fig. 4: W and ND_L in the 0.524% C_2F_6-Ar Mixture